OPERATIONAL TRIALS OF SITE PREPARATION AND PLANTING METHODS IN THE GOULAIS RIVER AREA ONTARIO

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Weldwood of Canada furnished one of the tractors used for site preparation, and the Company provided labour and supervision for some of the planting operations.

The trials were initiated by Messrs. B. S. P. Wang and K. W. Horton, who at that time were on the staff of the Ontario Region, Department of Forestry and Rural Development. Throughout the project, Mr. F. W. E. Curtis assumed major responsibility for field assessment of the results of treatment and for compilation of the data.

All these contributions were vital to the success of the project, and are gratefully acknowledged.

Frontispiece. V-blade mounted on 50-hp tractor.

ABSTRACT

Between 1965 and 1967, operational trials of three methods of site preparation and planting were carried out in each of three important forest-site-types in the Goulais River area of Ontario. On the basis of total treatment cost and subsequent survival of the planted stock (white spruce, white pine and red spruce), the relative efficiency of the various treatments was determined.

On the tolerant hardwood site-type, site preparation with a V-blade, followed by hand planting, was the most efficient treatment tested. Scalping with an angle-dozer blade (followed by hand planting) ranked second, and scarification with shark-fin drums (also followed by hand planting) was least efficient.

On the understocked intolerant hardwood site-type, V-blade scarification in conjunction with machine planting was most efficient; and among the other treatments, differences were small.

On the cut-over mixedwood site-type, the V-blade with machine planting was most efficient; and the angle-dozer blade with hand planting was next. This was followed by the V-blade with hand planting, and lastly by the shark-fin drums with hand planting.

First-year survival was not less than 79 per cent for any treatment on any site-type, and differences in efficiency were largely the result of differences in the cost of treatment.

TABLE OF CONTENTS

INTRODUCTION

Since the early 1960's, site preparation with heavy equipment has been an integral part of the rapidly expanding reforestation program of the Ontario Department of Lands and Forests. A great variety of scarification equipment is employed on this work, some of it being standard equipment of the agriculture or construction industries, and some especially developed for the purpose. The staff involved in the program has acquired considerable experience in the selection of tools and techniques to handle various site conditions; and on the basis of this experience, Morawski (1966) summarized methods and recommendations for equipment usage. However, there have been few opportunities to determine the relative efficiency of alternative treatments applied to the same site-type under uniform test conditions. In view of the large expenditures made for site preparation and planting and the wide range in costs and results, such comparisons of efficiency appear to be warranted.

In 1965, a series of operational trials of site preparation and planting techniques was initiated in the Goulais River area (Wang and Horton 1966). The project involved the co-operative effort of the Forestry Branch of the Department of Forestry and Rural Development, the Ontario Department of Lands and Forests and Weldwood of Canada, Limited, the major timber operator in the area. The work stemmed from the results of a study by Wang (1964), showing that underplanting of conifers in cut-over tolerant hardwood and understocked intolerant hardwood stands was silviculturally feasible when accompanied by mechanical site preparation. The first operational trials (in 1965) were designed to compare the efficiency of several techniques applied on each of these two site-types (Wang and Horton 1966). In 1967, the trials were extended to a cut-over mixedwood stand in the same general area, and additional treatments were carried out on one of the original hardwood site-types. In this report all treatments are described, treatment costs are shown, and survival data are recorded as of September 1968. On the basis of survival relative to cost, the "efficiency" of each treatment is determined.

THE AREA

The work was carried out in the Algoma Section L. 10 of the Great Lakes-St. Lawrence Forest Region (Rowe 1959), in the Goulais River valley about 45 miles northeast of Sault Ste. Marie, Ontario (Fig. 1).

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Lacate and Wang (1963) prepared a detailed description of the climate, geology and physiography of the area, as well as of its logging and fire history. The brief description given here is drawn largely from that source.

The Goulais River Valley is of preglacial origin, and the last glaciation filled the lower valley with glacial drift and smoothed the uplands and ridges to some extent. Lacate and Wang (1963) noted that "The glacial drift deposits consist of till derived mainly from local bedrock, and glacio-fluvial and outwash sands and gravels in the deep valleys cutting through the uplands. These deposits are overlain in part at lower elevations by waterlaid fine sands and silts which were deposited in ice dammed lake basins."

The regional climate is described as cool and moist, with an average total precipitation of about 36 inches, of which nearly half falls during the 164-day growing season (Rowe 1959).

The trials were carried out on two major land types described by Lacate and Wang (1963) as "uplands, predominantly tolerant hardwoods ...on shallow to moderately deep glacial till overlying rolling rock-cored hills", and "lowlands and valleys, predominantly softwood and intolerant hardwood cover types on a complex of deep glacio-fluvial and river terrace deposits". Within the latter land type, operations were conducted on two distinct forest-site-types distinguished by differences in cover type and stand history. The following are brief descriptions of each of the three forest-site-types on which the trials were carried out.

1. *Tolerant Hardwood*

Typical of much of the forest cover on upland sites in Algoma, this was an overmature stand of hard maple[1] and yellow birch on moderately deep and well drained glacial till overlying granitic bedrock. Slopes range from about 5 to 20 per cent throughout the treated area. The stand was lightly cut over in 1960-61 for birch and maple of veneer and sawlog quality, leaving a heavy residual stand, predominantly maple, with an average diameter of about 14 inches and a crown cover of about 75 per cent. Maple seedlings formed a dense carpet on the undisturbed portions of the forest floor.

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[1] A list of species showing common and botanical names is given in the Appendix.

2. *Intolerant Hardwood*

This was an understocked immature stand of trembling aspen and white birch resulting from a severe fire in 1920. The site is a flat river terrace adjacent to the Goulais River, and the soil is a complex of deep, excessively to well drained, stratified, water-laid sands and gravels. There was a scattered understory of white spruce and balsam fir and a fairly dense ground cover of blueberries, spiraea and sedges in the open, and hazel and bracken fern in shaded areas.

3. *Cut-over Mixedwood*

This area was in the valley bottom adjacent to the intolerant hardwood type, and physiographic conditions were as described for that type.

Until 1964 the area was occupied by a mature softwood-intolerant hardwood stand consisting of white spruce, balsam fir, trembling aspen and white birch. The softwoods were clear cut for pulpwood in 1964-65, and a prescribed burn was carried out in the spring of 1967, chiefly to reduce the fire hazard. The fire consumed the smaller slash and reduced the thickness of the duff layer, but it was not sufficiently intense to expose any appreciable amount of mineral soil.

SITE PREPARATION AND PLANTING

During the course of these trials, at least three treatments were applied to each of the three site-types, over a span of 3 years. Site preparation was carried out by four different tractors (and operators) and various phases of the work were supervised by different individuals. Consequently the operations must be described in rather general terms.

Each area of similar site conditions was divided into convenient operating blocks of 3 to 15 acres and one treatment was applied to each. The tractor started at the outside edge of a block and worked toward the middle in a concentric pattern, producing a series of alternate strips of treated and untreated ground. The aim had been to scarify about one-third of the gross area of each block, but the actual range was from 22 to 44 per cent, largely depending on the equipment used. A careful record was maintained of the time required to complete site preparation on each block, and the average rate of treatment was determined for all blocks of the same site-type treated in the same manner. On the blocks treated in 1967, a study was made to determine the percentage of the time required for non-productive phases of the operation such as "backing-up", "winching", "resting" and "equipment adjustment". This study gave some indication as to why one method of treatment was faster and more efficient than another.

machine was used. Wang and Horton (1966) reported that scarification in the tolerant hardwoods was effected by manipulating the blade in a gentle up and down scalping action. On the other sites treatment was more severe: the blade was set at a level where it would scalp off all minor vegetation, duff, sod (if present) and most of the humus layer (Fig. 4). The tractor moved ahead until the blade was completely filled with debris, then it turned slightly to permit the accumulation to slide off the trailing edge of the sharply-angled blade (Fig. 5). After backing a few feet, the tractor returned to its original course, dropped its blade and moved ahead. The difference in technique probably accounts for the fact that in the tolerant hardwoods only about 55 per cent of the area of the scarified strips was classed as adequate seedbed (Wang and Horton 1966), whereas on the other sites virtually the whole area of the strips was well prepared. A row of seedlings was planted along each side of the scalped strips at approximately 6 x 6-foot spacing.

Treatment 3. 50- or 75-horsepower tractor with front-mounted V-blade.

In spite of the big difference in the power of the tractors, treatment with both machines was essentially the same; and on the two sites where both were employed, the costs were similar. Both blades were about 5 feet wide but the one used with the smaller tractor had a scalping shoe 2 feet wide that projected 1 1/2 feet below the edge of the blade (Frontispiece). Most of the ploughing action was produced by this shoe, the remainder of the blade serving mainly to slide debris clear of the tracks. Both blades produced a thoroughly scarified strip from several inches to 1 foot deep, but the one made by the smaller tractor was 2 to 3 feet in average width (Fig. 6) and that made by the larger one was 4 to 6 feet wide. A row of seedlings was planted along each edge of the wider furrows, and a single row in the middle of the narrow ones.

Treatment 4. 50- or 75-horsepower tractor with front-mounted V-blade, and Lowther Wildland planting machine.

Site preparation was essentially the same as in Treatment 3, but in this case planting was part of the same operation. A single row of trees was planted in the centre of the furrow at about 5- to 6-foot spacing (Fig. 7). Rough terrain and heavy residual timber precluded the application of this treatment on the tolerant hardwood site, but no particular difficulties were encountered on the other two sites.

SAMPLING

Shortly after planting, sample plots were located randomly in all treated blocks. In general, the percentage sample for a particular

Fig. 4. General view of understocked intolerant hardwood site-type, showing planting strip scalped by angle-dozer blade.

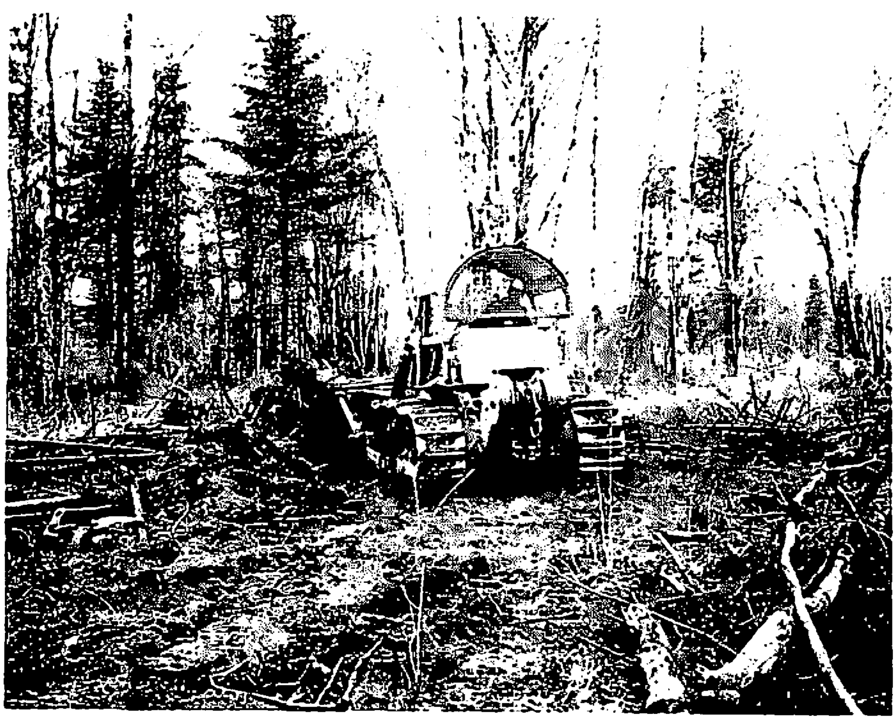

Fig. 5. Site preparation with 112-hp tractor and angle-dozer blade, cut-over and burned softwood-intolerant hardwood site-type.

block was inversely proportional to the number of trees planted. The intensity of sampling ranged from 3 to 10 per cent of the total number of trees planted in each block, the average sample being 4.4 per cent. The plots were either 1 or 2 chains in length, and they varied in width to correspond with the width of the treated strips. The ends of the plots were marked by aluminum stakes, and a wire pin was inserted beside each seedling.

The first measurement was made at the end of the first growing season after planting. For each seedling, the soil horizon in which it was planted was recorded in one of nine classes ranging from "undisturbed litter" to "parent material".

Remeasurements were made at the end of each growing season, and the data recorded included the condition (healthy, sickly or dead), total height and current height growth of each seedling. Competition from minor vegetation was assessed subjectively for each seedling, and was recorded as open, very light, light, moderate or heavy. Values from 0 (open) to 4 (heavy) were assigned to the competition classes, and by using these figures the average competition condition was calculated for each site-type and method of site preparation.

In the tolerant hardwood stand, it was expected that natural regeneration of yellow birch would be a by-product of site preparation. The extent of this regeneration was assessed on milacre quadrats located at half-chain intervals within the same plots on which survival of planted conifers was recorded.

RESULTS AND DISCUSSION

Table 1 is a summary showing for each treatment (and each tractor) the rate and cost of site preparation, percentage scarified, number of trees planted per acre, planting cost and total treatment cost per acre. It will be noted that different degrees of scarification were achieved, and that varying numbers of trees per acre were planted on each area. In order to facilitate comparisons between treatments, Table 1 shows an adjusted cost per acre based on an arbitrarily chosen standard degree of scarification (35 per cent) and a uniform number of trees planted per acre (600).[3] The actual costs of both site preparation and planting were increased or decreased proportionally in order to determine this adjusted cost. Table 1 also includes average survival data for each treatment and site-type. In the final column, the

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[3] Both these figures are close to the averages achieved in these trials, and they are similar to the levels normally obtained in operational plantings made by the Department of Lands and Forests.

Fig. 6. Site preparation with V-blade and 50-hp tractor, understocked intolerant hardwood site-type.

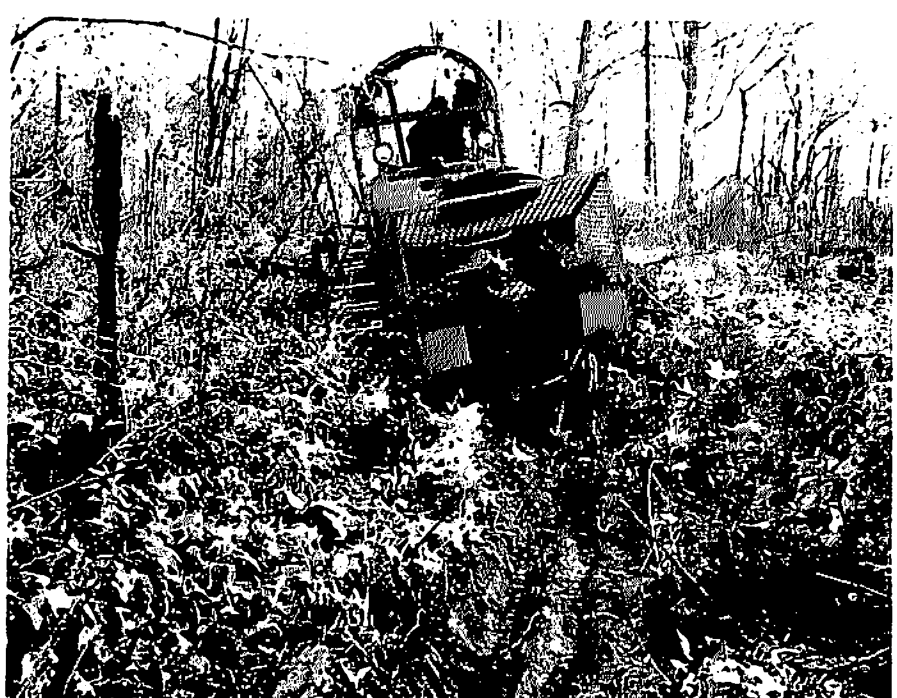

Fig. 7. Simultaneous site preparation and planting with 50-hp tractor and Lowther Wildland Planter, cut-over and burned softwood-intolerant hardwood site-type.

Table 1 Statistical summary, site preparation and planting trials, Goulais River, 1965-68.

	Forest-site-type												
	Tolerant hardwood			Intolerant hardwood						Cut-over mixedwood			
	S.-f.[a] drums	Angle-dozer	V-blade	S.-f. drums	Angle-dozer	V-blade	V-blade	V-blade	V-blade	S.-f. drums	Angle-dozer	V-blade	V-blade
Tractor	144	144	75	112	112	75	50	75	50	112	112	50	50
Planting method	Hand	Hand	Hand	Hand	Hand	Hand	Hand	Machine	Machine	Hand	Hand	Hand	Machine
Area treated (a)	33.0	150.0	10.0	30.9	29.4	17.0	15.1	13.0	10.6	30.5	23.4	10.7	10.2
Tractor rental[b] ($/hr)	23.30	23.30	14.80	19.25	19.25	14.80	10.50	14.80	10.50	19.25	19.25	10.50	10.50
Rate of site preparation[c] (a/hr)	0.53	1.54	1.25	3.21	1.61	1.67	2.26	1.67	1.47	3.26	2.63	1.85	1.22
Cost of site preparation ($/a)	43.96	15.13	11.84	6.00	11.96	8.86	4.65	8.86	7.14	5.90	7.32	5.68	8.61
% of area scarified	43	28	40	32	44	42	24	42	34	24	42	23	22
No. of trees planted/a	539	530	670	720	740	720	556	580	630	707	703	417	449
Cost of planting[d] ($/a)	16.17	15.90	20.10	21.60	22.20	21.60	16.68	7.75	8.51	21.21	21.09	12.51	7.15
Total cost ($/a)	60.13	31.03	31.94	27.60	34.16	30.46	21.33	16.61	15.65	27.11	28.41	18.19	15.76
Adjusted cost[e] ($/a)	53.78	36.91	28.36	24.56	27.51	25.38	24.78	15.00	15.62	26.60	24.10	26.64	23.93
% Survival													
First year	86	83	91	85	95	83	94	91	97	79	83	91	92
Second year	64	74	79	78	90	76		82		69	75		
Third year	59	72	77			75		77					
Efficiency[f]	62.5	44.5	31.2	28.9	29.0	30.6	26.4	16.5	16.1	33.7	29.0	29.3	26.0

[a] Shark-fin.

[b] Based on Ontario Department of Highways schedule of rental rates for construction equipment. Rev. July 1967 (includes wages of operator @ $2.50/hr).

[c] Treatment time includes minor delays, routine servicing and adjustment of equipment.

[d] Calculated on basis of 1¢/tree for planting stock, 2¢/tree for hand planting, $1.25/hr rental rate for planting machine, $2.00/hr wages for planter.

[e] Actual cost adjusted to show cost required to obtain a uniform degree of treatment (35% scarified, 600 trees/a planted).

[f] $\frac{\text{Adjusted cost/a}}{\text{First-year survival}}$.

adjusted cost is divided by the first-year survival percentage,[4] and the resulting figures make it possible to compare the relative efficiency of the treatments, with the smaller figures indicating the more efficient ones.

Although actual costs of treatment varied widely within each site-type, the range was reduced when actual costs were adjusted on the basis of a uniform standard of treatment. The range in first-year survivals was not great, and survival was adequate in the second and third years in all blocks for which data are available. Thus, from a silvicultural standpoint all treatments were effective, and their relative efficiency was determined more by differences in treatment cost than survival.

Efficiency

With an "efficiency rating" of about 31, the V-blade combined with hand planting was clearly the most efficient of the three treatments employed on the tolerant hardwood site. The angle-dozer blade treatment ranked second (44) and the shark-fin drums, a poor third (62).

On the intolerant hardwood site, the V-blade combined with machine planting was the most efficient treatment, and among the others, the differences did not appear to be significant.

The V-blade with machine planting (rating 26) was the most efficient treatment employed on the cut-over mixedwood site. The angle-dozer blade and the V-blade (with hand planting) showed almost the same level of efficiency (29), and both were somewhat superior to the shark-fin drum treatment (34). On this site the overall range in the efficiency of the different techniques was not great.

Treatment Cost

As mentioned above, the relative efficiency of the various treatments was determined largely by cost, and this hinged on the rate of site preparation in relation to the cost of tractor rental. This explains the outstanding efficiency of the V-blade on the tolerant hardwood site-type. Because of the lower power requirements of the narrow V-blade in comparison with either the broad angle-dozer blade

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[4] Because the trials were carried out over a 3-year period, complete second- and third-year survival data are not available for all combinations of site-type and treatment. However, the available figures do not suggest that long-term survival trends will make any major change in the relative efficiency of the various treatments.

or the heavy drums, site preparation was possible with a 75-horsepower tractor in the former instance, whereas a 144-horsepower tractor was required for the latter two treatments. The rate of site preparation was almost as fast with the V-blade as with the angle-dozer, and it was more than twice as fast as with the shark-fin drums.[5] As the rental rate for the smaller tractor was $8.50 per hour less than for the large one, it is obvious why the cost of treatment was much less for the V-blade than for the other treatments.

On the other two site-types, the rate of treatment with the shark-fin drums was much faster than with the V-blade, and the difference was sufficient to offset the higher hourly cost of the larger tractor. However, where machine planting was carried out simultaneously with site preparation (by a V-blade), the overall cost of treatment was low and efficiency was correspondingly high. In comparison with the angle-dozer blade, a faster rate of site preparation with the shark-fin drums can be explained by the fact that with the former, from 19 to 26 per cent[6] of tractor time was spent in non-productive "backing", whereas with the latter, the tractor was moving ahead virtually all the time. The shark-fin drums were developed primarily for treatment of pulpwood cut-overs and brushy areas, and it is reasonable to expect that their performance would be better on these sites than in the tolerant hardwood.

Survival

As noted earlier, the range in species, age classes and planting seasons tended to confound the survival data obtained in these trials. In an earlier study, Wang and Horton (1968) recorded substantial differences in the survival of 2 + 0, 3 + 0 and 2 + 2 white spruce and white pine, with older stock consistently better than younger. Working with red and jack pine, Mullin (1968) reported significantly better survival and growth for spring than for fall planting. However, in these trials no such consistent trends were noted, and within-treatment differences (owing to planting stock or season) were small. In some instances, survival of 2 + 0 stock was higher than that of the older classes, and survival of fall plantings higher than that of spring plantings. Thus, although differences in survival were small, it would seem reasonable to attribute them largely to the method of treatment.

Survival of planted stock was generally satisfactory for all treatments on all sites. On the tolerant hardwood and the cut-over

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[5] Principally due to the necessity of making two runs over each strip prepared by the drums.

[6] Calculated only for treatments carried out in 1967.

Table 2 Seedling survival by site-type, method of treatment and seedbed class. Site preparation and planting trials, Goulais River, 1965-68.

Forest site-type		Method of treatment											
		S.-f. drums			Angle-dozer			V-blade H.P.[a]			V-blade M.P.[b]		
		1[c]	2	3	1	2	3	1	2	3	1	2	3
Tolerant hardwood	No. in sample	121	475	201	512	1542	11	61	302	97			
	% Survival	77	88	88	76	85	91	88	91	95			
Intolerant hardwood	No. in sample	33	168	865	72	242	961	227	479	486	140	244	326
	% Survival	55	71	89	79	87	98	74	88	93	95	90	95
Cut-over mixedwood	No. in sample	63	205	372	35	141	757	87	27	267	45	32	272
	% Survival	48	69	89	60	72	86	77	89	95	82	84	94

[a] Hand planting.

[b] Machine planting.

[c] Nine seedbed classes initially recognized were grouped as follows:

Group 1 - undisturbed, disturbed litter, humus
" 2 - mixtures of humus + A and B horizons
" 3 - B, BC and C horizons (mineral soil).

mixedwood sites, survival was highest on blocks treated with the V-blade. Survival was uniformly high on the intolerant hardwood site, and none of the treatments showed a clear advantage in this respect.

The data in Table 2 suggest that survival was affected by the particular seedbed in which the seedlings were planted.

Table 2 shows that survival was higher for seedlings planted on the lower soil horizons, and this held true for all site-types and all treatments. These data also help to explain differences in survival between treatments, as those with a high percentage of seedlings planted on the lower soil horizons had a correspondingly high average survival.

Growth

Because the planting stock included several age classes and species that could be expected to show varying growth rates, no attempt was made to correlate growth with method of site preparation (Fig. 8).

Fig. 8. Healthy 16" white spruce seedling, at end of third growing season, tolerant hardwood site-type.

However, in Table 3 the average height at the end of the third growing season is shown for the three main classes of stock planted on the tolerant and intolerant hardwood site-types.[7]

Table 3 Average height of seedlings at end of third growing season. Site preparation and planting trials, Goulais River, 1965-68.

Site-type	2 + 0 White spruce in	3 + 0 White spruce in	3 + 0 White pine in
Tolerant hardwood	10.1	11.6	12.5
Intolerant hardwood	10.7	11.9	14.1

From a study that preceded these trials, Wang and Horton (1968) reported consistently greater height growth on the tolerant than on the intolerant hardwood site-type; this is not surprising in view of the superior soil moisture and nutrient status of the former. However, the present data show the opposite trend, possibly because of the heavy crown canopy of the tolerant hardwood stand. Although this canopy evidently was too dense to permit optimum growth of underplanted conifers, it apparently did reduce competition from minor vegetation.

Competition

Among the three site-types, re-invasion of minor vegetation was most rapid in the cut-over mixedwood and slowest in the tolerant hardwood. On the former site, the principal competitors were raspberry, pin cherry, bracken fern, trembling aspen suckers, honeysuckle and hazel; and the growth of these species evidently was stimulated not only by removal of the overstory, but also by the fire. On the intolerant hardwood site, the same species formed the competition, but bracken fern and hazel were most prominent and raspberry and pin cherry were insignificant. The heavy crown cover of the tolerant hardwoods probably accounted for the slower rate of re-invasion on this site. Maple saplings appeared to be the main competitors, but raspberry and pin cherry were prominent under openings in the crown, and sedges were abundant in poorly drained depressions.

On all site-types, re-invasion of minor vegetation appeared to be most rapid on areas treated with the V-blade, and slowest on areas

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7 Three-year growth data are not available for the cut-over mixedwood site.

treated with the angle-dozer blade. Table 4 shows the average degree of competition relative to different treatments and site-types.

Table 4 Competition from minor vegetation re-establishing on prepared sites. Site preparation and planting trials, Goulais River, 1965-68.

Site-type	Site preparation	Average competition condition[a] after		
		1 yr	2 yr	3 yr
Tolerant hardwood	Shark-fin drums	1.5	2.1	2.8
	Angle-dozer blade	1.2	1.5	2.4
	V-blade	1.8	2.1	3.3
Intolerant hardwood	Shark-fin drums	1.8	3.3	-
	Angle-dozer blade	1.7	2.8	-
	V-blade	2.3	2.2	3.3
	V-blade[b]	2.2	-	-
Cut-over mixedwood	Shark-fin drums	2.1	3.9	-
	Angle-dozer blade	1.0	2.8	-
	V-blade	2.2	-	-

[a] Calculated on basis of open = 0, very light = 1, light = 2, moderate = 3, heavy = 4

[b] Treatment carried out in fall of 1967.

The narrowness of the treated strips probably accounts for the early development of competition on areas prepared by the V-blade. The mixing action of the shark-fin drums, while providing a good seedbed, did not eliminate minor vegetation as effectively as the scalping action of the angle-dozer blade. Thus, in terms of reducing the need for subsequent release, the angle-dozer blade must be ranked as most effective, the shark-fin drums second and the V-blade least effective. However, none of the treatments eliminated the need completely on any of the sites, and the trend of increasing competition from year to year suggested that release might eventually be required.

Yellow Birch Regeneration

As expected, on the tolerant hardwood site all methods of site preparation produced a supplementary benefit in the form of yellow birch regeneration. In this respect, the shark-fin drum treatment was clearly the best, as sampled milacres along the scarified strips indicated a yellow birch stocking[8] of 61 per cent, compared to 53 per cent for the angle-dozer blade treatment, and 42 per cent for the V-blade. Wang and Horton (1966) noted that the well mixed topsoil and humus seedbed created by drum treatment appeared most favourable for birch regeneration, and the present figures support their observation.

SUMMARY AND CONCLUSIONS

To compare the relative efficiency of several site-preparation and planting methods, a series of operational trials was carried out between 1965 and 1967 in the Goulais River area of Ontario. Three treatments were applied to each of three major forest-site-types: a lightly cut-over tolerant hardwood stand, an understocked intolerant hardwood stand and a recently clear-cut and burned mixedwood stand. The different site preparations are described below, and in each case preparation was followed by hand planting of conifers except where machine planting is indicated:

Treatments

1. Shallow furrows about 3 feet wide prepared by shark-fin drums pulled by a tractor in the 112- or 144-horsepower class.

2. Strips about 10 feet wide scalped by the angle-dozer blade of a tractor in the 112- or 144-horsepower class.

3. Deep furrows 2 to 6 feet wide made by a V-blade mounted on a 50- or 75-horsepower tractor.

4. Site preparation same as 3., but machine planting carried out simultaneously, with a Lowther Wildland Planter.[9]

Cost of treatment was recorded, and survival to the end of the 1968 growing season was assessed. Actual costs of treatment were adjusted on the basis of a standard level of site preparation (35 per cent of the area scarified) and a uniform planting rate (600 trees/acre). The "efficiency" of each treatment was calculated by dividing the total "adjusted" treatment cost per acre by the percentage survival after one growing season.

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[8] Two- and 3-year-old seedlings with an average height of about 2 feet in 1968.

[9] This treatment was not carried out on the tolerant hardwood site-type.

On the tolerant hardwood site, V-blade treatment ranked first in order of efficiency; the angle-dozer blade was second, and the shark-fin drum treatment was a poor third. However, in terms of incidental yellow birch regeneration, the last treatment was most effective.

On the intolerant hardwood site, the V-blade in conjunction with machine planting was most efficient; and all other treatments ranked about the same, but at a considerably lower level.

For the cut-over mixedwood, the V-blade with machine planting proved most efficient, the angle-dozer ranked second, the V-blade (with hand planting) was third and shark-fin drum treatment was least efficient. However, the range in efficiency was not as great on this site as on the other two.

Although survival was adequate for all treatments on all three site-types, the costs varied widely, with the result that some methods were much more efficient than others. This suggests that there is a need to determine the most efficient methods of treatment for other important forest-site-types, and that the application of these methods will increase the effectiveness of reforestation efforts.

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APPENDIX A

Common and Botanical Names Mentioned in Text

Aspen, trembling	*Populus tremuloides* Michx.
Birch, white	*Betula papyrifera* Marsh.
Birch, yellow	*Betula alleghaniensis* Britt.
Blueberry	*Vaccinium* (spp.)
Cherry, pin	*Prunus pensylvanica* L. f.
Fern, bracken	*Pteridium aquilinum* (L.) Kuhn
Fir, balsam	*Abies balsamea* (L.) Mill.
Grasses	*Graminae* (spp.)
Hazel, beaked	*Corylus cornuta* Marsh.
Honeysuckle	*Diervilla lonicera* Mill.
Maple, hard	*Acer saccharum* Marsh.
Pine, jack	*Pinus banksiana* Lamb.
Pine, red	*Pinus resinosa* Ait.
Pine, white	*Pinus strobus* L.
Raspberry	*Rubus strigosus* Michx.
Sedge	*Carex* (spp.)
Spiraea	*Spirea* (spp.)
Spruce, red	*Picea rubens* Sarg.
Spruce, white	*Picea glauca* (Moench) Voss

FIGURE I

Goulais River Area, showing landtypes, site-types, and areas treated in site preparation and planting trials 1965-67

Scale in Chains

0 20 40 60

LEGEND

LANDTYPE A — Uplands, predominantly tolerant hardwoods on shallow to moderately deep glacial till overlying rolling rock-cored hills.

FOREST SITE TYPE TH — Tolerant hardwoods cover type of Landtype A

FOREST SITE TYPE M — Mixedwood/softwood intolerant