REHABILITATION OF OVERMATURE MIXEDWOOD WITH WHITE SPRUCE AFTER DYBAR (FENURON) TREATMENT

by

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Résumé en français

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Abstract

A factorial experiment, replicated five times, was established in 1959 on fresh fertile sites in a shrubby, boreal Ontario mixedwood. Pelleted fenuron herbicide ("Dybar") was broadcast at 0, 8, 16, 32, and 48 lbs. per acre in plots of 3, 6, 9, 12, and 15 yards diameter in all combinations. Dybar at 32+lbs. per acre was highly effective in killing mountain maple and speckled alder where complete shrub root system complexes lay within the area treated. Balsam fir and white spruce advance growth was more susceptible than mountain maple. Beaked hazel was highly resistant even to 48 lbs. per acre treatments. Fourth-year height growth of white spruce planted one year after the herbicide treatment (in groups of 9 per plot) was highly significantly ($p < .001$) increased in the 48 lbs. per acre Dybar treatments in plots 9 or more yards in diameter.

Résumé

Une expérience, que l'on a répétée cinq fois, a été entreprise d'après un plan factoriel, en 1959, dans des stations à sol frais et fertile situées dans un peuplement mixte broussailleux des forêts boréales de l'Ontario. On a semé à la volée de l'herbicide de fenuron en granules (marque "Dybar") à raison de 0 (placeau témoin), 8, 16, 32 et 48 livres à l'acre, dans des placeaux de 3, 6, 9, 12 et 15 verges de diamètre, dans toutes les combinaisons possibles. Le Dybar répandu à raison de 32 livres et plus à l'acre s'est révélé très efficace, en ce sens qu'il a fait mourir l'érable à épis aussi bien que l'aune commun là où le traitement atteignait le système radiculaire tout entier. Les semis préexistants de sapin baumier et d'épinette blanche sont encore plus vulnérables au Dybar que l'érable à épis, mais le noisetier à long bec s'est révélé très résistant à cet herbicide, même à des traitements de 48 livres à l'acre. La croissance en hauteur, au cours de leur quatrième année, de plants d'épinette blanche plantés l'année qui a suivi le traitement herbicide (9 semis par placeau), a été grandement favorisée ($p < .001$), particulièrement dans les placeaux de 9 pieds et plus de diamètre traités à raison de 48 livres de Dybar à l'acre.

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Rehabilitation of overmature mixedwood with white spruce after Dybar (fenuron) treatment

by

R. F. SUTTON[1]

INTRODUCTION

Intolerant mixedwoods ("Aspen-Birch-Spruce-Fir") occupy the most fertile sites in boreal Ontario. Many mixedwoods are producing a trifling fraction of their potential production of merchantable wood. This is particularly true of those many stands, now overmature, which originated after fire during the first half of the last century. Commonly, growth potential is largely taken up by shrubs, and any rehabilitation of these fertile mixedwood uplands will be dependent on artificial regeneration.

New chemical herbicide peparations coming onto the market offer silviculturists an increasing range of treatments with which to aid regeneration. "Dybar" was developed as a non-selective pelleted herbicide to be applied dry, as a surface dressing, with no need for special equipment or weather conditions. This prompted an evaluation of Dybar in mixedwood rehabilitation. Dybar contains 25 per cent fenuron (3-phenyl-1, 1-dimethylurea), as the active ingredient. Fenuron has a solubility of about 3,850 parts per million in distilled water at 25°C., i.e. much higher than its relatives monuron (230 p.p.m.), diuron (40 p.p.m.) and neburon (4 p.p.m.), and in theory should pass quickly downwards through the soil, so enabling planting to follow with a minimum of delay in order to maximize exploitation of the reduction in competition. (The findings of another study (Sutton, 1965) carried out at the same time have since demonstrated the feasibility of planting concurrently with Dybar treatment.) Dybar is non-corrosive, non-flammable, low in volatility, and low in toxicity to man and other animals under recommended procedures.

OBJECTIVES OF STUDY

There were three objectives:

1. To test the effects of Dybar on species commonly present in the boreal mixedwoods of Ontario;
2. to determine how soon after treatment with Dybar a piece of ground may safely be planted to white spruce[2]; and
3. to determine the minimum diameter of Dybar patch treatment necessary to be of significant benefit to planted white spruce.

THE STUDY AREA

The study was carried out in a shrubby, overmature mixedwood on a gentle to moderate south-facing slope on Ontario Paper Company limits about 30 miles south of Manitouwadge. The fertile site had grown fine, scattered stems of white spruce, but these had been cut for boom timber some years before the present study was begun. The remaining trees, mostly decrepit trembling aspen (Figure 1), with some balsam poplar and white birch, now muster a basal area of less than 50 square feet per acre. Balsam fir, a minor component in the overstorey, is in places beginning to form an understorey. Regeneration of white spruce is sparse. Tall shrubs number

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2/ Botanical names are given in the Appendix.

some 21,000 stems per acre, mainly beaked hazel (50 per cent) and mountain maple (46 per cent) in seemingly random intermixture; alder, mountain ash, chokecherry, serviceberry, and dogwood make up the balance. Low shrubs (below 3 feet), mainly Canada and bush honeysuckles, are occasional. Characteristic herbs are bigleaf aster, clintonia, sarsaparilla, and twisted stalk.

A mildly acid moulded till, mostly 4 or more feet thick, covers the underlying granitic and gneissic bedrock. The till ranges in texture from sandy loam to loamy sand, and is stony to very stony except for minor pockets of silty to loamy sand. Soil moisture regimes (Hills, 1952) are mainly in the 2 to 3 range, with the southern part of the study area approaching moisture regime 4.

METHODS

A randomized factorial experiment replicated five times was laid out in July 1959. Two sets of five treatments were applied in all combinations:

Diameter of plot treated	Rate of Dybar broadcast
A 3 yards	P 0 lbs. per acre (0.000 oz. per sq. yd.)
B 6 "	Q 8 lbs. " " (0.026 oz. " " ")
C 9 "	R 16 lbs. " " (0.053 oz. " " ")
D 12 "	S 32 lbs. " " (0.106 oz. " " ")
E 15 "	T 48 lbs. " " (0.158 oz. " " ")

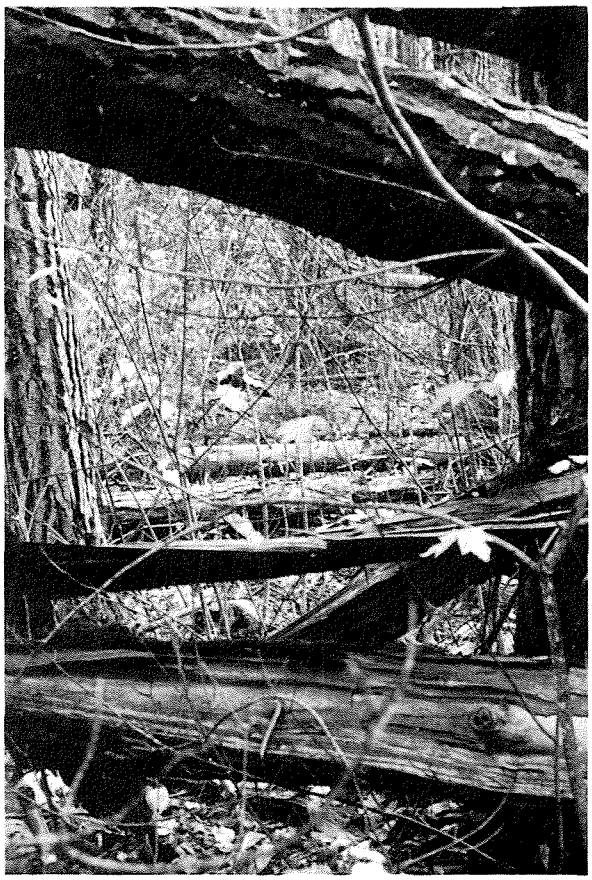

FIGURE 1. Part of study area, showing windfallen trembling aspen in overmature mixedwood.

It should be noted that in this study although Dybar was applied at rates of up to 48 lbs. per acre, no one acre received this amount of herbicide. If 15-yard diameter plots are squeezed into an area at 18-yard centres and if herbicide is applied at 48 lbs. per acre to each and every plot, the amount of herbicide actually used will be 26.4 lbs. per acre. With 9-yard diameter plots similarly spaced, less than 10 lbs. of herbicide is needed for every acre treated.

A trial planting with 2+2 white spruce was carried out in early June 1960 to determine whether any residual toxic effect of Dybar remained in the soil. There was none. Subsequently, in September 1960, nine 3+0 white spruce were planted at three-foot spacing in the form of a cross at the centre of each plot. Annual tallies were made of mortality and height growth.

RESULTS AND DISCUSSION

(a) Effects of Dybar on main shrub and tree species.

Table 1 presents an evaluation of the control achieved with Dybar under the conditions of this study.

TABLE 1. EVALUATION OF EFFECTS OF DYBAR ON MAIN SHRUB AND TREE SPECIES OF THE BOREAL MIXEDWOOD.

Species	Results and Symptoms	Susceptibility Rating
Mountain maple (*Acer spicatum*)	Strong response on plots of 6+ yards diameter at 48 lbs./acre (Figure 2) and in plots of 12 yards diameter at 32+ lbs./acre. Broadcast applications to plots less than 6 yards in diameter were ineffective, even at rates as high as 48 lbs./acre, probably due to plot in relation to root geometries. — Application at 8 lbs./acre gave 75% kill in 15-yard diameter plots. — Onset of symptoms delayed until after leafing-out in year following summer application. — Marginal and interveinal necrosis and revolute margin followed by leaf-fall. (Figure 3). — Often subsequent production of sprouts and epicormic shoots at base of stem, seldom vigorous (Figure 4).	High
Beaked hazel (*Corylus cornuta*)	No response to summer broadcast application at up to 48 lbs./acre in plots as large as 15 yards diameter.	Low
Speckled alder (*Alnus rugosa*)	Very similar response to that of mountain maple.	High
Red osier (*Cornus stolonifera*)	Information inadequate for generalization.	Tentatively high
Mountain juneberry (*Amelanchier bartramiana*)	As for *Cornus*	Tentatively high
Mountain ash (*Sorbus decora*)	As for *Cornus*	Tentatively medium
Balsam fir (*Abies balsamea*)	Mortality of 0-15′ regeneration 90 per cent at 32 + lbs./acre, even in the smaller plots — About 50 per cent mortality in plots of 9+ yards diameter at 16+ lbs./acre. — Needles die and many fall before spring following application. — Around plot borders, especially in trees taller than 15′, damage may be restricted to certain branches or parts of the crown, generally the most vigorous parts.	Very high
White spruce (*Picea glauca*)	As for balsam fir	Very high
Trembling aspen (*Populus tremuloides*)	Sapling mortality of 90 per cent at rates of 48 lbs./acre in plots of 12+ yards diameter — Cambium dies from top down. — No subsequent sprouting observed.	High
Balsam poplar (*Populus balsamifera*)	As for trembling aspen	High
White birch (*Betula papyrifera*)	As for trembling aspen but rather more slowly.	High

FIGURE 2. Stereo pair showing good kill of mountain maple in view across plot ET, Block 2. Before treatment, view beyond 2 or 3 yards had been obstructed by foliage. (Photographed June, 1960).

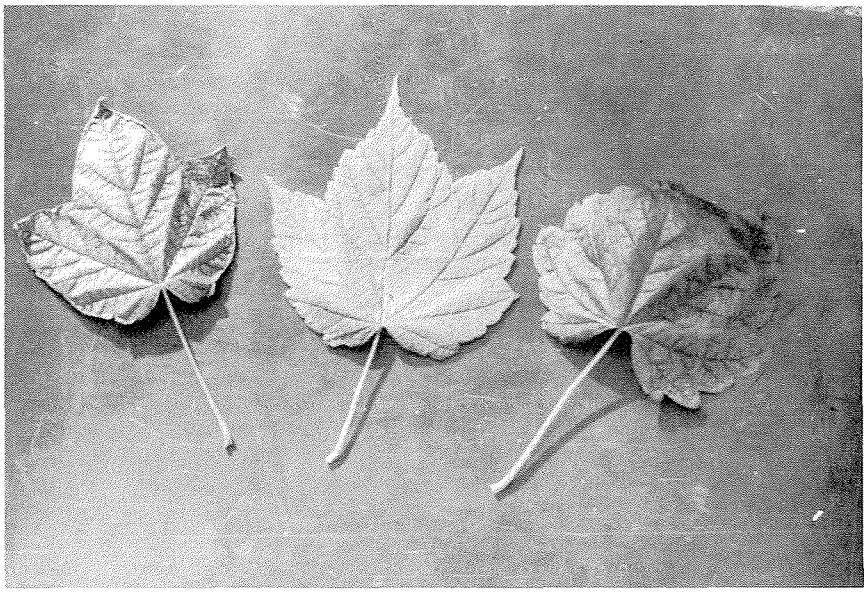

FIGURE 3. Normal leaf of mountain maple flanked by Dybar-affected leaves showing necrotic and revolute margins. Affected leaves are glossier than normal.

FIGURE 4. Normal leaf of mountain maple held against small, curled leaves on epicormic shoot.

(b) Influence of treatments on growth of planted white spruce.

Survival over-all, four growing seasons after planting, was 77 per cent. None of the mortality was attributable to residual Dybar toxicity. Table 2 gives information on the cause and rate of mortality, which was related neither to blocks nor to treatments.

TABLE 2. SURVIVAL AND MORTALITY OF PLANTED WHITE SPRUCE.

End of growing season	Survival %	Annual Mortality % of originally planted trees		
		Browsing	Smothering	Shading and Unknown causes
1960	96.0	1.9	1.7	0.4
1961	90.0	0.7	0.0	5.3
1962	78.4	3.7	1.0	6.9
1963	77.3	0.1	0.1	0.9
Totals		6.4	2.8	13.5

By the fall of 1963, much of the planted stock was beginning to show promise (Figure 5). For example, average height increment in 1963 for plots CT and ET of block 5 was 7.6 and 6.5 cm. respectively. Meaningful characterization of the environment, especially of the canopy density, for the nine trees comprising each plot as a whole has not been possible, although for single trees in similar conditions a highly significant correlation has been found between canopy density and height growth (Sutton, 1965). However, the growth figures tell their story without resort to canopy density data. Tables 3 and 4 present height increment data for 1963 (the fourth growing season after planting) by plots and by herbicide-rate and plot-size treatment totals. Height increment data for 1963 when subjected to analysis of variance (Table 5) show that while combined treatments have exerted a highly significant ($p < .01$) effect on height growth of the planted white spruce, rate of application of herbicide is by far the most influential factor, with significance in excess of $p < .001$. Differences between means of the herbicide-rate treatments and their significance are presented in Table 6.

FIGURE 5. White spruce, planted 1959, well-established and with 13.0 cm. leader in 1963. Plot CT, Block 5. (Photographed Sept. 1963.)

TABLE 3. AVERAGE 1963 HEIGHT INCREMENT (CMS.) OF PLANTED WHITE SPRUCE.

Block	Plot size, yards, diameter																									Block Total
	3 (A)					6 (B)					9 (C)					12 (D)					15 (E)					
	Herbicide rate lbs. per acre																									
	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)	
	Average height increment (cm.)																									
1	4.2	3.4	3.0	4.1	4.6	3.3	3.1	2.2	2.9	4.6	1.9	4.1	3.8	3.0	5.9	3.0	5.1	2.7	3.9	4.6	3.5	3.7	4.0	3.3	3.9	91.8
2	3.0	3.4	4.0	2.2	2.9	3.3	1.6	3.1	4.9	4.8	2.9	3.1	2.4	3.4	3.5	2.8	2.8	3.3	3.2	7.9	3.0	3.2	3.8	4.8	6.2	89.5
3	2.8	3.0	1.7	2.4	2.0	2.9	3.1	1.8	2.2	3.3	2.4	2.4	2.9	2.8	4.2	2.5	2.9	4.0	3.0	3.9	4.7	4.2	2.0	4.1	4.2	75.4
4	2.5	5.0	3.1	2.2	3.6	3.5	3.3	3.8	4.0	3.2	4.8	2.6	3.2	3.3	2.1	2.0	3.3	3.0	2.6	6.0	3.5	2.0	2.2	3.0	4.1	81.9
5	2.6	1.8	4.1	2.8	2.2	3.8	5.6	3.1	2.4	7.6	2.3	4.7	2.8	2.1	8.3	3.6	3.1	3.5	4.6	3.0	3.4	3.8	2.1	5.0	6.5	94.8
Combined Treatment	15.1	16.6	15.9	13.7	15.3	16.8	16.7	14.0	16.4	23.5	14.3	16.9	15.1	14.6	24.0	13.9	17.2	16.5	17.3	25.4	18.1	16.9	14.1	20.2	24.9	433.4
Total Mean	3.02	3.32	3.18	2.74	3.06	3.36	3.34	2.80	3.28	4.70	2.86	3.38	3.02	2.92	4.80	2.78	3.44	3.30	3.46	5.08	3.62	3.38	2.82	4.04	4.98	

TABLE 4. HERBICIDE RATE AND PLOT SIZE TREATMENT TOTALS AND MEAN OF 1963 HEIGHT INCREMENT OF PLANTED WHITE SPRUCE.

Plot size yds. diam.	Herbicide rate, lbs./acre					Plot size Total	Mean
	0 (P)	8 (Q)	16 (R)	32 (S)	48 (T)		
3 (A)	15.1	16.6	15.9	13.7	15.3	76.6	15.32
6 (B)	16.8	16.7	14.0	16.4	23.5	87.4	17.48
9 (C)	14.3	16.9	15.1	14.6	24.0	84.9	16.98
12 (D)	13.9	17.2	16.5	17.3	25.4	90.3	18.06
15 (E)	18.1	16.9	14.1	20.2	24.9	94.2	18.84
Herbicide Treatment Total	78.2	84.3	75.6	82.2	113.1	433.4	
Mean	15.64	16.86	15.12	16.44	22.62		

TABLE 5. ANALYSIS OF VARIANCE OF 1963 HEIGHT INCREMENT IN WHITE SPRUCE PLANTED IN 1959.

Source	D.F.	Sums of squares	Variance	F	Snedecor's F	
					p.05	p.01
Blocks	4	10.01	2.5025	2.139	2.46	3.51
Plot size	4	7.00	1.7500	1.496	2.46	3.51
Herbicide rate	4	36.74	9.1850	7.851***	2.46	3.51
Interaction	16	15.50	0.9688	1.201	1.75	2.19
Total treatments	24	59.24	2.4683	2.110**	1.63	1.98
Error	96	112.31	1.1699			
Total	124	181.56	—	—	—	—

** $p < .01$
*** $p < .001$

TABLE 6. DIFFERENCES BETWEEN MEANS OF HERBICIDE RATE TREATMENTS.

Herbicide rate	T (48 lbs./acre)	S (32 lbs./acre)	R (16 lbs./acre)	Q (8 lbs./acre)	P (control)
Mean	22.62	16.44	15.12	16.86	15.64
Difference	T—S =6.18***				
	T—R =7.50***	S—R =1.32			
	T—Q =5.76***	S—Q =0.42	R—Q =1.74		
	T—P =6.98***	S—P =0.80	R—P =0.52	Q—P =1.22	

*** $p < .001$

Table 4 shows that the 4 best combined treatments were DT, ET, CT, and BT. These have in common a herbicide rate of application of 48 lbs. per acre. Three of them are highly significantly superior to the control, and the fourth is very nearly so.

Plot size does not contribute significantly to variance (Table 5). Nevertheless, in spite of the lack of statistical significance, plot size *is* important, and may yet become significant. The pronounced effect of plot size on the effectiveness of shrub control has been noted (Table 1), and while the reflection of this effect in the height increment of planted white spruce is not statistically significant at present, 7 of the best 9 combined treatments are in 15- or 12-yard diameter plots, and 9 of the worst 11 are not. A further pointer to the importance of plot size is the significant difference between the small plot AT and the other treatments with 48 lbs. per acre of herbicide (Table 4). Dominance of the 48 lbs. per acre treatment, and the variability

(in treatment effects) consequent upon a shrub layer consisting essentially of an irregular mixture of mountain maple which is highly susceptible to Dybar, and beaked hazel, which is not, account mainly for the lack of statistical significance of plot size.

These results are convincing evidence of the effectiveness of the 48 lbs./acre treatments with Dybar in increasing the height growth of planted white spruce by reducing competition from mountain maple. Since sturdiness and vigour in general and bud size in particular are apparently correlated with current height growth, height growth differences might well underestimate the real differentials between treatments.

PRACTICAL APPLICATION

The study shows that mountain maple was readily killed by summer broadcast application of Dybar at 32 lbs. per acre in plots 12 yards or more in diameter. Hazel was the only species that did not succumb to the 48 lbs. per acre treatments. In general, control of shrubs is improved if the herbicide is applied to areas sufficiently large to include complete shrub root system complexes. Further, it was demonstrated that planting with white spruce may safely follow Dybar treatments as heavy as 48 lbs. per acre within a year of the herbicide application. With broadcast application at 48 lbs. per acre, plots of 9 yards diameter or more were needed before improvement in growth of nine tree groups of white spruce achieved high significance ($p < .001$) within the period of study. In commercial operations, herbicide treatment and planting, freed from the confines of experimental design, should show greater effectiveness.

It follows that where mountain maple is the main obstacle to regeneration, Dybar may be broadcast in patches, where white spruce groups are to be planted after an overwinter wait. Height growth should be highly significantly better than in comparable areas not previously treated with herbicide. In large-scale operations consideration might be given to the possibility of developing a method of aerial application of herbicide in the form of bombs or grenades, i.e. aggregates of Dybar granules that would break up on impact, scatter, and so treat a patch of convenient planting size.

ACKNOWLEDGEMENTS

Mr. Art R. Appleton of the Biochemicals Section of Du Pont of Canada Ltd. is warmly thanked for his co-operation in establishing the study and for supplying the Dybar used.

The interest and co-operation of Mr. Joe Bird of the Ontario Paper Company are also much appreciated.

APPENDIX

Botanical Names of Species Mentioned

English Name	Nom Français	Botanical Name
Alder, speckled	Aune commun	*Alnus rugosa* (Du Roi) Spreng. var. *americana* (Regel) Fern.
Aspen, trembling	Peuplier faux-tremble	*Populus tremuloides* Michx.
Birch, white	Bouleau à papier	*Betula papyrifera* Marsh.
Cherry, choke	Cerisier de Virginie	*Prunus virginiana* L.
Dogwood, red-osier	Cornouiller stolonifère	*Cornus stolonifera* Michx.
Fir, balsam	Sapin baumier	*Abies balsamea* (L.) Mill.
Hazel, beaked	Noisetier à long bec	*Corylus cornuta* Marsh.
Honeysuckle, bush	Dièreville chèvrefeuille	*Diervilla lonicera* Mill.
Honeysuckle, Canada	Chèvrefeuille du Canada	*Lonicera canadensis* Bartr.
Maple, mountain	Érable à épis	*Acer spicatum* Lam.
Mountain-ash, showy	Sorbier des montagnes	*Sorbus decora* (Sarg.) Schneid.
Poplar, balsam	Peuplier baumier	*Populus balsamifera* L.
Serviceberry, Bartram's	Amélanchier de Bartram	*Amelanchier bartramiana* (Tausch) Roemer
Spruce, white	Epinette blanche	*Picea glauca* (Moench) Voss
Aster, bigleaf	Pétouane	*Aster macrophyllus* L.
Clintonia, yellow	Clintonie boréale	*Clintonia borealis* (Ait.) Raf.
Sarsaparilla	Salsepareille	*Aralia nudicaulis* L.
Twisted-stalk, rose	Rognon de coq	*Streptopus roseus* Michx.

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