FOREST RESEARCH REPORT

NOVA SCOTIA DEPARTMENT OF LANDS AND FORESTS
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FIFTEEN YEAR ASSESSMENT OF THIRTY YEAR OLD RED SPRUCE STANDS CLEANED AT VARIOUS INTENSITIES IN NOVA SCOTIA

INTRODUCTION

Cleaning[1] is utilized as a method to allow natural forest stands of dense saplings to reach a merchantable size sooner than if left to grow naturally. Various field trials have been undertaken to quantify the effect of this silvicultural activity (Axelsson, 1973; Gillis, 1977; Ker, 1981; Piene, 1982). In some jurisdictions, variable density growth and yield computer programs were developed to aid in predicting these effects, among them the softwood variable density model for Nova Scotia. However, there is little long-term growth and yield data available to determine the accuracy of these growth model predictions for cleaned red spruce stands. Therefore, two red spruce stands cleaned at different intensities in 1968 were remeasured in 1983 and compared with projected values from the Nova Scotia Department of Lands and Forests (NSLF) variable density model for softwoods.

1. Cleaning is defined in Nova Scotia as a spacing operation carried out in naturally regenerated stands ranging from 5 - 30 feet in height for the purpose of improving the percentage of desirable species and promoting the growth of crop trees.

SITE DESCRIPTION

The two cleaned stands (Site A and Site B) are located on lands owned by Bowater Mersey Paper Company Ltd. north of French Village Station in the St. Margaret's Bay area (44° 47' N, 63° 57' W). At an elevation of 200 to 250 feet, the growing season at these sites ranges from 152 to 171 frost free days and the site index for red spruce is 50 feet at 50 years (Anon., 1984). The stands occur on the Gilbratar soil series which is sandy loam in texture, well drained, and derived from granitic till. The present stand of trees originated after a 1954 hurricane, which caused extensive damage to the previous red spruce stand. Salvage cuts carried out shortly afterwards removed mature timber and released the young advance regeneration. Fourteen years later (1968) the Canadian Forestry Service established cleaning trials on the two sites. For further site and establishment information refer to Meikle and Hughes (1969).

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METHODS

Site A was divided into five blocks varying in size from 1.6 to 3.3 acres. Four intensities of cleaning (4 x 4, 6 x 6, 8 x 8 and 9.5 x 9.5 foot spacings) and an untreated control were randomly assigned to the blocks (Table 1). Initially, the average density of the red spruce thickets at Site A was approximately 9500 stems/acre. Following treatment, two permanent sample plots, 0.1 acres in size, were established in each of the treated blocks. The plots in the controls were .025 acres in size due to the high density of the stands. When remeasured in 1983, by Lands and Forests staff, plots 8, 9 and 10 had been destroyed by road construction.

Site B was divided into four rectangular blocks each approximately two acres in size. Three intensities of cleaning (6 x 6, 8 x 8 and 9.5 x 9.5 foot spacings) and an untreated control were assigned randomly to these blocks (Table 1). Initially, Site B supported approximately 5700 stems/acre on average. Two permanent sample plots were also established in each block at this site. Plot 4 was not analyzed due to the heavy porcupine damage which occurred within this plot. Plot 3 also sustained porcupine damage, but not to the extent of that found in Plot 4 and therefore was included.

Table 1. Cleaning treatments, block sizes and pre-treatment density.

Site	Treatment	Block Area (acres)	Plot Numbers	Pre-treatment Density* (stems/ac)
A	Control	1.8	1,2	8015
	4' x 4'	1.6	3,4	10055
	6' x 6'	1.8	5,6	11285
	8' x 8'	3.3	7,8	8610**
	9.5' x 9.5'	3.1	9,10	-
B	Control	2.0	1,2	5655
	6' x 6'	2.0	3,4	5820***
	8' x 8'	2.0	5,6	5220
	9.5' x 9.5'	2.1	7,8	6265

* Average for both plots
** Plot 7 only
*** Plot 3 only

RESULTS

DENSITY

The number of trees per acre after treatment (1968) and at the time of measurement (1983) is shown in Table 2. Within the cleaned plots, the number of trees remaining after treatment in 1968 ranged from 2120 (4.5' x 4.5') per acre in the prescribed 4 x 4 foot spacing to 790 (7.4' x 7.4') per acre in the prescribed 8 x 8 foot spacing at Site A and from 1140 (6.2' x 6.2') per acre in the prescribed 6 x 6 foot spacing to 505 (9.3' x 9.3') per acre in the prescribed 9.5 x 9.5 foot spacing at Site B. As can be seen, the actual spacing varied from that prescribed. In addition, tree density decreased between 1968 and 1983. This was a result of tree mortality induced mainly by porcupine feeding. The damage was more extensive at Site B with the greatest tree loss occurring in Plot 3, where 25% mortality occurred.

SPECIES COMPOSITION

Red spruce accounted for 75% and 59% of the stems at Sites A and B respectively before cleaning in 1968. The cleaning operation favoured red spruce and resulted in an increase in its content to 92% at Site A and 89% at Site B.

DIAMETER

All intensities of cleaning resulted in a larger average diameter than the control blocks, fifteen years after treatment (Figure 1 and Table 2). The wider the spacing the greater the increase in diameter. For example, at Site B the average diameter of the control was 2.4 inches compared to 6.0 inches for the widest prescribed spacing of 9.5' x 9.5'.

The average diameters resulting from these cleanings were then compared against the expected average stand diameters as predicted by the NSLF growth projection curves[1] (Figure 2). The actual spacings after treatment in 1968 were used to determine these predicted values. The results of this comparison (Table 2) show that there was only a minimal difference between the actual measured diameters and the predicted diameters, with the largest difference occurring in Plot 3 at Site B, where the actual diameter was 0.5 inches (10%) less than predicted. This less than anticipated diameter growth is attributed to the porcupine damage to the living trees within this plot. When averaged over all sites and treatments, the predicted average stand diameter was within 1.0% of the actual value (Table 2).

1. Curves derived from the N.S. Dept. of Lands and Forests variable density growth and yield computer simulation model for softwood species (Unpublished).

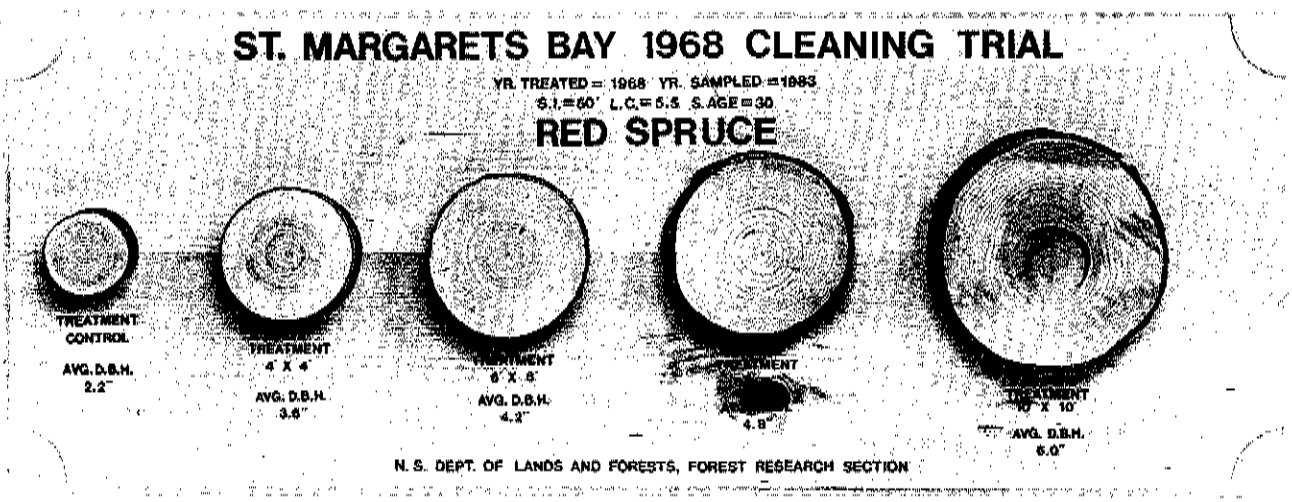

Figure 1. Photograph of discs taken from average trees at breast height, showing the effect of different spacing intensities on average stand diameter.

Table 2. Fifteen year results of spacing two young red spruce stands[1]. Effect of spacing intensity on average diameter, basal area and volume as compared to estimates from the Nova Scotia Department of Lands and Forests growth projection curves.

	Stump Age	Prescribed Spacing	Actual Spacing (trees/ac)		Total Avg. Dia. (in)			MAI[10] Gross Merch. Vol.[5] (cords/ac/yr)					Actual Total Volume	Actual TBA[6]	% Merch.[7]
	(years)	(trees/ac)	1968[2]	1983	Pred.[3]	Act.[4]	Diff.	Pred.[3]	Adj.[8]	Act.[4]	Diff.	Adj. Diff.	(ft^3/ac)	(ft^2/ac)	
Site A															
Plot 1,2	27	Control	2.3' (8015)	2.4' (7840)	-	2.2	-	-	-	0.39	-	-	2374	203	33
3,4	29	4' (2722)	4.5' (2120)	4.7' (1980)	3.6	3.6	0.0	0.82	0.77	0.60	+0.22	+0.17	1918	144	74
5,6	27	6' (1210)	5.8' (1285)	6.0' (1200)	4.2	4.2	0.0	0.63	0.58	0.56	+0.07	+0.02	1530	115	83
7	28	8' (680)	7.4' (790)	7.5' (780)	5.0	4.8	+0.2	0.57	0.56	0.55	+0.02	+0.01	1380	100	94
Site B															
Plot 1,2	31	Control	2.8' (5655)	2.7' (6080)[9]	-	2.4	-	-	-	0.48	-	-	2261	187	48
3	34	6' (1210)	6.2' (1140)	7.1' (860)	5.3	4.8	+0.5	0.86	0.65	0.50	+0.36	+0.15	1546	109	92
5,6	30	8' (680)	8.7' (575)	9.3' (500)	5.9	6.3	- 0.4	0.56	0.49	0.63	- 0.07	- 0.14	1600	108	99
7,8	30	9.5' (483)	9.3' (505)	9.9' (445)	6.0	6.0	0.0	0.52	0.46	0.49	+0.03	- 0.03	1258	87	99
Overall Mean:					5.00	4.95	+0.05 (+1.0%)		0.585	0.555		+0.03 (+5.4%)			

1. Both stands have a site index of 50 (Anon., 1984) .
2. After treatment in 1968.
3. Based on NSLF Growth Projection Curves, using actual spacing (1968), Forestry Field Handbook (Anon., 1984) .
4. Actual values represent the average of the plots in each treatment.
5. Assuming 80 solid cubic feet in a cord.
6. TBA = Total basal area.
7. % Merch. = (merchantable basal area/total basal area) x 100.
8. Prediction adjusted for mortality by the ratio of actual density in 1983 to actual density in 1968.
9. 1983 density is greater than the 1968 density due to difficulties in reestablishing the measurement plot boundaries.
10. MAI = Mean annual increment.

VOLUME AND BASAL AREA

Fifteen years after cleaning, the total volume and total basal area (TBA) were inversely related to spacing. For example at Site A, the TBA of the control (203 ft²/acre) was approximately twice that of the widest spacing (Table 2). On the other hand, percent merchantability[1] increases as spacing increases. At site A, the percent of the total basal area considered merchantable increased from 33% for the control to 94% at the prescribed 8 x 8 foot spacing.

Mean annual increments (MAI) (cords/acre/year) at Site A and B were compared against the values predicted by the NSLF growth projection curves (Table 2). The actual spacing values from 1968 were again used for the projections. These predictions closely matched the actual values except for the prescribed 6 x 6 foot spacing at Plot 3, Site B and the prescribed 4 x 4 foot spacing at Plots 3 and 4, Site A. At Site B, the prescribed 6 x 6 foot spacing resulted in an actual MAI 0.36 cords/acre/year lower than the predicted value while at Site A the prescribed 4 x 4 foot spacing resulted in a MAI 0.22 cords/acre/year less than the predicted value. These discrepancies are due in part to the reduction in tree density between 1968 and 1983 caused by porcupine feeding at these sites. To compensate for the loss of trees, the predicted MAI values were multiplied by the ratio of 1983 to 1968 density. The discrepancy was thus reduced to 0.15 cords/acre/year and 0.17 cords/acre/year respectively for the prescribed 6 x 6 foot spacing at Site B and the prescribed 4 x 4 foot spacing at Site A. On average for all treatments and sites combined, the predicted MAI (adjusted) was within 5.4 % of the actual value.

1. Defined as the percentage of the total basal area made up of stems greater than 3.5 inches in diameter.

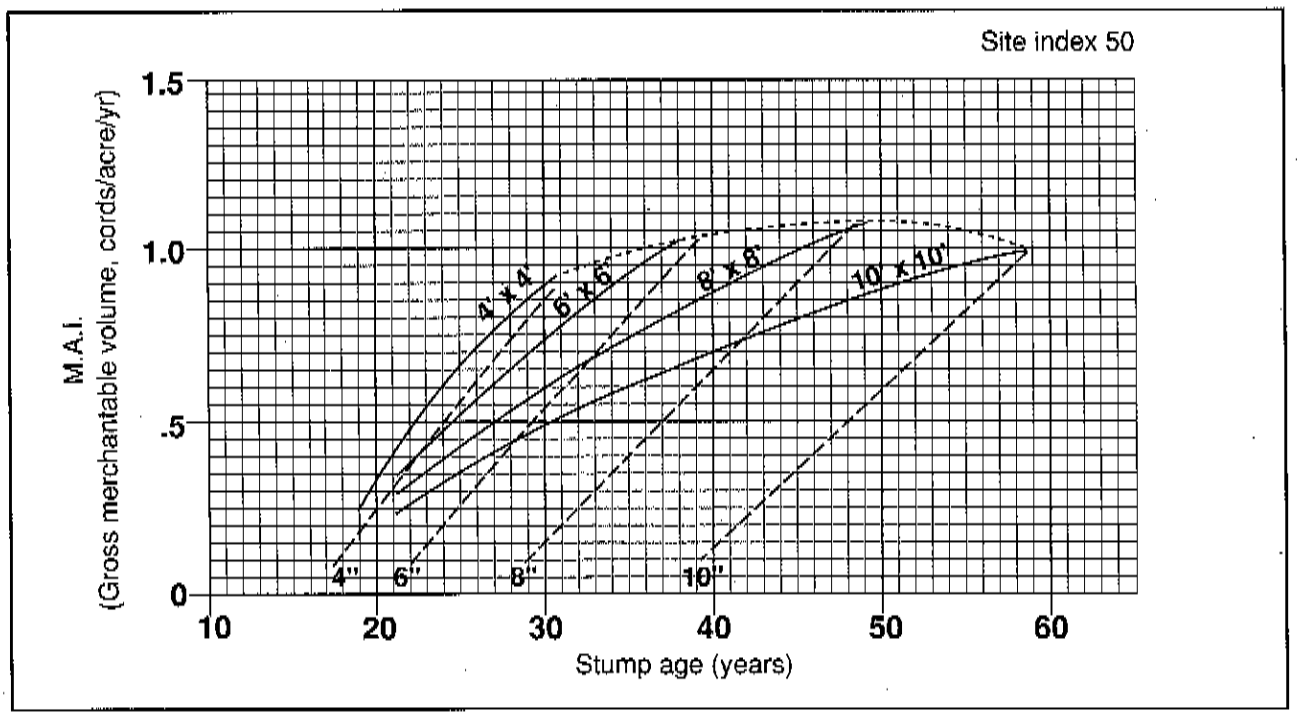

Figure 2. Diameter and merchantable volume growth projection curves for softwood species in plantations or cleaned stands. From the Nova Scotia Forestry Field Handbook (Anon., 1984).

_ _ _ _ _ _ Expected total average stand diameter for any age and spacing intensity.
_____ Expected average volume growth (MAI) for different initial spacing intensities.
. . . . . Point of maximum mean annual increment or full stocking. Projections not valid beyond this point.

INGROWTH

Ingrowth of spruce, fir and hardwoods occurred to varying degrees within the blocks. These trees seeded in or sprouted after the 1968 spacing. Ingrowth was not included in the 1983 assessment.

SUMMARY

Fifteen years after cleaning two dense, young red spruce stands, in western Nova Scotia, it was found that (Figure 3):

1) Average stand diameter was increased by 56%, 96%, 139% and 161%, for plots cleaned to 4 x 4, 6 x 6, 8 x 8 and 9.5 x 9.5 foot spacings respectively, as compared to the controls.

2) Total volume and total basal area were inversely related to spacing. The widest spacing (9.5' x 9.5') resulted in the highest average decrease in total volume and total basal area equivalent to 46% and 55% of the respective value for the controls.

3) Merchantable volume increased with cleaning. The largest increase was found at the 4 x 4 foot spacing and was 37% greater than the control.

4) The percentage of the total basal area considered merchantable increased with cleaning. At 30 years of age, almost all of the basal area in the plots spaced to 8 x 8 and 9.5 x 9.5 feet was merchantable, whereas, in the control plots only 41% was found to be merchantable.

5) Cleaning increased the percentage of red spruce in each block. Before cleaning, red spruce accounted for 75% and 59% of the stems at Sites A and B respectively. After cleaning, the red spruce content increased to 92% and 89%.

This experiment also indicates that the NSLF growth projection curves can accurately predict average stand diameter, volume growth and therefore rotation age for cleaned red spruce stands. For the two stands in this study, the predicted MAI and average stand diameter, averaged for all treatments, were within 5.4% and 1.0% respectively of actual values. The major discrepancies between the predicted and actual mean stand density, merchantable volume and mean annual increment occurred in Plot 3, Site B and Plots 3 and 4, Site A. These differences are attributed to the excessive damage within these plots caused by porcupine feeding.

DISCUSSION

Which of the various spacing treatments is the best? In order to provide some answers to this question, the red spruce stands studied here were projected ahead to rotation age using the NSLF growth curves and 1983 actual densities (Table 3). By examining these projections and the values shown in Table 2, it can be seen that the treated stands were yielding only 47 to 63% of their peak MAI in 1983. They also indicated that the time required to achieve peak MAI increases as spacing increases. At the widest spacing (9.9' x 9.9'), maximum MAI will not be reached until age 58 versus 38 years for the 6.0' x 6.0' spacing. It is interesting to note that the MAI at rotation age is approximately the same no matter what the spacing (Table 3). The choice of spacing, therefore, must be based on economic considerations as well as the needs and objectives of specific land owners or governments.

For example, if the forest manager's goal is to avoid wood shortages in the short term, then choosing a narrow spacing will make wood available in the least amount of time. Spacings less than 6' x 6' are not normally prescribed because of the high cost of harvesting small diameter wood. If on the other hand, wood supply in the near term is not a consideration, a wider spacing will result in larger diameter trees and lower logging costs. However, if volume production is not to be sacrificed, these benefits will only be realized at the expense of a longer rotation age. Similarly, the growth projection curves indicate that the production of large diameter trees for sawlogs, where intermediate thinnings are not planned, can best be achieved by choosing a wider spacing.

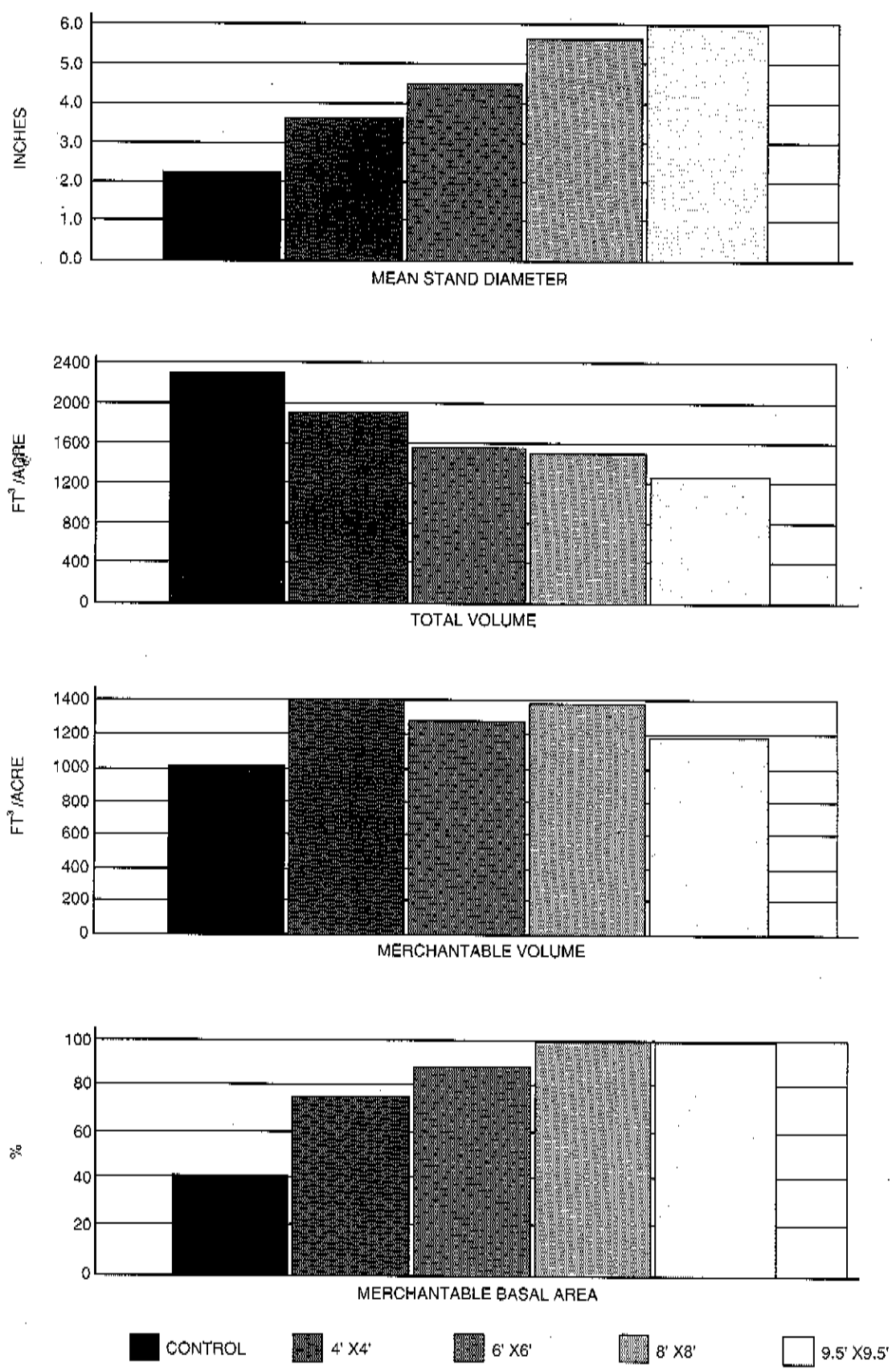

Figure 3. Fifteen year changes in diameter, volume and percent merchantable basal area (averaged for both sites) as a result of cleaning two dense, young red spruce stands.

Table 3. Projected effect of spacing intensity on average stand diameter, mean annual increment, merchantable volume and rotation age.[1]

Actual Spacing 1983	Rotation Age[2] (years)	Avg. Total Stand Dia.[3] (inches)	MAI Gross Merch Vol.[3] (cords/acre/year)	Merch. Volume[3] (cords/acre)
SITE A				
4.7' x 4.7'	33	4.3	0.96	32
6.0' x 6.0'	38	5.7	1.03	39
7.5' x 7.5'	46	7.5	1.07	49
SITE B				
7.1' x 7.1'	44	6.9	1.06	47
9.3' x 9.3'	56	9.3	1.05	59
9.9' x 9.9'	58	9.9	1.01	59

1. Based on Nova Scotia Lands and Forests growth projection curves (Anon., 1984).
2. Defined as the age at maximum MAI (cords/acre/year).
3. At rotation age.

The reader will also note that spacing and the average diameter at rotation age are approximately numerically equal (Table 3). This illustrates an important rule of thumb for red spruce and most of the other softwood species; namely, that the average diameter at rotation age will be approximately equal to the initial spacing when specified in imperial units. For example, if an average diameter of 6" is desired at rotation age, the immature softwood stand should be spaced to 6' x 6'. This rule of thumb does not apply to the heavy softwoods, i.e. larch and jack pine.

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