The growth, branchiness, and resprouting of sapling northern hardwoods after spacing

by
J. C. Lees

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Abstract

Spacing in a 10-year-old sapling hardwood stand in central New Brunswick was used in 1979 to shorten the pulpwood rotation, and to adjust the species mix to meet hardwood kraft mill requirements. White and yellow birch were favored. Three spacings, 5 x 5 ft (1.5 m), 7 x 7 ft (2.1 m), and 9 x 9 ft (2.7 m) were compared with an untreated control in 1/5-acre (0.08-ha) plots in a 4 x 4 Latin square design. Resprouting was assessed after 5 years of sprout growth, and growth and branchiness of crop trees after fifth and tenth growing seasons. In ascending order, crop tree basal areas, heights, and diameters were consistently: control, potential crop trees in control plots, 5 x 5, 7 x 7, and 9 x 9 ft spacings. Resprouts, usually an average of four per cut sapling stump, have not persisted competitively in any spacing treatment. Heaviest branching (clear-bole length, 3.4 m, with a mean top height of 9.1 m, at the widest spacing) is acceptable. According to this study, the target of 1500 trees/ha with an average diameter of 16 cm at age 35 should now be attainable. Other management options could then be estimated.

Résumé

En 1979, on a procédé à l'espacement des gaules d'un peuplement de feuillus de 10 ans, dans le centre du Nouveau-Brunswick, afin de réduire le temps de révolution du bois à pâte et de modifier le mélange d'essences en fonction des besoins des usines fabriquant de la pâte kraft à partir de feuillus. Le bouleau à papier et le bouleau jaune ont été favorisés. La réaction des arbres à trois espacements différents, soit 1,5 x 1,5 m, 2,1 x 2,1 m et 2,7 x 2,7 m, a été comparée à celle d'arbres témoins (non traités) de placettes de 0,08 ha, selon un plan expérimental en carré latin de 4 x 4. Les rejets de souche ont été évalués après la cinquième et la dixième saison de croissance. La surface terrière, la hauteur et le diamtètre des arbres d'avenir se sont accrus selon l'ordre ascendant suivant et ce, de façon constante : arbres témoins, arbres d'avenir possibles de placettes témoins et arbres espacés de 1,5 m, de 2,1 m et de 2,7 m. Les rejets de souche, habituellement au nombre de quatre en moyenne par gaule coupée, n'ont pas persisté de façon compétitive, quel que soit l'espacement pratiqué. Le degré de ramification le plus marqué (tige dégagée de 3,4 m et hauteur maximale totale de 9,1 m en moyenne pour les arbres les plus espacés) est acceptable. D'après les résultats de cette étude, l'objectif de 1500 arbres par hectare, d'un diamètre moyen de 16 cm à 35 ans, devrait maintenant pouvoir être atteint. D'autres options d'aménagement pourraient ensuite être évaluées.

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a) 7 x 7 spacing in 1979

b) Control ← and → 9 x 9 spacing in 1979

c) Spaced sugar maple sprout clump and resprouts in 1991

Figure 1

Introduction

Predictably, clearcutting in mixed northern hardwoods produces an increase in the pioneer (intolerant) species component and in the frequency of regeneration of stump sprout and root sucker origin (Lees, 1987).

Valley Forest Products Ltd., the Woodlands Division of the Ste. Anne Nackawic Pulp Co. Ltd. in New Brunswick, is committed to a 35-year rotation producing 200 m^2/ha (1500 trees/ha of 16 cm av. dbh). The target species mix has been 30% maple-beech, 30% birch-ash, 30% poplar, and 10% softwood (preferably larch) (Higgs, 1981). At present, no softwood is accepted while product demands fluctuate.

Current mill deliveries can be readily adjusted by purchasing wood in the required proportions from traditional local suppliers, and clearcutting in the mixed northern hardwood stands that surround the mill.

For the next rotation, spacing of the natural regeneration with brush saws at age 10 is one way to accelerate growth and to adjust the proportions of the species required. The spacing programs at Valley Forest is now 16 years old. A nominal spacing of 6 x 6 ft (1.8 m) has been used and usually results in a mean of 7 x 7 ft (2.1 m) because of site variation and natural gaps. Non-crop species, such as pin cherry and striped maple, may be left by the crews as fillers to maintain even stocking and to prevent excessive branchiness of the crop tree species. Sprout clumps, usually of red maple, sugar maple, and white ash are reduced to two stems per clump in the spacing operation.

In 1978, the Canadian Forest Service was asked to work with the company on two aspects of this program — optimum spacing and resprouting of cut stems.

Methods

A 10-year-old sapling stand on a uniform gentle north slope at Flat Top Mountain near Pokiok, New Brunswick was thinned to three spacings, 5 x 5 ft (1.5 m), 7 x 7 ft (2.1 m), and 9 x 9 ft (2.7 m)[1]. The treatments, together with an untreated control, were assigned to a 4 x 4 Latin square of 16 1/5-acre (0.08-ha) plots, and the work was completed by the company brush-saw crew in November 1979. Within each plot, a 1/10-acre (0.04-ha) measurement plot was established and all trees were tagged for remeasurement. Potential crop-tree stems at 5 x 5 ft (1.5 m) spacing in the control plots were identified, but not released. The 7 x 7 and 9 x 9 plots in column 1 were inadvertently transposed during the spacing operation, but this did not prevent the row and column effects from being examined.

Height, diameter, crown length, and width of the spaced saplings, the control saplings, and crop trees in the control plots were measured in 1980, 1985, and 1990. Resprouting began in the first year after cutting. Measurements began only in the following year, 1981, to minimize damage to the sprouts, which at first have only a fragile point contact with the stump. Measurements were taken in four 4-m^2 quadrats per plot. The use of several small plots prevented trampling and breaking the new sprouts during sampling. The number of sprouts on each cut stump, the percentage of cut stumps with sprouts, and the basal diameter and height of the tallest sprout were measured in 1984 and 1986, five and seven growing seasons after treatment.

Results

Photographs (Figures 1 and 2) show the 7 x 7 ft, control, and the 9 x 9 treatments shortly after spacing in 1979. Analysis of variance was used to examine spacing treatment means and, where there were significant differences ($p \leq 0.05$), indi-

[1] Exact Canadian yard/pound measurements with metric conversions

a) Control treatment in 1991

b) 5 x 5 spacing in 1991

c) 7 x 7 spacing in 1991

d) 9 x 9 spacing in 1991

Figure 2

Table 1 Crop tree growth repsonses

Basal area (sq cm/tree)	Control	5 x 5 (c)	5 x 5	7 x 7	9 x 9
1980	2.7	8.9	8.3	13.1	18.4
1985	2.7	18.9	26.4	35.2	50
1990	14.7	32	49.2	66.7	93.3
Diameter (cm)					
1980	1.7	2.8	2.7	3.2	3.9
1985	2.7	4.2	5.2	6	7.1
1990	3.8	5.4	7	8.3	9.9
Height (m)					
1980	3.5	4.4	4.3	4.6	5.1
1985	5	6.2	6	6.5	6.9
1990	6.6	7.9	8.3	9.1	9.2
Crown length (m)					
'1980	1.7	2.6	2.7	2.9	3.2
1985	2.3	3.2	4.2	4.8	5
1990	2.6	3.5	4.9	5.8	5.8
Crown width (m)					
1980	1.1	1.8	1.5	1.6	1.7
1985	1.4	2	2.8	3	3.3
1990	1.4	1.8	2.4	2.7	3.4

Table 2 Basal area (m^2/ha) and proportion of species (%)

		Control		Control Crop Trees		5 x 5		7 x 7		9 x 9	
Species	Period	m^2	%	m^2	%	m^2	%	m^2	%	m^2	%
Beech	1980	2.4	29.5	1.2	40.3	1.1	36.6	0.8	23.5	1.4	42.7
	1985	3.1	25.0	1.8	30.6	2.6	26.9	1.8	19.5	2.3	27.7
	1990	3.6	21.5	2.3	25.7	3.5	21.0	2.4	15.0	3.1	22.4
White birch	1980	0.5	6.4	0.2	7.7	0.3	11.3	0.3	9.1	0.2	6.1
	1985	1.0	8.0	0.5	8.7	1.2	12.3	1.0	11.0	0.7	8.8
	1990	1.6	9.8	0.9	10.1	2.4	14.8	2.0	12.6	1.4	9.7
Yellow birch	1980	2.8	34.5	0.9	29.0	0.9	28.3	0.8	23.5	0.9	28.7
	1985	4.0	32.1	2.4	40.7	3.6	37.4	3.5	38.8	3.5	42.8
	1990	5.3	32.0	3.8	44.3	6.4	38.6	6.7	42.4	6.4	45.6
Red maple	1980	0.6	6.9	0.1	2.3	0.2	7.1	0.1	2.4	0.1	1.5
	1985	1.3	10.2	0.2	2.8	0.9	9.4	0.4	4.0	0.2	2.4
	1990	2.3	14.0	0.3	2.9	1.9	11.4	0.9	5.7	0.5	3.6
Sugar maple	1980	1.5	18.8	0.5	16.0	0.4	13.2	1.4	40.5	0.5	15.2
	1985	2.4	19.3	0.8	13.5	0.9	9.9	2.2	24.8	1.0	12.5
	1990	2.8	16.9	1.1	12.7	1.6	9.8	3.5	22.3	1.8	13.1
Ironwood	1980	0.4	4.2	0.1	4.6	0.1	3.9	0.1	1.5	0.2	5.8
	1985	0.7	5.5	0.2	3.8	0.4	4.2	0.2	1.9	0.5	5.7
	1990	0.9	5.9	0.3	3.4	0.7	4.3	0.3	2.0	0.8	5.9

vidual means were compared using the SAS (1990, Version 6) packages[2] on file. Basal area, height, diameter, and crown length and width of the spaced trees and controls are shown in Table 1 and Figures 3-7. Responses to treatment are consistent for the two 5-year measurement periods, with best tree growth at 9 x 9 ft. Severe crown competition has reduced crown width in 1990 at closer spacings. In Table 2, mean basal area for each species and their proportional representation in the sapling stand at three measurement dates are presented. The spacing operation has clearly discriminated against beech, and its proportion dwindled over the 10-year period while the proportion of yellow birch increased. Growth in basal area at even the widest spacing has already caught up with control values for beech and white birch, and yellow birch exceeded control values in all spacing treatments by 1990. White birch, yellow birch, and sugar maple at the 7 x 7 spacing now exceed control basal area levels. Table 3 shows the basal area increment for the remeasurement periods. In 1985, white birch, well represented in all plots and treatments, ranged from 2.16 cm^2/ha/year in control plots to 11.92 cm^2/ha/year in 9 x 9 plots and, in 1990, from 3.15 cm^2/ha/year to 16.2 cm^2/ha/year. In Table 3, the other species are presented more or less in rank order of increments. Beech, already affected by bark disease, performed poorly, and red maple showed an intermediate response. Yellow birch, which prefers small gaps and openings, grew vigorously after release. Sugar maple, a tolerant species, did not perform as well as red maple or the birches. In ascending order, basal area increase for all species combined was consistently: control, crop trees in control plots, 5 x 5 ft, 7 x 7 ft, and 9 x 9 ft spacing.

Because the routine spacing treatment is 7 x 7, it was worthwhile to compare resprouting and crop tree branchiness at this spacing to the closer and wider spacings. The cut sapling stumps produced a mean of four sprouts in 1981 which, after 5 more years (1986), were 1.4-1.6 m tall and 1.1-1.3 cm in basal diameter (Table 4). At this time, the crop tree saplings were already 6-7 m tall and 5-7 cm in basal diameter. In 1991, those resprouts that persisted were observed to be part of the shrub layer and well below the main canopy of all treatments (Figure 2).

In the treated plots, all sprouting species produced a few sprouts, beech least and sugar maple most vigorously (Table 5). Ironwood proved to be a vigorous resprouter, but was only sparsely represented in the original stand. A sugar maple sprout clump with two selected crop trees is shown in Figure 1. These reprouts are no longer in a competitive position.

Species comparisons were possible after several measurement dates, but each assessment led to some mechanical damage to the dwindling resprout population (Table 5). The 1986 mean height values are ranked in Table 6. Although the species sample numbers varied widely, mean heights of resprouts for the three spacings combined were significantly different ($p \leq 0.05$). Pin cherry and red maple resprouted aggressively. The comparative persistence of some sugar maple resprouts in 1991, may be an expression of its shade tolerance (Figure 1). Yellow birch resprouts, in contrast, dropped out more quickly, and beech was poorly represented among resprouts.

Branchiness of spaced saplings, expressed by clear bole length to the first persistent lateral branch (1 cm diam.), is greatest at the widest spacing, 9 x 9 (Table 7), and least in the control plots. But there are no significant differences ($P \leq 0.05$) between the three spacing treatments. Least clear bole length, 3.35 m at 9 x 9 spacing with a mean total tree height of 9.1 m is acceptable at this date, 10 years after treatment. The appearance of the treatment plots in 1991 (Figure 2) confirms that canopy closure is almost complete at even the widest spacing.

Discussion and Conclusion

This spacing trial began in 1979 when few local guidelines were available for precommercial thin-

[2] SAS Institute Inc. 1990. SAS/STAT users guide Version 6. SAS Inst. Inc., Cary, N.C.

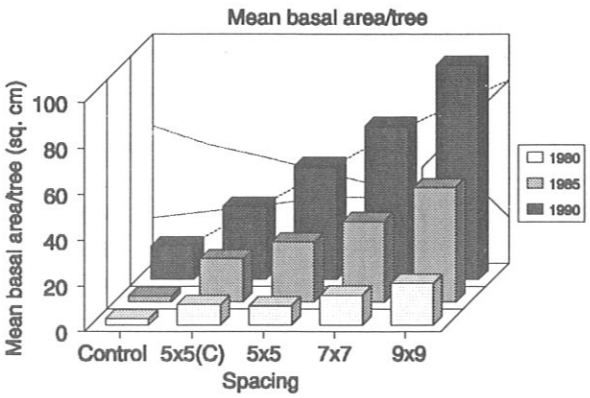

Figure 3

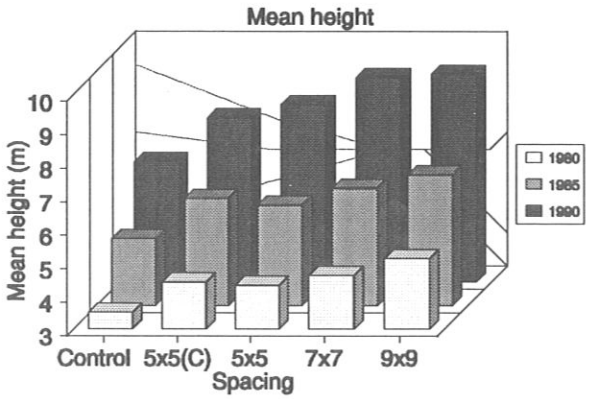

Figure 4

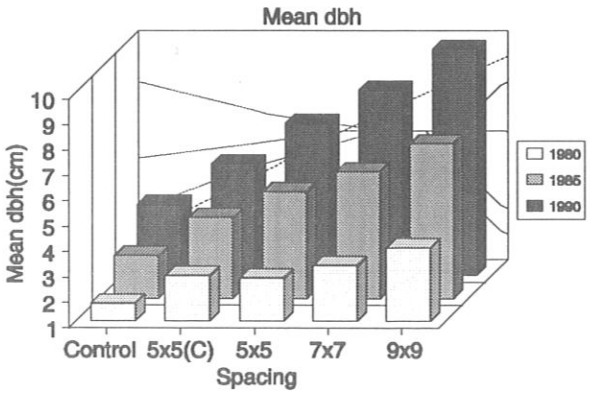

Figure 5

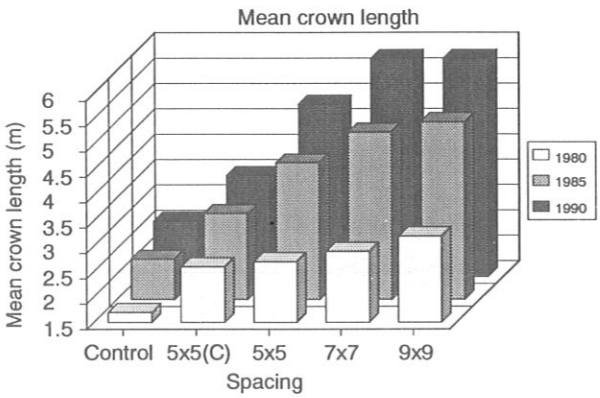

Figure 6

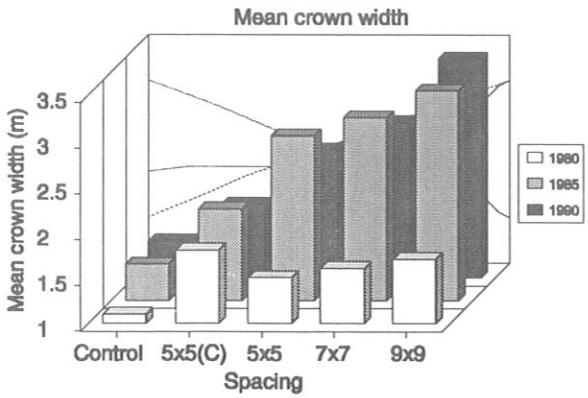

Figure 7

Table 3 Mean basal area increment (cm^2/ha/yr)

Species	Period	Treatment				
		Control	Control Crop Trees	5 x 5	7 x 7	9 x 9
White birch	80-85	2.16 a	7.39 b	7.79 b	7.84 b	11.92 c
	85-90	3.15 a	9.38 b	11.86 c	11.68 c	16.21 c
Yellow birch	80-85	1.47 a	2.47 b	4.14 c	5.13 d	5.60 d
	85-90	1.59 a	2.75 a	5.32 b	6.90 c	7.43 c
Red maple	80-85	1.97 a	1.57 a	3.55 b	3.78 b	5.22 c
	85-90	3.34 a	2.32 a	5.44 b	7.60 b	10.66 c
Sugar maple	80-85	0.35 a	1.02 a	2.69 b	3.29 b	5.02 c
	85-90	0.27 a	1.20 a	3.61 b	4.92 b	7.45 c
Beech	80-85	0.36 a	1.24 b	2.51 c	3.24 c	7.10 d
	85-90	0.33 a	1.27 a	2.49 b	3.62 c	8.42 d
All species	80-85	0.77 a	1.87 b	3.59 c	4.40 d	6.10 e
	85-90	0.90 a	2.14 b	4.63 c	6.14 d	8.23 e

Note: Treatment means in each period that have the same letter are not significantly different ($P \leq 0.05$), Scheffe grouping.

Table 4 Mean number of resprouts from the cut stems

	Year	Treatment		
		5 x 5	7 x 7	9 x 9
No. sprouts/stump	1981	4.2	3.9	3.6
Height tallest (m)	1986	1.4	1.6	1.5
Diam. tallest (cm)	1986	1.1	1.3	1.3

Table 5 Mean number of sprouts per cut stump and percentage of cut stumps with sprouts in 1981 and 1984

	Treatment								
	5 x 5			7 x 7			9 x 9		
Species	1981	1984	%	1981	1984	%	1981	1984	%
Sugar maple	4.5	1.7	100	5.1	2.0	83	4.6	2.0	92
Pin cherry	6.3	1.6	60	4.9	2.1	65	4.8	1.9	68
Beech	2.7	1.9	37	4.4	2.3	82	3.4	1.8	47
Yellow birch	2.7	3.7	92	3.7	1.0	76	3.9	2.6	70
Red maple	3.0	2.8	100	-	1.9	-	-	3.2	-
White ash	8.0	-	100	-	1.0	-	-	-	-
Striped maple	3.0	1.8	70	3.0	2.0	60	2.5	2.4	81
Ironwood	3.5	2.4	89	4.2	3.4	100	3.3	3.1	100
Willow	-	-	-	2.0	-	100	3.0	-	100

Table 6 Mean tallest resprout height in 1986 (all spaced plots)

Species	Height (cm)
Pin cherry	171.9 a
Red maple	112.4 b
Striped maple	69.4 c
Sugar maple	66.6 c
Yellow birch	64.8 c
Ironwood	56.0 c
Beech	49.6 c

Note: Means with the same letter are not significantly different ($p \leq 0.05$), Scheffe grouping

Table 7 Mean height to first branch in 1990

Treatment	Height to first branch (m)
Control	4.00 a
Control crop trees	4.41 b
5 x 5	3.41 c
7 x 7	3.35 c
9 x 9	3.37 c

Note: Treatment means with the same letter are not significantly different ($p \leq 0.05$), Scheffe grouping

ning in northern hardwoods. Drinkwater (1960) had reported promising results in a 30-year-old sugar maple stand in Nova Scotia and recommended crown spacing of 5 ft as a guideline. Other studies were underway elsewhere, but were not yet concluded (Lees, 1987; Lamson and Smith, 1987; Smith and Lamson, 1983). Treatment in fast-growing softwood species is a success (Piene, 1981; Bella and Yang, 1991), and routinely qualifies for subsidy under current regional federal/provincial Forest Resource Development Agreements. However, a special case had to be made for spacing hardwoods in 1978 while research results were being gathered. Work with trembling aspen in the Boreal Mixedwood (Steneker, 1976; Bella and Yang, 1991) indicated varying negative responses in pure stands, but positive improvements in stem quality in the remaining trees. Heitzman and Nyland (1991) reviewed 30 recent sources of work in northern hardwood stands and concluded that long-term effects on tree quality and economic benefits are still awaited, but that early growth responses are positive.

The 1984, 1985, and 1986 results of this study positively supported the subsidy in New Brunswick and, by 1989, criteria were approved for precommercial thinning in sapling hardwoods.

Concerns had been expressed about the suitability of the operational spacing, about crop tree form and branchiness, and about resprouting from cut stems. This study has tested responses to three spacing treatments and a control. The 4 x 4 Latin square field design has proved to be robust for data analyses and useful for field demonstration. Because the widest spacing, 9 x 9 ft, produces the largest crop trees but does not significantly increase branchiness, total stand volume may well be more important than individual tree size. Reprouts from cut stems are not competitive in any spacing treatment.

The early positive responses in height and diameter growth at the test spacings now suggest a range of management options. At age 35, the straight, finely-branched stems of quality species such as yellow birch, sugar maple, and white ash provide an attractive option for sawlog production within the next 35-year period, and veneer log production in a subsequent cutting cycle. Repeated thinnings could continue the trend to a higher proportion of the shade-tolerant species, including promising sawlog quality softwoods. Use of conventional stocking guidelines for the northern hardwoods will lead to the steady diameter growth patterns that produce veneer quality bolts.

These thinning options, and the application of the shelterwood silvicultural system, are already attractive to local woodlot owners and industrial woodland managers who have visited the area. Without the spacing treatments, choices are restricted to the pulpwood and fuelwood production clearly demonstrated in the untreated control plots. Crown release of the crop trees in the control plots may be another viable prescription.

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