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Mechanical Site Preparation and Early Chemical Tending in White Spruce: 19-year Results

by

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Abstract

A white spruce outplanting trial, with about 480 trees, was established on a fertile mixedwood site in Ontario (47°N, 84°W) in 1967 to study the effects of two site preparation methods and early chemical tending on the development of the crop species and non-crop woody vegetation. Nineteen-year results are presented. Early chemical tending of white spruce resulted in a significant increase in growth on the drum-prepared block, but not on the blade-prepared block. On the drum-prepared block, mortality of white spruce outplants did not differ significantly between herbicide-treated and untreated plots. On the blade-prepared block, mortality was significantly greater with herbicide application than without it. Similar non-crop tree and shrub species were found on sites prepared with both sharkfin drums and angle-dozer blades. However, woody weeds were less abundant on the herbicide-treated plots than on the untreated plots.

Key words: white spruce outplant performance; chemical weed control; 2,4-D and 2,4,5-T; mechanical site preparation; herbicide efficacy; silvicultural efficacy; early tending; sharkfin drum; angle-dozer blade.

Résumé

En 1967, on a effectué des plantations expérimentales d'épinettes blanches, avec 480 essences environ, sur un terrain fertile de forêt mixte situé en Ontario (47°N, 84°O), afin d'étudier les effets de deux méthodes de préparation du terrain et les effets d'un traitement chimique précoce d'entretien sur le développement des espèces commercialisables et de la végétation ligneuse non commercialisable. On présente les résultats portant sur 19 années. Grâce au traitement chimique précoce d'entretien de l'épinette blanche, il y a eu une augmentation importante de la croissance dans le bloc préparé au tambour mais non dans le bloc préparé à la lame de terrassement. Dans le premier bloc, la mortalité des plants repiqués d'épinettes blanches ne différait pas de façon significative entre les parcelles traitées à l'herbicide et les parcelles non traitées. Dans le bloc préparé à la lame, la mortalité était nettement plus importante après l'application d'herbicide qu'en l'absence de traitement. On a trouvé des essences non commercialisables et des espèces ligneuses semblables sur les terrains préparés à la fois avec des tambours en aileron de requin et à la lame en biais. Cependant, les mauvaises herbes ligneuses étaient moins abondantes dans les parcelles traitées à l'herbicide que dans les parcelles non traitées.

Mots clés : rendement des plants repiqués d'épinettes blanches; desherbage chimique; 2,4-D et 2,4,5-T; préparation mécanique du terrain; efficacité de l'herbicide; efficacité du traitement d'entretien; traitement d'entretien précoce; tambour en aileron de requin; lame en biais.

Introduction

The need to justify forestry practices, particularly the use of pesticides, has created an interest in long-term crop response data from older, initially short-term experiments. For northeastern North American conifers, these data are virtually

non-existent at present. However, one experiment of continuing interest was initiated in 1967 by the Canadian Forestry Service near Sault Ste. Marie, Ontario. The original study, reported by Haig and Curtis (1974), was designed to examine the effectiveness of two different site preparation methods with and without chemical weed control on the development of white spruce³ outplants. In autumn 1985, the outplants were reassessed and the development of competing woody vegetation was examined. The results of the assessment are described in this paper.

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³Botanical names are listed in the appendix.

Objectives

The 1985 re-evaluation of this experiment was designed to: 1) assess the development of 19-year-old white spruce on sites prepared by either sharkfin drums or angle-dozer blades; and 2) determine silvicultural efficacy and herbicidal efficacy (cf. Sutton 1985) of a 2,4-D + 2,4,5-T post-planting treatment.

Description of Study Area

The experimental area is located in LaVerendrye Township (47°N, 84°W), about 60 km northeast of Sault Ste. Marie, Ontario in the Algoma Section (L.10) of the Great Lakes-St. Lawrence Forest Region (Rowe 1972). The area falls within the Batchawana Site District (2) of the Lake Temagami Site Region (4200) (Hills 1959, Skeates 1979). Lacate and Wang (1963) described this site as a complex of deep glacial outwash terraces of fine sand to gravel. Some of the terraces are stone free, whereas others are very stony or cobbly. The experimental site lies within the Superior Climatic Region, where the growing season averages 163 days, the mean annual temperature is 1.7°C, and the average annual precipitation is 864 mm, 406 mm of which falls from May through September (Chapman and Thomas 1968). Prior to the softwood harvest in 1964 and 1965, the research blocks supported a mature stand of white spruce, balsam fir, trembling aspen, and white birch (Haig 1969). Both the sharkfin drum and angle-dozer blade blocks were established on similar sites (Haig and Curtis 1974).

Silvicultural Treatments

The following information was derived from Haig (1969) and Haig and Curtis (1974). In the spring of 1967 a prescribed burn was conducted as a fire hazard reduction measure. Site preparation followed immediately. One block (3.9 ha) was site-prepared by sharkfin drums (cf. Brown 1966). In this method, two rows of water-filled drums were towed in tandem to produce cleared strips 3.0 m to 3.6 m wide containing two rough furrows about 1.0 m wide. Typically, the depth of these furrows ranged from 10 to 30 cm; occasional furrows were deeper. In this block, 3 + 0 white spruce were hand planted at 2-m spacing along the sides of the furrows, close to the undisturbed, nutrient-rich humus layer. About 70% of the seedlings were planted in mineral soil. A second, similar block (4.1 ha) was site prepared by angle-dozer blade. Haig (1969) described this operation as follows: "... 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. 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 ... After backing a few feet, the tractor returned to its original course, dropped its blade and moved ahead." White spruce 2 + 0 stock was hand planted at 2-m spacing along the sides of the approximately 3.5-m-wide scalped strips. Both blocks were planted in mid-May, immediately after site preparation.

Within each block, 40-m-long plots, each 6 to 10 m in width and containing about 40 planted white spruce arranged in two parallel rows, were established. On 13 August 1968, 15 months after planting, four of the seven plots in the drum-prepared area and three of the five plots in the blade-prepared area were sprayed with herbicides to control competing vegetation. The primary competing species were: red raspberry, pin cherry, bracken fern, trembling aspen, bush honeysuckle, and beaked hazel. Equal quantities of 2,4-D and 2,4,5-T esters were mixed in water and applied to planted

strips using a motorized mist-blower. Approximately 5.27 kg a.e. (acid equivalent) per ha were applied, a rate considerably higher than that which was formerly applied in operational forest spraying in Ontario.

Assessment Methods — 1985

Crop Species Assessment

The characteristics of outplants measured included total height and stem diameter at 0.3 m and 1.4 m above ground level. Total stem volume was calculated for each tree by means of Smalian (Wenger 1984) and right circular cone volume formulae. Mortality data were analyzed by means of Pearson Chi-square test to compare the frequencies of living and dead trees. Growth data were examined through one-way analysis of variance. The degree to which trees were overtopped by competing vegetation was assessed by means of a system proposed by Herring and Pollack (1985). The trees were rated as "not overtopped" (leader of crop tree well above the surrounding vegetation and not likely to become threatened immediately), "threatened" (leader at or near the same height as the surrounding vegetation, but likely to be overtopped within two growing seasons), or "overtopped" (leader currently overtopped by surrounding vegetation and available sunlight greatly reduced).

Because the same stock types were not planted in each area and site preparation treatments were unreplicated, the influence of site preparation on performance of outplants was confounded. In this report, statistically valid comparisons are, therefore, limited to blocks that were site prepared in a similar fashion.

Woody Plant Competition Assessment

Within each plot, six subplots were established to permit an assessment of tree and shrub vegetation. [From a randomly placed post at the start of each plot, subplot centres were located at 6-m intervals beginning 5 m from the post, along the long axis of the plot and running between the two rows of planted white spruce.] Circular subplots of 20m² for tree assessment and 10m² for shrub assessment were established. The numbers of tree and shrub stems in each subplot were counted, and total height was measured for each tree in the subplot. Percent cover was ocularly estimated to the nearest 5% for each shrub species. Vertical projection of a visualized cylinder encompassing the area from the branch tips to the ground was used to obtain this estimate, since the deciduous species were leafless at the time of the assessment in early November.

Results and Discussion

Crop Tree Response

In 1973, total height and % mortality of 3 + 0 white spruce on the drum-prepared block did not differ significantly ($P = 0.05$) between treated and untreated sites (Haig and Curtis 1974). In 1985, relative mortality remained the same (Fig. 1), but trees in the treated plots were significantly ($P = 0.05$) taller than trees in untreated plots (3.6 m versus 2.7 m [Fig. 2]). Average individual stem volume was also significantly greater in the treated plots than in the untreated plots (about 6400 cm³ versus 3500 cm³). In a study in western Canada, Cayford (1957) found that when white spruce was suppressed beneath a trembling aspen overstory, total volume per tree was reduced by almost 50%. In both Cayford's and the current study, reducing vegetative competition

Figure 1. Total white spruce mortality (%) in LaVerendrye Township, Ontario, after 2, 7, and 19 growing seasons. On the basis of cumulative mortality, treatments (i.e. sharkfin + herbicide vs. sharkfin, and angle-dozer + herbicide vs. angle-dozer) with the same letters do not differ significantly at $P = 0.05$.

resulted in increased height growth of crop trees and higher volume growth to an even greater extent (Stewart and Row 1981, Zedaker and Lewis 1983). The importance of long-term measurements to the proper interpretation of weed control treatments is emphasized by the observation that differences in total height did not become significant until some time after 1973 (Fig. 2).

In several other Ontario studies (Sutton 1965, 1968, 1975, 1978), white spruce has also responded well to chemical weed control. However, good weed control, particularly in the boreal region, can expose young white spruce outplants to damaging late spring frosts (Sutton 1984). For outplants in northern Ontario, there may be an optimum amount of vegetative cover that provides protection from frost while interfering little with growth.

In the 1973 measurements of the angle-dozed untreated plots, 7 years after establishment, the 2 + 0 white spruce had significantly ($P = 0.05$) lower mortality (Fig. 1) and were significantly ($P = 0.05$) taller (Fig. 2) than trees in the treated plots. Haig and Curtis (1974) attributed the lower survival in the treated plots to injury caused by herbicides, frost damage and insolation resulting from the lack of a protective forest cover. In the 1985 remeasurement, total mortality remained significantly ($P = 0.05$) lower in the untreated than in the treated plots (Fig. 1), although differences in average height (2.8 m in untreated plots and 2.5 m in treated plots) were no longer significant. After 19 growing seasons, individual stem volume of trees planted in the treated (angle-dozed) and untreated plots did not differ significantly ($P = 0.05$) (approximately 3400 cm³ and 3000 cm³, respectively).

The most striking difference between the two types of site preparation was in the response of crop trees to chemical weed control. In the drum-prepared block, crop trees benefitted greatly from chemical weed control; in the angle-dozed block, growth did not differ significantly between herbicide and non-herbicide treatments after 1973. Initial differences in stock type may explain these growth responses to some extent, but it is likely that the method of site preparation was a more important influence on crop tree response to tending. Although site preparation by angle-dozing can benefit crop trees by increasing soil temperatures and reducing vegetative competition, these beneficial effects can be outweighed by decreased soil fertility when nutrient-rich organic layers are moved beyond the reach of the

Figure 2. Progression of crop tree mean total height (m) in LaVerendrye Township, Ontario, after 2, 7, and 19 growing seasons. Within site preparation method and year, treatments with the same letters do not differ significantly at $P = 0.05$.

seedling's roots (Tappeiner 1971; McMinn 1982, 1985). In comparison, the mixing action of drums can increase the depth of soil that can be easily penetrated by roots, can result in faster organic matter decomposition, and consequently, can improve soil fertility (Tappeiner 1971, McMinn 1985). However, competition was a major constraint limiting growth on the drum-prepared plots. This constraint was successfully ameliorated by good weed control. These results reinforce Sutton's (1988) observations that the forest manager's task is to identify and evaluate those constraints most likely to frustrate management objectives, and then to develop prescriptions to overcome the constraints.

Weed Control

Measurements made in 1985 in the sharkfin drum block indicated that the treated and untreated plots contained similar competing tree species (Fig. 3, Graph 1). Trembling aspen in the untreated plots were taller (6.3 m versus 4.5 m) and had notably higher density, than those in the treated plots, which accounted for much of the observed overtopping of white spruce. In all, 82% of the crop trees were either threatened or overtopped in the untreated plots compared with 56% in the treated plots (Table 1). Sugar maple and white birch were more abundant and taller in the treated plots than in the untreated plots (Fig. 3, Graph 1).

Measurements made in 1985 in the drum-prepared block revealed that shrub abundance and the proportion of ground covered by shrubs was lowest in plots treated with herbicides (Fig. 3, Graphs 2 and 6). Density and percentage cover of mountain maple, beaked hazel, choke cherry, willow, elderberry, and American mountain-ash were all higher in the untreated plots than in those which received herbicide. In contrast, serviceberry and pin cherry were more abundant in the treated plots than in the untreated plots, although the percentage cover for the latter species was considerably lower in the treated plots. The reason for this apparent inconsistency is that in the plots receiving herbicide, there were many small pin cherry stems with little crown area while in the untreated plots there were fewer but older stems with large crowns.

In the angle-dozed block in 1985, there were fewer tree species and fewer stems/ha in the herbicide-treated plots than in the untreated plots (Fig. 3, Graphs 3 and 5). Both red and sugar maples were present in the untreated plots but not

Figure 3. Average stem density ('000/ha) of non-crop trees (Graphs 1 and 3), shrubs (Graphs 2 and 4), combined trees (Graph 5) and combined shrubs (Graph 6) in LaVerendrye Township, Ontario, 17 growing seasons after herbicide treatment. Letters above the bars represent average total height (m)^a of tree species, average percentage cover^b of shrub species, average total height (m)^c of tree species combined, and total percentage cover^d of shrub species combined. See appendix for list of abbreviations.

in the plots treated with herbicide. Aspen density was higher and trees were taller in the untreated plots than in the treated plots. The plethora of tall aspen in the untreated plots largely explains why over 90% of white spruce outplants were threatened or overtopped by competing vegetation in 1985 (Table 1). In comparison, only 14% of the white spruce outplants in the treated plots were threatened, and none were overtopped.

In the angle-dozer block, shrubs were less abundant and covered less of the area of the plots treated with herbicide than of the untreated plots in 1985 (Fig. 3, Graphs 4 and 6). Specifically, the stem density and percentage cover of beaked

Table 1. Degree of overtopping of white spruce outplants 17 years after weed control.

Treatment	Not overtopped		
	%	Threatened	Overtopped
Sharkfin drums + herbicide	44	49	7
Sharkfin drums	18	68	14
Angle-dozer blade + herbicide	86	14	0
Angle-dozer blade	8	75	17

hazel, pin cherry, willow, elderberry, and American mountain-ash were lower. However, the number of stems/ha and percentage cover of serviceberry and choke cherry were higher on the plots treated with herbicide than on the untreated plots.

Even though the site preparation treatments were not replicated and comparisons must be valued accordingly, the following differences between blocks were observed in 1985. Although similar tree and shrub species were present in both the drum-prepared and the angle-dozer blocks (Fig. 3, Graphs 1 versus 3, and 2 versus 4, respectively), on the treated plots, there were fewer trees in the angle-dozer block than in the sharkfin block. In the untreated plots, there were substantially more sugar maple and fewer aspen in the drum-prepared than in the bladed block. The density and total percentage cover of shrub species were similar (Fig. 3, Graph 6), both within treatments and between blocks, although the density and percentage cover of shrubs in the untreated plots were somewhat higher in the drum-prepared block than in the angle-dozer block.

Long-term control of several species (most notably trembling aspen, beaked hazel and willow) on both areas was achieved through the application of a mixture of 2,4-D and 2,4,5-T. However, differences in species abundance within similarly prepared blocks cannot be attributed to residual herbicide phytotoxicity (Beste 1983, Norris *et al.* 1984, Thompson *et al.* 1984). A possible explanation of these differences might be that the site was less receptive (because of litter, low ground cover, and other related factors) to the establishment of weeds after the herbicide treatment than after mechanical site preparation, and as a result less abundant non-crop vegetation developed.

Conclusions

The results of this study demonstrate to the forest manager that on fertile northern mixedwood sites similar to those described in this study, chemical weed control at an early age can effectively release conifers from competing tree and shrub vegetation. In this particular experiment, on the drum-prepared block in which duff and mineral soil were mixed by site preparation, early tending resulted in significantly larger crop trees 17 years after the herbicide application. However, good weed control is not the only prerequisite to the successful establishment of spruce. For example, inappropriate site preparation, such as severe blading which removes all minor vegetation and most of the organic layers, can lessen crop tree growth (Tappeiner 1971; McMinn 1982, 1985).

In evaluating weed control treatments, long-term measurements are essential for the proper interpretation of results. When assessing the growth response of crop trees to weed control, one should measure stem diameter (from which stem volume can be calculated) as well as height; the former appears to be more sensitive than stem height to changes in levels of competing vegetation.

Non-crop woody trees and shrubs were generally less abundant on the herbicide-treated plots than on the untreated plots 17 years after the herbicide application. Similar non-crop tree and shrub species were found on sites prepared with both sharkfin drums and angle-dozer blades.

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APPENDIX

Botanical names and abbreviations of plants mentioned in text.

Common Name	Botanical Name	Abbreviation ^a
aspen, trembling	<i>Populus tremuloides</i> Michx.	Pot
birch, white	<i>Betula papyrifera</i> Marsh.	BPa
birch, yellow	<i>Betula alleghaniensis</i> Britton.	Ba
cedar, eastern white	<i>Thuja occidentalis</i> L.	THo
cherry, choke	<i>Prunus virginiana</i> L.	PRv
cherry, pin	<i>Prunus pensylvanica</i> L.f.	PRp
elderberry	<i>Sambucus canadensis</i> L.	SMc
fern, bracken	<i>Pteridium aquilinum</i> (L.) Kuhn	
fir, balsam	<i>Abies balsamea</i> (L.) Mill.	ABb
hazel, beaked	<i>Corylus cornuta</i> Marsh.	CLc
honeysuckle, bush	<i>Diervilla lonicera</i> Mill.	
maple, mountain	<i>Acer spicatum</i> Lam.	ACSp
maple, red	<i>Acer rubrum</i> L.	ACr
maple, sugar	<i>Acer saccharum</i> Marsh.	ACSc
mountain-ash, American	<i>Sorbus americana</i> Marsh.	SOa
raspberry, wild red	<i>Rubus idaeus</i> L. var. <i>strigosus</i> (Michx.) Maxim.	
serviceberry	<i>Amelanchier</i> spp.	AM
spruce, white	<i>Picea glauca</i> (Moench) Voss	Plg
willow	<i>Salix</i> L. spp.	SA

^aSpecies abbreviations after Day 1967.