

FOREST RESEARCH REPORT

No. 45: March, 1993

PLANTATION WEEDING WITH GLYPHOSATE: EFFECTS ON CROP GROWTH

INTRODUCTION

Controlling competing vegetation in forest plantations increases the chances of obtaining healthier, faster growing crop trees (Newton *et al.*, 1991; Anon, 1991; NBDNR, 1988.). A study of two 11 year old Norway Spruce plantations in Georgefield, Nova Scotia, showed crop-tree volume in areas weeded with glyphosate, 2 to

13 times that of unweeded areas (NSDLF, 1990). To obtain estimates of crop growth for other species and locations in Nova Scotia, a survey was made of a number of operational plantations containing glyphosate weeded and unweeded areas.

SITE DESCRIPTIONS

Eight plantations originating from clearcuts (4 softwood, 2 mixedwood and 2 hardwood) were selected for this study (Figure 1). All were site prepared 1 to 5 years following harvest (Appendix I) and planted within 2 years of site preparation with either multipot or bare root tree seedlings. Black spruce (*Picea mariana* (Mill.) B.S.P.) was planted on 3 sites; a mix of red

spruce (*Picea rubens* Sarg.) and black spruce at 2 sites, red pine (*Pinus resinosa* Ait.) at 2 sites, and Norway spruce (*Picea abies* (L.) Karst.) on 1 site; all at an initial approximate spacing of 1.8 X 1.8 m. Except for the control blocks, each location was weeded in the fall of the first or second year following planting with one application of the herbicide glyphosate (4.5 - 4.7 l/ha of Roundup®).

METHODS

In each plantation, 10 plots were located and measured in an unweeded control block and 10 plots in a weeded block. The treated and control blocks were located in areas similar with respect to aspect, drainage and micro-site. At each plot, crop tree measurements were col-

lected in the fall of 1990. Competition data were collected at four of the 8 sites (Donny Brook, Sand River, Shulie Lake and Dows Brook) during mid-summer of the following year. Crop tree measures are described in Appendix II.

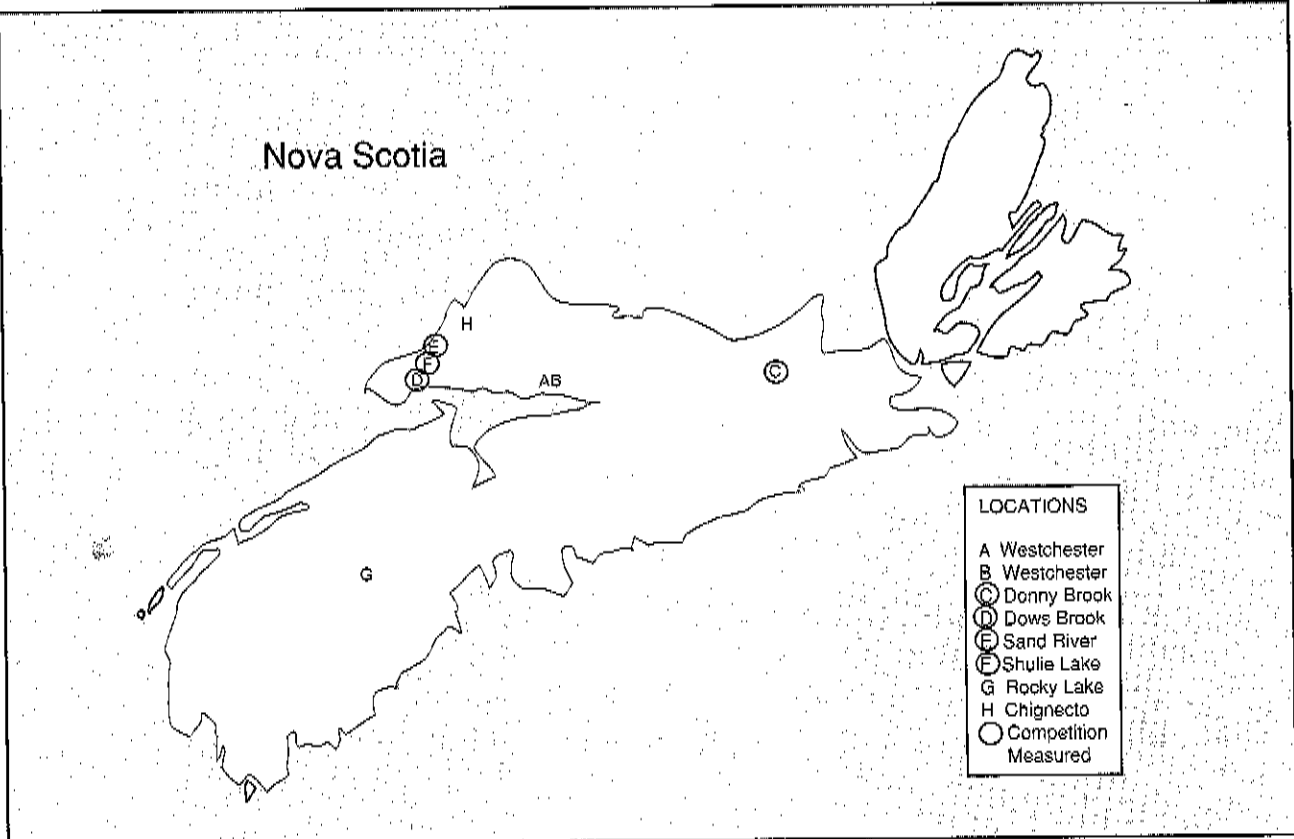


Figure 1. Locations of sampled plantations

RESULTS AND DISCUSSION

Competition

At the time of measurement, 5 to 8 years following weeding, the control blocks exhibited more severe vegetative competition than the treated blocks (Figure 2, Appendix III). On average, the hardwood tree competition in the unweeded blocks was as tall as the crop trees (2.0 m) and covered 39% of the area. In the weeded areas, the hardwood was only about half as tall as the crop trees (1.2 versus 2.1 m) and covered only 5% of the area. Competition height and cover were used to derive a **Competition Index** which is calculated as follows:

$$CI = C \times H$$

where, CI = Competition Index,

C = Percent of ground covered by each species,

H = Average height (metres) of each species.

The hardwood Competition Index for all the measured sites averaged only 8 in the weeded blocks, compared to 90 in the control blocks. However, the height and cover of shrub and

ground cover competition were relatively unaffected by treatment (Figure 2).

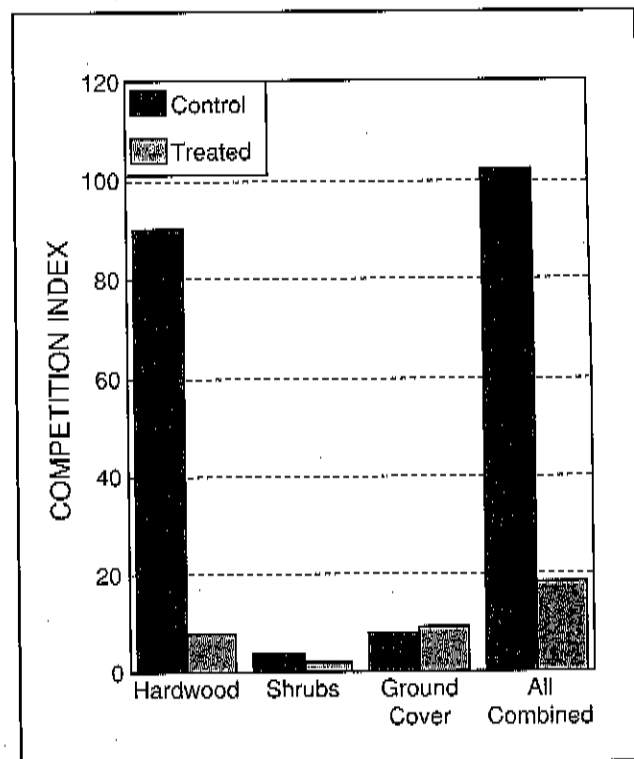


Figure 2. Competition Index by cover and treatment.

Growth of Crop Trees

Crop tree **diameter** was 32% and **volume** 71% greater in the treated blocks over all locations. Significant increases in mean crop tree diameter (measured at 10 cm above ground level) and volume occurred at all but the Westchester red and black spruce location (Appendix IV, Figures 3 and 4). At this site, crop tree diameter was only 4% greater in the treated block, while tree volume was 10% less. This result could be due to a higher proportion of black spruce in the control than the treated block (Appendix V). From a previous study (NSDLF, 1989), it was shown that black spruce height growth can exceed that of red spruce in young plantations.

For the locations where competition data was collected, Shulie Lake showed the largest increase (81%) in tree volume and the largest decrease (91%) in competition index. At the

other extreme, Sand River showed the smallest increase (12%) in crop tree volume and had the smallest decrease (59%) in competition index between weeded and control.

Free to grow status was improved in all treated blocks and locations (Appendix II, Appendix IV, Figure 5). Over all, 25% more of the crop trees were rated as free to grow on treated blocks.

Leader growth was greater in the treated blocks by 8% and **crown volume** by 41% on average over all sites (Appendix IV, Figures 6 and 7). Increases were not found at all locations. Leader growth was slightly less at Donny Brook and Sand River and crown volume less at the Westchester red and black spruce location.

Crop tree **density** (trees per hectare) did not appear to be influenced by treatment in these areas (Appendix IV).

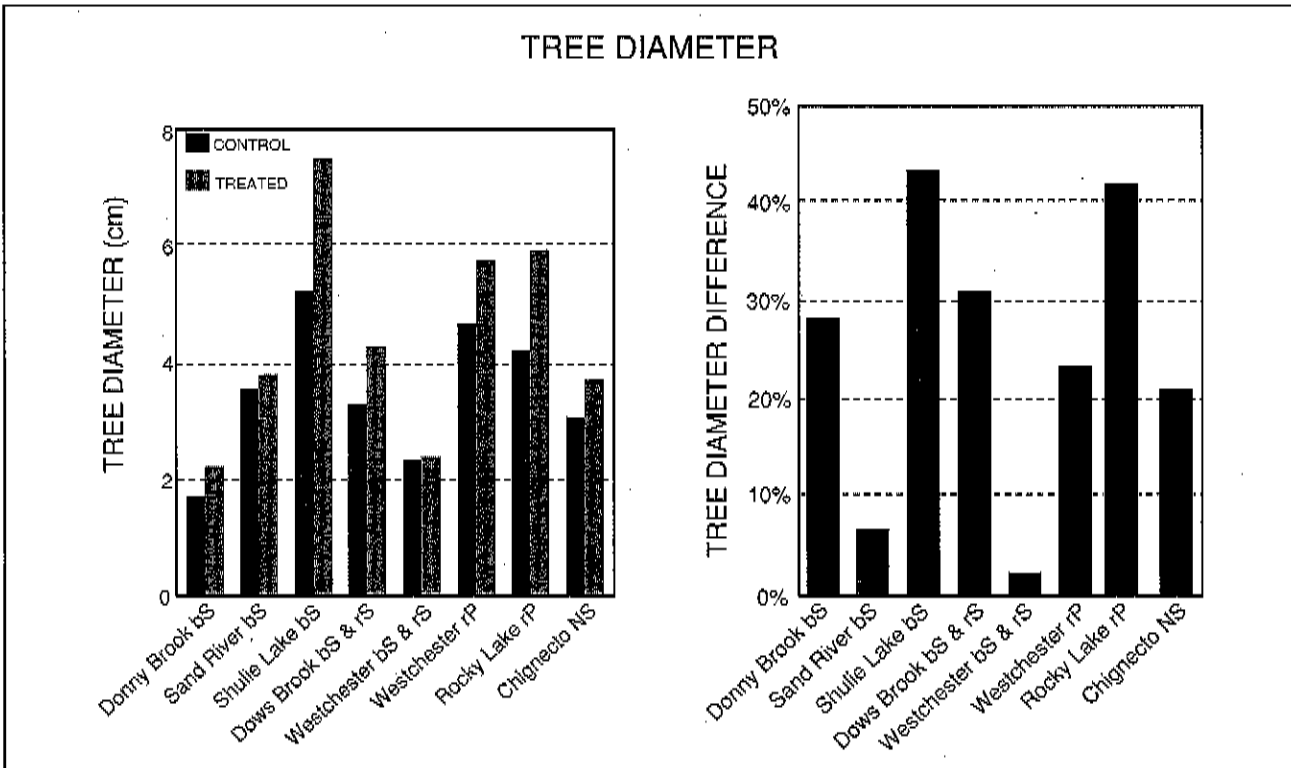


Figure 3. Average Tree diameter by location and treatment.

TREE VOLUME

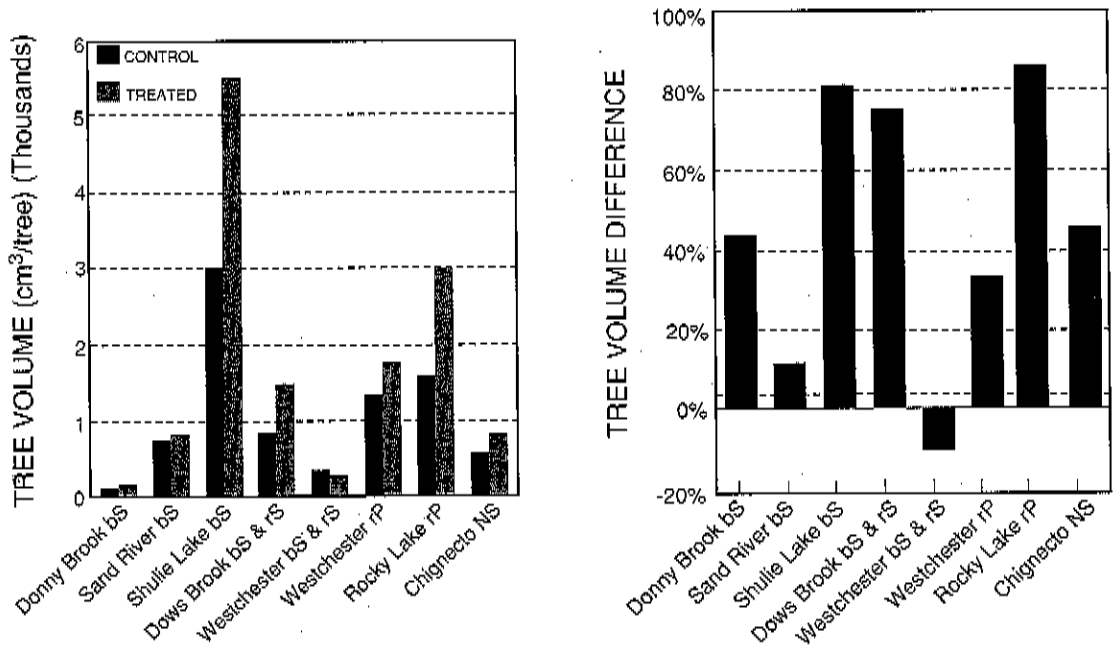


Figure 4. Average Tree volume by location and treatment.

FREE TO GROW

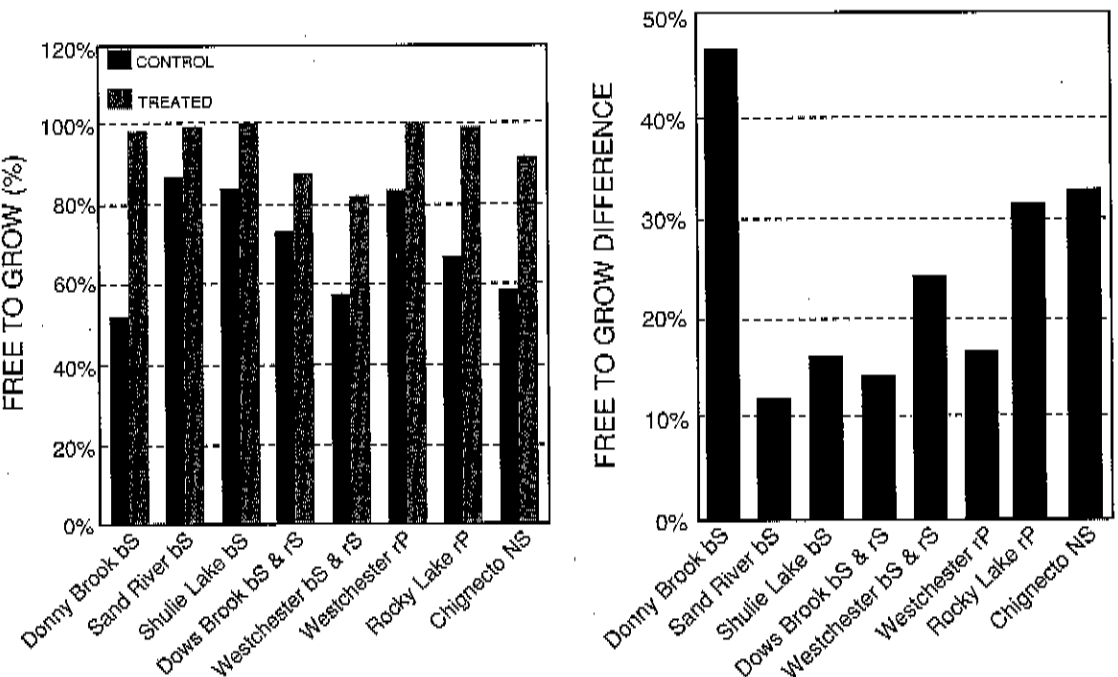


Figure 5. Percent of crop trees free to grow by location and treatment.

LEADER LENGTH

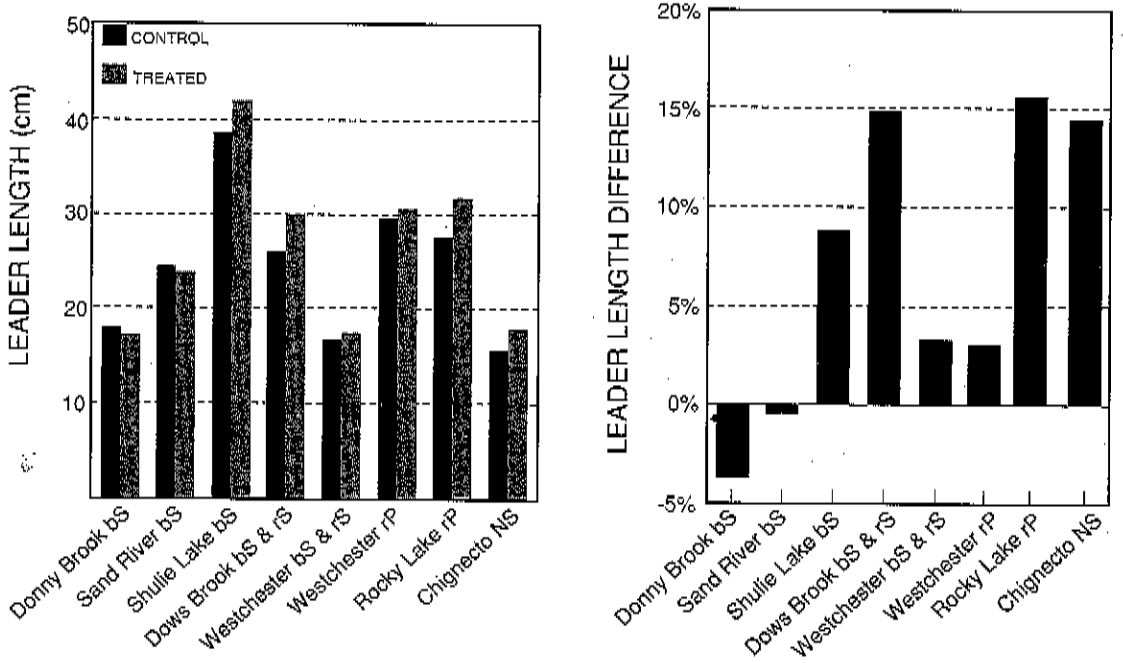


Figure 6. Average Annual leader-length since weeding by location and treatment.

CROWN VOLUME

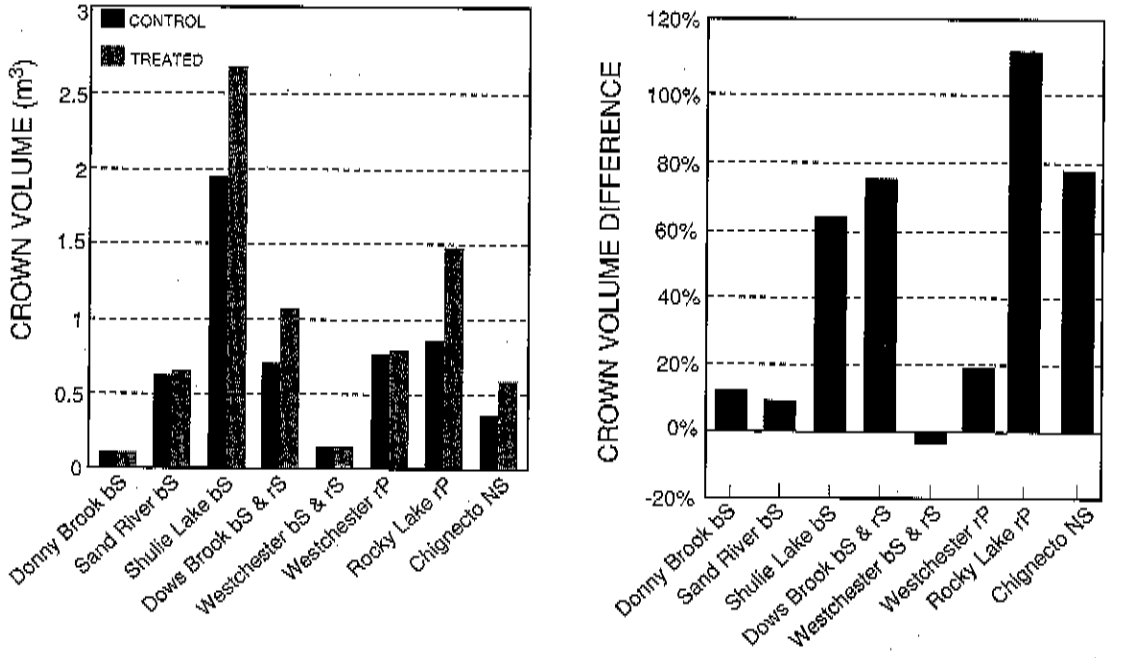


Figure 7. Crown volume by location and treatment.

SUMMARY

The results of a survey to determine the effect on crop growth of weeding operational plantations with one glyphosate application, are as follows:

1) Crop tree **diameter** and **volume** were 32 and 71% respectively greater in the weeded blocks.

2) Twenty-five percent more trees were **free to grow** in the weeded blocks.
 3) Average crop tree **leader length** and **crown volume** were 8 and 41% respectively greater than in control blocks.

LITERATURE CITED

ANONYMOUS, 1991. *Growth enhancement from Vision^{®1} herbicide in Ontario and Quebec.* Arbex Forest Development Co. Ltd. 23pp.

NBDNR, 1988. *Softwood growth response study after Roundup^{®1} treatments.* Internal Working Document No. 88-1. 5 pp.

Newton, M., E.C. Cole, M.L. McCormack Jr., and D.E. White. 1992. *Young spruce-fir forests released by herbicides II. Conifer response to residual hardwoods and overstocking.* North. J. Appl. For. 9: 130-135.

NSDLF, 1989. *A comparative growth and yield study of red and black spruce planted on the same site.* Forest Research Section, Nova Scotia Department of Lands & Forests. For. Res. Rept. No. 12, 4pp.

NSDLF, 1990. *Norway spruce release with glyphosate: 10 year results.* Forest Research Section, Nova Scotia Department of Lands & Forests. For. Res. Rept. No. 23, 8pp.

APPENDIX I.

Plantation site history and establishment records.

Location	History	Harvest Year (H)	Site Prepared (SP)	Years from H to SP	Method of site Preparation	Planted (P)	Years from SP to P	Stock Type	Stock Age	Species	Crop Trees Released from Competition	Age of Plantation at time of Measurement and (years since spraying)	Application Method	Roundup [®] Application Rate (l/ha)
Denny Brook	Softwood	1983	1984	1	Root Rake	1985	1	Multipot	2	Black Spruce	1985	5 (5)	Aerial	4.5
Sand River	Softwood	1976	1981	5	Rome Disc	1983	2	Multipot	1.5	Black Spruce	1984	7 (6)	Aerial	4.5
Shulie Lake	Softwood	1979	1981	3	Brush Rake	1982	1	Multipot	1.5	Black Spruce	1984	8 (6)	Aerial	4.5
Dows Brook	Softwood	1978	1980	2	Dozer Rake	1982	2	Multipot	1.5	Red and Black Spruce	1984	8 (6)	Aerial	4.5
Westchester	Mixedwood	1978	1983	5	Rome Disc	1984	1	Multipot	1.5	Red and Black Spruce	1985	6 (5)	Aerial	4.5
Westchester	Mixedwood	1979	1983	4	Rome Disc	1984	1	Multipot	1	Red Pine	1985	6 (5)	Aerial	4.5
Rocky Lake	Hardwood	19—	1981	-	Flanish Plow	1982	1	Bareroot	3/0	Red Pine	1984	8 (6)	Aerial	4.7
Chignecto	Hardwood	19—	1979	-	Rome Disc	1981	2	Bareroot	2/0	Norway Spruce	1982	9 (8)	Ground	4.6

¹ Vision[®] and Roundup[®] are registered trademarks of Monsanto Company. Monsanto Canada Inc. is a registered user.

APPENDIX II.

Definitions.

Crown Volume - Based on the volume of a cone: $V_c = \frac{1}{3} * \frac{\Pi D_c^2}{4} * H_c$
 where: V_c = volume in m^3 ,
 D_c = diameter of crown in m, measured at the base of the live crown,
 H_c = length of live crown in m.

Free to Grow - Talled as either yes or no, if yes then the crop tree is taller than the competition canopy and is expected to remain free of competition. Judgement is based on crop tree species, height and general vigour as well as competition species, health, height and density. (Root competition was not estimated.)

Leader Growth - Length of all internodes and leader since time of spray divided by the years since spray.

Volume per Tree - Based on the volume of a cone: $V_t = \frac{1}{3} * \frac{\Pi D_t^2}{4} * H_t$
 where: V_t = volume in cm^3 ,
 D_t = stem diameter in cm, at 10 cm above the ground,
 H_t = height of tree in cm.

APPENDIX III.

Competition characteristics by location¹ at assessment time.

Location and Species	Block	Crop Tree Height (cm)	Hardwood					Shrubs				Ground Cover					Combined		
			Cover (%)	Height (cm)	Competition Index	Primary Species ²	Secondary Species ²	Cover (%)	Height (cm)	Competition Index	Primary Species ²	Cover (%)	Height (cm)	Competition Index	Primary Species ²	Secondary Species ²	Cover (%)	Height (cm)	Competition Index
Donny Brook Black Spruce	Control	109	40	175	86	rM	wB	11	35	4	Rsp	51	22	11	Bub	Grs	102	83	101
	Treated	107	1	107	1	rM	wB	22	23	5	Rsp	54	30	16	Grs	Sdg	77	29	22
Sand River Black Spruce	Control	180	17	169	31	wB	pC	16	32	9	Rsp	20	18	4	Bub	Ast	58	71	44
	Treated	180	8	113	10	wB	pC	10	24	3	Rsp	19	28	5	Ast	Mos	37	48	18
Shulte Lake Black Spruce	Control	299	69	272	188	wB	rM	1	30	0	Rsp	13	38	4	Ast	Frn	83	232	192
	Treated	338	4	147	11	wB	rM	1	20	0	Rsp	24	42	7	Sdg	Mos	29	56	18
Dows Brook Red and Black Spruce	Control	199	29	189	55	yB	wB	6	28	2	Rsp	75	26	14	Mos	Bub	110	69	71
	Treated	228	7	122	9	wB	rM	1	18	0	Rsp	60	13	7	Mos	Bub	68	24	16
Average	Control	197	39	201	90	wB	rM	8	31	4	Rsp	40	26	8	Bub	Ast	87	114	102
	Treated	212	5	122	8	wB	rM	8	21	2	Rsp	39	28	9	Mos	Sdg	53	38	18

¹Competition data for the 2 Westchester sites, Rocky Lake and Chignecto are not available.
²Primary and Secondary Species: pC - pin cherry, *Prunus pensylvanica* L.f., Ast - Asters, Aster L., Mos - Mosses, Moses, *Rubus* L., rM - red maple, *Acer rubrum* L., Bub - Bunchberry, *Cornus canadensis* L., Rsp - Raspberry, *Rubus* L., wB - white birch, *Betula papyrifera* Marsh., Frn - Ferns, *Polypodiaceae*, Sdg - Sedges, *Cyperaceae*, yB - yellow birch, *Betula alleghaniensis* Britton, Grs - Grasses, *Gramineae*

³Competition Height is weighted by Cover (%) for the Combined column.

APPENDIX IV.

Results of Mann-Whitney non-parametric tests comparing control versus treated blocks.

Location	Species	Trees/hectare (sample size)			Average Leader Growth (cm)		Crown Length (cm)		Crown Width (cm)		Crown Volume (m ³)		Diameter (cm)		Tree Volume (cm ³)		Free to Grow (%)	
		Control	Treated		Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated
Donny Brook	Black Spruce	2308 (116)	1751 (88)	Average	18	17	90	88	59	6.2	0.11	0.11	1.7	2.2	120	172	51	98
				Standard Error	0.6	0.5	3.1	3.1	1.8	1.8	0.01	0.01	0.1	0.1	11	15	5	2
				Z/Significance ¹	-0.82	(.206)	-0.25	(.403)	-1.49	(.068)*	-0.79	(.214)	-4.45	(.000)***	-3.18	(.001)***	-7.29	(.000)***
Sand River	Black Spruce	2626 (132)	2765 (139)	Average	24	24	163	162	109	114	0.62	0.64	3.6	3.8	740	828	86	99
				Standard Error	0.6	0.6	4.5	4.2	2.8	2.3	0.03	0.04	0.1	0.1	49	50	3	1
				Z/Significance ¹	-0.16	(.437)	-0.11	(.455)	-1.23	(.109)	-0.61	(.272)	-1.88	(.030)**	-1.38	(.084)*	-3.83	(.000)***
Shulie Lake	Black Spruce	2149 (108)	2168 (109)	Average	39	42	281	333	144	170	1.95	2.70	5.3	7.5	3020	5467	83	100
				Standard Error	1.3	0.8	10.1	6.2	4.3	2.9	0.12	0.12	0.2	0.2	239	250	4	0
				Z/Significance ¹	-1.23	(.108)	-3.26	(.001)***	-4.00	(.000)***	-3.77	(.000)***	-7.63	(.000)***	-6.63	(.000)***	-4.44	(.000)***
Dows Brook	Red and Black spruce	2029 (102)	1373 (69)	Average	26	30	177	208	103	125	0.71	1.08	3.3	4.3	837	1466	73	87
				Standard Error	1.1	1.2	7.8	8.8	3.8	5.1	0.08	0.10	0.1	0.2	99	149	4	4
				Z/Significance ¹	-2.64	(.004)***	-2.90	(.002)***	-3.90	(.000)***	-3.71	(.000)***	-4.19	(.000)***	-3.81	(.000)***	-2.24	(.013)**
Westchester	Red and Black Spruce	1194 (60)	1512 (76)	Average	17	17	97	98	61	60	0.15	0.14	2.3	2.4	316	284	57	82
				Standard Error	1.1	0.8	7.5	5.2	3.4	3.0	0.02	0.02	0.2	0.1	57	43	4	6
				Z/Significance ¹	-0.99	(.162)	-0.75	(.228)	-0.29	(.385)	-0.21	(.417)	-0.18	(.427)	-0.22	(.413)	-3.15	(.001)***
Westchester	Red Pine	1054 (53)	1413 (71)	Average	30	31	170	174	119	128	0.75	0.79	4.7	5.8	1330	1765	83	100
				Standard Error	1.0	0.5	6.2	3.2	4.8	2.6	0.07	0.04	0.2	0.1	128	102	5	0
				Z/Significance ¹	-0.35	(.365)	-0.03	(.487)	-1.39	(.082)*	-0.89	(.187)	-3.27	(.001)***	-2.34	(.010)***	-3.59	(.000)***
Rocky Lake	Red Pine	1273 (64)	1373 (69)	Average	27	32	175	206	105	142	0.86	1.49	4.2	5.9	1603	2973	67	99
				Standard Error	1.5	1.2	10.8	9.1	6.6	6.3	0.11	0.17	0.3	0.3	212	325	6	1
				Z/Significance ¹	-1.87	(.031)**	-2.02	(.022)**	-3.37	(.000)***	-2.95	(.002)***	-3.86	(.000)***	-3.22	(.001)***	-4.85	(.000)***
Chignecto	Norway spruce	2905 (146)	2089 (105)	Average	16	18	115	137	90	110	0.36	0.59	3.0	3.7	364	819	58	91
				Standard Error	0.5	0.6	4.1	5.4	3.0	3.9	0.04	0.06	0.1	0.1	61	81	4	3
				Z/Significance ¹	-2.86	(.002)***	-3.38	(.000)***	-3.39	(.000)***	-3.94	(.000)***	-3.61	(.000)***	-3.31	(.000)***	-3.78	(.000)***
All	All	1942 (98)	1805 (91)	Average	24	26	158	178	99	115	0.68	0.96	3.4	4.5	1021	1743	70	95
				Standard Error	0.4	0.4	89	93	45	48	0.03	0.04	0.1	0.1	34	84	2	1
				Difference T-C and (% T>C)	2	(8)	20	(13)	16	(16)	0.28	(41)	1.1	(32)	722	(71)	25	

¹Z / Significance: Z is a statistic for testing the null hypothesis H₀ which can be rejected at the .01 (***) , .05 (**), or .10 (*) significance level (H₀ = treated value greater than control value).

APPENDIX V.

Proportion of red and black spruce in mixed plantations.

Location	Block	Red Spruce		Black Spruce		Total (#)
		(#)	(%)	(#)	(%)	
Westchester	Control	14	23	46	77	60
	Treated	31	41	45	59	76
Dows Brook	Control	22	22	80	78	102
	Treated	0	0	69	100	69

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