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**REGENERATING WHITE PINE WITH SEED
TREES AND GROUND SCARIFICATION**

by
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Regenerating White Pine with Seed Trees and Ground Scarification

(Project H-113)

by

K.W. HORTON*

Success was achieved in establishing white pine regeneration on 130 acres of cut-over old-growth in western Quebec, by combining scarification with seed-tree cutting timed advantageously with an abundant seed crop.

The area treated is reasonably representative of the northern "virgin" pine country, of the sort that has fed the major segments of the white pine industry in eastern Canada for more than half a century. Such stands are overmature and in general very lightly stocked, but are highly valued as the chief remaining source of high-quality white pine lumber. The sites are eminently suitable for pine and it is reasonable to allot such areas permanently to white pine production. Every year's harvest, however, presses closer toward the pine's northern range limit and sees more square miles transformed to brush or low-quality mixedwood stands of balsam fir, white birch and aspen, which form the natural understorey. White pine reproduction is inadequate on the better till sites and is acceptably stocked only on the drier sites. Conventional winter logging has not usually provided suitable regeneration conditions. Natural establishment of most white pine stands in the past depended on fire to prepare suitable seedbeds (Horton and Brown 1960, Horton and Bedell 1960).

The experiment was established in 1955 on a co-operative basis by the Forest Research Branch and the lumber firm of Gillies Bros. and Company Limited, to test a likely combination of treatments for regenerating white pine naturally. Observations throughout the central Canadian pine region (Logan and Brown 1956, McCormack 1959) had suggested that there were measures other than the as yet unaccepted prescribed burning which could regenerate white pine, namely, cutting methods which would provide adequate seed, and scarification which would provide a receptive mineral soil seedbed and reduced vegetative competition. Appropriate treatments were devised, with the Company providing the area and undertaking the necessary mechanical scarification and logging, and the Forest Research Branch designing the experiment, marking seed trees and carrying out the research.

The Area

Situated in the heart of the Coulonge Limit of Gillies Bros. and Company Limited, at latitude 46° 22', longitude 76° 44', the area is typical of the L4b Section of the Great Lakes—St. Lawrence Forest Region (Rowe 1959) which has been noted for its fine pine stands. The topography is strongly rolling with shallow till-capped hills of granite, granite gneiss and biotite schists. Sandy outwash and terrace landforms are common in the valleys. The climate is cold and moist relative to the region, with a mean annual temperature of 36°F. and a mean annual precipitation of 35 inches, 19 inches occurring during the growing season.

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Sandy, dumped-till soils of dry to fresh moisture regime (*sensu* Hills 1950) prevail, with numerous bedrock outcrops on the ridges and numerous moist depressions of silt loam. On the experimental area the sites are described and distributed as follows:

Moisture Regime	Description	Per cent of area
0 Very dry.....	Shallow loamy sand or loamy gravel on ridges, often exposed	11
1 Dry.....	Excessively drained slopes; usually less than 3 feet of stony loamy sand.....	34
2-3 Fresh.....	Well-drained slopes or benches; usually more than 5 feet of sandy loam or loamy sand with an inch or two of humus..	45
4-5 Moist.....	Lower slopes and gullies with telluric moisture; silt loam with a humus cap several inches deep.....	6
6+ Wet.....	Pockets with 1 foot or more of peat.....	4

The wet site will be ignored as impractical for white pine production. It is the fresh site, where pine grows very well yet competition is strong, that is the chief concern.

Before treatment the stands were divisible into two white pine site types, ridge and slope, each with a different understorey composition. In general the ridge type consisted of the very dry and dry moisture regimes, and the slope type the fresh and moist. Average basal areas per acre of trees four inches d.b.h. and larger are shown in Table I. The diameters of merchantable pines ranged mainly from 20 to 30 inches, and the heights around 100 feet.

TABLE I.—AVERAGE BASAL AREA IN SQUARE FEET PER ACRE

Site Type	Species*										Total
	wP	rP	bF	wS	bS	jP	rM	wB	tA	Other Hdwds	
Ridge....	77.74	1.05	1.74	2.19	4.75	—	0.73	3.10	0.56	1.05	92.91
Slope....	*40.04	—	3.14	2.77	0.43	0.04	0.47	1.77	2.48	1.58	52.72

*See "Nomenclature".

These low total basal areas are explained by the stand history. The white pines were about 160 years old when cut. When younger, the stands on the slopes were evidently well-stocked, mainly to balsam fir, white pine and white birch. The fir suffered from periodic attacks of spruce budworm (*Choristoneura fumiferana* Clem.), and the last, beginning in 1948, caused extensive mortality. The white birch suffered latterly from over-maturity and dieback, and many of the spruce were blown down. This periodic progressive opening of the canopy encouraged prolific shrub growth, mainly mountain maple and hazel, and conditions suitable for natural white pine reproduction deteriorated.

On the ridges there had been much less change in stand composition and structure, white pine remaining dominant, sometimes in fairly well-stocked groves, and a mixed spruce-fir understorey gradually developing. Sparse competition from ground vegetation had permitted a reasonable stocking of white pine and spruce advance growth.



FIGURE 1. Before treatment the area was lightly stocked to old white pine, and heavy underbrush prevailed.



FIGURE 2. After treatment 5 to 10 seed trees per acre were left and one-third of the ground area was scarified. Poorer specimens here are residual culls.

Treatments

On an area of 200 acres, ten well-formed, full-crowned white pine seed trees per acre were marked to be left on the slopes, and five per acre on the ridges. This procedure took eight man-days, costing (including supplies, transportation and labour) about 50 cents per acre, or less than 10 cents per thousand ft. b. m. (Roy Rule) of logs removed.

In August, 1955, 130 acres were scarified by a D-4 tractor equipped with a standard dozer blade. The operator was instructed to concentrate on exposing mineral soil and eliminating heavy shrub cover on the slopes, aiming at 40 to 50 per cent coverage. This operation required 158 tractor hours (at \$7.50 per hour) and the total cost as determined by the Company was \$10.00 per acre or \$1.48 per thousand ft. b.m. of logs removed.

The scarified area was logged conventionally, using horses for skidding, somewhat earlier in the season than usual, during October and November, 1955. The cut averaged close to 8,000 ft. b.m. of white pine sawlogs per acre. This amounts to some 13 pine trees per acre or about two-thirds of the original number of stems. Slash was not treated in any special way. Sampling indicated that 35 per cent of the area was covered to some degree with slash, including bulldozed piles of debris which resulted from the scarification and skid road construction. The greatest slash concentrations were on the ridges where pine volume was highest.

Sampling

Sampling was carried out on four, parallel, randomly established lines of contiguous milli-acre quadrats or plots which traversed the treated area and comprised 0.5 per cent of the total acreage. It was done in the spring and autumn of 1956 and subsequent autumns to 1960. Accurate quadrat relocation was assured by painted stakes placed at one-chain intervals. Each plot was assessed initially as to physiographic site and per cent coverage of scarification and slash. Then an annual record was kept of shrubs and herbs (per cent cover and main species), of white pine stocking (presence of one or more seedlings), and of the tallest species present. On 72 plots, randomly selected on each line, all white pine seedlings were marked to follow seasonal mortality. In 1960 the height of the tallest specimen of each species per plot was tallied.

Extent of Scarification

The results of the scarifying operation are shown in Table 2. For classification purposes a plot was considered scarified if mineral soil was exposed on more than five per cent of its area (equivalent to a spot of approximately two square feet). The scarified area of each plot was estimated to the nearest ten per cent beyond this five per cent minimum.

TABLE 2.—AMOUNT OF SCARIFICATION

Site	Total number of milli-acre plots sampled	Per cent of plots with some scarification	Per cent of sampled area scarified
Very Dry.....	79	49	29
Dry.....	235	41	37
Fresh.....	312	57	37
Moist.....	42	64	47
All.....	668	57	37

The amount of ground scarified, about one-third of the total area, is considered ideal, and the distribution of scarified patches (on about 60 per cent of plots on the better sites) is acceptable, being in line with standards proven to be efficient elsewhere (Decie and Fraser 1960). Evidently the operator followed instructions, concentrating more on the slope sites where shrub competition was heaviest, and less on the ridges. At the cost involved and in view of the rough ground and heavy brush, the scarifying operation was considered a practical success.

Seedfall

The experiment was fortunate in initially coinciding with an excellent seed crop. On September 8, 1955, a heavy pine cone crop was evident, and a count of seed in 30 randomly located one-foot squares on the ground gave a rough seedfall estimate of more than 11 pounds of seed per acre. The estimate is likely low for the season, since much seed would normally not have fallen by this date. This abundant supply was greatly depleted by rodents, which left frequent small caches of husked cones as evidence; however, an ample amount survived, judging by the number of germinants in the following summer.

In 1956 the cone crop was generally classed as light, in 1957 and 1958 there were virtually no cones, and in 1959 another light crop was observed.

Advance Growth

Relative stocking of advance growth after logging on the different sites is shown in the 1956 spring tally in Tables 3 and 5. Advance growth of white pine was originally appreciable only on the drier sites, and was much reduced by the scarifying and logging operations. Balsam fir was the main species among the advance growth, with a stocking of 30 to 50 per cent on the unscarified plots of all sites. Scarification greatly reduced the fir. Advance growth of hardwood species was negligible.

Regeneration

The five-year regeneration trends of white pine and competing species are shown in Tables 3, 4 and 5 for scarified and unscarified quadrats within the seed-tree cutting area.

TABLE 3.—PERCENTAGE OF MILLIACRE PLOTS STOCKED¹ TO WHITE PINE REPRODUCTION.

Site	1956 Spring (advance growth)	1956 Fall (first year)	1957 Fall (second year)	1958 Fall (third year)	1960 Fall (fifth year)
	S ² U	S U	S U	S U	S U
Very dry.....	15 37	74 55	64 57	51 52	56 52
Dry.....	4 20	84 60	72 57	62 53	65 48
Fresh.....	2 10	87 47	80 44	66 33	63 * 29
Moist.....	2 3	52 27	63 33	52 20	41 * 20

¹ One or more seedlings present.

² Subsequent tallies include surviving advance growth as well as seedlings.

S = scarified 5% or more. U = unscarified.

* Differences between 1960 values significant at the 0.01 level by Chi-square test.

Differences between values on the drier sites not significant at the 0.05 level.

TABLE 4.—WHITE PINE SEEDLING DENSITY TRENDS—ALL SITES.

Season	Scarified (37 plots)		Unscarified (35 plots)	
	Number of Seedlings per acre ¹	Seasonal Seedling Mortality per cent	Number of Seedlings per acre	Seasonal Seedling Mortality per cent
Spring 1956 (advance growth).....	260	—	—	—
Fall 1956.....	5,730	5	—	—
Spring 1957.....	5,460	7	3,140	4
Fall 1957.....	6,300	13	3,660	8
Spring 1958.....	5,650	10	3,110	15
Fall 1958.....	5,780	4	2,800	10
Fall 1960.....	4,860	—	2,110	—

¹ Net figure involving surviving and new seedlings.

— Not assessed.

TABLE 5.—STOCKING OF REPRODUCTION OF MAJOR COMPETING SPECIES, FALL, 1960

Site	Per cent stocking							
	bF		wS and bS		tA		wB	
	S	U	S	U	S	U	S	U
Very dry.....	18	50	5	3	41	3	44	22
Dry.....	29	40	16	1	53	5	63	18
Fresh.....	18	41	5	5	51	3	50	9
Moist.....	11	33	4	7	52	20	48	7

TABLE 6.—HEIGHT CLASS DISTRIBUTION OF DOMINANT¹ REPRODUCTION OF MAIN SPECIES IN 1960.

Site	Height Class ²	Relative per cent by height class							
		wP		bF		tA		wB	
	(inches)	S	U	S	U	S	U	S	U
Very dry.....	0-5	18	12	28	0	6		0	0
	6-23	64	46	29	19	24		41	17
	24+	18	42	43	81	70		59	83
Dry.....	0-5	18	26	15	3	0		1	0
	6-23	70	48	18	16	3		13	24
	24+	12	26	67	81	97		86	76
Fresh.....	0-5	20	43	23	2	0		1	0
	6-23	75	39	6	12	2		16	10
	24+	5	18	71	86	98		82	90

¹ Only the tallest specimen of each species per milli-acre plot was measured.² The three height classes represent different survival chances for white pine: 0-5" = poor (very suppressed or recent seedlings); 6-23" = fair (established seedlings most of which will survive especially if released); 24" + = good (mostly established advanced growth).



FIGURE 3. Scarification produced a suitable seedbed and reduced vegetative competition for these 2-year-old white pine seedlings on a fresh site.



FIGURE 4. Lush grass growth resulted from scarification on this moist site two years after treatment, and precluded pine regeneration.

The salient points about regeneration from Tables 3 to 6 and field observations are as follows:

(a) Stocking to white pine was significantly increased (more than doubled after five years) on the fresh and moist sites as a result of scarification. The stocking level was satisfactory on the scarified fresh site but not on the moist. (Table 3).

(b) No significant improvement of stocking to pine resulted from scarification on the drier sites. (Table 3).

(c) The number of stems per acre of white pine reproduction on the area as a whole (Table 4) is more than adequate at about 5,000 seedlings per acre on the scarified plots. At about 2,000 per acre on the unscarified plots, the number of seedlings is perhaps acceptable but their distribution is poor (note again the deficiency of stocking on the important fresh sites—Table 3).

(d) Mortality in the white pine seedlings was not severe on either seedbed during any year (Table 4), and was partially offset each year by a small amount of new regeneration resulting either from delayed germination or from the seed crop of the preceding year. In 1960, for example, 360 cotyledonous seedlings were recorded per acre. During this year also, white pine blister rust (*Cronartium ribicola* Fischer) killed vigorous seedlings in some locations.



FIGURE 5. Vigorous pine regeneration was established on both scarified and unscarified portions of drier sites such as this five years after logging. Brush competition was not excessive.

(e) Major competitors of white pine are aspen and white birch on the scarified areas and balsam fir on the unscarified (Table 5). The hardwoods outnumbered and outgrew the pine on all scarified sites from the first year. A count in 1956 showed 11,600 hardwood stems per acre, and this doubled in 1957. This, however, is the normal ecological pattern and may be advantageous in that the hardwoods may act as a nurse crop and decrease weevilling.

The dominance of balsam fir over pine on the unscarified areas is of greater concern, and the advantage of scarification in reducing this is important.

(f) White pine growth (Table 6) benefited from scarification on the fresh site, the proportion of trees in the poor height class being appreciably smaller in scarified than in unscarified plots. On the driest site, however, scarification was detrimental, reducing the proportion of tall advance growth. The issue is in balance on the intermediate dry site.

Vegetation Development

Initially competition from lesser vegetation is more of a problem to pine than is competition from the reproduction of other tree species. Herb and shrub cover were estimated separately on each milliacre plot each year and the averages for each condition are presented in Tables 7 and 8. It should be borne in mind that development of the herb stratum is progressively affected by the increasing growth of the overtopping shrubs.

TABLE 7.—DEVELOPMENT OF SHRUB AND HERB COVER

Site	Stratum	Average per cent cover on plots each fall							
		1956		1957		1958		1960	
		S	U	S	U	S	U	S	U
Very dry.....	Herbs	22	9	27	11	34	15	18	10
	Shrubs	17	26	19	27	22	32	32	39
Dry.....	Herbs	26	13	34	16	35	20	34	17
	Shrubs	11	25	14	30	20	40	39	52
Fresh.....	Herbs	32	17	43	19	48	23	36	19
	Shrubs	12	28	16	31	29	38	45	51
Moist.....	Herbs	19	27	36	21	52	30	48	18
	Shrubs	15	35	16	40	24	53	25	65

TABLE 8.—RELATIVE IMPORTANCE OF MAJOR SHRUBS AND HERBS BY SITE AND SEEDBED, 1960

Shrubs*	Percentage of plots in which species dominates							
	Very Dry		Dry		Fresh		Moist	
	S	U	S	U	S	U	S	U
Raspberry.....	28	22	37	31	36	24	38	15
Hazel.....	34	19	36	40	39	47	19	15
Mountain maple.....	10	29	6	9	3	24	6	54
Sweet-fern.....	14	0	8	0	13	0	6	0
Willows.....	0	0	0	0	1	0	25	0
Herbs, etc.								
Aster.....	63	44	40	68	56	68	14	37
Grasses.....	16	19	16	2	19	7	71	12
Bracken.....	0	25	15	5	4	3	0	25
Bunchberry.....	0	6	10	16	5	5	0	0
Sarsaparilla.....	0	6	2	2	5	9	0	13
Hair cap mosses.....	16	0	16	0	9	0	0	0

*see "Nomenclature"

Analysis of Tables 7 and 8 provides the following points which were borne out by field observations.

(a) On scarified ground compared with unscarified there was an immediate and considerable increase in herb cover but shrubbery was set back appreciably for two or three years.

(b) Vegetation competition is not a problem on the very dry site, and varied little between scarified and unscarified plots by the fifth year. The cover at present levels on the driest sites is likely advantageous rather than detrimental to pine seedling survival, through its protection against exposure.

(c) On the fresh and dry sites, the herb layer developed strongly on scarified plots but the shrub layer was effectively reduced for two or three years. However, by the fifth year, dense tall shrub patches covered about half of the area, on scarified as well as unscarified ground, and were suppressing much of the regeneration.

(d) On the moist site the treatments greatly encouraged shrub development on the unscarified portions and herbs on the scarified. Dense patches of grass, forming in the second year on scarified ground, were particularly detrimental to pine regeneration.

(e) Raspberry, hazel and mountain maple were the predominant shrubs. Scarification increased the raspberry sprouting, particularly on fresh and moist sites, and greatly decreased maple. Hazel sprouted in abundance and remained frequently dominant on all conditions.

(f) Aster prevailed as the dominant herb on all conditions except the moist site where scarification resulted in lush grass. On the drier sites, scarification was advantageous in encouraging a fair amount of hair-cap moss, which is considered a good seedbed for coniferous regeneration.

Competition Control

Brush control is considered unnecessary on the driest sites where the vegetation is needed for protection, and unfeasible on the moist site in view of the difficulty in killing dense grass which prevails on scarified areas and exceptionally vigorous shrubbery which characterizes unscarified areas.

On the fresh and moderately dry sites, scarification provides temporary brush control, but by about four years the shrub layer redevelops to the point where established pine regeneration needs releasing. On unscarified brushy areas this point is reached a year or two after logging. Herbicide spraying is advocated as a remedy.

Preliminary spraying trials were carried out on the experimental area in the mid-summer of 1959, using a back-pack power sprayer with "Esteron 2,4,5 o.s.", a 2,4,5-T compound, mixed at various concentrations in water. These tests indicated that an acceptable kill of the major shrubs could be achieved with a fine-spray mixture of one part compound to 60 parts water. The spray was applied both systematically in strips and irregularly alongside skid-roads and trails. A three-man crew was able to treat 4 to 5 acres in half a day using either method. Thus at a rate of 1/3 man-days per acre, plus material and handling, the total cost of brush control was estimated at \$5 per acre.

It is possible that another application of herbicide will be required after another three years to keep the pine leaders above the shrub sprouts, particularly on unscarified areas where initial seedling growth was slow.

For moderately large brush control jobs a tractor-mounted spraying machine operating from the skid roads in a cut-over area would be far easier to operate and therefore probably more efficient than back-pack sprayers. And for areas approaching 1,000 acres or larger, aerial spraying would unquestionably be

most efficient. Relevant tests in the northern U.S.A. (Arend and Roe 1961) and in Ontario in conditions very comparable to the experiment area have proven that effective brush kill and pine release can be achieved over practically the whole acreage sprayed, at costs somewhat below \$5 per acre.

Control of blister rust is another problem in this as in almost all white pine areas. Eradication of *Ribes*, the host plant, is the practical solution. The summer spraying of 2,4,5-T applied on the experimental area did not kill the *Ribes* plants but encouraged them by reducing competing species. It is clear that a special *Ribes* removal treatment will be required in the area and environs, using either manual or chemical methods, preferably in the spring when the plants are easily discernible. This, according to a general experience in some Ontario areas, will cost another \$5 per acre, but it should be regarded as an inevitable cost in white pine management. A pertinent analysis of blister rust control and the overall economics of white pine management in the Lake States has recently been published (King *et al.* 1960).

Conclusions

The trial was successful in regenerating white pine adequately and, more important, in qualifying the applicability of the seed tree method and scarification on a variety of conditions.

Treatment Timing

The outstanding point is that treatments should be timed to take advantage of good natural seed crops. In this case the ground was scarified a few weeks before a heavy seedfall, then logged in late autumn, and the regeneration "catch" was excellent despite depredations by small rodents.

In these lightly stocked old stands, the ground could be scarified a year or so before a major seedfall, since it remains a reasonably receptive seedbed, and the logging could be delayed several years, provided it be done in winter when deep snow will protect most established seedlings. For pre-scarification planning, the local seed crop can be predicted a year in advance by examining immature cone crops on cut trees. Good crops are expected to occur every 3 to 5 years (anon. 1948).

Post-cut scarification on areas with seed trees may be carried out any time after the cut, but preferably just prior to a good seedfall.

Seed Trees

If neither advance growth nor the current seedfall are adequate at the time of cutting, seed trees must be relied upon for natural regeneration. They were not, as it happened, essential in this particular trial but were, in effect, an insurance measure. The heavy cone crop of the uncut stand in 1955 resulted in a roughly estimated seedfall of 11 lbs. per acre. At this rate the seed supply from the remaining one-third of the stand, chosen as the most productive seed trees, would amount to about 4 lbs. (over 100,000 seeds per acre), which would seem ample for regeneration provided other factors, notably the small rodent population and the seedbed conditions, were favourable. Thus ten seed trees per acre seems an appropriate number to leave on the fresh slope sites. Scarification will be needed but is best deferred to the next heavy seed crop. On the drier ridge sites, where advance growth pine is frequent, five seed trees per acre seems sufficient to bolster the reproduction stocking, and scarification is unnecessary.

The seed trees should be relatively full-crowned, well-formed and free of apparent genetic defects, but these standards may have to be compromised in some cases to assure reasonable spacing. In the overmature stands there are invariably a number of cull trees which are probably not worth logging, yet,

being decadent only because of over-age, are acceptable as seed trees for the next crop. It seems reasonable to leave perhaps two or three of the fullest crowned cull trees per acre for seed supply insurance, even where regeneration is already satisfactorily established.

Windfall among the seed trees left on the experimental area over the five-year period was negligible, occurring only sporadically on moist shallow soils. Such susceptible conditions for windthrow can be avoided when marking.

Scarification

Scarifying randomly in well-distributed patches covering roughly a third of the area appears to be silviculturally effective as a pine seedbed treatment for the important fresh and transitional fresh sites. It was not appropriate on the drier sites in this area, where pine regeneration was practically as successful on unscarified as on scarified seedbeds. Neither scarification nor herbicide spraying as applied were sufficiently effective in reducing competition on the moist sites, so that such areas, which are minor in any case, should either be avoided in terms of pine silviculture or treated more intensively.

At a cost of \$10 per acre using an ordinary bulldozer, scarification is both economical and practical. But this cost can be lessened if mechanical logging methods are used. An area adjacent and comparable to the trial area was logged in the fall of 1957, skidding tree-lengths by bulldozer. The operation incidentally scarified 20 per cent of the area, distributed over 43 per cent of 700 milliacres sampled on the fresh sites, an amount of scarification close to adequate for pine regeneration. This could be augmented at little expense by selectively scarifying missed patches during the logging when men and equipment are at hand. Thus an area could be regenerated practically at the expense of a few seed trees.



FIGURE 6. Mechanical logging in the fall incidentally resulted in adequate scarification on this site.

In addition to producing favourable seedbeds for white pine germination and initial survival, scarification greatly reduces the less valuable balsam fir advance growth and greatly increases aspen and white birch regeneration. The latter is not viewed with alarm since it is a normal ecological trend for intolerant hardwoods to act as a nurse crop for pine. The hardwood competition is liable to be excessive only on the fresh sites where it can be overcome by herbicide spraying which is recommended in any case to control shrubs such as hazel, raspberry and mountain maple. Spraying to release pine seedlings should be done on the fresh sites only, after three or four years on scarified areas, and earlier, if necessary, in unscarified stands.

Costs

The per-acre costs of the treatments comprising this trial were: seed tree marking 50c., scarification \$10, brush spraying \$5. Also required are *Ribes* control (estimated \$5) and, perhaps, a second brush spraying (\$5) after three or four years. From the operational viewpoint there is another cost involved in leaving or salvaging the seed trees. However, seed trees were not needed for successful regeneration in this case because the cutting followed a heavy seedfall. Through such timing the costs of marking and leaving seed trees can be eliminated. In other cases the cost of scarification could be largely avoided by using mechanical logging methods which provide scarified ground incidentally. Here, seed trees would be essential.

Thus the flexible combination of seed year timing, seed tree cutting, and scarification or mechanical logging can provide white pine regeneration at reasonable costs. The alternative is clear cutting and planting. But for success this may require as much site preparation, brush and *Ribes* control as the recommended approach—and planting costs in out-of-the-way rough cut-over areas, considering the accommodation, transportation, supervision and other overhead costs required for large planting crews, can range up to \$50 per acre.

Summary

Adequate stocking and density of white pine regeneration resulted from ground scarification by bulldozer shortly before a heavy seedfall followed by logging in an overmature, lightly stocked white pine stand in western Quebec.

Though seed trees were not needed because of this fortunate timing, 5 to 10 good specimens per acre were left to ensure a seed supply. This is considered adequate for regeneration of dry and fresh sites respectively if other factors are favourable.

Scarification is not necessary for white pine regeneration on the drier ridge sites and is ineffective on the moist sites because of grass buildup. It is needed on the important fresh sites for the preparation of suitable pine seedbeds, the reduction of undesirable balsam fir advance growth and the temporary set-back of the shrubs, hazel and mountain maple. Herbicide spraying to release pine seedlings is advocated by the fourth year following scarification on the fresh sites only.

The cost of scarifying by bulldozer was \$10 per acre but this could be mostly avoided by mechanical logging which scarifies incidentally. Seed tree costs can be avoided by scarifying before and logging after a good seedfall. Brush control and *Ribes* eradication cost about \$5 per acre each but would be required also with the expensive alternative of planting white pine. Thus the treatments advocated are considered economical as well as silviculturally effective for regenerating white pine.

Résumé

Une forte tombée de graines précédée de la scarification du sol à l'aide d'un bulldozer et suivie d'une coupe dans un peuplement de faible densité de pins blancs trop mûrs dans l'ouest du Québec a eu pour résultat la création d'un peuplement de pins blancs de population et de densité convenables.

Les porte-graines n'étant pas nécessaires par suite du choix du moment opportun de la coupe, on a laissé de 5 à 10 bons sujets afin d'assurer une bonne quantité de graines, ce qui est considéré comme un nombre convenable pour la régénération de stations sèches et fraîches respectivement, à condition que les autres facteurs soient favorables.

La scarification n'est pas nécessaire à la régénération du pin blanc dans les stations situées sur des crêtes plus sèches, mais elle est inefficace dans les stations humides par suite de la présence d'un abondant tapis herbacé. Dans les importantes stations fraîches, elle est nécessaire à la préparation de terrain convenable de germination du pin, à la réduction de la régénération indésirable du sapin baumier et à l'étouffement provisoire des éricacées, du noisetier et de l'érable à épis. La pulvérisation d'herbicides dans le but de libérer les semis de pin est avantageuse la quatrième année après la scarification du sol, mais seulement dans les stations fraîches.

Le coût de la scarification au bulldozer était de \$10 l'acre, mais cette opération peut être remplacée presque entièrement par le débusquage mécanique qui a par ailleurs un effet de scarification. On peut éliminer le coût de conservation des porte-graines en effectuant la scarification avant une bonne tombée de graines et en reportant la coupe après la chute des graines. Le coût de la suppression des broussailles et de l'éradication des *Ribes* s'élève à \$5 pour chacune de ces deux opérations qui seraient tout aussi nécessaires avec l'alternative coûteuse de la plantation de pins blancs. Par conséquent, les traitements préconisés sont jugés économiques et efficaces du point de vue sylvicole, pour la régénération du pin blanc.

Nomenclature

Trees

White pine	wP.....	<i>Pinus strobus</i> L.
Red pine	rP.....	<i>Pinus resinosa</i> Ait.
Jack pine	jP.....	<i>Pinus banksiana</i> Lamb.
Balsam fir	bF.....	<i>Abies balsamea</i> (L.) Mill.
Black spruce	bS.....	<i>Picea mariana</i> (Mill.) BSP.
White spruce	wS.....	<i>Picea glauca</i> (Moench) Voss
White birch	wB.....	<i>Betula papyrifera</i> Marsh.
Trembling aspen	tA.....	<i>Populus tremuloides</i> Michx.
Red maple	rM.....	<i>Acer rubrum</i> L.

Shrubs

Hazel.....	<i>Corylus cornuta</i> Marsh.
Mountain maple.....	<i>Acer spicatum</i> Lam.
Raspberry.....	<i>Rubus strigosus</i> Michx.
Sweet-fern.....	<i>Comptonia peregrina</i> (L.) Coult.
Willows.....	<i>Salix</i> spp.

Other vegetation

Aster.....	<i>Aster macrophyllus</i> L.
Bracken.....	<i>Pteridium aquilinum</i> (L.) Kuhn
Bunchberry.....	<i>Cornus canadensis</i> L.
Sarsaparilla.....	<i>Aralia nudicaulis</i> L.
Hair cap mosses.....	<i>Polytrichum</i> spp.

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