

CLEAR CUTTING ALTERNATE STRIPS AND SCARIFYING IN PURE WHITE SPRUCE

STANDS TO INDUCE WHITE SPRUCE REGENERATION - SASKATCHEWAN

by

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V.S. Kolabinski¹ and J.M. Jarvis²

INTRODUCTION

White spruce (Picea glauca (Moench) Voss) regeneration is scarce in both disturbed and undisturbed stands (Candy 1951) in the Mixedwood Forest Section of the Boreal Forest Region (Rowe 1959) primarily because suitable seedbeds are lacking. Various experiments have shown that exposed humus and mineral soil are favorable seedbeds (Phelps 1948 and 1951; Lees 1963 and 1964) because on such media moisture is usually available near the surface, especially in the early part of the summer when most seedlings are establishing a root system.

In 1959 the Canadian Forestry Service, in co-operation with the Saskatchewan government, undertook to establish a series of cutting trials in the Mixedwood Forest Section. The purpose was to test at the operational level the hypothesis that scarification by mechanical methods in conjunction with logging would induce sufficient white spruce regeneration to form potentially merchantable stands. In this series of trials strip clear cutting in an east-west direction was employed to create a range of environments (shaded on the south side of clear cut strips to full exposure on the north side) on which to observe seedling development.

This report has been prepared to bring pertinent information together and to present, in the form of case histories, results for each of the trials established; with exception of one trial area the results are for the first 5-year period following establishment.

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CASE HISTORIES

Trial 1

Location: Twp. 41, Rge. 3, Sec. 36, W.2, Mer. (Figure 1)

Description: Trial 1 is on an area about 53 acres in size which in 1959 supported a mature white spruce stand with a total basal area of about 144 square feet per acre; of this total about seven square feet was hardwood (Table 1). The terrain is flat and the soil is a high lime clay-loam till. Sites on the area vary from moderately moist to wet but most are in the categories moist to very moist.

Work done: During the winter of 1959-60 alternate 2-chain wide strips were logged under the supervision of the Saskatchewan Forestry Branch. All trees, whether merchantable or not were felled and skidded off the area.

In August 1960, seedbed treatment was carried out on portions of the cut-over strips (Figure 2). A TD-14 crawler-type tractor equipped with a Saskatchewan fire-line plow was used.

In 1961, 900 permanent milacre quadrats (300 on cut-over scarified areas, 301 on cut unscarified areas and 299 on uncut areas) were established to assess regeneration; ten 1/5-acre plots were established in the uncut strips to obtain stand data; three small plantations were established on an uncut strip and on cut-over strips in both scarified and unscarified conditions to obtain information on plantation development in the various environments; 112 seed traps were set out (56 on a cut-over strip and 56 on an uncut strip) to obtain information on seedfall (Figure 2); and five permanent observation transects were established to observe seedbed receptiveness with the passage of time.

Results:

1. Losses occurred in the total number and total basal area of spruce on the uncut strips during the five-year period after logging (Table 1). This was due mostly to "wind-throw" along the edges of the strips. On the other hand, increases occurred in total number and basal area of hardwoods. No hardwoods were "wind-thrown".
2. Abundant seed was produced in 1961, 1962 and 1964; in 1963 and 1965 the crop was much smaller (Table 2). The poor seed year in 1963 is reflected in the absence of new germinants tallied on the permanent observation plots in 1964 (Table 3). As indicated by Table 3, however, suitable seedbeds were still available five years after treatment.
3. After five years, occurrence and abundance of spruce seedlings were much greater on the cut-over scarified conditions than on the others (Tables 4 and 5). Seedlings in the uncut conditions were small and weak; it would appear that in the uncut conditions seedlings become established after each good seedfall but persist

for only a few years. On the cut-over unscarified conditions hardwood regeneration is dominant.

4. Occurrence and abundance of white spruce regeneration by site are shown in Tables 6 and 7. Stocking was best on the moist sites, poorest on the wet sites and intermediate on the moderately moist and very moist sites.
5. Number of seedlings (excluding cotyledons) five years after treatment by height classes is shown in Figure 3. The greatest number and the largest seedlings occur on the scarified areas. Except for the one to three inch class there are more and larger seedlings on the cut-over unscarified areas than on the uncut areas. As noted above, seedlings on the uncut conditions do not persist.
6. The distribution of the various types of seedbed on each of the three conditions (cut-over scarified, cut-over unscarified, and uncut) along with the occurrence of seedlings on each is shown in Table 8. From these data it is apparent that decayed wood and seedbeds created by the scarification are the most favourable for germination and subsequent survival.
7. Survival and growth of planted seedlings (Table 9) has been best on the cut-over scarified areas, poorest on the uncut areas and intermediate on the cut-over not-scarified areas. Seedlings planted on F horizon, humus, overturned sod, haulroads, and on litter appear to have had the best survival rate (Table 10). Planting in the deep litter at the base of stumps and on squirrel caches is definitely a poor risk. The results obtained by planting on overturned sod and on litter are attributed to the fact that plenty of moisture was available because the sites were moist (see description of area). If sites had been drier, planting success on overturned sod and on litter would probably have been poorer. Much of the mortality on humus was due to flooding.

Comments:

1. Results have indicated that scarifying moist to very moist white spruce cut-over will result in the establishment of adequate regeneration.
2. The Saskatchewan fire-line plow appears to be a good tool for treating these moister sites where footing for the tractor is poor. The tractor can maneuver the plow around stumps, removing the upper portions of the organic mantle, revealing the humus horizon without danger of becoming stuck.

3. To obtain natural regeneration a source of seed must be maintained for a few years. Trees that are exposed on these moist sites as a result of partial logging are susceptible to wind-throw and there is a real risk that substantial volumes of mature timber will be lost.
4. It would appear that moist to very moist white spruce cut-over (scarified or not scarified) can also be regenerated successfully by planting. Care should be taken to plant seedlings on spots where the organic mantle is the shallowest, and where the seedlings will not be flooded.
5. The year 1961 was extremely dry and this may have had an influence on survival on the moist sites.
6. Rabbit populations were at a peak level in 1961 and many planted seedlings were damaged by browsing.

Trial 2

This trial area was burned the year after logging and was abandoned.

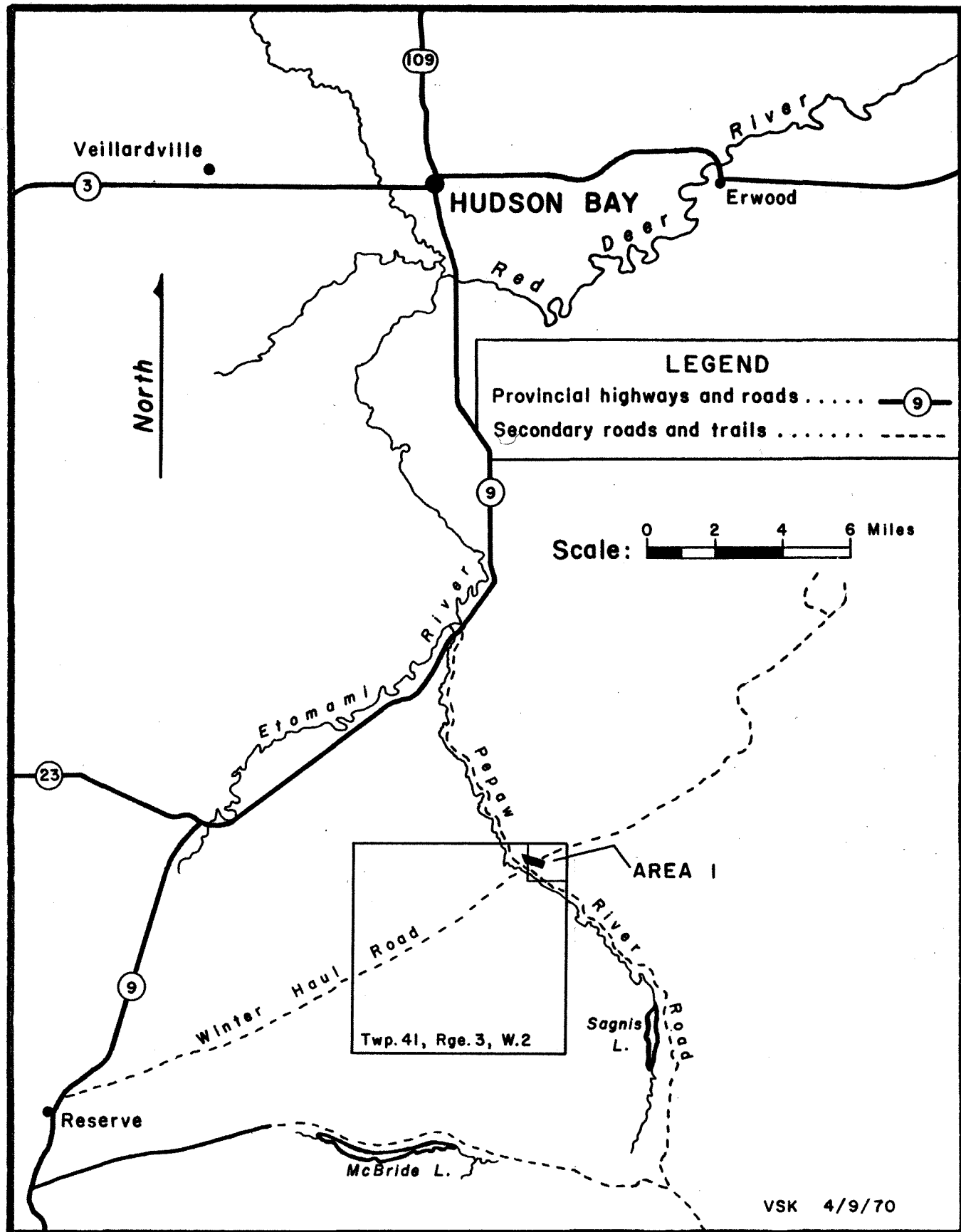


Figure 1. Location of Area 1.
Twp. 41, Rge. 3, Sec. 36, W.2 Mer.

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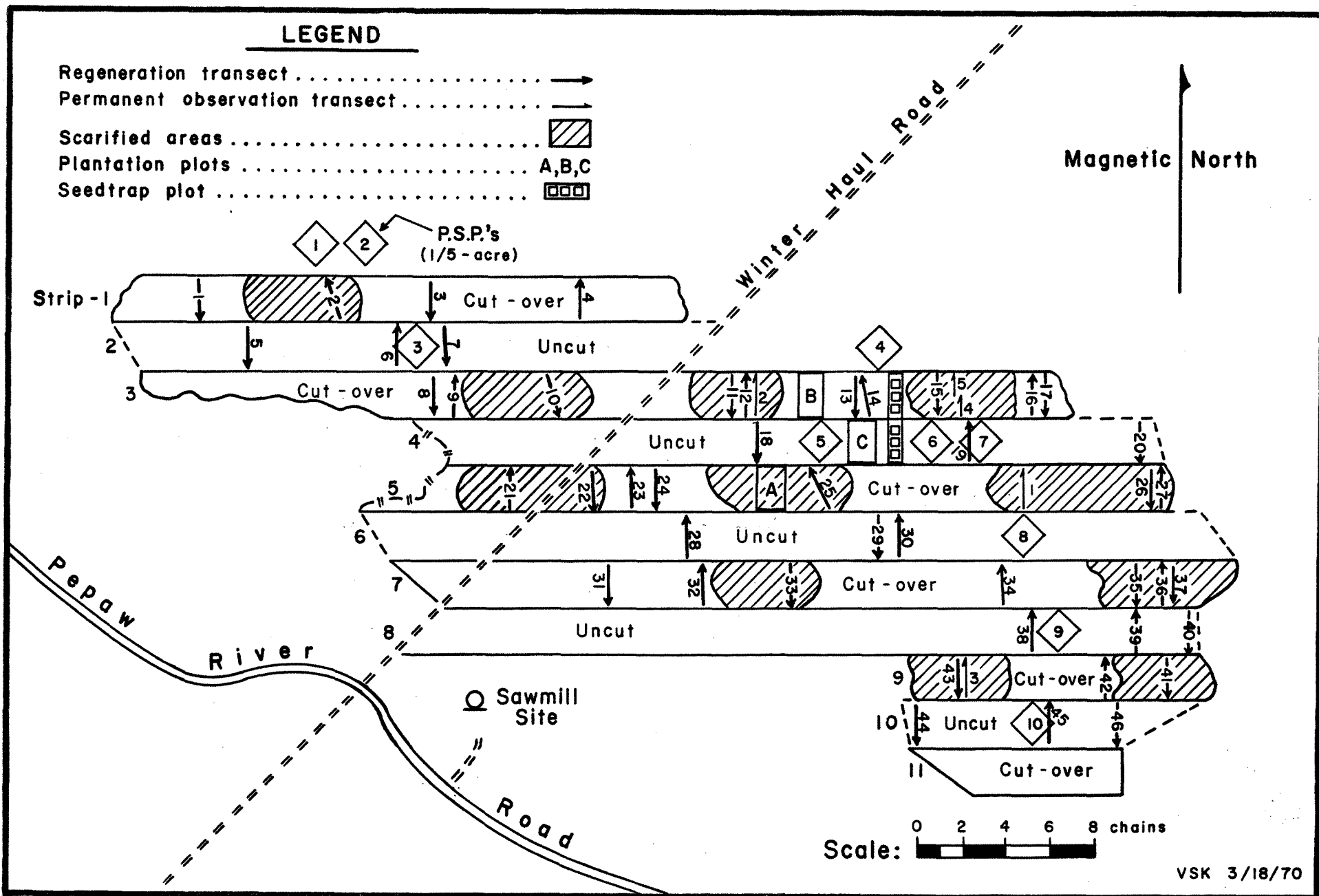


Figure 2. Sketch of Area 1 showing cut-over strips, scarified areas, and location of sample plots.

TABLE 1

STAND TABLE, AREA 1

(basis - 10, 1/5-acre P.S.P.'s

D.B.H. (inches)	Before Cutting				Five Years After Cutting			
	White spruce		Hardwoods		White spruce		Hardwoods	
	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)
1	2.5	.125	9.0	.045	1.0	.005	19.5	.098
2	8.0	.176	2.5	.055	8.0	.176	8.0	.176
3	12.5	.612	0.5	.024	11.5	.564	1.0	.049
4	14.0	1.218	1.0	.087	11.0	.957	1.0	.087
5	15.0	2.040			12.0	1.632		
6	11.5	2.254	1.0	.196	9.0	1.764	0.5	.098
7	13.0	3.471	1.0	.267	13.0	3.471		
8	16.0	5.584	1.5	.523	16.0	5.584	1.5	.524
9	20.0	8.840	0.5	.221	20.5	9.061	1.5	.663
10	21.5	11.718	0.5	.272	20.5	11.172	0.5	.272
11	21.0	13.860	1.0	.660	18.5	12.210	1.0	.660
12	13.5	10.598			12.5	9.812		
13	23.0	21.206	1.0	.922	24.0	22.128	0.5	.461
14	10.0	10.690	0.5	.534	8.5	9.086	0.5	.534
15	10.5	12.884	1.5	1.840	9.0	11.043	1.5	1.840
16	9.5	13.262	0.5	.698	10.5	14.658	0.5	.698
17	4.0	6.304			5.5	8.668	0.5	.788
18	3.0	5.301			3.5	6.184		
19			0.5	.984	0.5	.984		
20	1.5	3.273			1.0	2.182		
21	0.5	1.202			1.0	2.405	0.5	1.202
22	1.0	2.640			1.0	2.640		
ALL	231.5	137.258	22.5	7.328	218.0	136.386	38.5	8.150

TABLE 2

WHITE SPRUCE SEEDFALL AREA 1, 1960 to 1964

Location	Number Per Acre ¹				
	1960	1961	1962	1963	1964
Uncut strip					
South 1/3	No data	3,008,000 ²⁽¹⁷⁾	1,200,000 ⁽⁸⁾	278,461 ⁽¹³⁾	3,049,090 ⁽¹¹⁾
Middle 1/3	" "	3,000,000 ⁽⁵⁾	1,035,000 ⁽⁸⁾	340,000 ⁽⁹⁾	2,816,000 ⁽⁵⁾
North 1/3	" "	3,104,000 ⁽⁵⁾	1,416,667 ⁽⁶⁾	343,636 ⁽¹¹⁾	3,640,000 ⁽⁵⁾
Average	No data	3,024,000 ⁽²⁷⁾	1,119,091 ⁽²²⁾	316,970 ⁽³³⁾	3,134,286 ⁽²¹⁾
Cut-over strip					
South 1/3	No data	2,600,000 ⁽²¹⁾	1,018,333 ⁽¹²⁾	264,444 ⁽⁹⁾	2,542,222 ⁽⁹⁾
Middle 1/3	" "	1,998,000 ⁽⁸⁾	850,909 ⁽⁸⁾	150,667 ⁽¹⁵⁾	2,521,250 ⁽¹⁶⁾
North 1/3	" "	2,346,000 ⁽¹⁹⁾	953,333 ⁽⁹⁾	121,053 ⁽¹⁹⁾	2,408,750 ⁽¹⁶⁾
Average	No data	2,394,000 ⁽⁴⁸⁾	919,070 ⁽⁴³⁾	177,674 ⁽⁴³⁾	2,481,951 ⁽⁴¹⁾

¹Viability of 1961 seed in December 1962 determined by cutting test on 800 seeds was 35%.
Germination test of 1962 seed in January 1964 on 500 seeds indicated 12% viability.
Germination test of 1963 seed in January 1965 on 500 seeds indicated 7% viability.
Cutting test of 1964 seed in December 1965 indicated 63% sound.

²Figures in brackets indicate number of traps on which estimates were based.

TABLE 3
 NUMBER OF NEW WHITE SPRUCE GERMINANTS TALLIED ANNUALLY
 ON PERMANENT OBSERVATION TRANSECTS
 1961 TO 1965, AREA 1

Transect number	Total area (sq. ft.)	Number of New Germinants				
		1961	1962	1963	1964	1965
1	180	171	217	23	0	3
2	223	101	163	14	0	23
3	201	22	13	6	0	2
4	137	124	121	7	0	3
5	116	14	113	5	0	6
ALL	857	432	627	65	0	37
Number per acre		21,945	31,852	3,302	0	1,880

TABLE 4
PER CENT QUADRATS STOCKED TO WHITE SPRUCE, OTHER SOFTWOODS
AND HARDWOODS, AREA 1

Condition	Number of Quadrats	One Year After Treatment						Five Years After Treatment					
		White spruce		Other softwoods		Hardwoods		White spruce		Other softwoods		Hardwoods	
		Regener- ation %	Advance growth %	Regener- ation %	Advance growth %	Regener- ation %	Advance growth %	Regener- ation %	Advance growth %	Regener- ation %	Advance growth %	Regener- ation %	Advance growth %
Cut and scarified	300	63	4	-	-	- ¹	15	47	2	-	-	-	25
Cut not scarified	301	4	23	-	1	-	42	8	10	-	0	-	54
Uncut	299	1	17	-	< 1	-	8	18	5	-	0	-	31
All	900	23	15	-	< 1	-	21	26	6	-	0	-	37

¹ All hardwood regeneration classed as advance growth.

TABLE 5
NUMBER OF WHITE SPRUCE, OTHER SOFTWOODS AND HARDWOOD
STEMS PER ACRE, AREA 1

Condition	Number list quadrats	First Year						Five Years After					
		White spruce		Other softwoods		Hardwoods		White spruce		Other softwoods		Hardwoods	
		Regener- ation	Advance growth	Regener- ation	Advance growth	Regener- ation	Advance growth	Regener- ation	Advance growth	Regener- ation	Advance growth	Regener- ation	Advance growth
		Number per acre		Number per acre		Number per acre		Number per acre		Number per acre			
Cut and scarified	58	1,034	52	-	-	-	69	1,483	17	-	-	-	672
Cut not scarified	60	50	267	-	17	-	450	200	250	-	0	-	2,617
Uncut	60	34	250	-	-	-	34	683	67	-	-	-	900
All	178	365	191	-	6	-	185	781	112	-	0	-	1,404

TABLE 6

PER CENT STOCKING OF WHITE SPRUCE REGENERATION BY SITE, AREA 1

Condition	Number Per Acre First Year ¹				Number Per Acre Five Years After			
	Site				Site			
	Moderately moist	Moist	Very moist	Wet	Moderately moist	Moist	Very moist	Wet
Cut and scarified	47(87)	69(195)	44(18)	0(0)	39(87)	52(195)	39(18)	0(0)
Cut not scarified	0(82)	5(144)	5(59)	6(16)	2(82)	10(144)	12(59)	6(16)
Uncut	1(95)	1(127)	1(74)	0(3)	14(95)	27(127)	12(74)	0(3)
All	19(264)	31(466)	8(151)	5(19)	19(264)	32(466)	15(151)	5(19)

¹ Figures in brackets represent number of quadrats.

TABLE 7

NUMBER OF WHITE SPRUCE REGENERATION PER ACRE BY SITE, AREA 1

Condition	Number Per Acre First Year ¹				Number Per Acre Five Years After			
	Site				Site			
	Moderately moist	Moist	Very moist		Moderately moist	Moist	Very moist	Wet
Cut and scarified	611 ⁽¹⁸⁾	1,278 ⁽³⁶⁾	750 ⁽⁴⁾	0 ⁽⁰⁾	778 ⁽¹⁸⁾	1,639 ⁽³⁶⁾	3,250 ⁽⁴⁾	0 ⁽⁰⁾
Cut not scarified	0 ⁽¹⁶⁾	34 ⁽²⁹⁾	91 ⁽¹¹⁾	150 ⁽⁴⁾	0 ⁽¹⁶⁾	379 ⁽²⁹⁾	0 ⁽¹¹⁾	0 ⁽⁴⁾
Uncut	53 ⁽¹⁹⁾	38 ⁽²⁶⁾	0 ⁽¹⁵⁾	0 ⁽⁰⁾	526 ⁽¹⁹⁾	1,038 ⁽²⁶⁾	267 ⁽¹⁵⁾	0 ⁽⁰⁾
All	226 ⁽⁵³⁾	593 ⁽⁸¹⁾	133 ⁽³⁰⁾	150 ⁽⁴⁾	453 ⁽⁵³⁾	1,198 ⁽⁸¹⁾	467 ⁽³⁰⁾	0 ⁽⁴⁾

¹Numbers in brackets equal number of list quadrats.

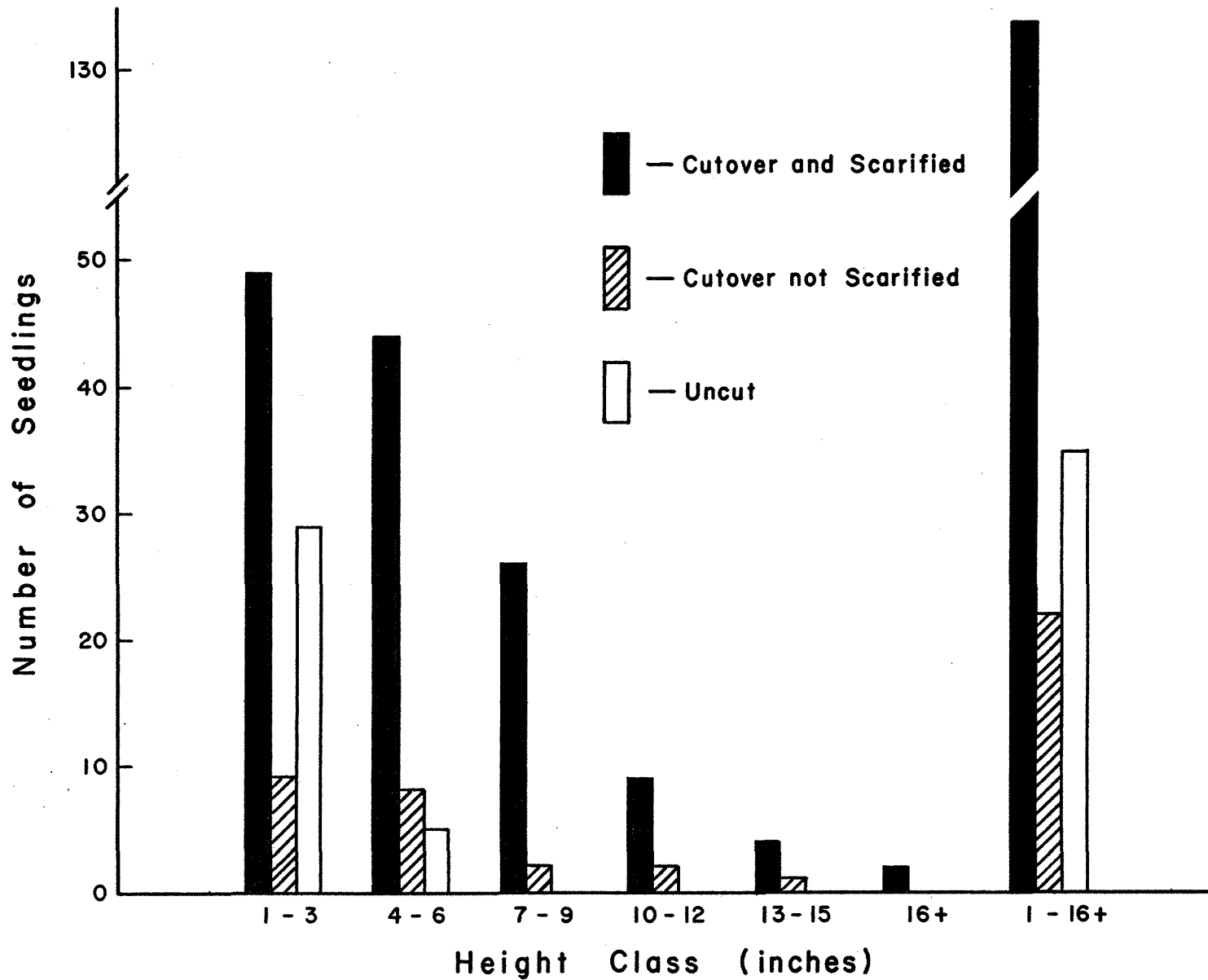


Figure 3. Number of white spruce seedlings (excluding cotyledons) by height class five years after treatment, Area 1. (Basis: tallest seedling on each stocked quadrat).

TABLE 8

DISTRIBUTION OF SEEDBED TYPES AND OCCURRENCE OF WHITE SPRUCE SEEDLINGS,
ONE YEAR AND FIVE YEARS AFTER TREATMENT, AREA 1

Type of seedbed	Per Cent Occurrence Seedbeds and White Spruce Seedlings								
	Cut-over scarified areas basis: 300 quads.			Cut-over not scarified areas basis: 301 quads.			Uncut areas basis: 209 quads.		
	Seedbeds	Seedlings		Seedbeds	Seedlings		Seedbeds	Seedlings	
1st year		2nd year	1st year		2nd year	1st year		2nd year	
Litter	8	1	1	48	0	20	75	0	15
Grass	1	0	0	14	0	0	17	0	0
Feather moss	0	0	0	2	0	10	5	0	10
F-horizon	1	14	3	0	0	0	0	0	0
Humus	4	40	12	1	58	0	0	0	0
Mineral soil	3	22	17	0	0	0	0	0	0
Mixture (organic + mineral)	78	23	67	6	34	7	0	0	0
Debris piles	2	0	0	1	0	0	1	0	2
Slash	3	0	0	27	0	7	2	0	0
Decayed wood	0	0	0	1	8	56	0	100	73
All	100	100	100	100	100	100	100	100	100

TABLE 9
 PER CENT SURVIVAL AND AVERAGE HEIGHT WHITE SPRUCE PLANTATIONS ON AREA 1,
 1961 TO AUGUST 1965

Planting site	Number planted June 1961	Per Cent Survival				Average Height (inches)				
		July 1962	August 1963	July 1964	August 1965	1961	July 1962	August 1963	July 1964	August 1965
Cut-over scarified	321	80	73	68	63	6.4	8.4	12.7	15.8	18.8
Cut-over not scarified	315	61	55	49	46	5.3	7.1	10.4	13.4	16.9
Uncut	322	50	37	33	29	4.3	5.0	6.1	7.1	8.1

TABLE 10

PER CENT SURVIVAL OF PLANTED WHITE SPRUCE SEEDLINGS BY PLANTING SITE

AFTER 5 GROWING SEASONS, AREA 1

Condition on which seedling planted	Cut-over and Scarified		Cut-over not Scarified		Uncut	
	Number planted 1961	Survival 1965 (%)	Number planted 1961	Survival 1965 (%)	Number planted 1961	Survival 1965 (%)
Litter	108	57	254	49	203	36
F-horizon	29	65	0	-	0	-
Humus	39	67	1	0	0	-
Overturned sod	132	69	0	-	0	-
Haul road	0	-	9	89	0	-
Litter (base of stump)	0	-	13	15	50	8
Slash	11	45	27	64	0	-
Decayed wood	0	-	11	27	39	38
Debris piles	2	50	0	-	0	-
Squirrel cache	0	-	0	-	30	3
All	321	63	315	46	322	29

Trial 3

Location: Twp. 53, Rge. 26, Sec. 30, W.2 Mer. (Figure 4)

Description: Trial 3 is about 11 acres in size and in 1959 the area supported a mature white spruce stand with a total basal area of about 150 square feet per acre; of this total about 38 square feet was hardwood (Table 11). The terrain is slightly rolling and the soil is a silty loam. Sites vary from fresh to moist but most of the area is in the categories fresh to moderately moist.

Work done: During the winter of 1959-60 alternate 2-chain-wide strips were logged under the supervision of the Saskatchewan Forestry Branch. Only merchantable trees were felled and skidded off the area. In the spring of 1961 trees still remaining on the cut-over strips were girdled.

In August 1960, seedbed treatment was carried out. Except for the west end of strip 1 all cut-over strips were completely scarified (Figure 5). A TD-18 crawler-type tractor with a straight blade was used for preparing seedbeds.

In 1961, 603 permanent milacre quadrats (300 in cut-over scarified areas and 303 in uncut areas) were established to assess regeneration; five permanent 1/5-acre plots were established on the uncut strips to obtain stand data; 582 white spruce seedlings were planted (204 on cut-over scarified areas, 199 on cut-over unscarified areas and 179 on uncut areas) to obtain information on the development of planted stock in various environments; and two permanent observation transects were established to observe seedbed receptiveness with the passage of time. The Saskatchewan government provided information on annual seedfall from one of their studies nearby.

Results:

1. During the five-year period after logging no white spruce losses were observed as a result of "wind-throw". The spruce basal area on the uncut strips increased from 113 square feet per acre to 123 and the number of trees per acre increased from 326 to 361. On the other hand the hardwood basal area declined from 38 square feet per acre to 35 due to mortality of a few large trees; the total number of trees remained the same (Table 11).
2. Abundant seed was produced in 1960, 1962 and 1964; the crop in 1961 and 1963 was much smaller (Table 12). The poor seed years 1961 and 1963 are reflected in the smaller tally of new germinants in 1962 and 1964 than in 1961, 1963 and 1965 (Table 13). As indicated by Table 13 suitable seedbeds were still receptive five years after treatment.

3. After five years, occurrence and abundance of spruce seedlings were greater on the cut-over scarified areas than on the uncut areas (Tables 14 and 15). As on Area 1, seedlings on the uncut conditions were smaller and weaker than those on the cut-over scarified condition.
4. Occurrence and abundance of white spruce seedlings by site are shown in Tables 16 and 17. After five years they occurred more frequently and were more abundant on fresh and moderately moist sites than on moist sites. However, even moist sites on the cut-over scarified areas were well stocked.
5. Number of seedlings (excluding cotyledons) five years after treatment by height classes is shown in Figure 6. Seedlings on the cut-over scarified areas, as well as being more numerous, were much larger than those on the uncut areas.
6. Distribution of various seedbed types on cut-over scarified conditions and on uncut conditions is shown in Table 18. In keeping with results for Trial 1 those for Trial 3 show that mineral soil, humus, mixture and decayed wood seedbed appear to be the best for white spruce.
7. Survival of planted seedlings was best in cut-over scarified areas, poorest on cut-over unscarified areas and intermediate on uncut areas (Table 19).
8. Seedling development was better on cut-over areas than on uncut areas.
9. Seedlings planted on mineral soil and on areas covered with feather moss appeared to have had the best survival rate (Table 20).

Comments:

1. Results have indicated that scarifying fresh to moist white spruce cut-overs with a blade will produce seedbeds suitable for spruce germination and subsequent seedling survival. For the five-year period after logging none of the spruce trees in the uncut stand were wind-thrown. In that time the stand may not have experienced extremely strong winds. On the other hand, since the area is for the most part well-drained, deep root systems may have developed making the trees more wind-firm than those on Area 1 which had shallow root systems because of high water tables.
2. Results have also indicated that planting on bulldozed fresh to moist sites will give better results than planting on cut-over unscarified areas or under the existing stand.

3. The high mortality of transplants on cut-over unscarified areas was not in keeping with the results from Area 1. It may have been due to a combination of severe rabbit browsing, severe competition from grass which invaded that particular part of the unscarified strip where the seedlings had been planted, and effects of the drought.
4. Growth of survivors followed the same trend as on Area 1. It was best on cut-over scarified areas, poorest on uncut areas and intermediate on cut-over unscarified areas.
5. The year 1961 was extremely dry.

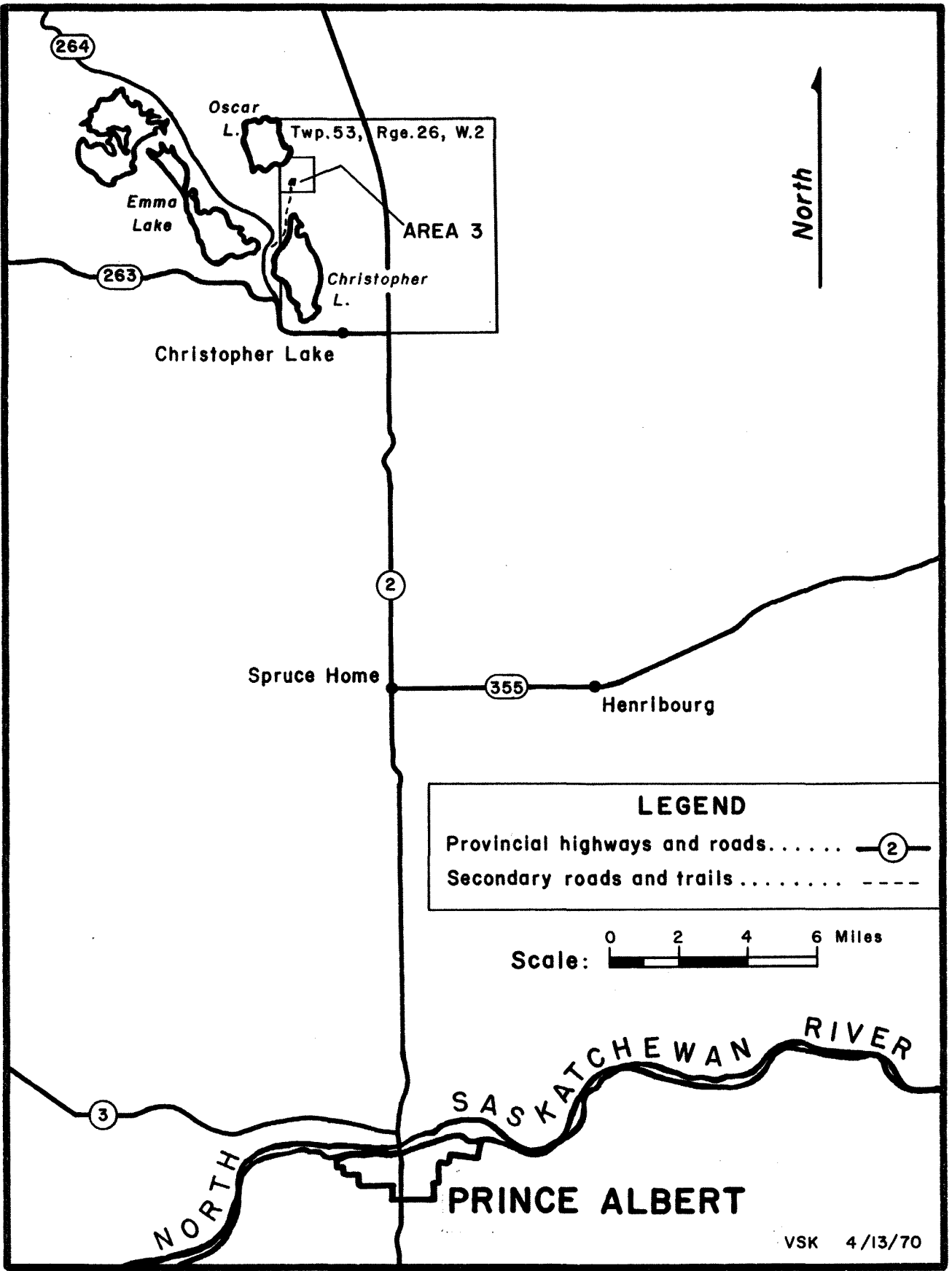


Figure 4. Location of Area 3, Twp. 53, Rge. 26, Sec. 30, W.2 Mer.

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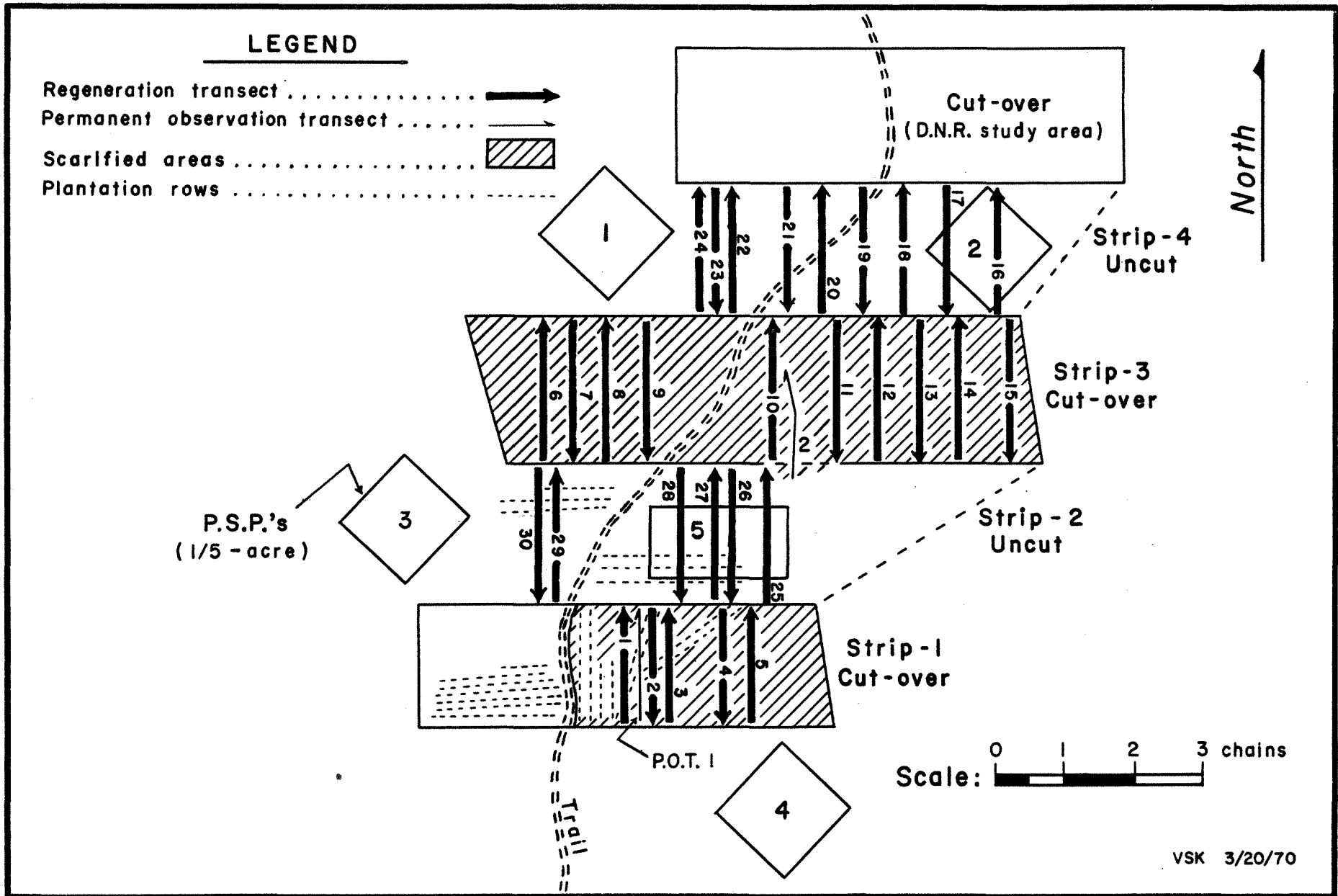


Figure 5. Sketch of Area 3 showing cut-over strips, scarified areas and location of sample plots.

TABLE 11

STAND TABLE, AREA 3

(basis - 4, 1/5-acre P.S.P.'s)

D.B.H. (inches)	Before Cutting				Five Years After Cutting			
	White spruce		Hardwoods		White spruce		Hardwoods	
	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)
1	18.8	.094	20.0	.100	26.2	.131	30.0	.150
2	15.0	.330	1.2	.026	16.2	.356		
3	18.8	.921			27.5	1.348	2.5	.122
4	31.2	2.714	1.2	.104	28.8	2.506	1.2	.104
5	32.5	4.420	1.2	.163	36.2	4.923	1.2	.163
6	31.2	6.115	8.7	1.705	38.8	7.605	6.2	1.215
7	28.8	7.690	15.0	4.005	25.0	6.675	12.5	3.338
8	25.0	8.725	23.7	8.270	32.5	11.342	21.2	7.340
9	30.0	13.260	21.3	9.414	27.5	12.155	11.2	4.950
10	30.0	16.350	11.2	6.104	32.5	17.712	12.5	6.812
11	27.5	18.150	3.7	2.442	25.0	16.500	10.0	6.600
12	18.8	14.758	3.8	2.983	17.5	13.738	1.2	.942
13	10.0	9.220	1.2	1.106	16.2	14.936	2.5	2.305
14	5.0	5.345	1.2	1.282	7.5	8.018	1.2	1.283
15	2.5	3.068			2.5	3.068		
16	1.2	1.675			1.2	1.675		
All	326.3	112.835	113.4	37.704	361.1	122.688	113.4	35.324

TABLE 12
WHITE SPRUCE SEEDFALL
AREA 3

Location	Number Seed per Acre				
	1960	1961	1962	1963	1964
Uncut strip	3,005,640	89,120	2,308,680	21,780	5,600,000
Cut-over strip	1,161,247	43,560	1,248,353	2,904	3,120,000

TABLE 13
 NUMBER OF NEW WHITE SPRUCE GERMINANTS TALLIED ANNUALLY ON
 PERMANENT OBSERVATION TRANSECTS
 1961 TO 1965, AREA 3

Transect number	Total area (sq. ft.)	1961	1962	1963	1964	1965
1	248	259	5	24	2	47
2	242	304	13	64	3	82
All	490	563	18	88	5	129
Number per acre		50,051	1,600	7,823	444	11,468

TABLE 14
 PER CENT QUADRATS STOCKED TO WHITE SPRUCE AND HARDWOODS,
 AREA 3

Condition	Number of quadrats	First Year				Five Years After			
		White spruce		Hardwoods		White spruce		Hardwoods	
		Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %
Cut and scarified	300	56	7	- ¹	76	58	4	-	80
Uncut	280	4	23	-	28	27	15	-	33
All	580	31	15	-	49	41	9	-	57

¹All hardwoods regeneration classed as advance growth.

TABLE 16
 PER CENT STOCKING WHITE SPRUCE REGENERATION BY
 SITE, AREA 3

Condition	Per Cent Stocking First Year ¹			Per Cent Stocking Five Years After		
	Site			Site		
	Fresh	Moderately moist	Moist	Fresh	Moderately moist	Moist
Cut and scarified	57 ⁽¹⁵⁹⁾	53 ⁽¹⁰³⁾	55 ⁽³⁸⁾	61 ⁽¹⁵⁹⁾	58 ⁽¹⁰³⁾	47 ⁽³⁸⁾
Uncut	4 ⁽²¹⁰⁾	4 ⁽⁷⁰⁾	0 ⁽⁰⁾	25 ⁽²¹⁰⁾	31 ⁽⁷⁰⁾	0 ⁽⁰⁾
All	27 ⁽³⁶⁹⁾	34 ⁽¹⁷³⁾	55 ⁽³⁸⁾	41 ⁽³⁶⁹⁾	47 ⁽¹⁷³⁾	47 ⁽³⁸⁾

¹ Figures in brackets represent number of quadrats.

TABLE 17

NUMBER OF WHITE SPRUCE REGENERATION PER ACRE BY SITE, AREA 3

Condition	Number Per Acre First Year ¹			Number Per Acre Five Years After		
	Site			Site		
	Fresh	Moderately moist	Moist	Fresh	Moderately moist	Moist
Cut and scarified	364 (33)	800 (20)	1,429 (7)	4,333 (33)	4,500 (20)	1,714 (7)
Uncut	0 (40)	0 (12)	0 (0)	1,250 (40)	1,500 (12)	0 (0)
All	164 (73)	500 (32)	1,429 (7)	3,877 (73)	3,375 (32)	1,714 (7)

¹Figures in brackets represent number of quadrats.

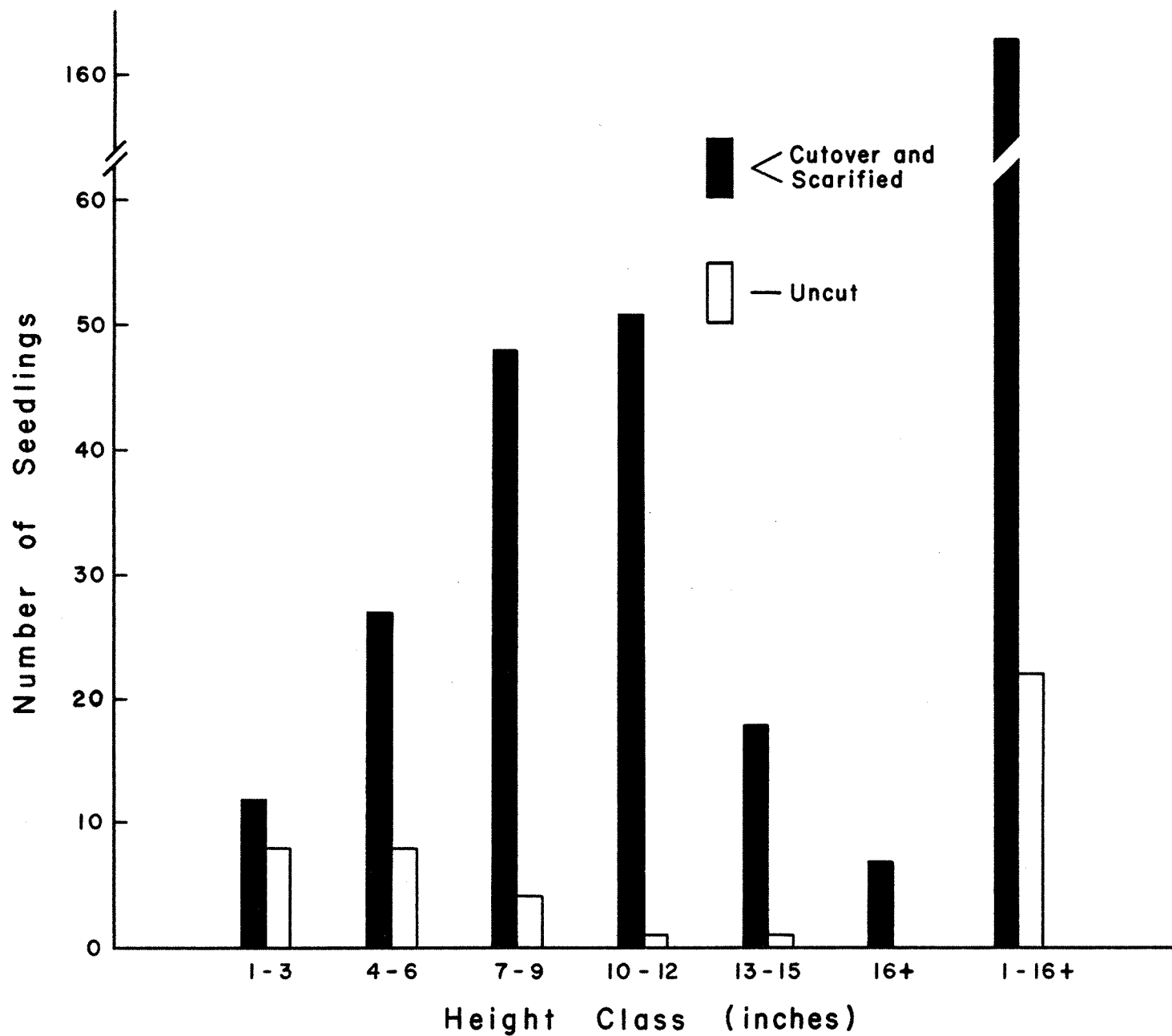


Figure 6. Number of white spruce seedlings (excluding cotyledons) by height class five years after treatment, Area 3. (Basis: tallest seedling on each stocked quadrat).

TABLE 18
 DISTRIBUTION OF SEEDBED TYPES AND OCCURRENCE OF WHITE SPRUCE
 SEEDLINGS ONE YEAR AND 5 YEARS AFTER TREATMENT,
 AREA 3

Type of Seedbed	Per Cent Occurrence Seedbed Types and White Spruce Regeneration					
	Cut-over and scarified basis: 300 quadrats			Uncut basis: 280 quadrats		
	Seedbeds	Regeneration		Seedbeds	Regeneration	
1st year		5th year	1st year		5th year	
Litter	21	0	1	66	9	16
Feather moss	5	0	1	22	0	5
F-horizon	1	4	0	0	-	-
Humus	2	17	12	0	-	-
Mineral Soil	24	71	65	1	18	6
Mixture (organic and mineral)	35	8	14	0	-	-
Debris piles	4	0	1	1	0	0
Haul road	0	-	-	1	-	6
Slash	7	0	0	8	0	0
Decayed wood	1	0	6	1	73	67
All	100	100	100	100	100	100

TABLE 19
 PER CENT SURVIVAL AND AVERAGE HEIGHT WHITE SPRUCE PLANTATIONS ON
 AREA 3, 1961 TO JULY 1965

Planting site	Number planted June 1961	Per Cent Survival				Average Height (inches)				
		July 1962	July 1963	- 1964	July 1965	July 1961	July 1962	July 1963	- 1964	July 1965
Cut-over scarified	201	70	66	No data	63	7.6	10.0	12.3	No data	22.5
Cut-over not scarified	199	29	25	No data	21	8.4	10.1	12.0	No data	18.4
Uncut	179	61	48	No data	44	5.9	6.9	8.4	No data	9.8

TABLE 20
 PER CENT SURVIVAL OF PLANTED WHITE SPRUCE SEEDLINGS BY PLANTING SITE
 AFTER 5 GROWING SEASONS, AREA 3

Condition on which seedling planted	Cut-Over and Scarified		Cut-Over not Scarified		Uncut	
	Number planted 1961	Survival (per cent) 1965	Number planted 1961	Survival (per cent) 1965	Number planted 1961	Survival (per cent) 1965
Litter	58	47	135	7	106	43
F-horizon	5	0	0	-	0	-
Mineral soil	137	76	6	50	0	-
Litter (base of stumps)	1	0	7	0	4	0
Slash	0	-	2	100	0	-
Feather moss	0	-	29	48	63	44
Dead feather moss	3	100	19	63	6	83
Decayed wood	0	-	1	0	0	0
All	204	63	199	21	179	44

Trial 4

Location: Twp. 68, Rge. 25, Sec. 4 and 9, W.2 Mer. (Figure 7).

Description: Trial 4 is about 12 acres in size and in 1960 the area supported a stand with a total basal area of 142 square feet per acre; white spruce, other softwoods (mainly balsam fir) and hardwoods accounted for about 92, 13 and 37 square feet of basal area per acre, respectively (Table 21). The terrain is gently rolling and the soil is a silty clay loam till. Sites vary from fresh to moist but most of the area is in the fresh to moderately moist category.

Work done: During the winter of 1960-61 alternate 2-chain-wide strips were logged under the supervision of the Saskatchewan Forestry Branch. In the summer of 1961 hardwoods remaining on the cut-over strips were girdled.

Seedbed treatment was carried out by the Saskatchewan government in August 1962 (Figure 8). A TD-14 tractor equipped with a Saskatchewan fire-line plow was used.

In July 1963 a total of 605 milacre quadrats (203 on cut-over scarified areas, 202 on cut-over unscarified areas and 200 on uncut areas) were established to assess regeneration. Five 1/5-acre plots were established on the uncut strips to supply stand data.

In May 1963 a total of 558 white spruce seedlings were planted on the area by the Saskatchewan government (192 on cut-over scarified areas, 192 on cut-over unscarified areas and 172 on uncut areas) (Figure 8).

Results:

1. During the five-year period after logging, losses occurred in the total number of trees and basal area per acre for all species (Table 21). All of the mortality was attributed to old-age; no trees were "wind-thrown".
2. The occurrence and abundance of white spruce, other softwoods and hardwood reproduction is shown in Tables 22 and 23. Stocking to white spruce is poor on all conditions.
3. Per cent stocking and abundance of spruce seedlings by site are given in Tables 24 and 25. Although stocking is poor on all sites it is better in the fresh sites than on either the moderately moist or moist sites.
4. As indicated by Figure 9 there are more and larger seedlings on the cut-over scarified areas than on the uncut and cut-over unscarified areas.

5. The distribution of seedbed types on each of the three conditions (cut-over scarified, cut-over not scarified and uncut) is shown in Table 26. These data like those from Areas 1 and 3 show that mineral soil, decayed wood and other seedbeds created by scarifying are the best for germination and survival.
6. Survival of planted seedlings has been good on all conditions (Table 27) and like the other areas development of seedlings is best in cut-over scarified areas, poorest on uncut areas and intermediate on cut-over unscarified areas.
7. Survival rate was good for all planting conditions. However, planting at the base of a stump and on litter produced poorer results than planting on other conditions (Table 28).

Comments:

1. Natural regeneration has been very poor on this area primarily because of poor scarification. Examination of Table 26 will show that only 33 per cent of the area was actually treated. Furthermore the seedbeds created were of a poor quality. The tractor operator had a tendency to plough too deeply creating deep furrows and high ridges. Many seedlings in the furrows were killed by flooding or were buried by alluvium washed from the ridges. Seedlings on the high ridges died from drought and those in the sides were washed from the soil.
2. As a result of this test it is recommended that scarification on fresh to moist sites be carried out using a straight blade--not a Saskatchewan fir-line plow.
3. The excellent survival rate of seedlings planted on all conditions may be due, at least in part, to the fact that weather conditions in 1963, 1964 and 1965 were near normal, much more favourable than in the drought year of 1961.

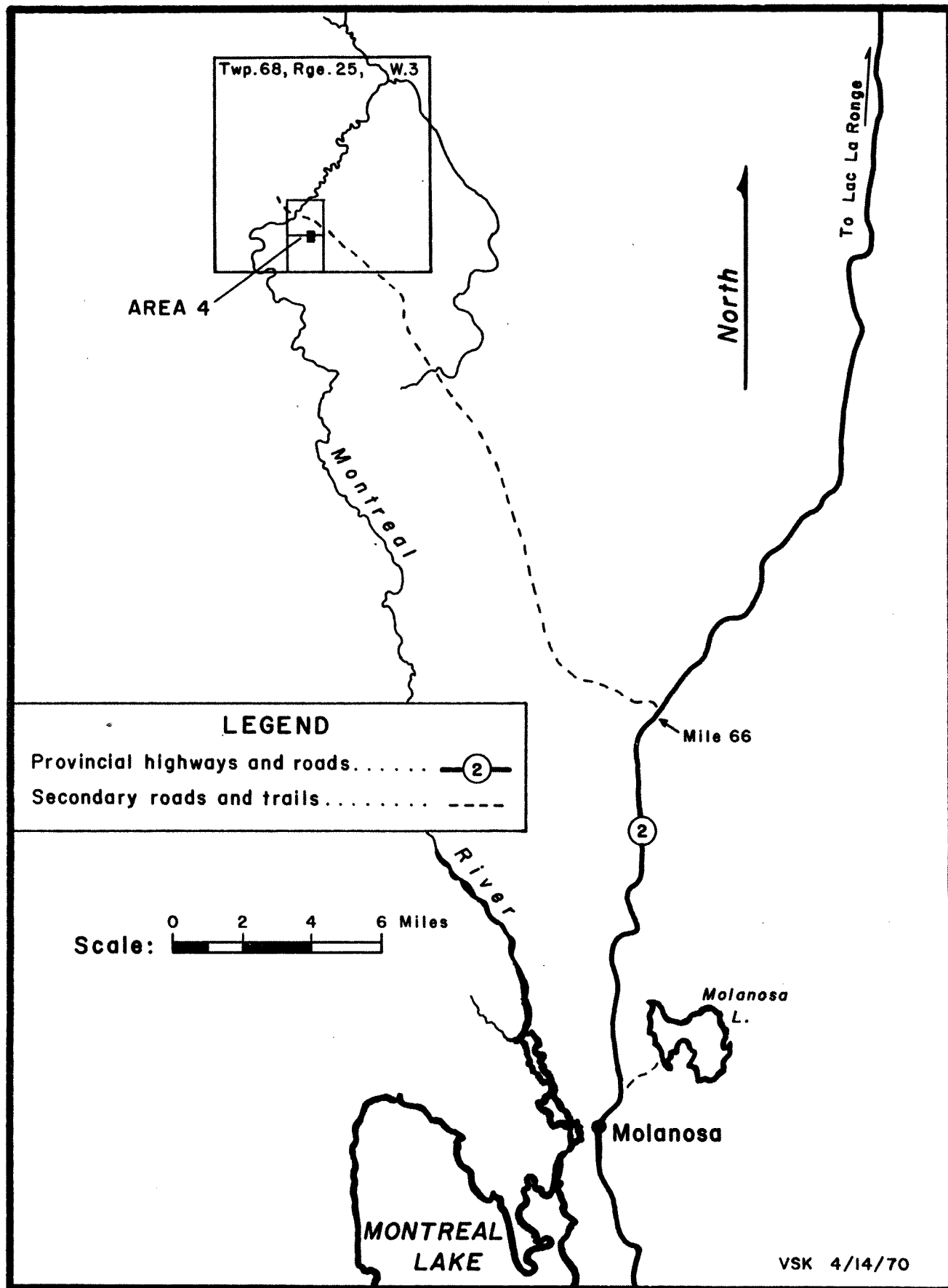


Figure 7. Location of Area 4.
 Twp. 68, Rge. 25, Sec. 4 & 9, W.2 Mer.

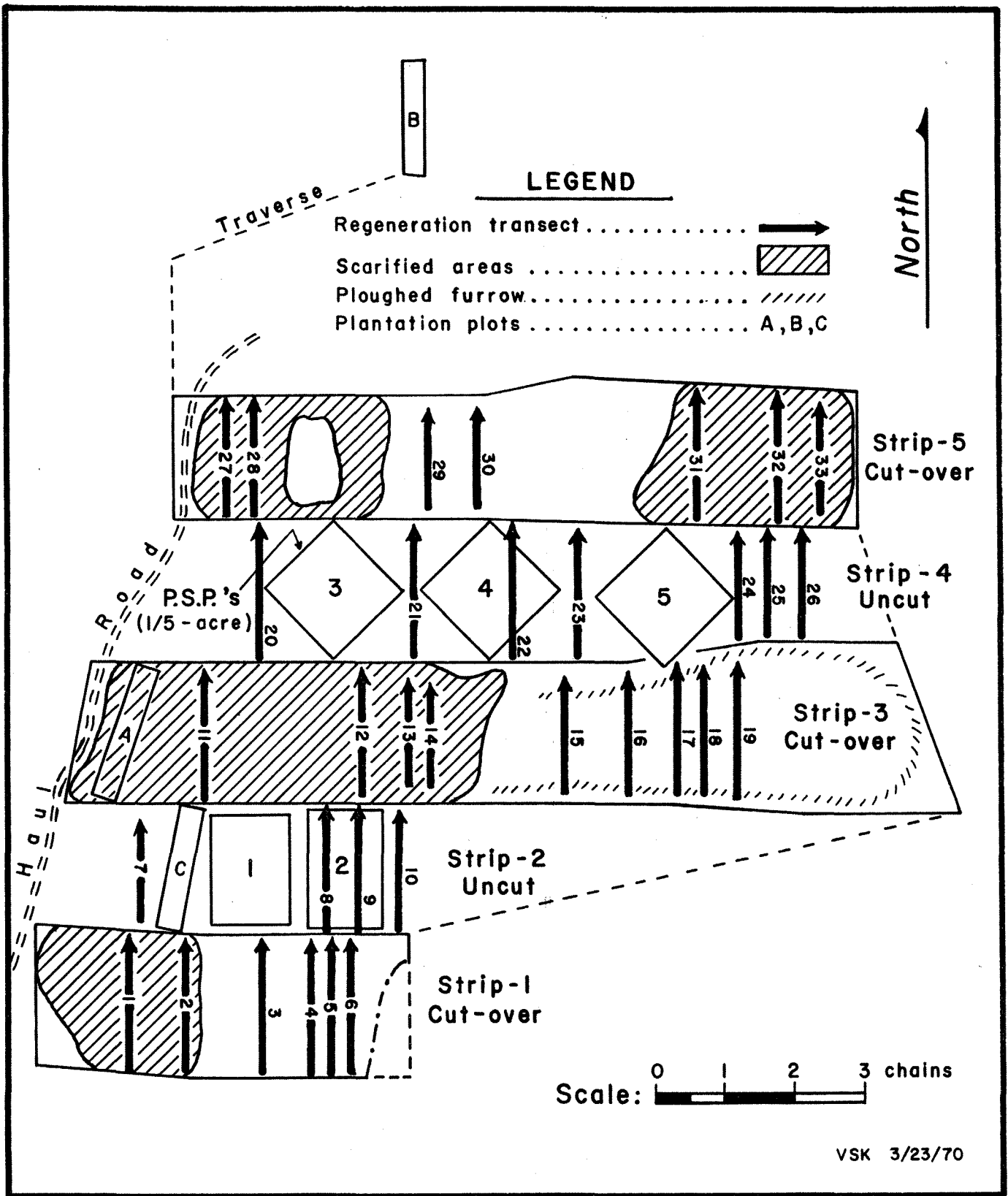


Figure 8. Sketch of Area 4 showing cut-over strips, scarified areas and location of sample plots.

TABLE 21
 STAND TABLE, AREA 4
 (basis - 5, 1/5-acre P.S.P.'s)

D.B.H. (inches)	Before Cutting						Five Years After Cutting					
	White spruce		Other softwoods		Hardwoods		White spruce		Other softwoods		Hardwoods	
	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)
1	59	.295	40	.200	95	.475	71	.355	42	.211	95	.475
2	50	1.100	35	.770	34	.748	37	.814	30	.660	34	.748
3	23	1.127	15	.735	9	.441	28	2.436	16	1.392	10	.490
4	17	1.479	7	.609	6	.522	15	1.305	6	.522	2	.174
5	15	2.040	3	.408	4	.544	13	1.768	3	.408	3	.408
6	12	2.352	8	1.568			15	2.940	5	.908	3	.588
7	14	3.738	3	.801	5	1.335	13	3.471	4	1.068	4	1.068
8	9	3.141	4	1.396	4	1.396	13	4.537	1	.349	3	1.047
9	13	5.746	3	1.326	3	1.326	13	5.746			7	3.094
10	2	1.090	4	2.180	9	4.905	4	2.180	2	1.090	9	4.905
11	5	3.300			7	4.620	3	1.980			5	3.300
12	6	4.710	1	.785	6	4.710	3	2.355			1	.785
13	7	6.454					8	7.376			4	3.688
14	9	9.621	2	2.138	5	5.345	5	5.345	1	1.069		
15	5	6.135					5	6.135	1	1.227	1	1.227
16	5	6.480					5	6.980				
17	5	7.880			1	1.576	4	6.304				
18	4	7.068					2	3.534				
19	3	5.907			2	3.938	2	3.938			1	1.969
20	1	2.182					2	4.364				
21	1	2.405					2	4.810				
22	3	7.920			1	2.640	2	5.280				
23					1	2.885	1	2.885				
All	268	92.170	125	12.916	192	37.406	266	86.838	111	8.976	182	23.966

TABLE 22
 PER CENT QUADRATS STOCKED TO WHITE SPRUCE, OTHER SOFTWOODS AND HARDWOODS,
 AREA 4

Condition	Number of Quadrats	First Year						Five Years After					
		White spruce		Other softwoods		Hardwoods		White spruce		Other softwoods		Hardwoods	
		Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %
Cut and scarified	203	40	5	2	3	- ¹	37	9	6	< 1	-	-	32
Cut not scarified	202	1	13	<1	2	-	54	2	15	-	2	-	57
Uncut	200	< 1	16	2	6	-	48	6	17	-	3	-	54
All	605	13	11	1	3	-	47	5	13	< 1	2	-	47

¹All hardwoods regeneration classed as advance growth.

TABLE 23

NUMBER OF WHITE SPRUCE, OTHER SOFTWOODS AND HARDWOOD STEMS PER ACRE,

AREA 4

Condition	Number list quadrats	First Year						Five Years After					
		White spruce		Other softwoods		Hardwoods		White spruce		Other softwoods		Hardwoods	
		Regen- eration Number	Advance growth per acre	Regen- eration Number	Advance growth per acre	Regen- eration Number	Advance growth per acre	Regen- eration Number	Advance growth per acre	Regen- eration Number	Advance growth per acre	Regen- eration Number	Advance growth per acre
Cut and scarified	36	694	28	-	-	-	944	250	0	-	-	-	528
Cut not scarified	39	0	333	-	-	-	1,462	0	256	-	77	-	2,179
Uncut	37	0	135	108	162	-	1,081	108	189	-	54	-	946
All	112	223	170	36	54	-	1,083	116	152	0	45	-	1,241

TABLE 24
 PER CENT STOCKING WHITE SPRUCE REGENERATION BY SITE,
 AREA 4

Condition	Per Cent Stocking First Year ¹			Per Cent Stocking Five Years After		
	Site			Site		
	Fresh	Moderately moist	Moist	Fresh	Moderately moist	Moist
Cut and scarified	56 (102)	31 (42)	14 (59)	8 (102)	0 (42)	< 1 (59)
Cut not scarified	1 (171)	0 (27)	0 (4)	2 (171)	0 (27)	0 (4)
Uncut	1 (97)	0 (83)	0 (20)	9 (97)	1 (83)	5 (20)
All	16 (370)	0 (152)	10 (83)	8 (370)	1 (152)	2 (83)

¹ Figures in brackets represent number of quadrats.

TABLE 25
 NUMBER OF WHITE SPRUCE REGENERATION PER ACRE BY SITE,
 AREA 4

Condition	Number Per Acre First Year ¹			Number Per Acre Five Years After		
	Site			Site		
	Fresh	Moderately moist	Moist	Fresh	Moderately moist	Moist
Cut and scarified	1,412 ⁽¹⁷⁾	125 ⁽⁸⁾	0 ⁽¹¹⁾	529 ⁽¹⁷⁾	0 ⁽⁸⁾	0 ⁽¹¹⁾
Cut not scarified	0 ⁽³²⁾	0 ⁽⁶⁾	0 ⁽¹⁾	0 ⁽³²⁾	0 ⁽⁶⁾	0 ⁽¹⁾
Uncut	0 ⁽¹⁷⁾	0 ⁽¹⁶⁾	0 ⁽⁴⁾	118 ⁽¹⁷⁾	62 ⁽¹⁶⁾	250 ⁽⁴⁾
All	364 ⁽⁶⁶⁾	33 ⁽³⁰⁾	0 ⁽¹⁶⁾	167 ⁽⁶⁶⁾	33 ⁽¹⁾	63 ⁽¹⁾

¹ Numbers in brackets equal number of list quadrats.

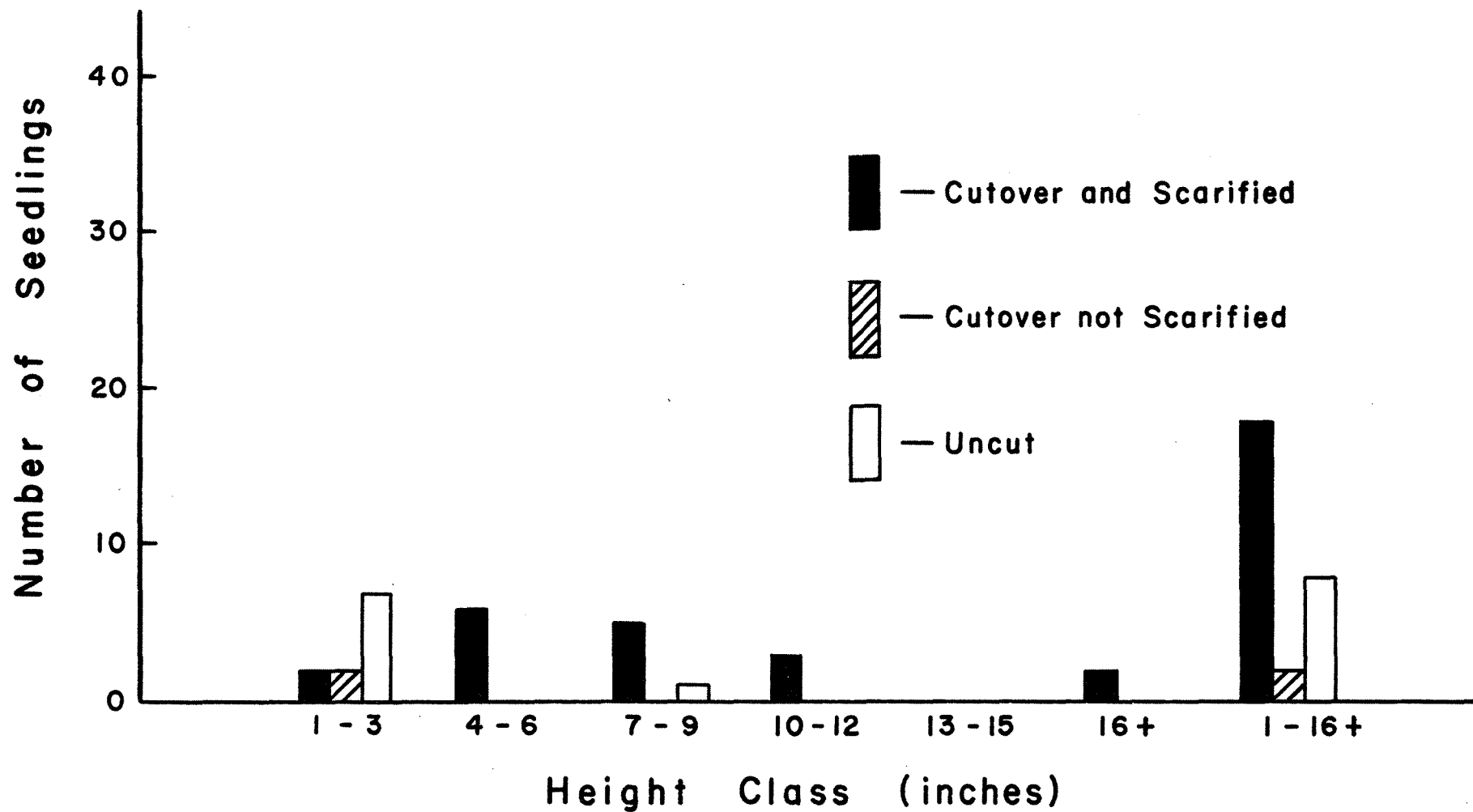


Figure 9. Number of white spruce seedlings (excluding cotyledons) by height class five years after treatment, Area 4. (Basis: tallest seedling on each stocked quadrat).

TABLE 26

DISTRIBUTION OF SEEDBED TYPES AND OCCURRENCE OF WHITE SPRUCE REGENERATION,
ONE AND FIVE YEARS AFTER TREATMENT, AREA 4

Type of seedbed	Per Cent Occurrence Seedbeds and White Spruce Seedlings								
	Cut-over scarified areas basis: 203 quads			Cut-over not scarified areas basis: 202 quads			Uncut areas basis: 200 quads		
	Seedbeds	Seedlings		Seedbeds	Seedlings		Seedbeds	Seedlings	
		1st year	2nd year		1st year	2nd year		1st year	2nd year
Litter	48	0	0	80	0	0	92	0	0
Grass	2	0	0	8	0	0	1	0	0
Feather moss	0	-	-	1	-	-	2	0	0
F-horizon	1	2	0	0	-	-	0	-	-
Humus	0	-	-	0	-	-	0	-	-
Mineral soil	18	63	90	1	33	0	0	-	-
Mixture (organic and mineral)	14	34	10	0	-	-	0	-	-
Debris	12	0	0	0	-	-	0	-	-
Slash	4	0	0	7	0	0	2	0	0
Decayed wood	1	1	0	3	67	100	3	100	100
All	100	100	100	100	100	100	100	100	100

TABLE 27
 PER CENT SURVIVAL AND AVERAGE HEIGHTS WHITE SPRUCE
 PLANTATIONS ON AREA 4,
 1963 TO JULY 1967

Planting site	Number planted May 1963	Per Cent Survival			Average Height (inches)		
		July 1963	August 1964	July 1967	July 1963	August 1964	July 1967
Cut-over scarified	192	99	95	83	12.2	15.2	29.7
Cut-over not scarified	192	97	96	88	10.6	12.8	26.0
Uncut	174	99	92	83	9.9	11.7	19.2

TABLE 28
 PER CENT SURVIVAL OF PLANTED WHITE SPRUCE SEEDLINGS BY PLANTING SITE
 AFTER 5 GROWING SEASONS, AREA 4

Condition on which seedling planted	Cut-over and Scarified		Cut-over Unscarified		Uncut	
	Number planted 1963	Survival 1967 %	Number planted 1963	Survival 1967 %	Number planted 1963	Survival 1967 %
Litter	72	75	186	88	157	80
F-horizon	17	88	1	100	6	83
Humus	5	100	0	-	0	-
Mineral soil	42	83	0	-	8	88
Overturnd soil	42	93	0	-	0	-
Litter (base of stump)	7	71	0	-	0	-
Slash	2	100	0	-	0	-
Decayed wood	0	-	1	100	3	100
Debris piles	5	100	4	100	0	-
All	192	83	192	88	174	82

Trial 5

Location: Twp. 42, Rge. 3, Sec. 10, W.2 Mer. (Figure 10).

Description: Trial 5 is about 34 acres in size and in 1962 the area supported a stand with a spruce basal area of about 122 square feet per acre and a hardwood basal area of about 28 square feet per acre (Table 29). The terrain is flat; soils are a high-lime clay-loam till; and sites vary from fresh to very moist. Most of the area is in the fresh to moist categories.

Work done: During the winter of 1962-63 alternate 2-chain-wide strips were cut under the supervision of the Saskatchewan government. In September 1963, portions of the clear-cut strips were scarified with a D-7 crawler-type tractor using a straight blade (Figure 11). Since 1963 was a poor seed year portions of the cut-over scarified areas were seeded. Captan-treated seed was sown with a cyclone seeder at the rate of 1/2 pound per acre; at time of sowing seed was 50 per cent viable. In July 1964, a total of 622 milacre quadrats (213 on cut-over scarified areas, 212 on cut-over unscarified areas and 197 on uncut areas) was established to assess regeneration; and six 1/5-acre plots were established in the uncut strips to provide stand data.

Also in the spring of 1964 a total of 363 white spruce seedlings was planted (130 on cut-over scarified areas, 114 on cut-over unscarified areas and 119 on uncut areas) to assess development on the various conditions.

Three permanent observation transects were established in July 1964 to assess seedbed receptiveness with the passing of time.

Results:

1. During the five-year period after logging there was a small increase in basal area of spruce on the uncut strips. However, numbers of trees declined from 182 to 176 per acre (Table 29). This was due mostly to blowdowns and/or breaking off of trees along the edges of strips. Very few were observed to be wind-thrown. Hardwood losses resulted in a decrease of basal area from 30 square feet per acre to 26 square feet. On the other-hand, the number of trees increased from 67 to 145 per acre, with the greatest increase in the 1-inch diameter class. No hardwoods were wind-thrown and mortality was attributed mainly to blowdowns of over-aged trees.
2. A greater number of new germinants were tallied on the permanent observation transects in 1965, 1967 and 1968 (Table 30); following good seed years in 1964, 1966 and 1967 (Table 31¹).

¹Since Areas 1 and 5 are within a few miles of one another it may be assumed the information on seed crops taken on Area 1 is applicable to Area 5.

The low number tallied in 1964 and 1965 was reflected in the poor seed years in 1963 and 1965. This trend as indicated by Table 30 shows that seedbeds on the cut-over scarified areas five years after treatment (provided seed was available) were still receptive.

3. Occurrence and abundance of white spruce and hardwood reproduction five years after treatment is shown in Tables 32 and 33. White spruce seedlings occurred more frequently on cut-over scarified and uncut areas than on cut-over unscarified areas. Cut-over scarified areas that were seeded showed the highest stocking. The good seed year in 1967 was reflected in the great abundance of 1968 cotyledons that were present on all conditions. In some instances they made up more than half of the seedlings measured. However (as has been noted), spruce germinants on untreated seedbeds are not likely to persist. Hardwood reproduction (mainly trembling aspen and balsam poplar) was more dominant on cut-over unscarified areas and appeared to show the most vigour on this condition (see Figures 12, 13 and 14). Data showed average heights of hardwoods after five years to be 10.1 feet on cut-over unscarified areas, 6.3 and 6.5 feet on cut-over scarified and the uncut areas respectively.
4. Per cent stocking and abundance of spruce seedlings by site are given in Tables 34 and 35. After five years, seedlings occurred more frequently on cut-over scarified areas, and were most numerous on the fresh and moderately moist sites. The very moist sites on this condition were least conducive for seedling establishment. Cut-over unscarified and uncut areas showed higher stocking on moderately moist and fresh sites than on either the moist and very moist sites.
5. Number of seedlings (excluding cotyledons) five years after treatment by height classes is shown in Figure 15. The greatest number and the largest seedlings occurred on the scarified areas. Except for the one to three-inch class there were more large seedlings on the cut-over unscarified areas than the uncut areas. The great numbers of seedlings in the one to three-inch class and the significantly low numbers of large seedlings on the scarified areas reflects the poor seed years during the early part of trials. This would indicate that seedlings were late in becoming established. As has been noted, the lack of large seedlings on uncut areas again tends to suggest that seedlings do not persist on this condition.
6. Distribution of seedbed types on each of the three conditions (cut-over scarified, cut-over unscarified and uncut) and the occurrence of seedlings on each seedbed is shown in Table 36. These data, like those from Areas 1, 3 and 4, show that the best seedbeds created by scarification for germination and subsequent survival of seedlings are mineral soil and humus. On the other conditions decayed wood appeared to be the most favourable germinating media.

7. Survival and growth of planted seedlings (Table 37), in keeping with the planting trials on the other areas, was the best on the cut-over scarified areas. Although planting survival rates of seedlings on uncut areas appeared slightly higher than those in cut-over unscarified areas, subsequent seedling development was much poorer. For size and comparison after five years, see Figure 16. Seedlings planted on mineral soil, F horizon and litter exhibited the best survival rates (Table 38). Here again poor results were obtained in plantings on deep litter at base of stumps and on squirrel caches.

Comments:

1. The D-7 tractor with straight blade produced excellent seedbeds.
2. Although scarified areas were well-stocked after five years, it is possible that the treated areas could have been fully stocked, providing that a good seed crop had been available during the initial establishment years of trials on this area. Regeneration results have shown that the early establishment of seedlings was dependant upon seed supply; i.e., seeded areas supporting more seedlings than non-seeded areas.
3. Difficulties to satisfactorily regenerate the wetter sites to white spruce were apparent. In spite of well prepared seedbeds, the moist and very moist sites after five years were still poorly stocked. Prepared seedbeds on these sites were especially prone to flooding during periods of heavy percipitations. Deeply scalped seedbeds on very moist sites in many instances remained non-productive due to flooding.
4. For the five-year period after logging, losses to wind damage of residual spruce in the uncut strips was not excessive. The few "wind-throws" observed were confined to shallow rooted trees on moist and very moist sites. It can be assumed that the trees on fresh and moderately moist sites are deeper rooted and consequently are more windfirm. On the other hand, it is possible the stands as yet may not have experienced extremely strong winds. Losses due to aging of trees will undoubtedly increase with the passing of time.
5. Survival and growth of planted seedlings has followed trends similar to those on the other areas. It was best on the cut-over scarified areas; growth on cut-over unscarified areas was superior to plantings in uncut stands. Therefore, if any degree of planting success is to be expected, some form of site preparation would be a requirement.

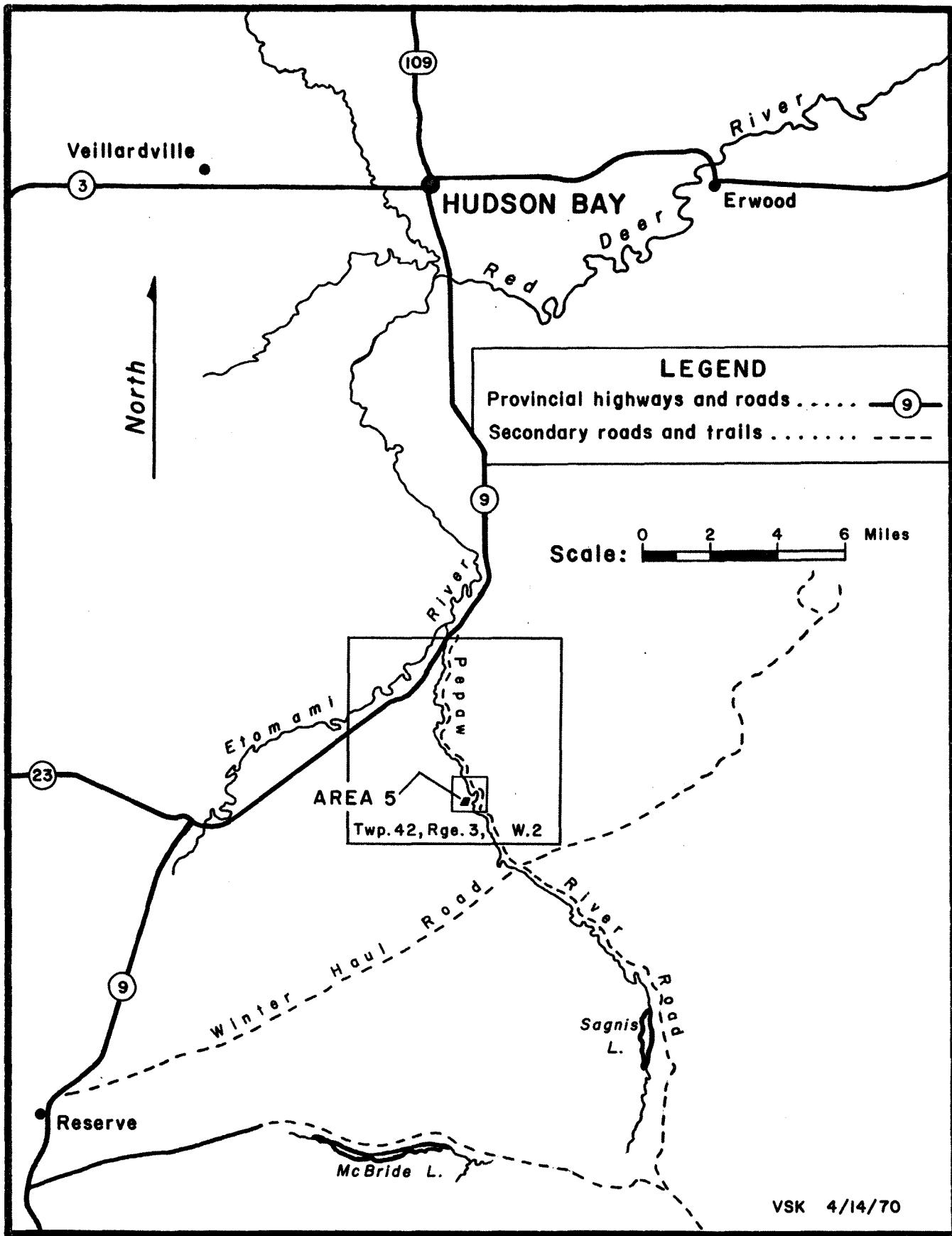


Figure 10. Location of Area 5; Twp. 42, Rge 3, Sec. 10, W.2 Mer.

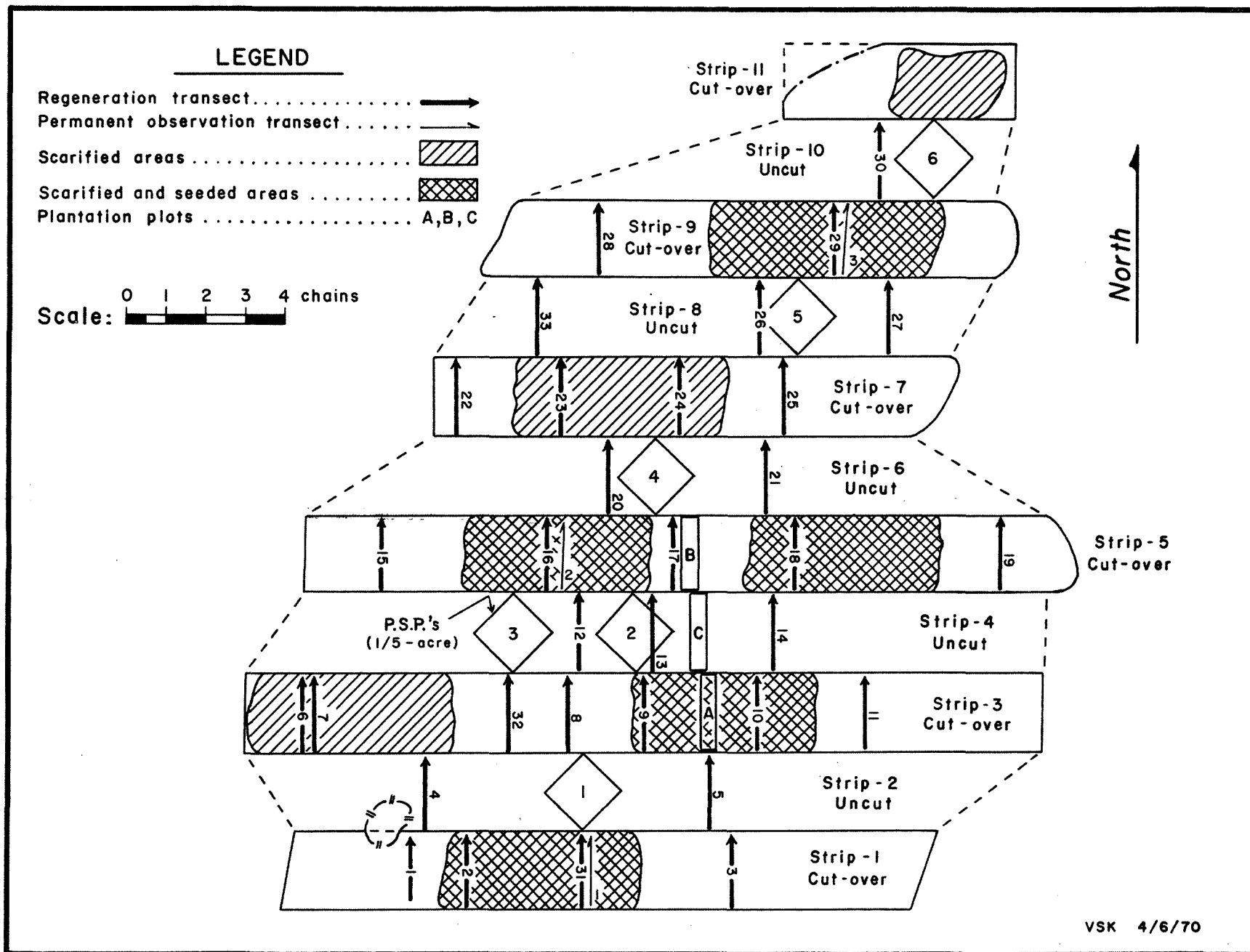


Figure 11. Sketch of Area 5 showing cut-over strips, scarified areas and location of sample plots.

TABLE 29

STAND TABLE, AREA 5

(basis - 6, 1/5-acre P.S.P.'s)

D.B.H. (inches)	Before Cutting				Five Years After Treatment			
	White spruce		Hardwoods		White spruce		Hardwoods	
	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)	Number of trees per acre	Basal area per acre (sq.ft.)
1	1.7	.008	29.2	.146	2.5	.012	111.7	.558
2	9.2	.202	5.0	.110	8.3	.183	5.0	.110
3	5.0	.245	1.7	.083	4.2	.206	2.5	.122
4	8.3	.722			7.5	.652	0.8	.070
5	2.5	.340			4.2	.571		
6	8.3	1.627			5.8	1.137		
7	7.5	2.002	0.8	.214	9.2	2.456		
8	9.2	3.211			7.5	2.618		
9	14.2	6.276			12.5	5.525		
10	23.3	12.698			19.2	10.464		
11	15.0	9.900	3.3	2.178	14.2	9.372	0.8	.528
12	20.8	16.328	10.0	7.850	20.8	16.328	8.3	6.516
13	16.7	15.397	5.0	4.610	16.7	15.397	5.8	5.348
14	12.5	13.362	5.8	6.200	14.2	15.180	4.2	4.490
15	11.7	14.356	2.5	3.068	10.8	13.252	3.3	4.049
16	9.2	12.843	1.7	2.373	10.0	13.960	0.8	1.117
17	2.5	3.940	0.8	1.261	2.5	3.940	0.8	1.261
18	1.7	3.004	0.8	1.414	3.3	5.831		
19	0.8	1.575			0.8	1.575	0.8	1.575
20	0.8	1.746						
21					0.8	1.924		
22	0.8	2.112			0.8	2.112		
All	181.7	121.894	66.6	29.507	175.8	122.695	144.8	25.744

TABLE 30
 NUMBER OF NEW WHITE SPRUCE GERMINANTS TALLIED ANNUALLY ON
 PERMANENT OBSERVATION TRANSECTS 1964 TO 1968,
 AREA 5

Transect number	Total Area (sq.ft.)	Number of New Germinants				
		1964	1965	1966	1967	1968
1	240	4	33	2	68	146
2	183	4	57	0	41	159
3	239	0	29	0	34	172
All	662	8	119	2	143	477
Number per acre		526	7,830	132	9,409	31,387

TABLE 31

WHITE SPRUCE SEEDFALL AREA 1, 1963 TO 1967

Location	Number Per Acre ¹				
	1963	1964	1965	1966	1967
Uncut strip					
South 1/3	278,461 ⁽¹³⁾ ²	3,049,090 ⁽¹¹⁾	52,500 ⁽¹⁶⁾	2,506,667 ⁽⁶⁾	3,262,200 ⁽¹⁰⁾
Middle 1/3	340,000 ⁽⁹⁾	2,816,000 ⁽⁵⁾	66,667 ⁽²¹⁾	2,669,333 ⁽¹⁵⁾	3,126,154 ⁽¹³⁾
North 1/3	343,636 ⁽¹¹⁾	3,640,000 ⁽⁵⁾	65,333 ⁽¹⁵⁾	2,282,500 ⁽⁸⁾	2,345,714 ⁽¹⁴⁾
Average	316,970 ⁽³³⁾	3,134,286 ⁽²¹⁾	61,923 ⁽⁵²⁾	2,528,276 ⁽²⁹⁾	2,867,568 ⁽³⁷⁾
Cut-over strip					
South 1/3	264,444 ⁽⁹⁾	2,542,222 ⁽⁹⁾	91,250 ⁽¹⁶⁾	778,000 ⁽¹⁰⁾	2,170,000 ⁽⁴⁾
Middle 1/3	150,667 ⁽¹⁵⁾	2,521,250 ⁽¹⁶⁾	47,826 ⁽²³⁾	785,000 ⁽²⁴⁾	2,157,273 ⁽²²⁾
North 1/3	121,053 ⁽¹⁹⁾	2,408,750 ⁽¹⁶⁾	38,750 ⁽¹⁶⁾	1,406,667 ⁽¹²⁾	2,546,667 ⁽¹²⁾
Average	177,674 ⁽⁴³⁾	2,481,951 ⁽⁴¹⁾	57,818 ⁽⁵⁵⁾	945,652 ⁽⁴⁶⁾	2,281,579 ⁽³⁸⁾

¹ Germination test of 1963 seed in January 1965 on 500 seeds indicated 7% viability.
Cutting test of 1964 seed in December 1965 indicated 63% sound.
Cutting test of 1965 seed in January 1968 indicated 33% sound.
Cutting test of 1966 seed in January 1968 indicated 57% sound.
Cutting test of 1967 seed in December 1968 indicated 46% sound.

² Figures in brackets indicate number of traps on which estimates were based.

TABLE 32
 PER CENT QUADRATS STOCKED TO WHITE SPRUCE AND HARDWOODS,
 AREA 5

Condition	Number of quadrats	First Year				Five Years After			
		White spruce		Hardwoods		White spruce		Hardwoods ³	
		Regeneration %	Advance growth %	Regeneration %	Advance growth %	Regeneration %	Advance growth %	Regeneration %	Advance growth %
Cut and scarified	138 ¹ 75 ²	47 ¹ 9 ²	0	-	40	68 ¹ 51 ²	0	-	60
Cut not scarified	212	3	9	-	70	26	8	-	79
Uncut	197	5	28	-	55	49	25	-	56
All	622	14	12	-	55	46	11	-	65

¹ Figures apply to seeded areas.

² Figures apply to non-seeded areas.

³ All hardwoods regeneration classed as advance growth.

TABLE 33
NUMBER OF WHITE SPRUCE AND HARDWOOD STEMS PER ACRE,
AREA 5

Condition	Number list quadrats	First Year				Five Years After			
		White Spruce		Hardwoods ³		White Spruce		Hardwoods	
		Regen- eration Number per acre	Advance growth Number per acre	Regen- eration Number per acre	Advance growth Number per acre	Regen- eration Number per acre	Advance growth Number per acre	Regen- eration Number per acre	Advance growth Number per acre
Cut and scarified	(26) ¹ (14) ²	(769) ¹ (214) ²	0	-	1,375	(12,538) (8,571)	0	-	2,175
Cut not scarified	40	75	50	-	4,500	975	75	-	3,375
Uncut	36	56	778	-	1,556	1,972	694	-	1,556
All	116	241	259	-	2,509	4,793	241	-	2,396

¹Figures apply to seeded areas.

²Figures apply to non-seeded areas.

³All hardwoods regeneration classed as advance growth.



Figure 12. Example of hardwoods reproduction on a cut-over unscarified strip five years after treatment, Area 5. Note vigour and density.

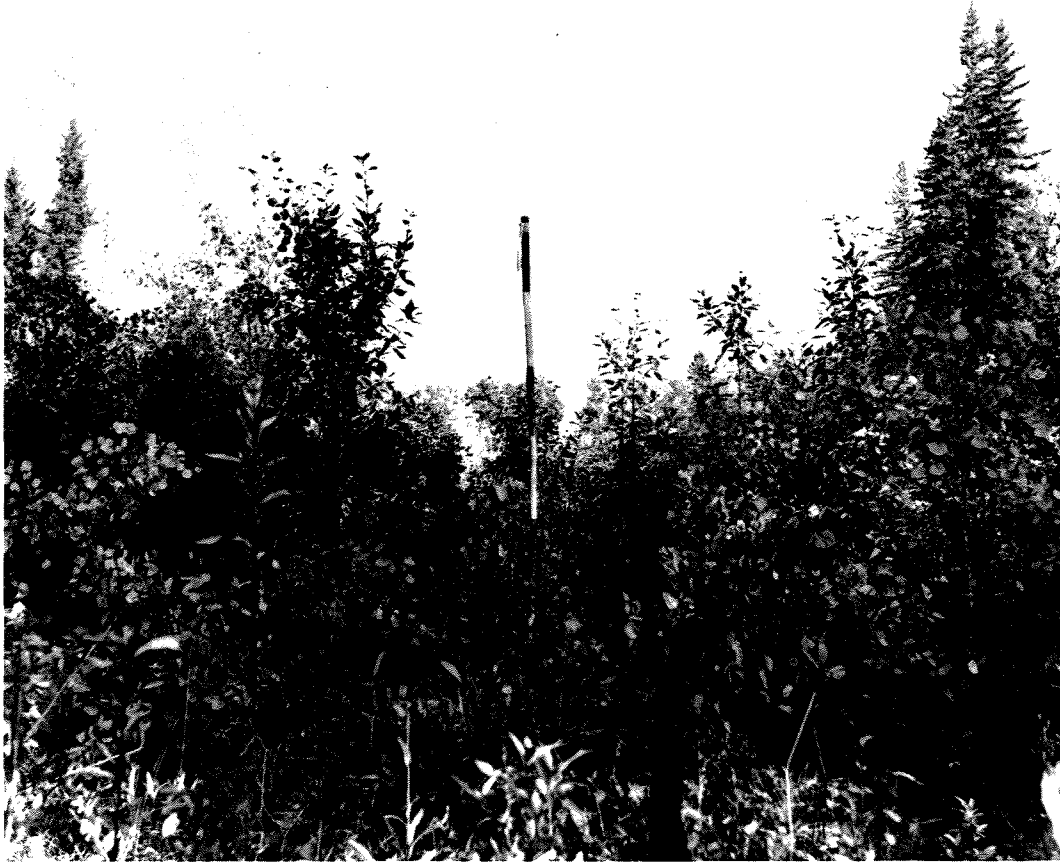


Figure 13. Example of hardwood reproduction on a cut-over scarified strip five years after treatment, Area 5. Note hardwoods less dense.



Figure 14. General view of stand in an uncut strip five years after treatment, Area 5. Note general scarcity of hardwood reproduction.

TABLE 34
 PER CENT STOCKING WHITE SPRUCE REGENERATION BY SITE,
 AREA 5

Condition	Per cent Stocking First Year ¹				Per cent Stocking Five Years After			
	Site				Site			
	Fresh	Moderately moist	Moist	Very moist	Fresh	Moderately moist	Moist	Very moist
Cut and scarified	42(77)	37(59)	30(50)	11(27)	80(77)	70(59)	42(50)	30(27)
Cut not scarified	0(70)	4(98)	0(22)	3(22)	24(70)	31(98)	18(22)	23(22)
Uncut	6(108)	6(63)	0(17)	0(9)	45(108)	57(63)	29(17)	78(9)
All	15(255)	14(220)	17(89)	10(58)	50(255)	49(220)	34(89)	34(58)

¹Figures in brackets represent number of quadrats.

TABLE 35
NUMBER OF WHITE SPRUCE REGENERATION PER ACRE BY SITE,
AREA 5

Condition	Number Per Acre First Year ¹				Number Per Acre Five Years After			
	Site				Site			
	Fresh	Moderately moist	Moist	Very moist	Moderately moist	Moist	Very moist	
Cut and scarified	583 ⁽¹²⁾	909 ⁽¹¹⁾	455 ⁽¹¹⁾	167 ⁽⁶⁾	23,000 ⁽¹²⁾	11,364 ⁽¹¹⁾	3,273 ⁽¹¹⁾	1,500 ⁽⁶⁾
Cut not scarified	0 ⁽¹³⁾	0 ⁽¹⁸⁾	0 ⁽⁵⁾	750 ⁽⁴⁾	231 ⁽¹³⁾	1,278 ⁽¹⁸⁾	400 ⁽⁵⁾	2,750 ⁽⁴⁾
Uncut	100 ⁽²⁰⁾	0 ⁽¹²⁾	0 ⁽³⁾	0 ⁽¹⁾	1,400 ⁽²⁰⁾	3,167 ⁽¹²⁾	1,000 ⁽³⁾	2,000 ⁽¹⁾
All	200 ⁽⁴⁵⁾	244 ⁽⁴¹⁾	263 ⁽¹⁹⁾	667 ⁽¹¹⁾	6,822 ⁽⁴⁵⁾	4,536 ⁽⁴¹⁾	2,158 ⁽¹⁹⁾	1,909 ⁽¹¹⁾

¹Figures in brackets represent number of list quadrats.

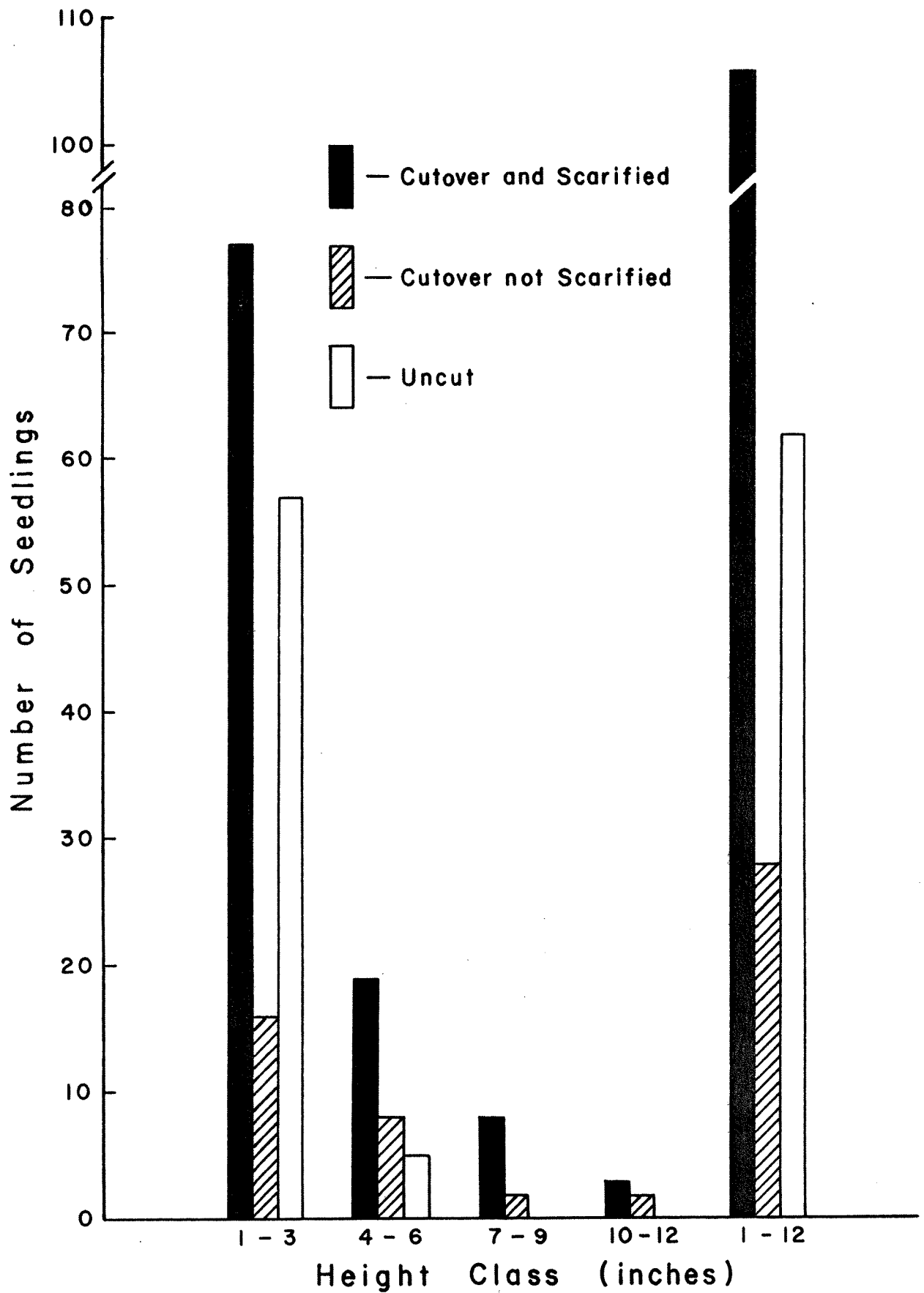


Figure 15. Number of white spruce seedlings (excluding cotyledons) by height class five years after treatment, Area 5. (Basis: tallest seedling on each stocked quadrat).

TABLE 36

DISTRIBUTION OF SEEDBED TYPES AND OCCURRENCE OF WHITE SPRUCE SEEDLINGS
ONE YEAR AND FIVE YEARS AFTER TREATMENT, AREA 5

Type of Seedbed	Per Cent Occurrence Seedbeds and White Spruce Seedlings								
	Cut-over scarified areas basis: 213 quads			Cut-over not scarified areas basis: 212 quads			Uncut basis: 197 quads		
	Seedbeds	Seedlings		Seedbeds	Seedlings		Seedbeds	Seedlings	
		1st year	5th year		1st year	5th year		1st year	5th year
Litter	4	0	1	72	0	13	78	0	30
Grass	1	0	0	10	0	0	5	0	1
Feather moss	0	-	-	1	0	9	8	0	11
F-Horizon	2	0	5	2	0	16	0	-	-
Humus	18	34	29	1	14	18	0	-	-
Mineral soil	41	65	50	0	-	-	1	-	3
Mixture (organic and mineral)	2	0	3	0	-	-	0	-	-
Debris piles	31	0	8	1	0	0	0	-	-
Slash	0	-	-	5	0	0	0	-	-
Decayed wood	1	1	4	8	86	44	8	100	55
All	100	100	100	100	100	100	100	100	100

TABLE 37

PER CENT SURVIVAL AND AVERAGE HEIGHTS, WHITE SPRUCE PLANTATIONS

ON AREA 5, 1964 TO AUGUST 1968

Planting site	Number planted spring 1964	Per Cent Survival				Average Height (inches)				
		August 1965	August 1966	August 1967	August 1968	After planting 1964	August 1965	August 1966	August 1967	August 1968
Cut-over scarified	130	82	78	70	68	5.7	9.0	13.2	18.0	20.2
Cut-over not scarified	135	62	56	56	53	5.6	7.6	10.7	13.6	15.3
Uncut	119	66	65	62	55	5.6	6.4	8.7	10.0	10.5



Left: Cut-over scarified (42.3 inches)



Center: Cut-over unscarified (36.2 inches)



Right: Uncut stand (16.2 inches)

Figure 16. Height comparison of tallest planted white spruce seedlings on three planting sites after five years, Area 5.

TABLE 38
 PER CENT SURVIVAL OF PLANTED WHITE SPRUCE SEEDLINGS
 BY PLANTING SITE AFTER 5 GROWING SEASONS, AREA 5

Condition on which seedling planted	Cut-over and Scarified		Cut-over Unscarified		Uncut	
	Number planted 1964	Survival 1968 (%)	Number planted 1964	Survival 1968 (%)	Number planted 1964	Survival 1968 (%)
Litter	5	20	98	61	89	60
Feather moss	0	-	0	-	7	43
F-horizon	12	75	6	83	0	-
Humus	11	27	1	100	0	-
Overturnd sod	2	100	0	-	0	-
Mineral soil	87	79	0	-	0	-
Litter (base of stump)	2	50	10	30	12	33
Slash	0	-	11	0	5	40
Decayed wood	0	-	3	38	4	75
Debris	11	27	0	-	0	-
Squirrel cache	0	-	1	0	2	0
All	130	68	135	53	119	55

Trial 6

Location: Twp. 66, Rge. 10, Sec. 9, W.3 Mer. (Figure 17)

Description: Trial 6 is on an area about 33 acres in size which in 1964 supported a stand containing white spruce, other softwoods (mainly balsam fir) and poplar. The spruce basal area was about 62 square feet per acre, other softwoods 62 square feet per acre and hardwoods eight square feet per acre (Table 39). The terrain is undulating; the soil is a sandy clay-loam till; and sites vary from fresh to moist. Fresh moderately moist and moist site occupy relatively equal amounts of the area.

Work done: During the winter of 1964-65 alternate 2-chain-wide strips were logged under the supervision of the Saskatchewan government. Seedbed treatment was carried out on the cut-over strips in September 1965. A TD-203 crawler-type tractor with a straight blade was used.

In July 1966, a total of 315 milacre quadrats were established to assess regeneration; 204 quadrats were located on cut-over strips (102 on scarified ground and 102 on unscarified) and 111 on uncut strips (Figure 18). In addition, 8 1/5-acre plots were established in the uncut strips to provide stand data.

Results:

1. Occurrence and abundance of white spruce, balsam fir and white birch reproduction are shown in Tables 40 and 41. It would appear that within five years the cut-over areas will be well stocked with spruce, fir and white birch.
2. Occurrence and abundance of white spruce regeneration by site is shown in Tables 42 and 43; all sites on the cut-over scarified area appear to be restocking well. Although large numbers of seedlings have been recorded on the uncut areas it is expected that they will not persist.
3. Distribution of seedbed types and occurrence of white spruce and balsam fir regeneration on each seedbed is shown in Table 44. Mineral soil and decayed wood appear to be the best seedbeds.

Comments:

1. This trial has not been established long enough to make a final statement about the status of regeneration. However, based on the present data it would appear that the treatment will be successful in promoting adequate spruce regeneration.

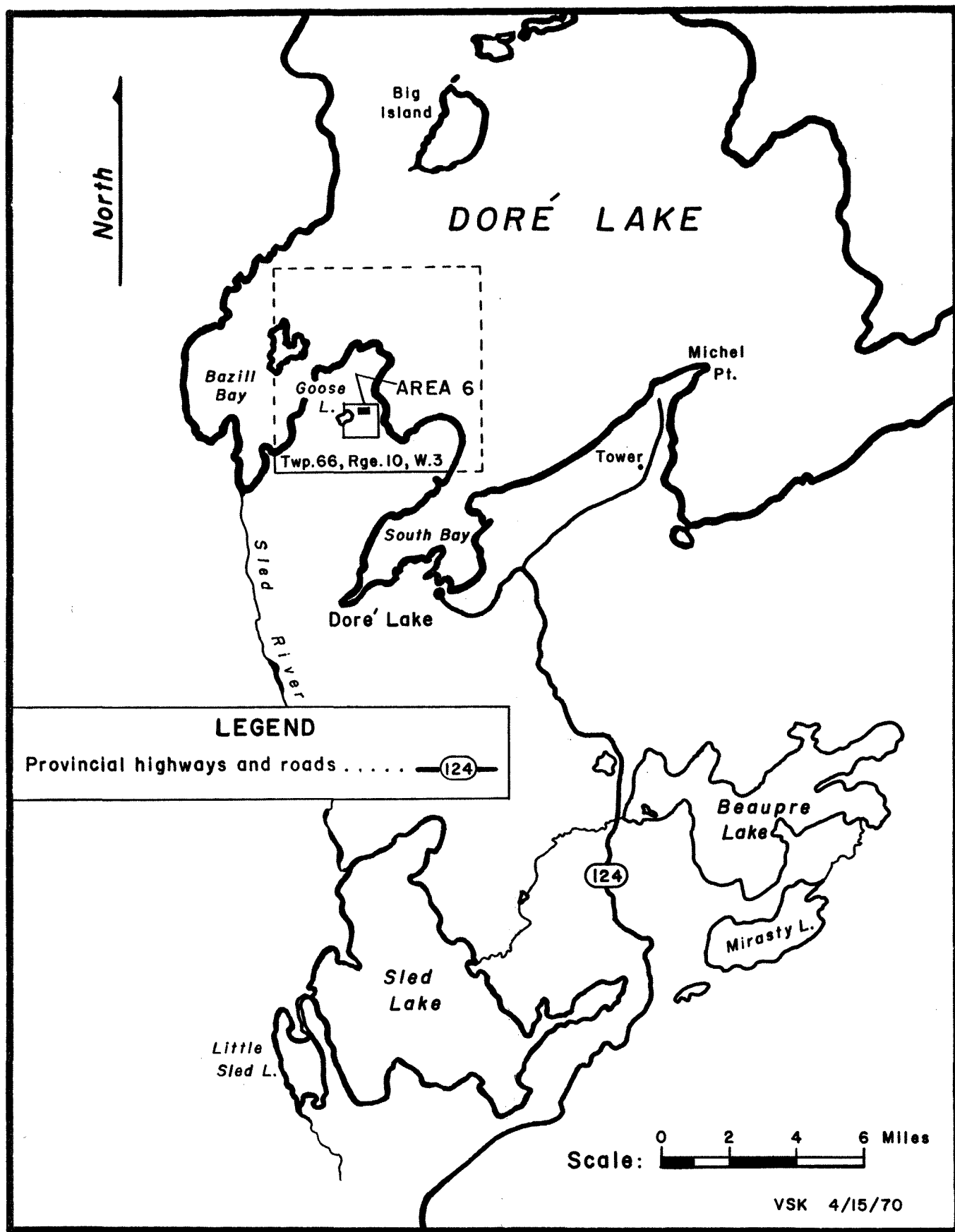


Figure 17. Location of Area 6.
Twp. 66, Rge. 10, Sec. 9, W.3 Mer.

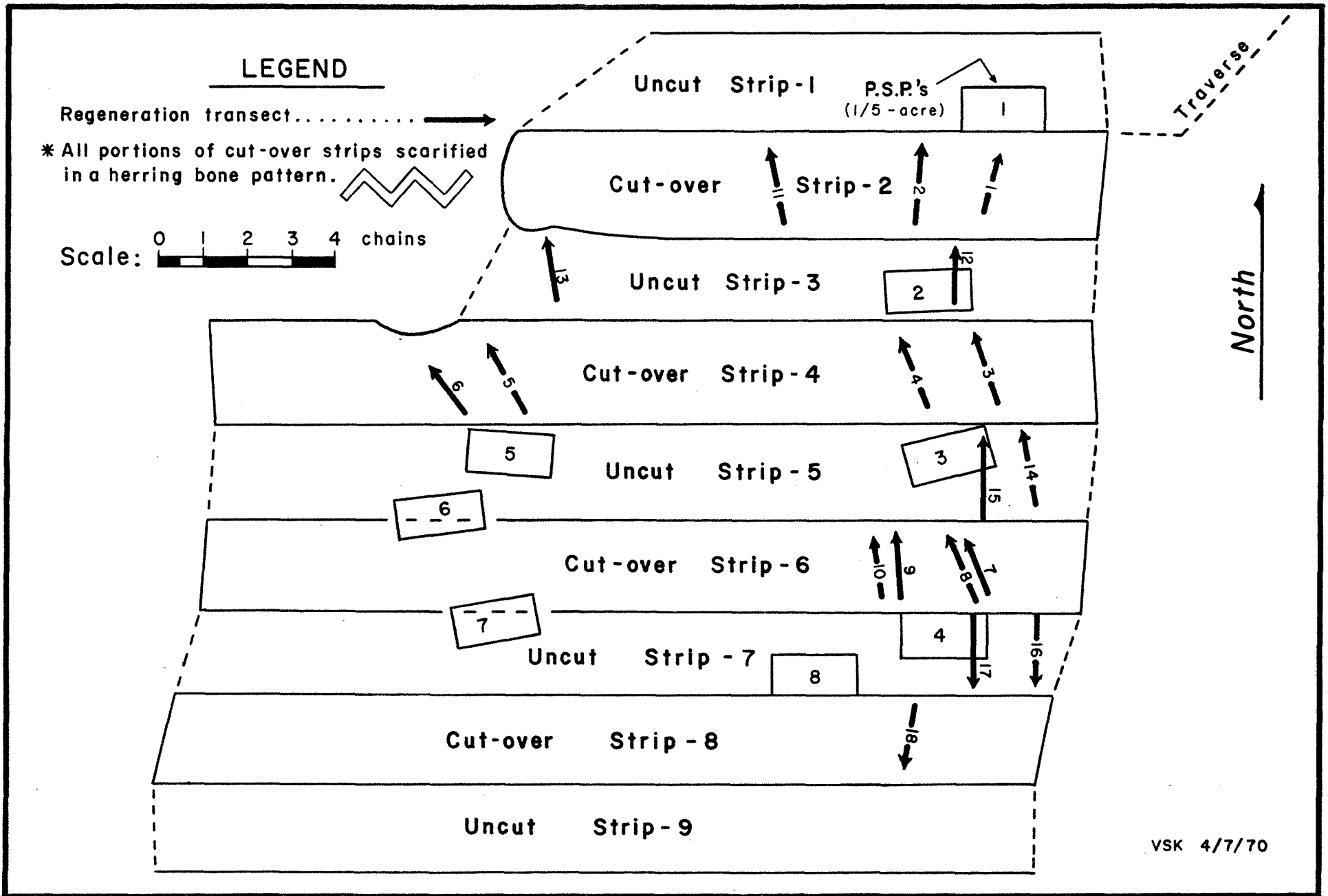


Figure 18. Sketch of Area 6 showing cut-over strips and location of sample plots.

TABLE 40
 PER CENT QUADRATS STOCKED TO WHITE SPRUCE, BALSAM FIR AND HARDWOODS,
 AREA 6

Condition	Number quadrats	First Year					
		White spruce		Balsam fir		Hardwoods	
		Regen- eration %	Advance growth %	Regen- eration %	Advance growth %	Regen- eration %	Advance growth %
Cut and scarified	102	34	8	26	11	79 ¹	1
Cut not scarified	102	8	21	36	80	6	13
Uncut	111	8	17	58	88	1	13
All	315	17	15	40	61	30	12

¹These figures represent white birch regeneration; all other hardwoods regeneration were classed as advance growth.

TABLE 43
 NUMBER OF WHITE SPRUCE REGENERATION PER ACRE BY SITE,
 AREA 6

Condition	Number Per Acre First Year ¹		
	Site		
	Fresh	Moderately moist	Moist
Cut and scarified	1,000 ⁽²⁰⁾	500 ⁽⁴⁾	3,000 ⁽¹⁾
Cut not scarified	0 ⁽¹²⁾	0 ⁽⁰⁾	0 ⁽¹⁾
Uncut	429 ⁽¹⁴⁾	1,600 ⁽⁵⁾	0 ⁽²⁾
All	565 ⁽⁴⁶⁾	1,111 ⁽⁹⁾	750 ⁽⁴⁾

¹ Figures in brackets equal number of list quadrats.

TABLE 44
DISTRIBUTION OF SEEDBED TYPES AND OCCURRENCE OF SOFTWOOD REGENERATION
ON AREA 6

Seedbed types	Per Cent Occurrence Seedbeds and White Spruce Regeneration								
	Cut-over scarified basis: 102 quads			Cut-over unscarified basis: 102 quads			Uncut basis: 111 quads		
	Seedbeds	wS	bF	Seedbeds	wS	bF	Seedbeds	wS	bF
Litter	0			49	12	11	29	11	2
Grass	0			1	0	0	0		
Feather moss	0			14	0	38	41	0	45
F-horizon	2	0	4	0					
Humus	<1	3	0	0					
Mineral soil	63	94	73	0					
Litter disturbed	11	0	8	0					
Debris	22	0	8	<1	0	0			
Overturned root	0			0			<1	0	0
Slash	0			14	0	0	9	0	0
Decayed wood	2	3	7	22	88	51	21	89	53
All	100	100	100	100	100	100	100	100	100

DISCUSSION AND CONCLUSIONS

Results from the five trials undertaken to determine whether scarification on an operational basis and in conjunction with logging would result in adequate spruce regeneration are most promising. Except for Trial 4 regeneration on the treated areas is adequate five years after treatment or indications are that it will be. The poor results from Trial 4 are attributed to poor scarification.

Of the two types of equipment used to make seedbeds (Saskatchewan fire-line plow and bulldozer blade) it is concluded that the ordinary blade is better for scarifying on the mesic sites. Practically all of the seedbeds made by this tool are suitable for regeneration and remain receptive for some years. Seedbeds such as piles of debris and overturned sod are generally not very good--they dry out too fast.

The Saskatchewan fire-line plow appears to be a reasonably good tool for treating the moister sites where footing for the tractor is poor. It can be maneuvered around stumps much easier than a blade without much danger of the tractor becoming stuck. By careful manipulation the operator can scalp off the litter exposing excellent humus seedbed. On the other hand, the one occasion where the Saskatchewan fire-line plow was used on mesic sites poor seedbeds were made. Coverage was poor and ploughing was too deep resulting in deep furrows and high ridges--conditions not suitable for seedling establishment.

Results have shown that good seed crops are essential to obtain good regeneration. Since seedbeds remain receptive for a number of years it would appear that lack of seed will not be a limiting factor at least in that portion of the B18a Forest Section in Manitoba and Saskatchewan. On the other hand, for early establishment of seedlings it may be feasible to seed scarified areas when seed crops are poor.

Survival results for transplants set out on the various areas have also been most promising. They indicate that white spruce can be planted successfully on cut-over areas. Pre-planting site preparation by scarification improves survival and growth of transplants.

It is quite evident from the results of these trials (established in different places at different times) that white spruce can be reproduced after logging. Scarification is necessary to provide seedbeds on planting sites and should be restricted to the fresh, moderately moist and moist sites.

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