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FOREST RESEARCH REPORT

No. 36 March 1992

A SURVEY OF PRECOMMERCIALLY THINNED SOFTWOOD STANDS IN NOVA SCOTIA

INTRODUCTION

Precommercial thinning is an operation designed to shorten the age to operability of dense, naturally regenerated forest stands by promoting the growth rate of desirable crop trees. If the operation is conducted when the average tree height is between 1.5 and 9 metres (m), the time to reach merchantable size can be reduced by up to 30 years (NSDLF, 1983). Because of this, precommercial thinnings play a major role in achieving the Provincial Government's goal of doubling forest industry production by the year 2,025 (Anon, 1986). In addition to shortening the time to reach operability, precommercial thinning also improves stand quality and composition through careful selection of desirable species and trees of good form and vigour. Precommercially thinned stands make ideal candidates for future commercial thinning because they will be available for treatment up to 30 years sooner than unmanaged stands. Often they have the added advantage of being more vigourous, higher in quality and more windfirm. To date, approximately 72,000 hectares (ha) of juvenile stands have been precommercially thinned in Nova Scotia.

In 1988, a survey was initiated by the Nova Scotia Department of Natural Resources to (i) assess the condition of stands precommercially thinned prior to 1984, and (ii) provide information required to calibrate and assess the accuracy of the Nova Scotia Variable Density Growth and Yield Model. This report concentrates on the former objective.

METHODS

Stand selection

Fifty three stands, treated between 1966 and 1983, were selected from a comprehensive list to ensure an even distribution by region and year treated. Spruce and fir precommercial thinnings, representing a range of spacing regimes, were given priority for selection. Stands that were severely damaged by the spruce budworm and/or improperly treated were rejected for assessment. Four assessed stands were eliminated due to insufficient data. With two exceptions, the assessed stands ranged from

Canada

Nova Scotia

2 to 20 ha in size. Table 1 and Figure 1 show the number and distribution of sampled stands by region and treatment period.

Table 1. Total area and number of precommercially thinned stands sampled by region and treatment period.

Region	1966 - 1970		1971 - 1975		1976 - 1980		1981 - 1983		Total by Region	
	(ha)	(#)	(ha)	(#)	(ha)	(#)	(ha)	(#)	(ha)	(#)
Eastern	83	6	53	5	67	5	53	3	256	19
Central	25	3	100	5	34	2	49	5	208	15
Western	57	4	55	5	20	4	19	2	151	15
Total	**165**	**13**	**208**	**15**	**121**	**11**	**121**	**10**	**615**	**49**

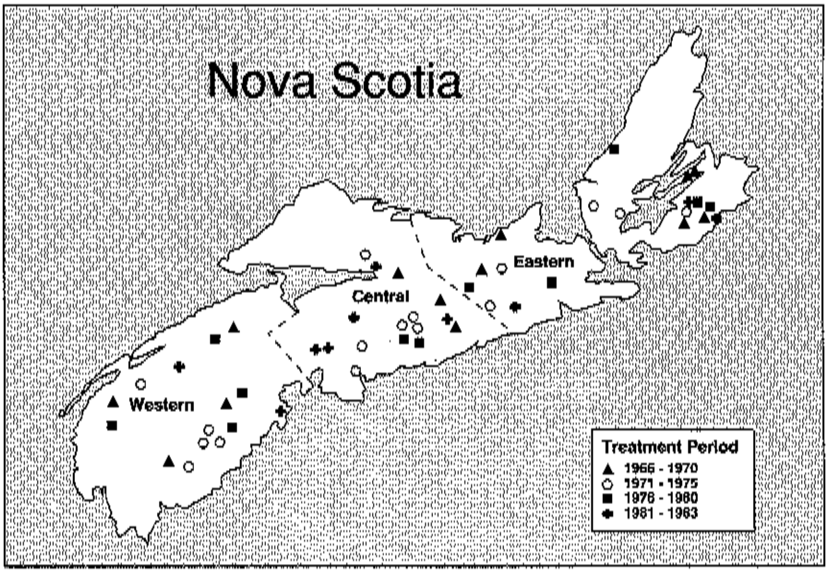


Figure 1. Location of sampled stands by treatment period and region.

Sampling procedure

Ten plots were located systematically along predetermined cruise lines in each stand. Plot size was based on the estimated average tree spacing (Table 2).

Table 2. Plot radius and size by average tree spacing.

Average Spacing (m)	Plot Radius (m)	Plot Size (ha)
1.8 x 1.8	6.12	1/85
2.1 x 2.1	7.00	1/65
2.4 x 2.4	7.98	1/50

Plots were excluded if: (i) a number of residual or remnant trees from the previous stand were present, (ii)greater than 10% of the plot fell on unproductive land[1], or (iii) the plot fell on a road or trail. An excluded plot was replaced by one located 1/2 the distance to the next plot.

In every plot, the **regeneration**[2] was tallied by species, height class, and origin. All other standing trees, **living** or **dead**, were measured at breast height for diameter in centimetres (cm) and rated as to their health, vigour, and dominance. Live trees were classified as either **crop**, if they were expected to be merchantable at the time of harvest, or **suppressed** if they were not. An estimate of the number of trees required to fill holes in the canopy was determined by considering average tree spacing and crown size. These trees were classified as **missing** and represented the estimated number of average crop trees required to bring the plot stocking to 100%.

Based on these stem counts the following estimates of stocking were made:

i) Stocking immediately after treatment,

$$\textit{Treatment Stocking} = \frac{\textit{Live + Dead Trees}}{\textit{Live + Dead + Missing Trees}} \quad [1]$$

ii) Stocking at the time of assessment, and

$$\textit{Assessment Stocking} = \frac{\textit{Live Trees}}{\textit{Live + Dead + Missing Trees}} \quad [2]$$

iii) Stocking to crop trees at the time of harvest (as judged by the data collectors).

$$\textit{Crop Tree Stocking} = \frac{\textit{Crop Trees}}{\textit{Live + Dead + Missing Trees}} \quad [3]$$

Three of the ten plots were required to be **stocked** (greater than 90% treatment stocking) for growth analysis purposes. If stocked plots were not found at the predetermined points along the cruise line, offsets were taken until 3 were located. In these plots, additional data were collected for growth analyses. Three trees,

[1] Land capability 3 or less (LC3), Figure 2a and Figure 2b.

[2] Trees that established themselves following the precommercial thinning, and were not part of the main canopy at assessment time were classified as regeneration.

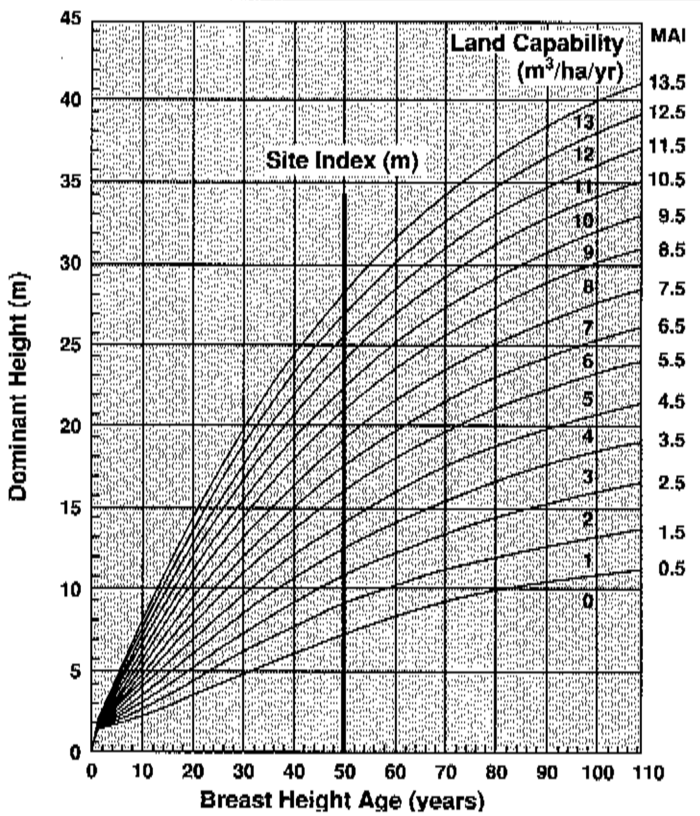


Figure 2a. Land capability (LC) and site index (SI) curves for Nova Scotia softwoods. Land capability is expressed in merchantable m³/ha/yr and site index as dominant height, in metres, at 50 years (breast height).

with diameters as close as possible to the quadratic mean diameter of the crop trees, were located and flagged. Their stump age and the distance to the nearest crop tree in a north, south, east, and west direction were measured. An increment core, or disk, was taken from each of the 3 trees at breast height. The diameter (inside and outside bark), age, 5 year growth increments, and diameter at the time of treatment were measured on each disk. In the same plot, the height, diameter, and stump age of the 3 tallest dominant trees, along with the height and diameter of 7 other trees representing the range of diameters and heights in the plot were recorded.

These data were used to calculate site index at age 50 (SI(50)) in 2 ways: (i) from top height and breast height age of dominant trees (Figure 2a), and (ii) from top height and stump height age of dominant trees (Figure 2b).

Spacing between trees was calculated by both a direct measurement and an indirect calculation. The **direct** method averaged the distances to the nearest crop tree in the north, south, east, and west directions. The direct calculation was made in the stocked plots only.

$$Spacing = \frac{North(m) + South(m) + East(m) + West(m)}{4} \quad [4]$$

The **indirect** method, based on stem density, is as follows:

$$Spacing = \sqrt{\frac{10{,}000\ (m^2/ha) \times Plot\ Size\ (ha)}{Live + Dead + Missing\ Trees}} \quad [5]$$

The indirect calculation was made in all plots.

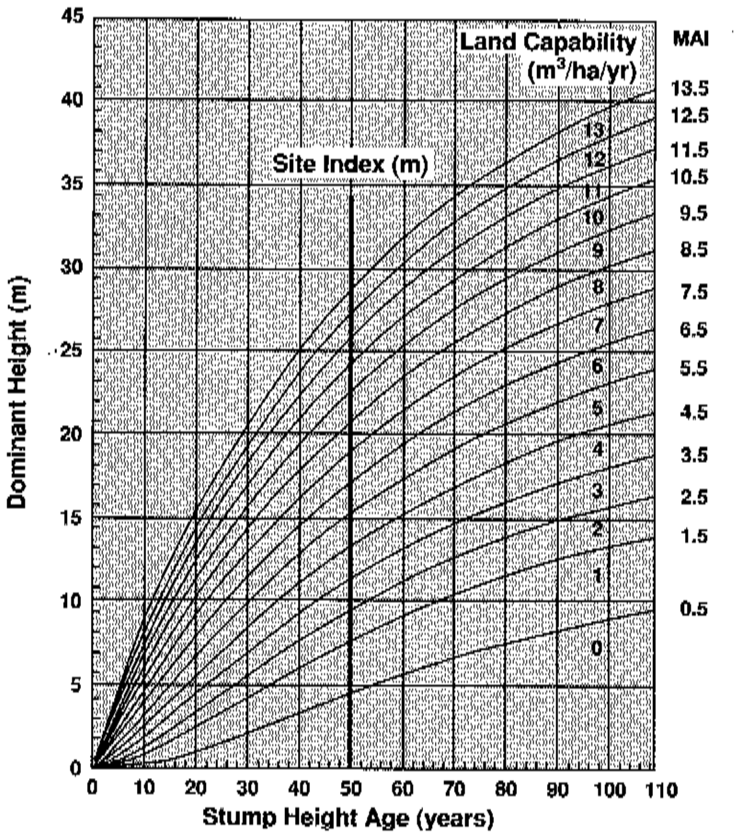


Figure 2b. Land capability (LC) and site index (SI) curves for Nova Scotia softwoods. Land capability is expressed in merchantable m³/ha/yr and site index as dominant height, in metres, at 50 years (stump height).

Sample description

Forty nine precommercially thinned stands, encompassing an area of 615 ha (1520 acres), ranging in age from 15 to 45 years, were sampled. The average stand size was 12.5 ha (31 acres) (Figure 3), and the total number of trees measured was 13,460.

In 67% of the stands, the major species by occurrence was balsam fir (*Abies balsamea* (L.) Mill.), while red, white, and black spruce [*Picea rubens* Sarg.; *Picea glauca* (Moench.) Voss; *Picea mariana* (Mill.)B.S.P.] were the predominate species in most of the remaining stands. The most commonly sampled tree was balsam fir (51%) followed by spruce (40%), pine (3%) (*Pinus* spp.), other softwood (1%), birch (3%) (*Betula* spp.), maple (2%) (*Acer* spp.), and other hardwood (0.5%).

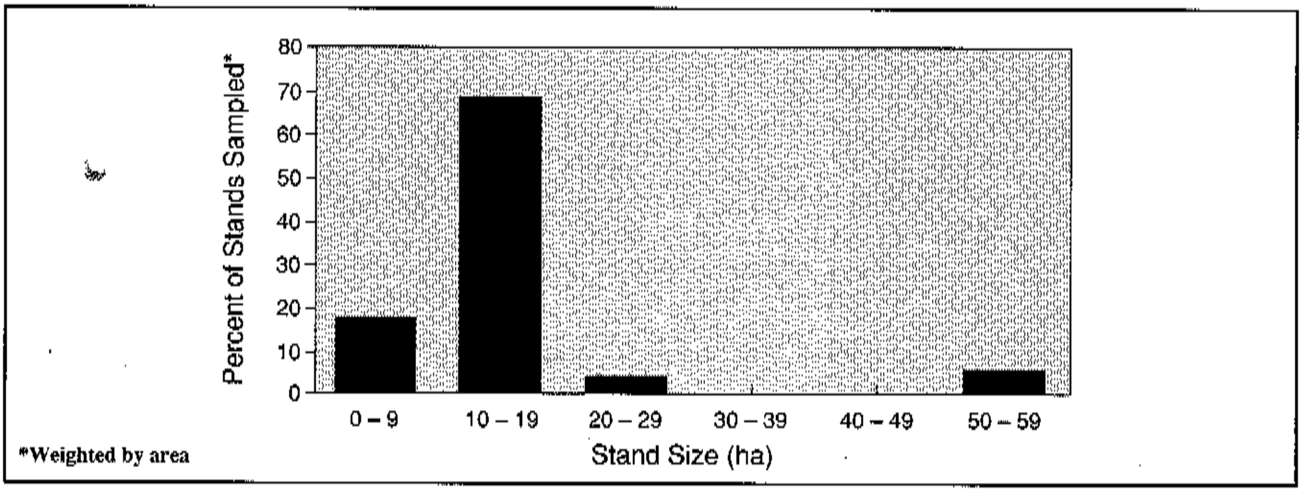


Figure 3. Distribution of stands by size.

Stocking[1]

The mean stocking, immediately after treatment, was estimated at 85%. By the time the stands were assessed, stocking had dropped to 82% due to mortality. At the time of assessment, it was estimated that some trees left for crop trees during the precommercial thinning operation would not be harvestable at rotation age due to suppression. When the suppressed and dead trees were excluded, crop tree stocking averaged 67%. Stocking to crop trees varied from 47% to 81%, with 72% of the sampled area over 60% stocked (Figure 4).

1 Stocking was determined including and excluding offset plots. The overall difference in stocking amounted to 1%. Unless otherwise noted, stocking figures cited in the text include offset plots.

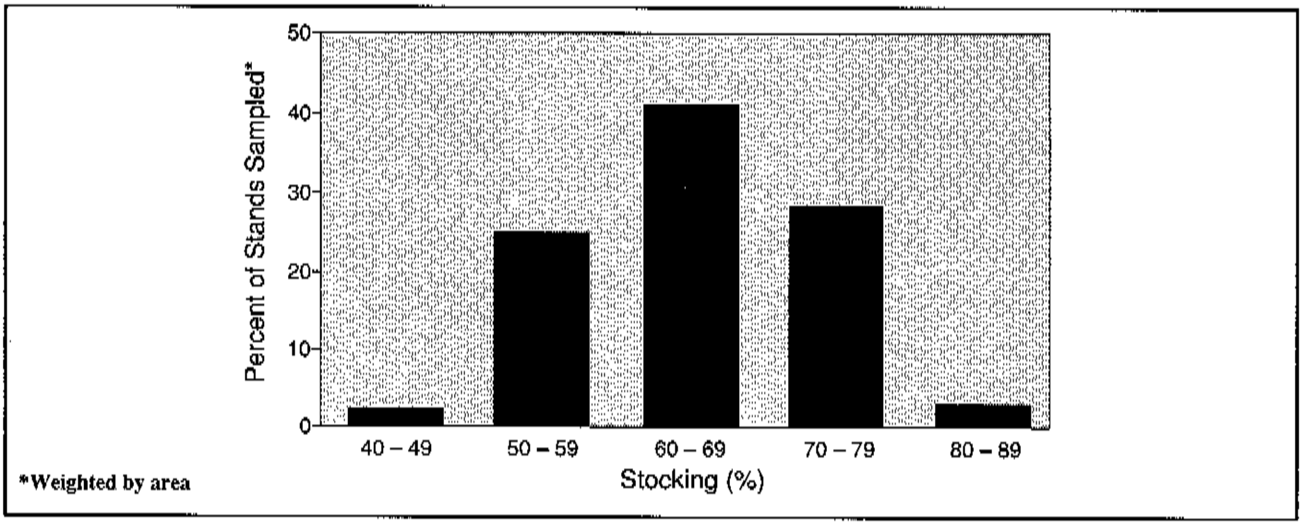


Figure 4. Distribution of stands by crop tree stocking *(excluding offset plots).*

Spacing

The mean spacing between trees, based on stem density, was 2.1 m, with 58% of the area sampled in the 1.5 to 2.0 m range (Figure 5). When the two methods of determining spacing were compared for the stocked plots (Equations [4] and [5]), it was found that the average difference of 4% was not significant at the 0.05 level (paired T-Test, n = 119).

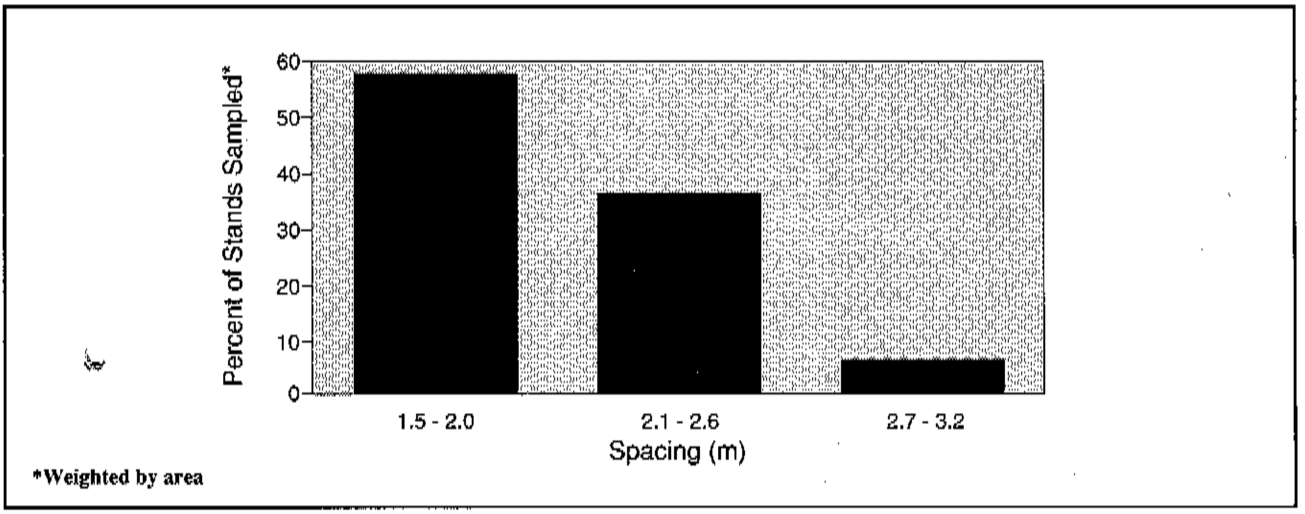


Figure 5. Distribution of stands by average spacing.

Age, DBH, and height at the time of precommercial thinning and time of remeasurement

Immediately after treatment, the average breast height age was 12 years and ranged from 3 to 30 years with over 70% in the 5-14 year group (Figure 6). Stump age averaged 18 years. The average diameter at breast height was 5.6 cm, and ranged from 1.8 to 10.3 cm (Figure 7). The average stand height at treatment time was estimated to be 5.5 m.

At the time of assessment, the average stand was 26 years at breast height, 32 years at stump height, 12.9 cm in diameter, and 9.4 m in height (Table 3).

Site index and land capability

The site index of all stands averaged 17.5 m at 50 years (SI(50) = 17.5 m), based on top height and age at breast height. The corresponding SI based on stump age SI(50) was 15.6 m. The average land capability (LC) based on breast age (Figure 2a) was 6.3 m^3/ha/yr. The land capability ranged from 3.8 to 9.9 m^3/ha/yr (Figure 2a; Figure 8), with over 60% of the area between LC 4.6 and LC 6.5.

Regional variations in selected stand parameters

The Eastern region had the youngest treatment age (9 years), the narrowest spacing (2.0 m), and the greatest crop tree stocking (70%) (Table 4). Conversely, the Western region had the oldest treatment age (14 years), widest spacing (2.3 m), and the lowest crop tree stocking (62%).

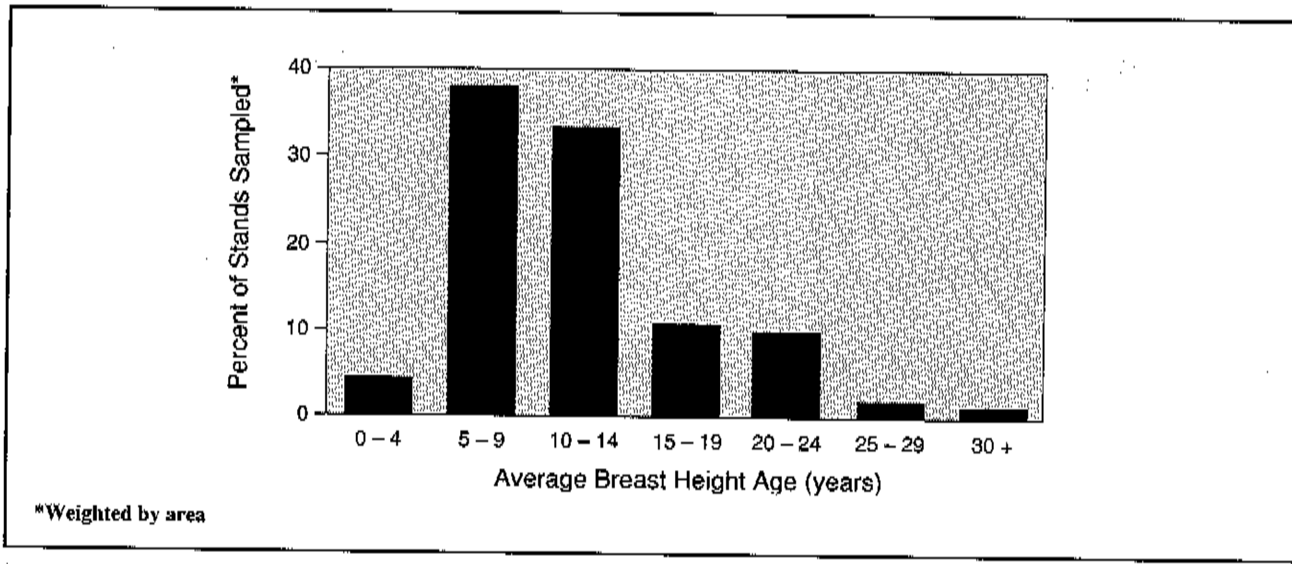


Figure 6. Distribution of stands by average age *immediately after treatment.*

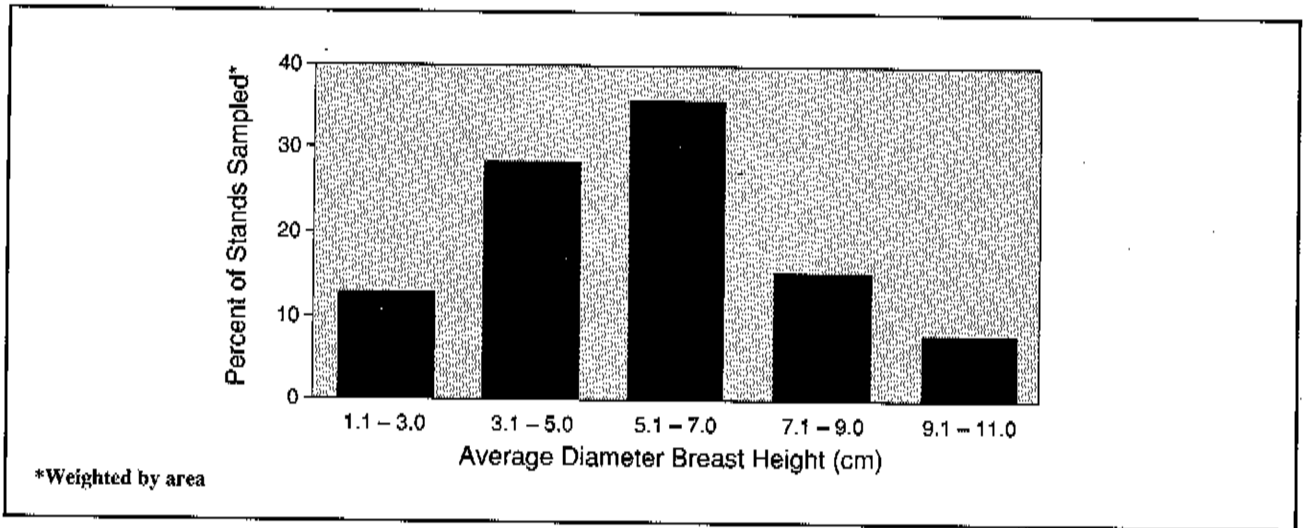


Figure 7. Distribution of stands by average diameter *immediately after treatment.*

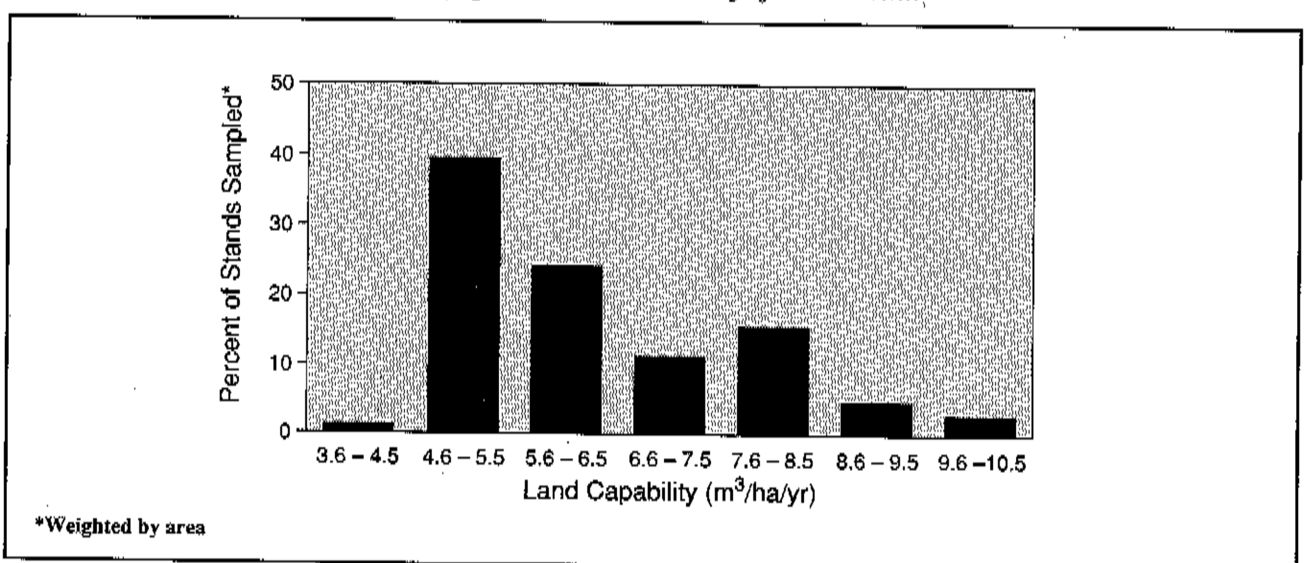


Figure 8. Distribution of stands by land capability.

Table 3. Average stand characteristics immediately after treatment and at time of assessment.

Stand Characteristics	Immediately After Treatment	Time of Assessment
Average Site Index (Breast Height) SI (50) (m)	-	17.5
Average Site Index (Stump Height) SI (50) (m)	-	15.6
Average Land Capability (m^3 / ha / yr) [1]	-	6.3
Stocking to All Trees (%)	85	82
Predicted Stocking to Crop Trees (%)	-	67
Average Stand Size (ha)	-	12.5
Breast Height Age (Average Tree (years))	12	26
Stump Age (Average Tree (years))	18	32
Spacing (m)	2.1	2.1
Total Diameter (cm)	5.6	12.9
Merchantable Diameter (cm)	-	14.6
Sawlog Diameter (cm)	-	18.1
Total Basal Area (m^2 / ha)	8.5	20.8
Merchantable Basal Area (m^2 / ha)	-	18.4
Sawlog Basal Area (m^2 / ha)	-	10.6
Total Height (m)	5.5	9.4
Merchantable Height (m)	-	9.8
Sawlog Height (m)	-	10.7
Total Frequency (live stems/ ha)	1927	1681
Merchantable Frequency (live stems/ ha)	-	1101
Sawlog Frequency (live stems / ha)	-	395
Total Volume (m^3 / ha)	-	98
Merchantable Volume (m^3 / ha)	-	78.4
Sawlog Volume (m^3 / ha)	-	50.2
(fbm / ha)	-	8885

[1] Based on Figure 2a.

Table 4. Selected stand parameters by region[1].

Region	Breast Height Age (yrs)		Average Crop Tree Diameter (cm)		Site Index (Breast Ht) SI (50) (m)	Spacing (m)	Total Height (m)	Stocking (%)	
	Treatment [2]	Assessment [3]	Treatment	Assessment				Treatment	Crop
Eastern	9	23	4.8	12.0	17.9	2.0	8.8	84	70
Central	14	27	6.1	12.6	16.4	2.1	9.3	83	68
Western	14	28	6.3	13.8	18.3	2.3	10.5	89	62
Province	**12**	**26**	**5.6**	**12.7**	**17.5**	**2.1**	**9.4**	**85**	**67**

[1] Weighted by Stand Area.
[2] Immediately after treatment.
[3] At assessment time.

Stand health and vigour

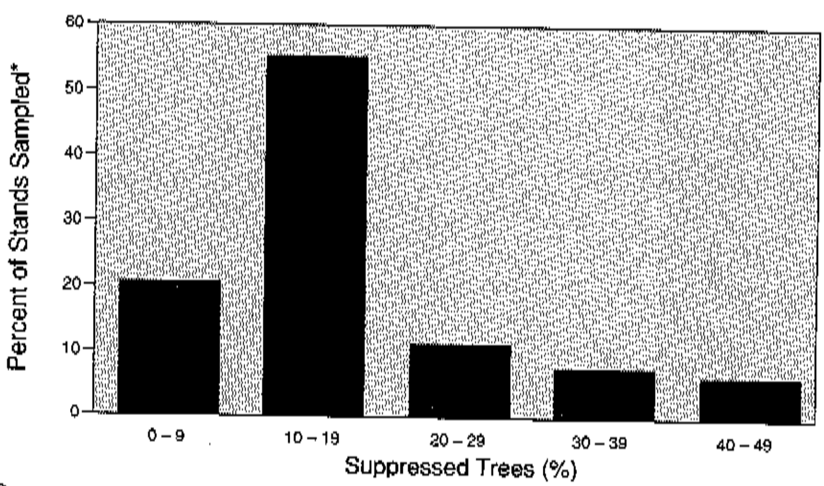
Of the 13,460 trees sampled, 94% were rated as healthy and 71% of the total were classified as free growing crop trees (Table 5). The percentage of crop trees was highest in the Eastern region (81%), and lowest in the Western region (65%). The number of suppressed trees was highest in the Western region (28%). The percentage of suppressed trees averaged 22% and ranged from 0 to 43%. Seventy-eight percent of the stands (weighted by area) had fewer than 20% suppressed trees (Figure 9).

Damage and disease

The number of damaged trees was minimal (3%, Table 5) with half of the damage being attrib-

Table 5. Status of trees assessed in the sample by region, expressed in percent.

Status	Description	Region			Total for Province
		Eastern	Central	Western	
Healthy	Crop	80.7	75.0	64.9	71.2
	Suppressed	14.3	15.1	28.0	21.8
	Residual	1.0	1.2	0.9	1.0
	Total Healthy	**96.0**	**91.3**	**93.8**	**94.0**
Damaged	Partial Blowdown	0.3	1.0	0.9	0.7
	Animal Damage	0.2	2.4	1.7	1.2
	Insect Damage	0.1	0.1	0.4	0.2
	Mechanical Damage	-	0.5	1.0	0.5
	Broken Top or Stem	0.2	0.7	0.3	0.4
	Total Damaged	**0.8**	**4.7**	**4.3**	**3.0**
Dead	Blowdown	0.2	0.5	-	0.3
	Animal Damage	0.1	2.6	0.4	0.7
	Insect Damage	1.4	-	0.1	0.4
	Mechanical Damage	-	0.1	-	-
	Broken Top	0.9	0.5	0.5	0.6
	Unknown	0.6	0.3	0.8	0.7
	Total Dead	**3.2**	**4.0**	**1.8**	**2.7**



***Weighted by area**

Figure 9. Distribution of stands by percentage of **suppressed trees.**

uted to animals. Mortality was also minimal (3%), 1/3 of which was also caused by animals. The highest rate of damage and mortality occurred in the Central region. It should be noted that severely budworm defoliated stands were excluded from the sample.

Regeneration

Regeneration was most abundant in the Central region at 4,000 stems/ha: 69% of it softwood. Regeneration was least abundant in the Eastern region at 2,414 stems/ha: 76% of it softwood. The average for all regions was 3,127 stems/ha.

Seventy percent of the measured plots had less than 4,000 stems/ha of regeneration and 4% had no regeneration (Figure 10). The majority of the regeneration was softwood. In 52% of the plots, over 80% of the regeneration was softwood. Thirty eight percent of plots had no hardwood regeneration. Where spacing was less than 2.1 m, softwood was more than twice as abundant as hardwood. Where spacing was greater than 2.7 m, the percentage of hardwood and softwood regeneration were almost equal.

More than 60% of the plots had regeneration in each of the height classes up to 4 m. Only 18% of the plots had regeneration in the 5 m+ category (Figure 11). The average stand height

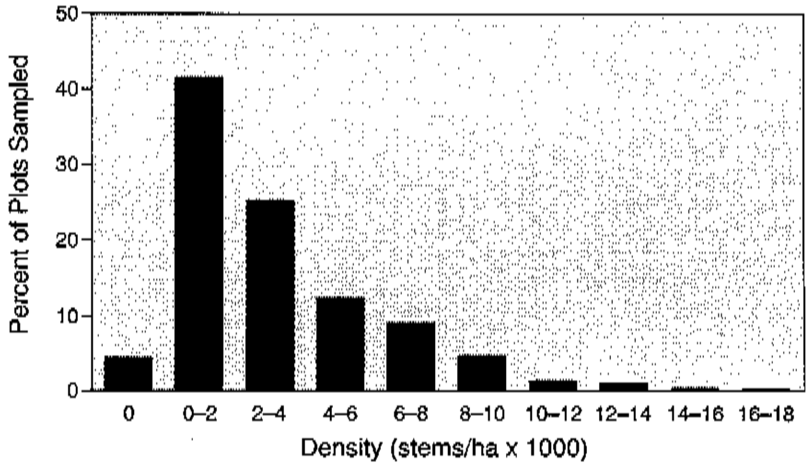


Figure 10. Distribution of plots by **regeneration density.**

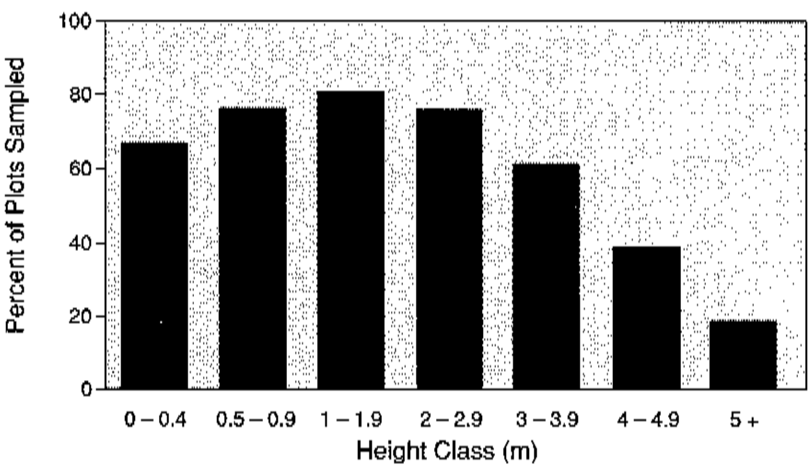


Figure 11. Distribution of stands by **regeneration height.**

in these plots was 9.7 m. Of the plots (82%) that did not have regeneration in the 5 m+ category, only 2% had an average regeneration height within 2 m of the average height of the main canopy (Figure 12). The taller regeneration consisted of mainly hardwood stems while the shorter regeneration was predominantly softwood. Of the regenerating stems exceeding 5 metres in height, 96% were hardwood (Appendix I). On the other hand, only 1% of the regeneration less than 0.5 m tall was hardwood. The average height of softwood was less than 2 m in 83% of the plots. The average height of hardwood was less than 5 m in 97% of the plots. Sixty four percent of the regeneration was classified as suppressed.

Only 10% of the regeneration stems originated from a live branch below the level of the stump cut (Appendix II). Regeneration originating from live branches was not interfering with crop trees. In fact, only 2% of these trees were within 4 m of the average stand height (Figure 13) and only 1 plot (0.2%) had live branch regeneration in the 5 m+ category.

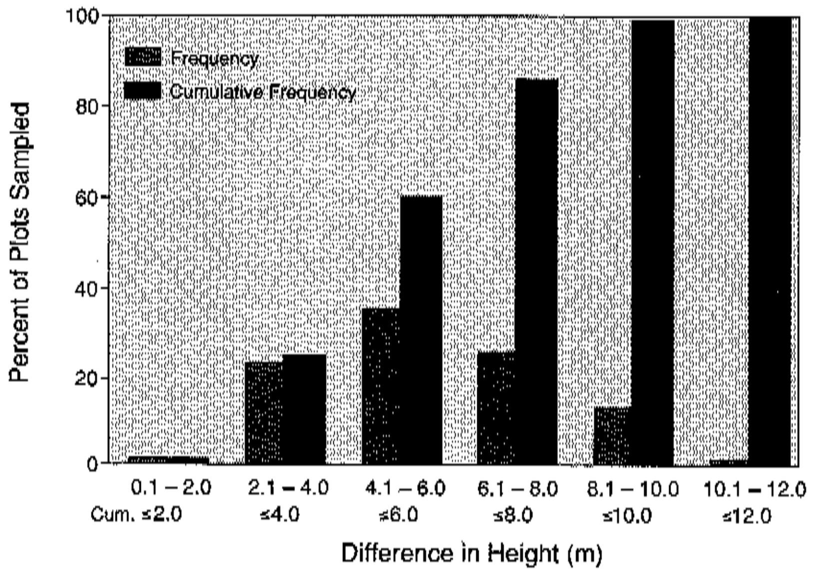


Figure 12. Distribution of plots by the difference in height between the main canopy and the tallest regeneration (excluding plots with regeneration in the 5m+ category).

Periodic diameter growth

Diameter growth measurements in stocked plots indicate that the average stand grew 3.0 cm the first 5 years after treatment, or 0.6 cm/yr. Subsequently, 5 year average diameter increments decreased; falling to 2.6 cm for years 6-10, 2.1 cm for years 11-15, and 1.6 cm for years 16-20.

Growth of precommercially thinned versus nontreated stands

How much sooner will a precommercially thinned stand reach rotation age[1] than an untreated stand? Growth projections based on Nova Scotia's Variable Density Softwood Growth and Yield model (unpublished), indicate that the rotation age for the average treated stand in this study, would be reached at a breast height age of 42 years. At this time, the mean annual increment (MAI) would be 7.4 m^3/ha/yr and the diameter (dbh) would be 19.1 cm. This compares with a rotation age of 55, an MAI of 5.6 m^3/ha/yr, and a dbh of 14.5 cm for an untreated natural stand located on the same site (Table 7). Precommercial thinning therefore, reduced projected rotation age by 13 years and increased MAI and average stand diameter by approximately 30%.

[1]Based on peak mean annual merchantable volume increment (MAI)

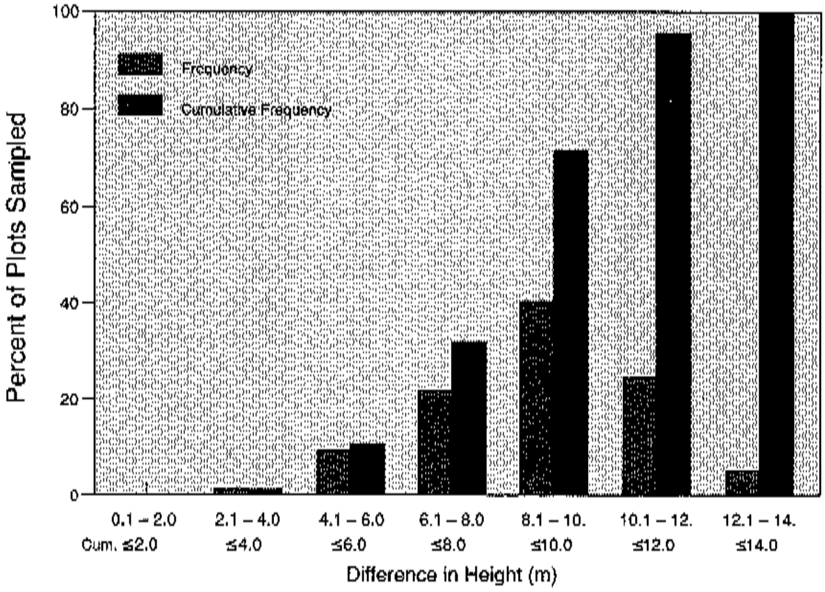


Figure 13. Distribution of stands by the **difference in height** *between the main canopy and the tallest regeneration originating from a live branch.*

Table 7. Comparison of projected[1] growth and yield, at 42 years breast height age, for a precommercially thinned stand[2] versus an untreated natural stand.

Treatment	Age (years)		Mean Annual Increment[3]		Total Diameter[4] (cm)	Time to Grow one cm in Diameter[5] (years)
	Breast Height	Stump Height	(cords / acre / yr)	(m^3/ha/ yr)		
Nil[6]	42	48	1.0	5.6	14.5	3.3
Precommercial Thinning[7]	42	48	1..3	7.4	19.1	2.5

1 Based on Nova Scotia's Variable Density Growth and Yield Model (unpublished).
2 Precommercially thinned to 2.1 m spacing when breast age was 12 years and LC = 6.3 m^3/ha/yr (Figure 2a) or SI (50) = 17.5 m.
3 Mean annual merchantable volume increment based on stump age.
4 Total diameter (all trees 1.5 cm and greater).
5 Based on stump age.
6 Rotation age 61 years (stump height) based on peak MAI.
7 Rotation age 48 years (stump height) based on peak MAI.

SUMMARY

The major results of a survey[1] of 49 precommercially thinned softwood stands, 6 to 23 years after treatment, is as follows:

1) Immediately after treatment, the average age of surveyed stands was 12 years at breast height and 18 years at stump height. At this time, diameter averaged 5.6 cm and the average stand height was 5.5 m.

2) At the time of assessment, the average age at breast height was 26 years. The breast height site index (SI(50)) was 17.5 m, the diameter averaged 12.9 cm and the average height was 9.4 m.

3) In 67% of the stands, the major species was balsam fir, while white, red, and black spruce were the predominant species in

1 **those thinnings not properly carried out, or severely defoliated by the budworm were not surveyed.**

most of the remaining stands. Fifty one percent of the trees sampled were balsam fir and 40% were spruce.

4) The average spacing between trees at the time of treatment was 2.1 m.

5) At the time of assessment, 94% of the 13,460 trees sampled were healthy, 3% were damaged, and 3% were dead. Half the damage and one third of the mortality was attributed to animals.

6) Average stocking at the time of assessment was estimated to be 82%, the stocking to crop trees at rotation was projected to be 67%.

7) Regeneration averaged 3,127 stems/ha. Eighteen percent of the plots had regeneration taller than 5 m (predominantly hardwoods). Excluding plots with regeneration in the 5 m+ category, only 2% had regeneration within 2 m of the average stand height.

8) Thirteen percent or 304 stems/ha, of the regeneration originated from a live branch below the stump cut. Only 2% of this regeneration was within 4 m of the average stand canopy.

9) The diameter growth for the first five years after precommercial thinning averaged 3.0 cm, and progressively decreased in subsequent 5 year periods.

10) The Nova Scotia Variable Density Softwood Growth and Yield Model (unpublished) indicates that precommercial thinning reduced the rotation age by 13 years for the average stand surveyed.

LITERATURE CITED

Anonymous, 1986. *Forestry, A New Policy for Nova Scotia.* Government of Nova Scotia, Halifax. 11 pp.

NSDLF, 1983. *Submission to the Royal Commission on Forestry.* Nova Scotia Dept. of Lands and Forests, Halifax. 332 pp.

NSDLF, 1988. *Forestry Field Handbook*, Forest Research Section, Nova Scotia Dept. of Lands and Forest, Truro. 29 pp.

APPENDIX I

Number of stems per hectare of regeneration by species group and height class.								
Height Class (m)	Species					Percent	Percent Hardwood	Percent Softwood
	Balsam Fir	Spruce	Other Softwood	Tolerant Hardwood	Intolerant Hardwood			
0 - 0.4	362	129	1	1	6	16	1	99
0.5 - 0.9	431	112	4	6	27	18	5	95
1.0 - 1.9	463	102	4	28	105	22	15	85
2.0 - 2.9	290	87	4	35	285	22	43	57
3.0 - 3.9	69	19	2	28	253	12	77	23
4.0 - 4.9	13	2	1	10	166	6	90	10
5.0 +	2	1	-	4	79	3	96	4
Percent	52	14	1	4	29			

APPENDIX II

Number of stems per hectare of regeneration by species and origin.							
Origin of Regeneration	Status	Species					Percent
		Balsam Fir	Spruce	Other Softwood	Tolerant Hardwood	Intolerant Hardwood	
Seedling	Suppressed	1318	362	9	7	103	58
	Free Growing	119	46	5	12	75	8
Coppice	Live Branch	192	42	1	20	49	10
	Suppressed	-	-	-	20	172	6
	Free Growing	-	-	-	52	523	18
	Percent	52	14	1	4	29	

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