Frontline

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BLACK SPRUCE STOCKING RETURNS TO NEAR PREHARVEST LEVELS 18 YEARS FOLLOWING ALTERNATE-STRIP CLEAR-CUTTING

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INTRODUCTION

In 1974, a long-term study was initiated near Nipigon, Ontario, on alternate-strip clear-cutting in natural black spruce (*Picea mariana* [Mill.] B.S.P.) forest on shallow soil upland sites (Jeglum 1980). The experiment was designed to study the influence of three strip widths and two leave times (seeding period) on natural regeneration. Results showed that regeneration was desirable or acceptable in all strip widths, and that 4 years of leave time was preferable to 2 years (Jeglum 1982). Further work on the biology of strip clear-cutting, in comparison to clear-cutting, indicated that higher proportions of black spruce relative to broadleaf species are maintained (Jeglum 1983).

The present technical note reports on a reassessment (completed in 1992) of regeneration on the study area 12 to 18 years after harvesting. In addition, previous data is presented for one area (Area 1) from preharvest (1974) through harvest (1975), and for assessments at 1, 3, and 5 years post-harvest. Black spruce was the main target species in this study, but regeneration data were collected on all tree species. The objective was to track changes in stocking and density, i.e., long-term black spruce stand development, as affected by the strip-cut method of harvesting.

STUDY AREA

A strip-cut experiment on shallow soil black spruce was established in 1974 and replicated in each of three successive years (Jeglum 1980). The study areas are located east of Lake Nipigon, and 20 to 40 km southeast of Beardmore, in the Central Plateau Section of the Boreal Forest Region (Rowe 1972). The experiment included 56 strips having various widths (20 m, 40 m, and 80 m), and leave times (2 years and 4 years). Additional 40-m strips were included as controls. The second-cut strips were not scarified. In Area 1, most of the second-cut strips had groups of seed trees, two per strip, retained so as to provide for natural seeding. In Areas 2 and 3 no groups of seed trees were left. Assessment quadrats were systematically located in each strip.

The location of the strips was determined using various criteria: including, dominance to black spruce, local topography, drainage, grade, etc. (Jeglum 1980). All areas were dominated by black spruce, although 10 percent of Area 1 was classified as mixedwood or hardwood. Jack pine (*Pinus banksiana* Lamb.) and balsam fir (*Abies balsamea* [L.] Mill.) were present in small amounts in mixture with the black spruce, and there were scattered individuals or clumps of trembling aspen (*Populus tremuloides* [Michx.]) and white birch (*Betula papyrifera* [Marsh.]).

A partial regeneration survey of Area 1 (first-cut strips) was conducted in 1989. In 1992 the remainder of the strips (second-cut strips) were surveyed. In each 2-m x 2-m quadrat, the presence and number of seedlings of each tree species were recorded according to their height or diameter class.

RESULTS

Stocking Levels for Black Spruce

Table 1 summarizes levels of stocking for black spruce in the first-cut strips from 1974 to 1992. For the purpose of this

study, the authors defined stocking as the percentage occurrence of one species, or group of species, in a number of 2-m x 2-m quadrats. Stocking of black spruce is divided into failure (0–39.9 percent), acceptable (40–59.9 percent), and desirable (60–100 percent) levels. In 2-year leave strips (first-cut strips with adjacent leave strips left as a seed source for 2 years), the stocking level dropped slightly between the year before harvesting, 1974 (54 percent), and the final year of assessment, 1989 (48 percent). In the 4-year leave strips, stocking dropped from a preharvest level of 58 percent to 51 percent in the first postharvest year, then increased to 65 percent by 1978, and finally to 69 percent by 1989. Therefore, most of the new regeneration was established in the first 3 years after harvesting. There was an increase in stocking of 11 percent between preharvest and 13-year postharvest levels. Of the strips that had the benefit of 4 years of seeding, the 20-m strips achieved the highest level of stocking (75 percent). The 40-m and 80-m strips achieved similar levels of 67.5 percent and 65 percent, respectively (desirable). For the strips with 2 years of seeding, the stocking level was acceptable for 20-m and 40-m strips (53 percent and 55 percent, respectively), but a failure (36 percent) for the 80-m strips.

The second-cut strips were harvested either 2 years or 4 years after the first-cut strips. The 4-year leave strips were regenerated by leaving groups, usually two, of seed trees within each strip. By 1992, both the 2-year and 4-year leave strips achieved an overall acceptable level of stocking: 48 percent and 57 percent, respectively. These were similar to stocking in the preharvest state: 54 percent and 58 percent for the 2-year and 4-year levels, respectively.

Both the 40-m and 80-m 4-year leave strips achieved desirable rates of stocking (61 percent) and, overall, were 20 percent higher than the 40-m and 80-m 2-year leave strips (Table 1).

Stocking and Density for All Tree Species

Table 2 summarizes the stocking levels and densities in Area 1 for five main tree species, from 1974 to 1992. For the first-cut strips, the level of stocking decreased from 57 percent to 49 percent after harvesting. Then it increased from 49 percent in 1976 (+1 year of natural seeding) to 69 percent in 1989 (+4 years). The level of 65 percent was achieved in 1978 with only 3 years of seeding.

For the second-cut strips, the level of stocking of black spruce in 1989 and 1992, 12 to 15 years after harvest, ranged from 40 percent to 57 percent. The 4-year leave strips had a higher stocking on average than did the 2-year leave strips (44 percent vs. 53 percent). The level of stocking of second-cuts, approximately 50 percent, was acceptable, but it was 19 percent lower than achieved by the first-cut strips with 4 years of natural seeding.

Density of black spruce was 4.2 stems per 2-m x 2-m quadrat (10 500/ha) in the preharvest forest. For the first-cut strips, the level dropped in Years 1 and 2 after harvesting (3.4 to 3.2) but then rose in Years 3 and 4 to preharvest levels (5.4 to 4.1). However, by 1989 levels had dropped considerably to 1.4 and 2.2 seedlings per quadrat, suggesting that considerable mortality occurs after the early wave of new seedlings. For the second-cut strips, densities of black spruce were consistently low, 1.1 to 2.1.

Harvesting Effects on Stand Composition

At the time of harvesting, the forest was composed mainly of black spruce with smaller components of jack pine, balsam fir, trembling aspen, and white birch. The proportion, in density, of conifer to hardwood was 82:18 (Jeglum 1982). Five years after harvest, in the first-cut strips, this ratio was 40:60 (Jeglum 1982). At 18 years, the ratio was 74:26 for both first- and second-cut strips (Table 3).

Table 1. Changes in black spruce stocking in Area 1 from preharvest (1974) to the final assessment (1992).

		Year of harvest (C1–C3) and assessments and years of natural seeding (+1, ... +4)												
Strip width,	Preharvest	First-cut strips										Second-cut strips		
2-year and 4-year leave periods	year 1974	'75	'76 (+1)	'77	'78 (+2)	'78 (+3)	'79	'80 (+2)	'80 (+4)	'89 (+2)	'89 (+4)	'83	'89	'92
20-m scarified strips														
2-year leave	59	C1	59	C2	50	-		51		53		-	50	62
4-year leave	52		53		-	67	C3		69		75	49*	49*	49*
40-m scarified strips														
2-year leave	49		48		49	-		50		55		-	32	37
4-year leave	49		38		-	63			61		67.5	53*	48*	61*
80-m scarified strips														
2-year leave	65		34		59	-		52		36		-	38	46
4-year leave	66		56		-	65			63		65	42*	48*	61*
All scarified strips														
2-year leave	54		47		53	-		51		48		-	41	48
4-year leave	58		51		-	65			65		69	47*	48*	57*

Source: Pre-1989 data from previous assessments (Jeglum 1980, 1983).

* Natural seeding from groups of seed trees.

The proportion of black spruce to all the other species in both the first- and second-cut strips was 58:42. In only one case (Area 1, second-cut strips) were black spruce numbers less than other species, 40:60. This was due to the presence of large numbers of balsam fir.

CONCLUSIONS

Alternate-strip clear-cutting is successful for facilitating the natural regeneration of black spruce. Strip width, leave period, scarification, and site type are key factors that influence this regeneration. Acceptable (> 40 percent) and desirable (> 60 percent) levels of stocking in both first- (66.3) and second-cut strips (52.3) were observed 12 to 18 years after harvest. Present stocking of first-cut strips with 4 years of seeding is 11 percent higher than the preharvest condition. Present stocking of black spruce is comparable to the preharvest level, and present stocking of all conifer species is 71.5 percent overall (desirable level).

Black spruce density levels of 4.2 stems per quadrat (preharvest) decreased to 2.9 stems per quadrat. However, density in the first-cut strips was 3.6 stems per 2-m x 2-m quadrat (over three areas), which decreased only slightly from preharvest levels.

These data indicate that most new regeneration occurs during the first 3 years after harvest. Black spruce then slowly increases to near preharvest levels. The decrease in densities of black spruce in 1989 suggests that considerable mortality

Table 2. Changes in stocking (percent) and density (number/quadrat) of five tree species in Area 1 from preharvest (1974)* to the final assessment (1992).

Species/ stocking/ density (per 2-m x 2-m quad.)	Preharvest year 1974	Year of harvest (C1 - C3) and assessments and years of natural seeding (+1, ... +4) First-cut strips									Second-cut strips			
		'75	'76 (+1)	'77	'78 (+2)	'78 (+3)	'79	'80 (+4)	'89 (+2)	'89 (+4)	'89 (2 year)	'92 (2 year)	'89 (4 year)	'92 (4 year)
Number of quadrats	600		565		300	265		265	300	265	300	300	300	300
Black spruce		C1		C2			C3							
Stocking	57		49		53	65		65	48	69	40	48	48	57
Density	4.2		3.4		3.2	5.4		4.1	1.4	2.2	1.3	1.5	1.1	2.1
Jack pine														
Stocking	1		32		13	20		19	17	18	11	10	5	7
Density	<0.5		2.6		0.8	0.8		0.6	0.4	0.3	0.2	0.2	0.1	0.1
Balsam fir														
Stocking	70		48		32	33		32	26	24	44	44	34	45
Density	7.2		2.9		1.0	1.6		1.4	0.5	0.5	1.1	1.2	1.0	1.5
Trembling aspen														
Stocking	8		44		44	51		38	21	12	22	24	13	16
Density	0.3		4.5		2.2	3.1		1.7	0.4	0.2	0.4	0.5	0.2	0.3
White birch														
Stocking	36		37		58	58		54	23	40	29	30	18	30
Density	2.5		3.4		8.2	7.7		6.4	0.5	0.8	0.9	0.9	0.3	0.9
Total species combined														
Stocking	88		87		88	88		87	80	86	83	84	74	87
Density	14.3		16.8		15.5	18.7		14.4	3.2	4.1	3.9	4.2	2.7	4.9

* Source: Pre-1989 data (Jeglum 1982).
Note: Strip widths are not differentiated.

Table 3. Ratios of numbers of black spruce to all other species, and conifers to hardwoods in first- and second-cut strips in all areas, based on density values.

Species	Area 1		Area 2		Area 3		Overall
	First-cut*	Second-cut	First-cut	Second-cut	First-cut	Second-cut	
	Jack pine, Balsam fir, Trembling aspen, White birch						
Black spruce	52:48	40:60	66:34	60:40	67:33	59:31	58:42
	Trembling aspen, White birch						
Black spruce, Jack pine, Balsam fir	75:25	72:28	73:27	67:33	78:22	76:24	74:26

* 1989 data.

occurs after the early wave of new seedlings. For jack pine, after a wave of ingrowth numbers also decrease.

The 20-m 2-year leave strips achieved a desirable level (62 percent) of stocking while the 20-m 4-year leave strips achieved a lower, but still acceptable, level (49 percent). This reduced stocking may be due to the site type (crest, upper slope) combined with extremely shallow soil, thereby resulting in a less receptive seedbed. Various strategies for increasing levels of regeneration of black spruce in second-cut strips are being investigated (Fleming and Groot 1984, Wood and Raper 1987, Frisque 1990, Jeglum 1990).

REFERENCES AND FURTHER READING

Fleming, R.L.; Groot, A. 1984. Alternatives for regenerating spruce clearcuts. Can. For. Serv., Sault Ste. Marie, ON. For. Newsl. Summer:2–5.

Frisque, G. 1990. Black spruce layers: A regeneration alternative? For. Ind. 1990:62–68.

Jeglum, J. K. 1980. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. I. Study establishment and site conditions. Dep. Environ., Can. For. Serv., Sault Ste. Marie, ON. Inf. Rep. O-X-337. 24 p.

Jeglum, J. K. 1982. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. II. Regeneration in the first study area. Dep. Environ., Can. For. Serv., Sault Ste. Marie, ON. Inf. Rep. O-X-315. 61 p.

Jeglum, J.K. 1983. Changes in tree species composition in naturally regenerating strip clearcuts in shallow-soil upland and black spruce. p. 180–193 *in* R.W. Wein, R.R. Riewe and I.R. Methven, eds. Resources and Dynamics of the Boreal Zone. Proc. Conf. August 1982, Thunder Bay, Ontario. Assoc. of Can. Univ. for North. Stud., Ottawa, ON.

Jeglum, J.K. 1987. Alternate strip clearcutting in upland black spruce. II. Factors affecting regeneration in first-cut strips. For. Chron. 63 (6):439–445.

Jeglum, J. K. 1990. Modified harvesting to promote natural regeneration of black spruce. p. 123–144 *in* B.D. Titus, M.B. Lavigne, P.F. Newton and W.J. Meades, eds. The Silvics and Ecology of Boreal Spruces. Proc. 11th IUFRO Northern Forest Silviculture and Management Working Party S1.05.12 Symposium. 12–17 August 1989, Gander and Grand Falls, Newfoundland. For. Can., St. John's, NF. Inf. Rep. N-X-271.

Jeglum, J.K.; Kennington, D.J. 1993. Strip clearcutting in black spruce: A guide for the practising forester. For. Can., Ontario Region, Sault Ste. Marie, ON.

Rowe, J.S. 1972. Forest regions of Canada. Dep. Environ. Can. For. Serv., Ottawa, ON. Publ. No. 1300. Ottawa, ON. 172 p.

Wood, J.E.; Raper, R. 1987. Alternate strip clear-cutting in upland black spruce. III. Regeneration options for leave strips. For. Chron. 63(6):446–456.

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