COOPERATION
COOPERATION AGREEMENT FOR FORESTRY DEVELOPMENT

ENTENTE DE COOPÉRATION SUR LE DÉVELOPPEMENT FORESTIER

FOREST RESEARCH REPORT

No. 51: July, 1994

A SURVEY OF REGENERATION UNDER SOFTWOOD AND MIXEDWOOD SHELTERWOODS (FIVE YEARS AFTER TREATMENT)

INTRODUCTION

Shelterwood cutting involves one or more spacing operation in a mature stand with the objective of regenerating a new evenaged stand under the shade of the existing overstory (Hannah, 1988). The new stand may develop from seed deposited after thinning or from advance regeneration developing under the protection of the thinned overstory. This method is particularly suited to regenerating shade tolerant species. In Nova Scotia, it is anticipated that a single thinning of 30 to 50 percent basal area removal will be sufficient to yield an adequate stocking of desirable established regeneration. If research proves this to be the case, expensive intermediate stages of shelterwood thinning will not be necessary.

The Shelterwood method began to gain popularity in Nova Scotia in 1978. Since then a total of 11,880 ha (29,360 acres) of mature forest have been treated under Federal/Provincial Forestry Agreements. Forty-six percent (5,460 ha) of this work has been carried out on small private land. Since 1987, over 80% of the shelterwoods occurred on small private holdings, with an average of 570 ha treated annually (Figure 1).

In 1992, a survey was initiated by the Nova Scotia Department of Natural Resources to determine the success, 5 years after treatment, of the Uniform Shelterwood method in softwood and mixedwood stands on small private lands (Appendix I). This report summarizes the survey findings particularly in relation to the following questions:

1. What is the stocking and density of desired commercial species?
2. What stage of development is regeneration at?
3. How many stands are adequately stocked with established commercial species?
4. What levels of competition are occurring?
5. What is the height growth rate of regeneration developing under the shelterwood canopy?
6. What future management input(s) will be required and when?
7. What levels of blowdown damage are incurred in the overstory as a result of thinning?

Canada

Nova Scotia

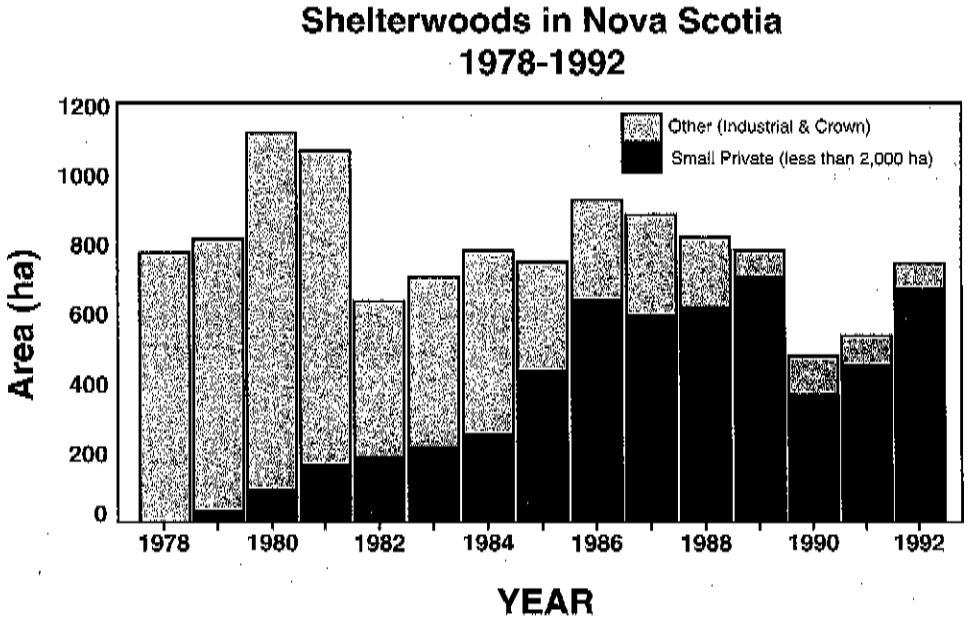


Figure 1. Area of shelterwood treatments in Nova Scotia since 1978 by ownership.

METHODS

Stand Selection

In 1987, 174 small private-land stands encompassing 572 ha were treated with a first stage uniform shelterwood cut. Thirty-two percent were less than 1 hectare in size and were excluded from the survey. The remaining 118 stands included an undeterminable number of hardwood stands which, when encountered during the survey, were excluded.

A total of 14 softwood and 5 mixedwood stands (106.5 ha) were selected to be surveyed (Figure 2). Average surveyed stand size was 5.6 ha. Seventy-four percent were less than 5 ha, 16% were between 5 and 15 ha, and 11% were larger than 15 ha. Eleven stands were located in the Western region and 8 in the Central region. All of the 1987 shelterwoods in the Eastern region were conducted in hardwood stands and thus were not included in the survey.

Sampling Procedure

Stands were sampled at an intensity of 1.5 percent with a minimum of 10 plots and maximum of 56:

$$\#\ \text{PLOTS} = \frac{\text{STAND AREA (HA)} \times 10{,}000\ \text{M}^2/\text{HA} \times 0.015}{16\ \text{M}^2/\text{PLOT}}$$

Prior to the field assessment, sketches were used to establish cruise lines and plot locations. Plots consisted of four, 4 m^2 quadrants. A plot radius of 2.25 m was used to provide 1/2500 ha quadrants, thus permitting stocking calculations based on a full stocking of 2500 trees/ha (2m x 2m spacing).

At each plot, basal area was measured with a 2-factor prism and the condition of the canopy, stand, site, and regeneration were assessed.

In each quadrant, the regeneration was assessed. The dominant and co-dominant tree were chosen based on height. The species and height were recorded, as well as the origin (seed, sucker,

or sprout) of the dominant tree. If of equal height, softwood species were given preference over hardwood for dominance, with the hardwood recorded as co-dominant.

A total stem count was made in the 4th quadrant, with a separate tally for each species, height class, and origin.

At each plot, the established softwood seedling nearest to plot center, and with at least 5 years of growth, was selected and the height, origin, competition, and last 5 years height growth, were recorded.

Stand blowdown, competition, slash, and scarification levels were visually assessed and recorded.

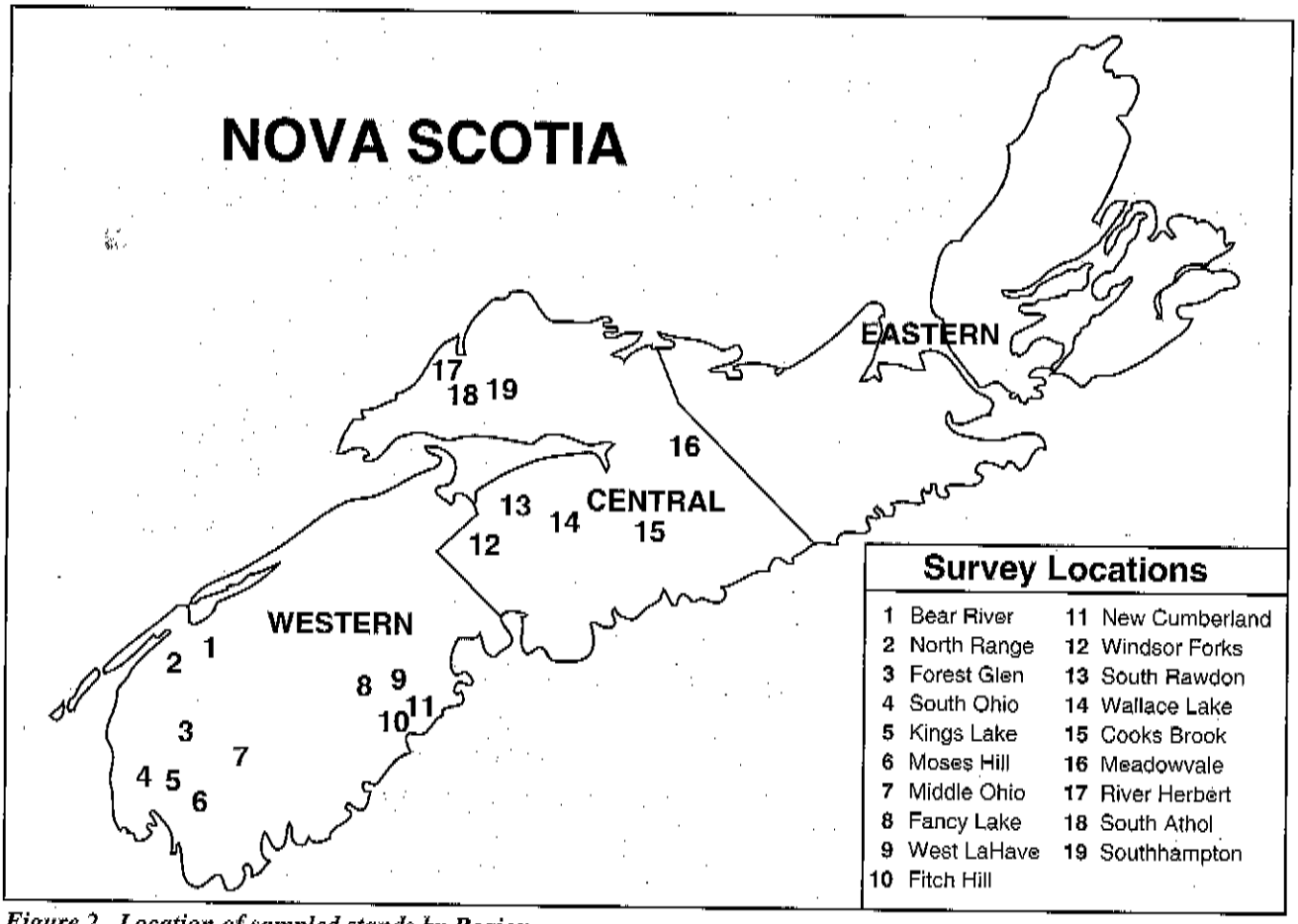


Figure 2. Location of sampled stands by Region.

DATA ANALYSES

In this report, stocking is based on a "select" Dominant/Codominant classification, in which codominant softwoods were preferentially "selected" to stock a quadrant over dominant hardwoods (Table 1). As well, codominant *preferred* hardwoods were selected over dominant *other* hardwoods (classification in Appendix II). This was done on the basis that future weeding or thinning would permit this selection.

Table 1. Example of "Select" classification.

Dominant	Codominant	Select Choice
Softwood (BF)	Softwood (RS)	Softwood (BF)
Softwood (RS)	Hardwood (YB)	Softwood (RS)
Hardwood (YB)	Softwood (RS)	Softwood (RS)
Other Hardwood (RM)	Preferred Hardwood (YB)	Preferred Hardwood (YB)
Other Hardwood (RM)	Other Hardwood (BE)	Other Hardwood (RM)

Each stand was given equal weighting in the analyses regardless of size or number of sample plots. With the largest stand (29.5 ha) accounting for 28% of the surveyed area, weighting by area would place too much emphasis on the performance of one site.

Height Classification

Seedling height is one of the main criteria for assessing the quality of regeneration (Maass, 1990). Height is also a major determinant in assessing the type and timing of the future management of shelterwood treated stands (Hannah, 1988; Yuill, 1980). Sufficient regeneration to insure adequate stocking should be established prior to overstory removal. Yuill (1980) suggests a height of 12 to 25 cm for softwood in Nova Scotia, while Federal - Provincial Cooperation Agreement Guidelines (Anon, 1994) recommend a minimum height of 10 cm for seedlings firmly rooted in mineral soil.

The regeneration was divided into 4 height classes to estimate its degree of establishment:

Table 2. Height class descriptions.

Height Class	Height Range (cm)	Description
1	less than 10	***PRE-ESTABLISHED:*** survival uncertain, with or without overstory removal.
2	10 to 29	***ESTABLISHED:*** capable of continued survival in understory, able to survive overstory removal
3	30 to 149	***ESTABLISHED:*** ideal stage for overstory removal
4	greater than 149	***TOO TALL:*** special care may be required during overstory removal to prevent damage.

RESULTS AND DISCUSSION

Regeneration Stocking

Stocking to commercial species (Appendix II) was 95 percent, with all stands averaging greater than 80% stocking. Most of the stocking was attributed to softwood (86%), followed by 2% *preferred* hardwood, and 7% *other* hardwood. Seventeen of nineteen stands averaged greater than 80% softwood stocking, with the remaining two stocked with 56 and 66 percent softwood (Figure 3). Both of the latter stands contained high stocking to hardwood. One had a hardwood dominated mixedwood overstory and regeneration composed of 44% beech and red maple sprouts. The other was a pure softwood stand in which 33% of the regeneration stocking was red maple and white birch seedlings. It contained abundant softwood regeneration that did not fall within the dominant/codominant classification (Appendix IIIa, Stand 14).

Height Class

The stands averaged 23, 68 and 4% stocking of *pre-established* (height class 1), *established* (2 & 3), and *too tall* (4) regeneration respectively (Table 3). The average height of regeneration was 35 cm (Table 3). *Established* regeneration (height classes 2 and 3 only) averaged 35 cm in height; 34 cm for softwood species, and 50 cm for hardwood.

Table 3. Average stocking by height class.

Height Class	Height Range (cm)	Average Height (cm)	Average Stocking (%)		
			Hardwood	Softwood	All
1	less than 10	6	1	22	23
2	10 to 29	17	2	40	43
3	30 to 149	61	3	22	25
4	greater than 149	227	2	1	4
Total		35	9	86	95

For height classes 2 and 3 combined (*established*), 64% of the stands had greater than 60% softwood stocking (Figure 4). Seventy-nine percent of stands had greater than 60% combined softwood and hardwood stocking, with *established* stocking in these stands averaging 75 percent. Ninety-five percent of the stands had greater than 60% softwood stocking in height classes 1, 2 & 3 combined. These results indicate that the softwood regeneration in approximately two thirds of the stands is sufficiently developed to permit immediate overstory removal, while the remaining third require additional growth to attain the minimum acceptable stocking of 60 percent. In stands where a high stocking of *pre-established* regeneration exists, it may be prudent to allow this to become established prior to overstory removal, even though the minimum stocking levels have been attained.

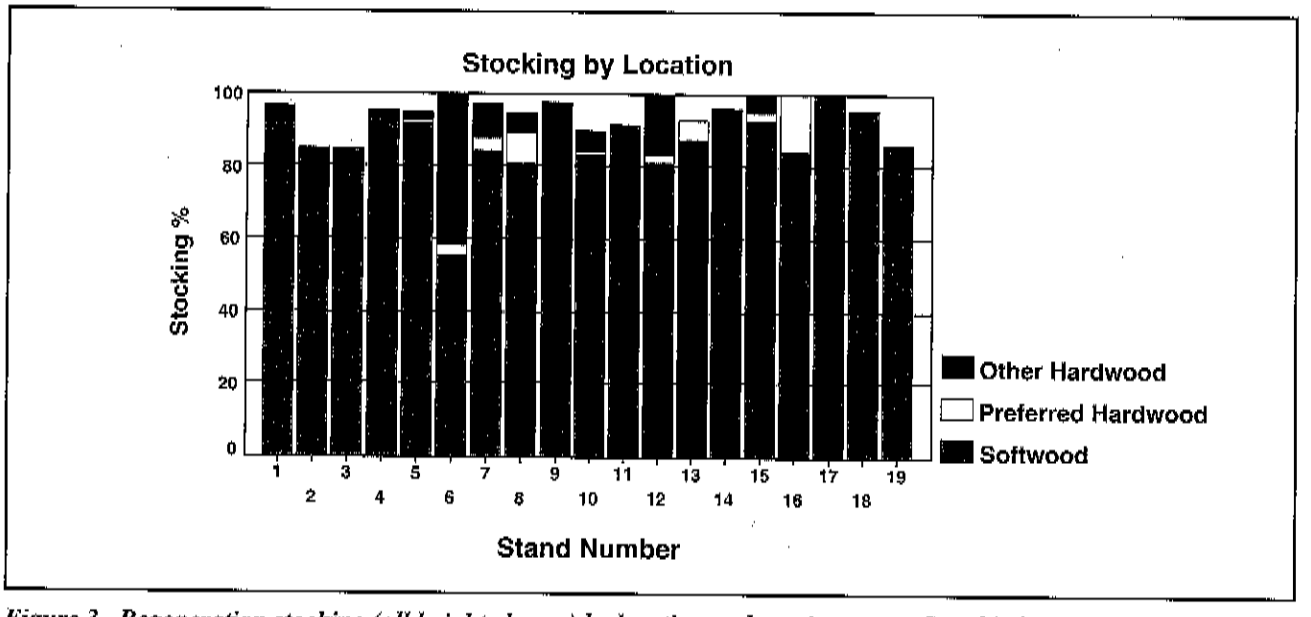
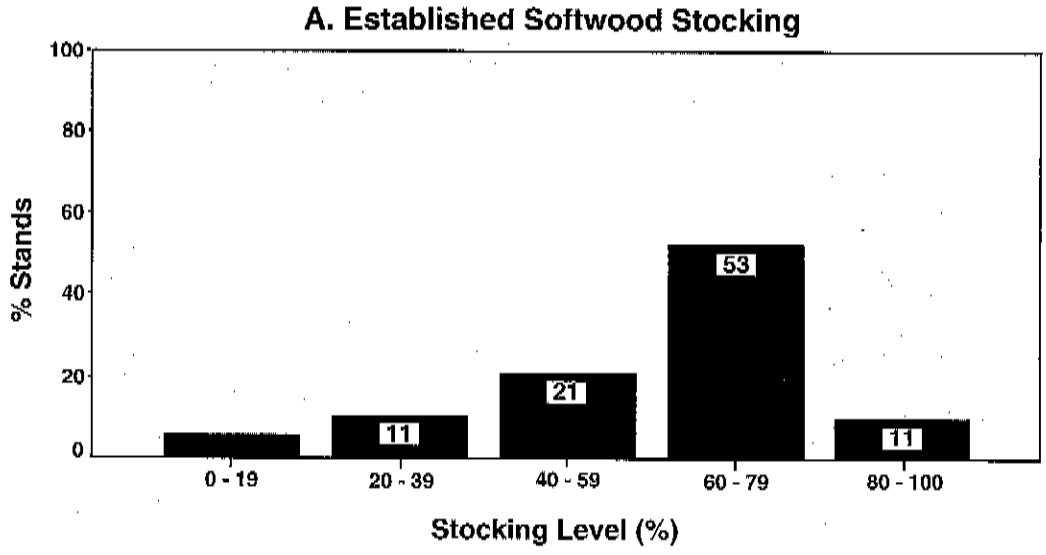


Figure 3. Regeneration stocking (all height classes) by location and species group. Stand information in Appendix I.



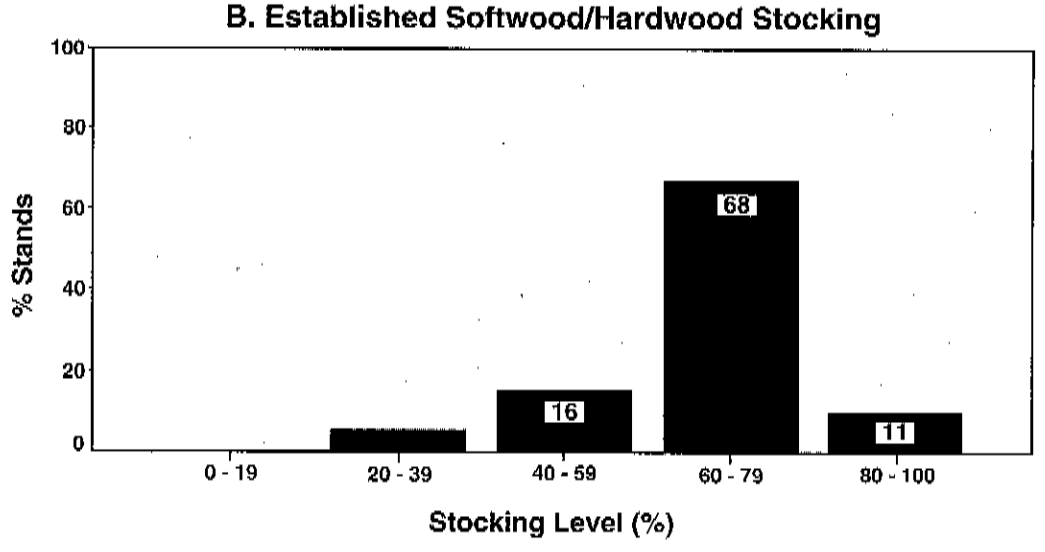


Figure 4 A & B. Percent of stands by stocking of established regeneration (Height Classes 2 & 3: 10 to 149 cm).

Species

Red Spruce had the highest average stocking per stand at 39 %, with Balsam Fir averaging slightly lower at 33 %. Hemlock and White Pine were next at 8 and 5 % respectively (Figure 5A). The average stand was stocked with 49% red spruce regeneration in either the dominant or codominant position.

When only *established* regeneration was considered (10 to 149.9 cm), stocking to balsam fir was slightly greater than to red spruce, averaging 28 and 26 % respectively (Figure 5B).

Under the select classification, hardwood species accounted for 9 % of the total stocking. Red maple accounted for 3 %, followed by yellow birch at 2 %. Disregarding this classification, stocking of dominant or codominant hardwood regeneration averaged 21 %.

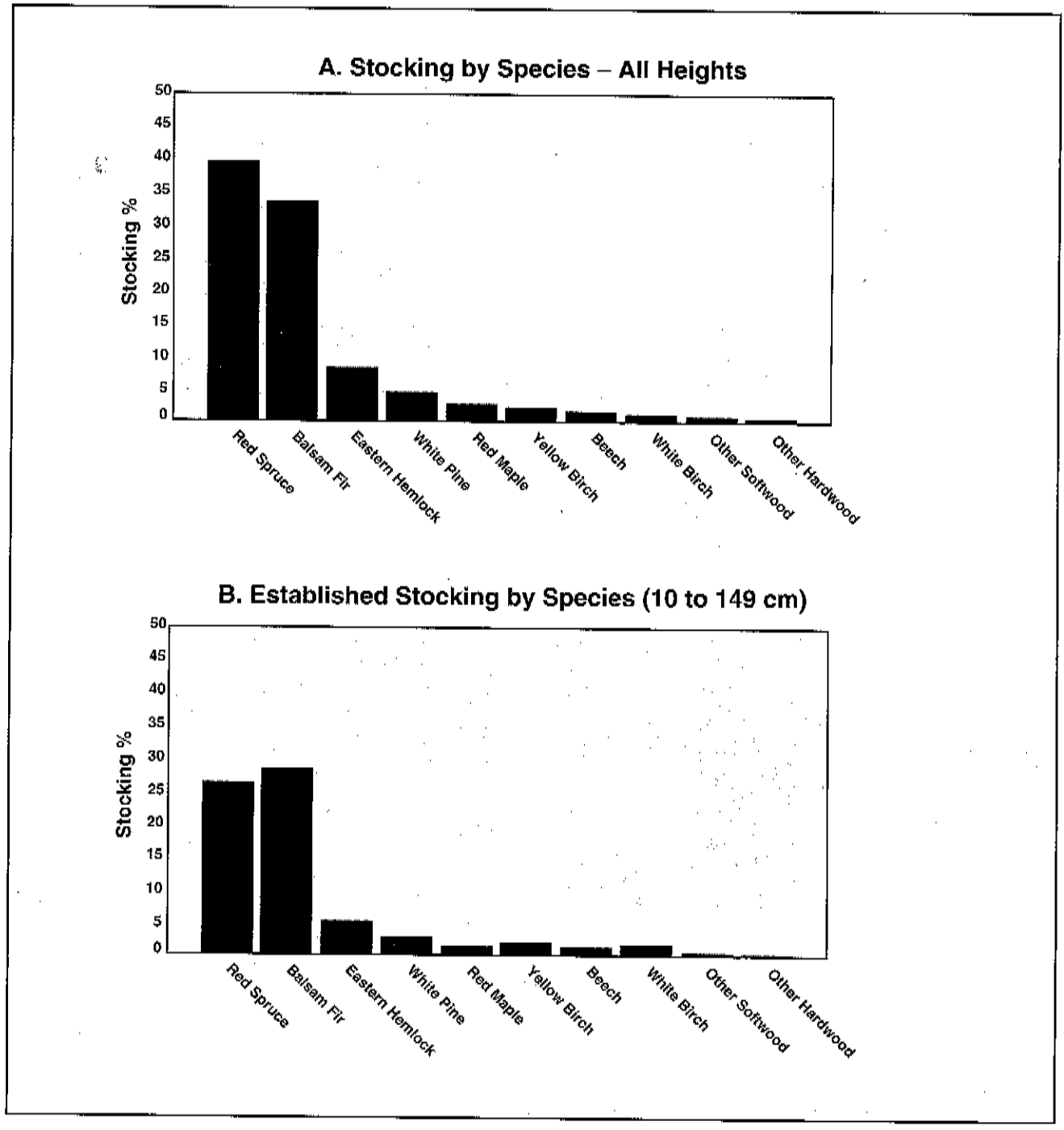


Figure 5 A& B. Regeneration stocking by species. Average for all locations.

Height Growth

Growth rates of softwood regeneration for the 5 year period following treatment were determined from measurements of 246 spruce and fir seedlings. The average growth was 6 cm/yr, and increased with height class (Table 4). Class 1 regeneration averaged 5 cm/yr, class 2 averaged 6 cm/yr, and class 3 averaged 8 cm/yr. A comparison of the growth rates between spruce and fir showed no major differences.

Table 4. Height growth rates of spruce/fir regeneration by height class

Height Class at Time of Treatment	Height Range at Time of Treatment (cm)	Average Growth for 5 Years Post Treatment (cm)	Average Annual Post Treatment Growth (cm)
1	less than 10	24	5
2	10 to 29	31	6
3	30 to 149	41	8
Overall Average	**less than 150**	**28**	**6**

Regeneration Density

Height Class

Very high regeneration densities were recorded. The average stand contained over 114,000 stems/ha, of which 87% was softwood (Appendix III). As with the stocking levels, most of the regeneration (96%) occurred in the lower 2 height classes (Figure 6).

Densities of regeneration in height class 1 averaged 89,000 stems/ha, or 77% of the total stems. Nineteen percent of the regeneration occurred in height class 2, with average densities of over 21,000 stems/ha. Densities of regeneration in height classes 3 and 4 averaged 3,000 and 1,000 stems/ha respectively.

The proportion of hardwood regeneration increased with height class (Figure 7). Hardwood comprised 10% of the class 1 regeneration, 17% of class 2, 42% of class 3, and 88% of class 4. Similarly, the proportion of hardwood regenerating from sprouts and suckers increased with height class, from 1% in height classes 1 and 2, to 52% in height class 3, and 74% in height class 4.

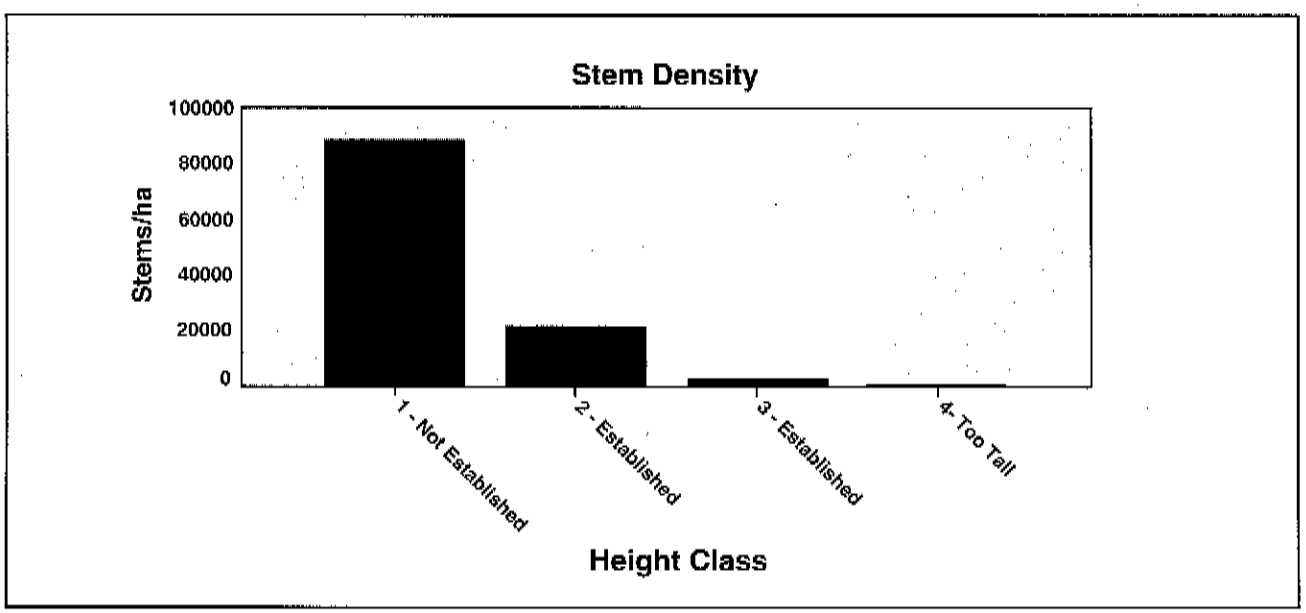


Figure 6. Regeneration density by height class. class 1: <10 cm; 2: 10-29 cm; 3: 30-149 cm; 4: >149cm.

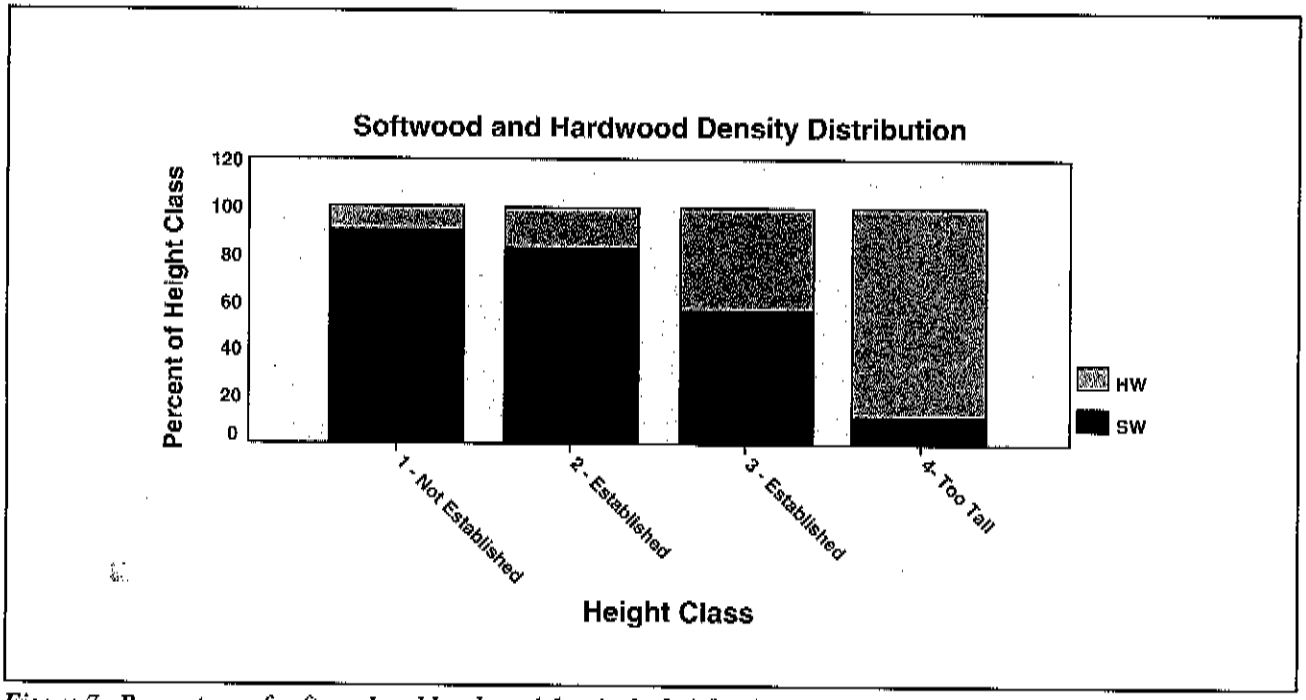


Figure 7. Percentage of softwood and hardwood density by height class. Class 1: <10 cm; 2: 10-29cm; 3: 30-149cm; 4: >149cm.

Percent of Stands by Density and Height Class

All stands had greater than 9,000 stems of softwood regeneration per hectare: 79% of the stands had greater than 20,000, and 63% had greater than 50,000 (Figure 8A). The highest stand density was calculated at over 370,000 softwood stems/ha (Appendix IIIa).

Softwood stem densities in height class 1 ranged from a low in one stand of 3,000 per hectare to a high in another stand of 362,000 stems. Fifty-three percent of the stands exceeded 50,000 softwood stems/ha in height class 1, and 79% had greater than 20,000 .

Densities of *established* regeneration (height classes 2 and 3) were considerably lower, with 5% of stands having less than 5,000 softwood stems/ ha, 58% having between 5,000 and 20,000, and 37% having greater than 20,000 softwood stems/ha (Figure 8B).

Only 21% of the stands had any softwood stem density in height class 4 and all of these had less than 2,000 stems/ha, averaging only 117.

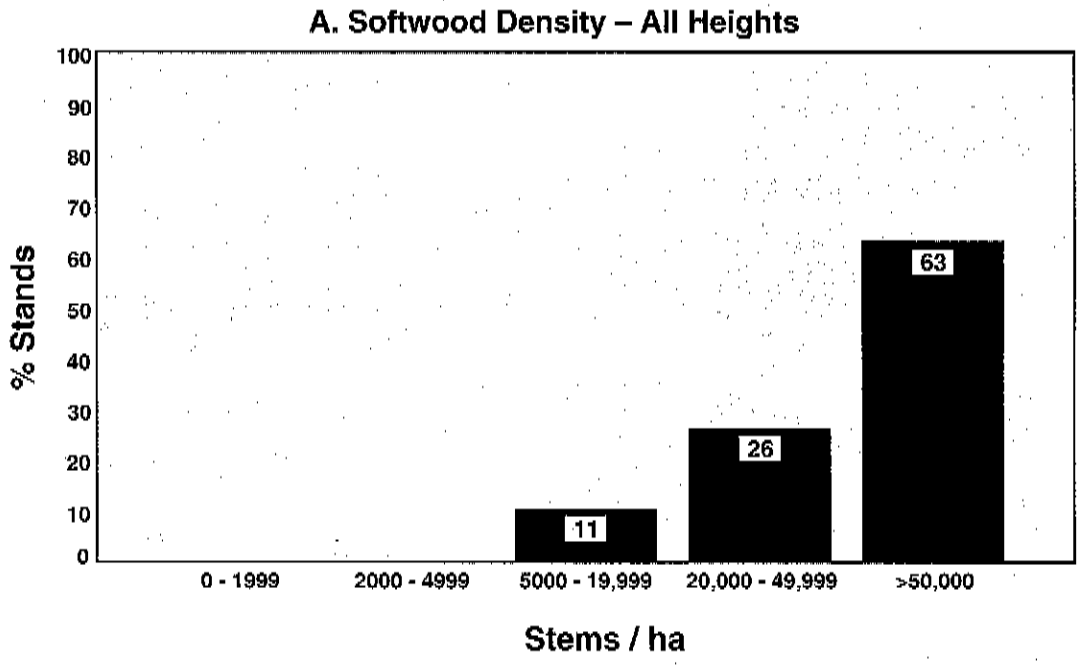
Species

Red Spruce was the most prevalent species of regeneration, averaging 60,000 stems/ha, and present in all stands (Appendix IV). Eighty-Six percent occurred in height class 1, and 13% in height class 2.

Eastern Hemlock had the second highest average density, 22,000 stems/ha, of which 93% was in height class 1. Hemlock was a significant component in 42% of the stands (8), ranging from 1,000 to 167,000 stems/ha, with an average of 53,000 stems/ha in those 8 stands.

Balsam Fir averaged approximately 17,000 stems/ha, with 45% in height class 1, 49% in height class 2, and 6% in height class 3. It was the most abundant species in height classes 2 and 3, comprising approximately 45% of the established softwood regeneration.

Red Maple was the most abundant hardwood, averaging 9,000 stems/ha. Seventy-eight percent was in height class 1. Preferred hardwood, composed of 95% yellow birch, averaged 4,000 stems/ ha, 43% in height class 1 and 54% in height class 2.



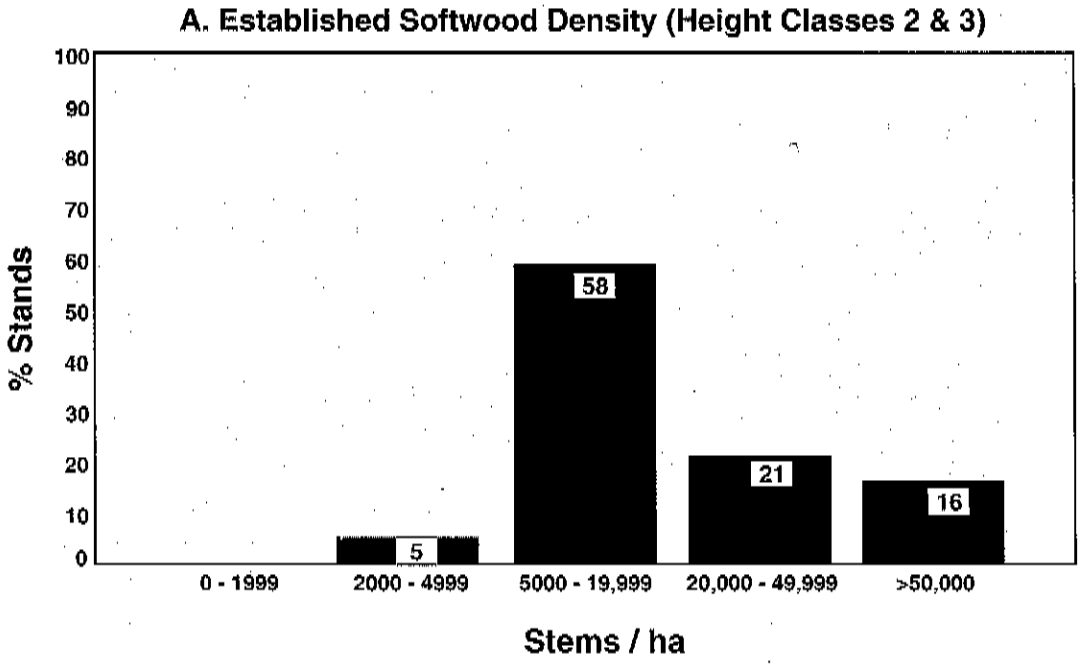


Figure 8 A& B. Distribution of stands by softwood density.

Competition

Data from the 4th quadrant density counts were used to measure the plot level competition exerted by hardwood upon the softwood regeneration. A dominance index (D.I.) was calculated as follows (Table 5):

$$D.I. = \frac{\text{Height of Tallest Hardwood - Height of Tallest Softwood}}{\text{Height of Tallest Softwood}}$$

Twenty-six percent of the stands were completely softwood dominated; 32% had less than 20 percent of their plots hardwood dominated, 21% had 20 to 40 percent hardwood domination, and the final 21% had 40 to 60 percent hardwood domination (Figure 9).

Table 5. Dominance Index results

Dominance Index Value	Percent of Plots	Interpretation
-1	55	Softwood dominant, no hardwood present
-.1 to -.9	24	Softwood dominant, hardwood present but shorter than softwood
0	3	Softwood and hardwood the same height
> 0 to 1	8	Hardwood dominant, less than twice as tall as softwood
greater than 1	11	Hardwood dominant, more than twice as tall as softwood

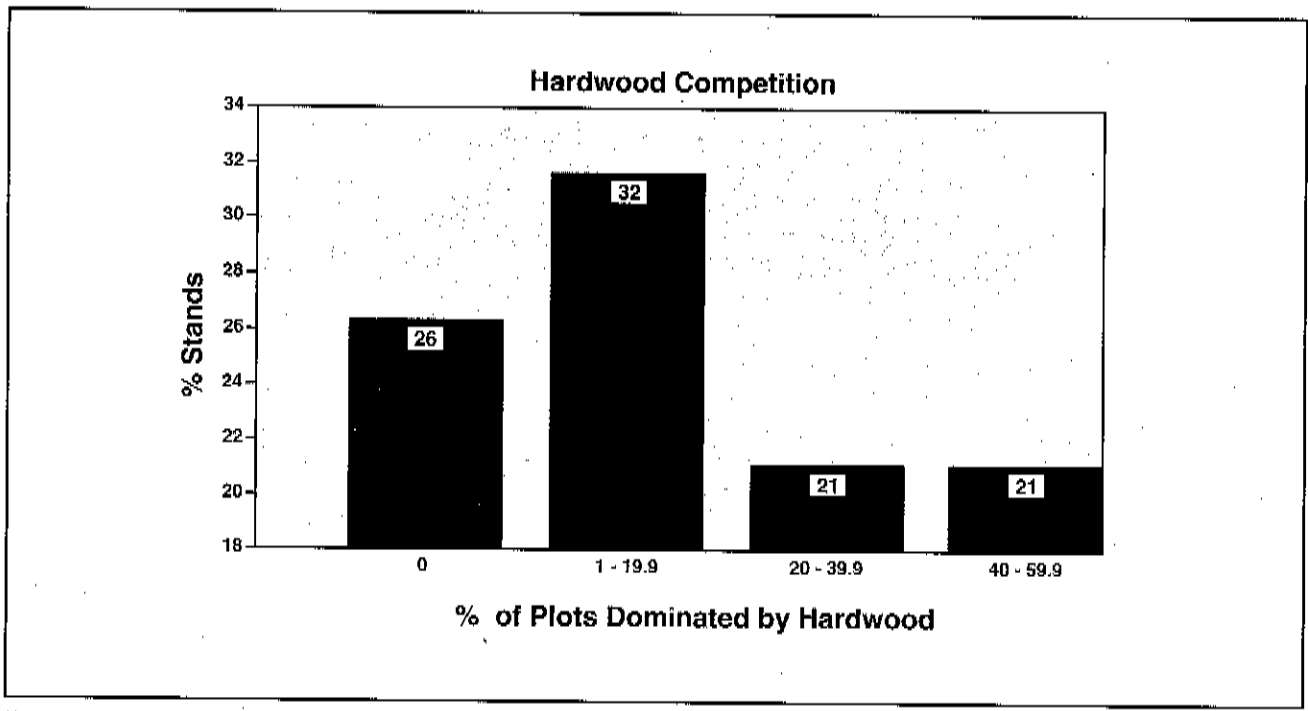


Figure 9. Percent of stands by level of hardwood dominance.

In addition to the hardwood dominance index, overall competition from all sources was visually assessed on a stand level. Sixty-three percent of stands had nil to light competition, 21% were rated as moderate competition, and 16% were rated as severe.

Blowdown

Ninety percent of stands were considered to have nil to light blowdown, and 10% were rated as moderate based on visual assessment. Blowdown was rated as a problem in 25% of the plots in one stand. The rest of the stands had less than 10% of plots affected by blowdown, with the average stand having only 1% affected.

Basal Area

Residual basal area 5 years after treatment averaged 26 m^2/ha. On a plot level, basal area ranged from 3 to 54 m^2/ha, with 64% of plots falling between 20 and 30 m^2/ha (Figure 10). On a stand level, 16% of the stands had an average basal area of less than 20 m^2/ha, 58% averaged 20 to 29.9 m^2/ha, and 26% averaged between 30 and 35 m^2/ha. A basal area of 26 m^2/ha represents a crown closure for softwood stands of approximately 50 percent (NSDNR, 1990).

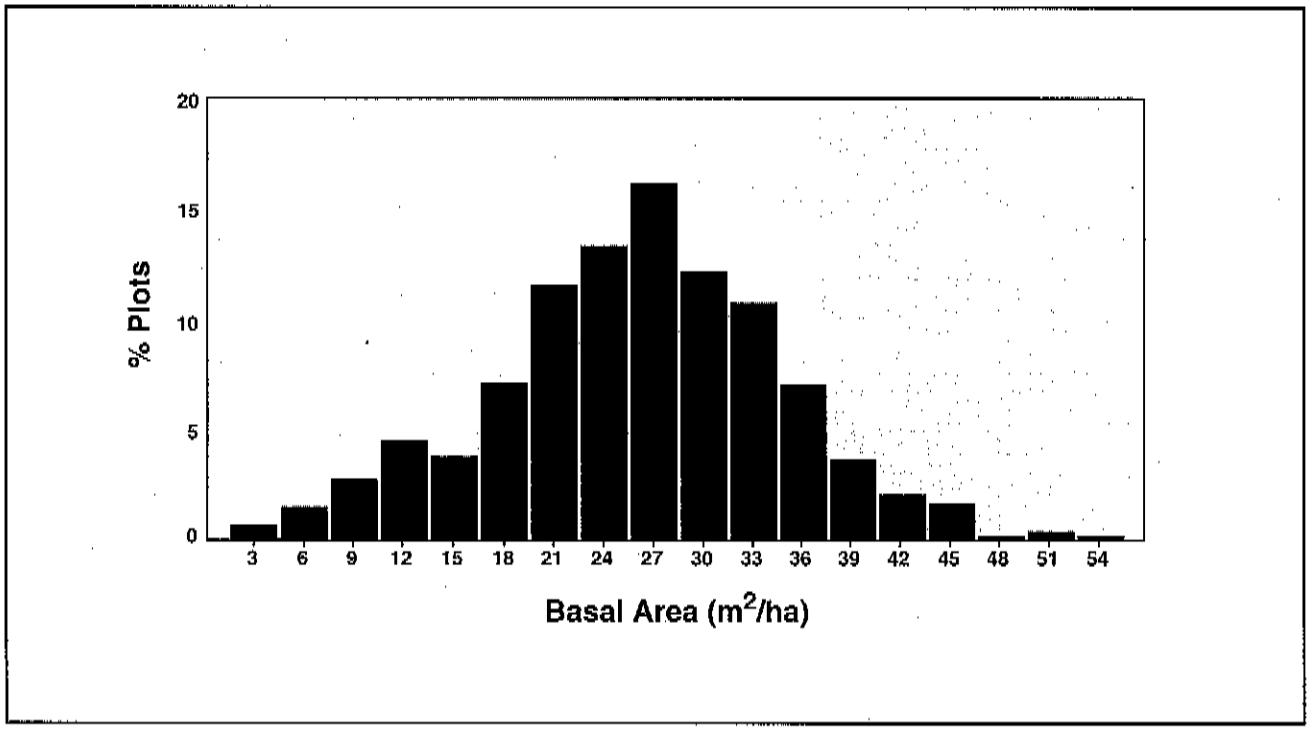


Figure 10. Basal area distribution five years following treatment.

SUMMARY AND DISCUSSION

In 1992, a survey was initiated to study regeneration in 14 softwood, and 5 mixedwood, uniform shelterwoods that were carried out on small private lands in 1987 (5 years post treatment). The major results follow.

1. All stands were at least 80% stocked to commercial softwood or hardwood regeneration (all height classes). Average stocking was 95 percent.

2. Softwood stocking averaged 86 %. Ninety-five percent of the sampled stands had greater than 60% softwood stocking in height classes 1, 2, and 3 combined (1 to 149 cm tall). Hardwood species averaged 9 % stocking.

3. In combined height classes 2 and 3 (10 to 149 cm tall), 79% of the stands had greater than 60% stocking to softwood and hardwood, and 64% had greater than 60% softwood stocking. These stands are adequately stocked to permit overstory removal based on a minimum objective of 60% stocking to established regeneration.

4. Post treatment height growth rates of spruce/fir regeneration averaged 5 cm/yr for trees in height class 1 (less than 10cm), 6 cm/yr in height class 2 (10 to 29 cm), and 8 cm/yr for trees in height class 3 (30 to 149 cm). No difference was found between the growth rates of spruce and fir.

5. Twenty-three percent of the stocking occurred in height class 1 (less than 10 cm, *pre-established*). Using the growth rates above, and assuming moderate survival, most of this should grow into height class 2 (*established*) within 2 years (7 years post treatment). This indicates that within 7 years all stands may attain sufficient stocking (greater than 60%) of established trees to permit overstory removal.

6. Red spruce had the highest stocking and density (39% and 60,000 stems/ha). Balsam fir had the second highest stocking (33%), and the highest density of *established* seedlings, comprising 45% of the regeneration in the 10 to 149 cm height range. Hemlock was a significant component of the regeneration in 42% of the stands, where it occurred at very high densities (49,000 stem/ha) in the less than 10 cm height class. Of the hardwood regeneration, red maple had the highest stocking and density, followed by yellow birch.

7. The average height of *established* regeneration was 35 cm overall, 34 cm for softwood and 50 cm for hardwood.

8. Regeneration densities were very high, with stands averaging 115,000 stems/ha and ranging from 19,000 to 372,000. Eighty-six percent was composed of softwood species.

9. Seventy-seven percent of the density was in height class 1 (less than 10 cm) and 19% was in height class 2 (10 to 29 cm). Densities of regeneration greater than 30 cm averaged 4,000 stems/ha, of which 48% was softwood.

10. Hardwood was dominant over softwood regeneration in 19% of plots. Twenty-one percent of the stands had greater than 40% domination by hardwood. Fifty-eight percent of the hardwood regeneration greater than 30 cm was composed of sprouts and suckers.

11. Residual, plot level, basal area was highly variable, ranging from 3 to 54 m^2/ha, and averaging 26 m^2/ha.

12. Blowdown was not a major factor in most stands, being rated light to moderate in 90% of the stands, and moderate in 10 percent.

MANAGEMENT IMPLICATIONS AND PROJECTIONS

1. A development period of 5 years post treatment was adequate to allow approximately two thirds of the stands to reach the overstory removal stage (minimum 60% stocked to *established* softwood regeneration). The remaining stands are projected to reach this stage at 7 years post treatment.

2. In stands where high levels of well growing *pre-established* regeneration exists, it may be advisable to delay overstory removal, despite acceptable stocking levels already being achieved. This will allow the smaller regeneration to become established, thereby increasing stocking.

3. The heavy densities of regeneration developing suggest that most stands will require future pre-commercial thinning. This will permit the selection of higher value crop trees.

4. Hardwood competition did not appear to be a major problem on 79% of the stands. On the remainder, competition may require control, if softwood dominance is desired.

5. Further research is required to determine the fate of regeneration following overstory removal in relation to harvest method, season, and seedling condition.

LITERATURE CITED

Anonymous, 1994. *Manual of procedures and standards.* Canada - Nova Scotia Cooperation Agreement for Forestry Development. Technical Manual, Chapter 5.

NSDNR, 1990. *Revised normal yield tables for Nova Scotia softwoods.* Nova Scotia Department of Natural Resources, Forest Research Section. Forest Research Report No.22, 45pp.

Hannah, P.R. 1988. *The shelterwood method in northeastern forest types: a literature review.* Northern Journal of Applied Forestry 5:70-77.

Maass, D. 1990. *Natural regeneration assessment methods for quality and quantity.* Pp. 169-179 *In* Simpson, C.M., ed. Fredericton: Proceedings of the Conference on Natural Regeneration Management, Hugh John Flemming Forestry Centre, Fredericton, New Brunswick 27-28 March, 1990, 261pp.

Yuill, B. 1980. *Shelterwood harvesting.* Scott Paper Int. Inc., Valley District. Office Report 21, 26pp.

APPENDIX I
Summary of stand and treatment conditions

Stand	County	Area[1] (ha)	Age[1]	Covertype[1, 2] (Species Composition)	Blowdown[3]	Compe-tition[4]	Ex-traction
1	DIGBY	4.0	40	**MW** (3RM 2BF 2RS 2WS 1YB)	LGT	LGT	Tractor
2	DIGBY	6.8	50	**MW** (4RS 3IH 2WS 1BF)	LGT	MOD	Tractor
3	YARMOUTH	1.0	44	**SW** (7RS 3WS)	NIL	SEV	.
4	YARMOUTH	1.1	.	**SW** (10WS)	LGT	LGT	.
5	YARMOUTH	10.0	68	**MW** (5RS 1WS 1SM 1YB 1RM 1WB)	MOD	MOD	Skidder
6	YARMOUTH	2.4	.	**MW** (4WB 3RM 2RS 1BF)	NIL	LGT	Porter
7	SHELBURNE	29.5	.	**SW** (7HE 2RS 1RM)	NIL	LGT	Skidder
8	LUNENBURG	1.7	60	**SW** (9RS 1WP)	LGT	LGT	Skidder
9	LUNENBURG	4.1	60	**SW** (8RS 2WP)	NIL	LGT	Porter
10	LUNENBURG	2.9	65	**SW** (7HE 2RS 1WP)	NIL	NIL	.
11	LUNENBURG	1.2	60	**SW** (8RS 2BF)	MOD	MOD	.
12	HANTS	1.3	96	**SW** (10RS)	NIL	LGT	Skidder
13	HANTS	1.8	71	**SW** (4RS 4BF 2HE)	LGT	LGT	Tractor
14	HANTS	2.1	62	**SW** (6RS 3WS 1BF)	LGT	MOD	Skidder
15	HALIFAX	1.5	.	**SW** (6WS 3RS 1BF)	LGT	LGT	Dion
16	COLCHESTER	1.6	88	**MW** (4BF 3RS 2YB 1RM)	NIL	NIL	.
17	CUMBERLAND	1.0	.	**SW** (7BS 2RS 1BF)	NIL	NIL	Tractor
18	CUMBERLAND	14.9	60	**SW** (8RS 2BF)	LGT	SEV	Dion
19	CUMBERLAND	17.9	60	**SW** (7RS 1BF 1WS 1WP)	LGT	SEV	Horse

1 Pretreatment data obtained from forest management plans.

2 SW - Softwood (composed of 80 percent or greater softwood species)
MW - Mixedwood (composed of 30 to 70 percent softwood species)
BF - Balsam Fir RS - Red Spruce WS - White Spruce WP - White Pine HE - Eastern Hemlock
RM - Red Maple YB - Yellow Birch SM - Sugar Maple WB - White Birch IH - Intolerant Hardwood

3 NIL - None; LGT - Light; MOD - Moderate

4 NIL - None; LGT - Light; MOD - Moderate; SEV - Severe

APPENDIX II

Classification and stocking of all commercial tree species found in survey

Species	Stocking %
Red Spruce (*Picea rubens* Sarg.)	39.1
Balsam Fir (*Abies balsamea* [L.] Mill.)	33.3
Eastern Hemlock (*Tsuga canadensis* [L.] Carr.)	8.2
White Pine (*Pinus strobus* L.)	4.8
White Spruce (*Picea glauca* [Moench] Voss)	0.3
Black Spruce (*Picea mariana* [Mill.] B.S.P.)	0.2
Eastern Larch (*Larix laricina* [Du Roi] K.Koch)	0.1
SOFTWOOD SPECIES - SUBTOTAL	86.1
Yellow Birch (*Betula alleghaniensis* Britton)	2.1
Red Oak (*Quercus rubra* L.)	0.1
Sugar Maple (*Acer saccharum* Marsh.)	0.0
White Ash (*Fraxinus americana* L.)	0.0
PREFERRED HARDWOOD SPECIES - SUBTOTAL	2.2
Red Maple (*Acer rubrum* L.)	2.7
Beech (*Fagus grandifolia* Ehrh.)	1.8
White Birch (*Betula papyrifera* Marsh.)	1.7
Trembling Aspen (*Populus tremuloides* Michx.)	0.4
Large Tooth Aspen (*Populus grandidentata* Michx.)	0.1
Balsam Poplar (*Populus balsamifera* L.)	0.0
OTHER HARDWOOD SPECIES - SUBTOTAL	6.7
GRAND TOTAL	95.0

APPENDIX IIIa

Softwood stem densities and stocking by height class for individual stands

Stand Number	Stocking[1] Density[2]	Height Class 1	2	3	4	2+3	All
1	STOCKING	14	51	24	3	75	92
1	STEMS/HA	55,063	20,188	7,563	688	27,751	83,500
2	STOCKING	21	29	26	6	55	82
2	STEMS/HA	17,009	6,205	4,241	268	10,446	27,723
3	STOCKING	13	60	13	0	73	85
3	STEMS/HA	21,250	7,000	500	0	7,500	28,750
4	STOCKING	23	56	15	0	71	94
4	STEMS/HA	45,833	28,542	417	0	28,959	74,792
5	STOCKING	1	21	57	14	77	92
5	STEMS/HA	2,560	12,619	8,929	1131	21,548	25,238
6	STOCKING	1	27	26	1	54	56
6	STEMS/HA	2,738	6,190	833	0	7,023	9,762
7	STOCKING	24	33	27	0	60	85
7	STEMS/HA	163,802	7,031	1,198	0	8,229	172,031
8	STOCKING	63	18	0	0	18	81
8	STEMS/HA	42,794	2,353	0	0	2,353	45,147
9	STOCKING	49	29	18	1	47	97
9	STEMS/HA	88,684	12,566	1,579	132	14,145	102,961
10	STOCKING	46	29	9	0	38	84
10	STEMS/HA	111,500	6,600	200	0	6,800	118,300
11	STOCKING	19	60	13	0	73	92
11	STEMS/HA	39,375	6,458	417	0	6,875	46,250
12	STOCKING	23	30	27	2	57	82
12	STEMS/HA	117,045	5,909	1,136	0	7,045	124,091
13	STOCKING	27	38	23	0	62	88
13	STEMS/HA	136,000	21,500	3,000	0	24,500	160,500
14	STOCKING	28	29	9	0	38	66
14	STEMS/HA	144,605	45,526	921	0	46,447	191,053
15	STOCKING	2	62	29	0	91	93
15	STEMS/HA	38,214	78,750	0	0	78,750	116,964
16	STOCKING	0	46	38	0	85	85
16	STEMS/HA	78,269	44,808	1,346	0	46,154	124,423
17	STOCKING	40	53	8	0	60	100
17	STEMS/HA	361,500	10,000	0	0	10,000	371,500
18	STOCKING	24	59	14	0	73	97
18	STEMS/HA	51,274	8,962	896	0	9,858	61,132
19	STOCKING	8	37	41	0	78	86
19	STEMS/HA	4,091	10,341	4,773	0	15,114	19,205
AVERAGE	**STOCKING**	**22**	**40**	**22**	**1**	**62**	**86**
AVERAGE	**STEMS/HA**	**80,085**	**17,976**	**1,997**	**117**	**19,997**	**100,175**

[1]Stocking was based on observations made in all quadrants.

[2]Density was based on stem counts made in the 4th quadrant.

APPENDIX IIIb

Stem densities and stocking of all commercial species[1] by height class for individual stands

Stand No.	Stocking[1] Density[2]	Height Class					
		1	2	3	4	2+3	All
1	STOCKING	14	52	26	4	78	97
1	STEMS/HA	60,563	20,563	8,438	938	29,000	90,500
2	STOCKING	21	30	28	7	58	85
2	STEMS/HA	18,080	6,384	4,732	357	11,116	29,554
3	STOCKING	13	60	13	0	73	85
3	STEMS/HA	22,750	7,250	500	0	7,750	30,500
4	STOCKING	23	56	17	0	73	96
4	STEMS/HA	46,458	28,958	417	0	29,375	75,833
5	STOCKING	1	21	57	15	79	95
5	STEMS/HA	12,619	20,060	12,440	5,476	32,500	50,595
6	STOCKING	4	35	43	19	77	100
6	STEMS/HA	23,095	8,810	7,143	1,786	15,952	40,833
7	STOCKING	29	40	29	1	69	98
7	STEMS/HA	192,135	12,188	2,031	0	14,219	206,354
8	STOCKING	69	24	1	1	25	96
8	STEMS/HA	44,118	2,647	294	3,382	2,941	50,441
9	STOCKING	49	29	18	2	47	99
9	STEMS/HA	92,500	12,632	3,421	263	16,053	108,816
10	STOCKING	49	31	10	0	41	90
10	STEMS/HA	128,000	7,400	200	0	7,600	135,600
11	STOCKING	19	60	13	0	73	92
11	STEMS/HA	39,792	7,292	417	0	7,708	47,500
12	STOCKING	25	36	30	9	66	100
12	STEMS/HA	145,227	10,000	1,364	4,091	11,364	160,682
13	STOCKING	27	38	28	0	67	93
13	STEMS/HA	136,500	24,833	4,833	0	29,667	166,167
14	STOCKING	28	33	29	8	62	97
14	STEMS/HA	144,737	48,421	9,868	2,368	58,289	205,395
15	STOCKING	2	64	34	0	98	100
15	STEMS/HA	72,857	97,143	1,786	0	98,929	171,786
16	STOCKING	0	56	44	0	100	100
16	STEMS/HA	92,115	67,308	1,346	0	68,654	160,769
17	STOCKING	40	53	8	0	60	100
17	STEMS/HA	361,500	10,000	0	0	10,000	371,500
18	STOCKING	24	59	14	0	73	97
18	STEMS/HA	51,274	8,962	896	0	9,858	61,132
19	STOCKING	8	37	41	0	78	86
19	STEMS/HA	4,091	10,341	4,773	0	15,114	19,205
AVERAGE	**STOCKING**	**23**	**43**	**25**	**4**	**68**	**95**
AVERAGE	**STEMS/HA**	**88,864**	**21,642**	**3,416**	**982**	**25,057**	**114,903**

1 Appendix I
2 Stocking was based on observations in all quadrants.
3 Density was based on stem counts in the 4th quadrant.

APPENDIX IV
Average stem density by species and height class

Species	Height Class				Total
	1	2	3	4	
Red Spruce	50,932	7741	778	65	59,516
Balsam Fir	7428	8104	942	51	16,524
Eastern Hemlock	20,578	1435	193	0	22,206
White Spruce	602	385	25	0	1012
White Pine	528	201	12	0	741
Other Softwood Species	17	110	48	0	175
Red Maple	6853	1075	187	653	8768
White Birch	379	565	633	19	1595
Preferred Hardwood Species	1531	1938	99	0	3569
Other Hardwood Species	16	88	500	194	797
Total Softwood	**80,085**	**17,976**	**1997**	**117**	**100,175**
Total Hardwood	**8779**	**3665**	**1418**	**865**	**14,728**
All	**88,864**	**21,641**	**3415**	**982**	**114,903**

FOREST RESEARCH SECTION
FORESTRY BRANCH
N.S. DEPT. OF NATURAL RESOURCES
P.O. Box 68, Truro, Nova Scotia, Canada B2N 5B8

FOREST RESEARCH SECTION PERSONNEL

Author / Forester:	Bruce Stewart
Technicians:	Dave Arseneau, Steve Brown, Sandy Chisholm, George Keddy, Randy McCarthy, Keith Moore, Bob Murray
Chief Technicians:	Laurie Peters, Cameron Sullivan
Data Processing:	Eric Robeson, Ken Wilton, Carl Weatherhead
Foresters:	Tim O'Brien, Peter Neily, Peter Townsend
Editor/Forester:	Tim McGrath
Supervisor:	Russ McNally
Director:	Ed Bailey
Secretary:	Angela Walker