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Growth and Yield of Noncommercially Thinned Black Spruce in Northern Minnesota

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ABSTRACT.—Presents yields in number of trees, basal area, diameter distribution, and total commercial volumes 38 years after thinning a black spruce sapling stand.

Key Words: *Picea mariana*, spacing/thinning, volumes.

Black spruce (*Picea mariana* (Mill)B.S.P.) is one of the most abundant conifers in northern North America. It ranges in a broad band from the northeastern U.S. to Labrador, and west across Canada to western Alaska. Its southern limits include the northern portions of the Lake States. In Minnesota, black spruce is the dominant timber species on organic soils, occupying 1.3 million acres in the northeastern third of the State (Johnston 1977).

Black spruce commonly regenerates dense stands. A study of the effects of thinning on a black spruce sapling stand in northern Minnesota was established in spring 1954. The objectives of this study were to (1) determine the stocking level that produces the maximum commercial yield, and (2) determine the effect of stocking density on length of rotation. In this note, we present information obtained from stand measurements after the 1953, 1967, 1973, and 1992 growing seasons.

METHODS

This black spruce stand was located on State land near Littlefork in Koochiching County. The organic soils there are in the Wildwood series, which consists of deep, very poorly drained, slowly permeable soils on glacial lake plains.

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Slopes are 0 to 1 percent. The study area was clearcut in 1921 and had reseeded naturally to black spruce. The ages of the trees ranged from 27 to 33 years in 1954, so we can assume the stand originated in 1924. In the spring of 1954, the stand was thinned to 800 trees/acre, thinned to 1,300 trees/acre, or left unthinned. Spacing guides were used (8x8 for the 800 trees/acre, and 6x6 for the 1,300 trees/acre), but good crop trees at closer spacing were left. Each treatment is unreplicated and subsampled with four permanent, circular measurement plots. Measurements were taken on 1/10-acre plots for the thinned, and on 1/20-acre plots for the checks. Trees were thinned using hand tools. Heinselman (1954) estimated that 2 to 3 workforce days per acre were needed to thin the stands, although no actual times were documented.

Diameters and heights were measured after the 1953, 1967, 1973, and 1992 growing seasons, using diameter tapes, a clinometer, and height poles.

RESULTS AND DISCUSSION

Growth and yield summaries are presented for measurements taken in 1953, 1967, 1973, and 1992; also included are basal area (ft^2/acre) projections using equation 7 developed by Perala (1971). Site index from the 1973 data was determined to be 38 feet at 50 years.

As expected, stand growth in the thinned and check plots responded proportionately to residual density. Thirty-eight years after thinning, trees in the most heavily thinned plots (800 trees/acre) averaged 1.45 inches more at d.b.h. (table 1) and trees >3.5 inches d.b.h. averaged 0.83 inches more at d.b.h. than trees in the check plots (table 2).

Table 1.—*Black spruce stand data by treatment for all trees*

Treatment	Pre-thin[1]	Number of trees per acre				Mean d.b.h. (inches)				Basal area per acre (feet^2)			
		1953[2]	1967	1973	1992	1953	1967	1973	1992	1953	1967	1973	1992
800	3,673	801	800	798	713	2.35	4.21	4.82	6.29	29	83	107	160
1,300	5,187	1,305	1,322	1,320	1,048	2.02	3.57	4.07	5.54	35	101	130	187
Checks	5,240	1,145[3]	1,980	2,075	1,285	2.32	3.02	3.30	4.84	37	111	140	182

Data based on:

[1]*Four 1/50-acre plots per treatment (all trees counted).*

[2]*Four 1/10-acre plots for each treatment of 800 and 1,300 trees/acre.*

[3]*Trees >1.5 in. d.b.h. only on 1/20-acre permanent plots in 1953.*

Table 2.—*Black spruce stand data by treatment (trees >3.5 in. d.b.h.)*

Treatment	Pre-thin[1]	Number of trees per acre				Mean d.b.h. (inches)				Basal area per acre (feet^2)			
		1953[2]	1967	1973	1992	1953	1967	1973	1992	1953	1967	1973	1992
800	30	95	558	683	698	4.24	4.77	5.12	6.36	10	71	102	159
1,300	25	53	580	790	953	4.54	4.59	4.85	5.75	6	69	105	177
Checks	85	85	440	765	955	4.26	4.60	4.58	5.53	9	52	91	166

Data based on:

[1]*Four 1/50-acre plots per treatment (all trees counted).*

[2]*Four 1/10-acre plots for each treatment of 800 and 1,300 trees/acre.*

The 800 trees/acre plots (with 257 fewer trees/acre) had a lower basal area per acre (7 ft^2 less) than the check plots (table 2), but produced 3.8 cords/acre more (table 3).

All these volumes exceed the 27 cords/acre estimated by Heinselman (1957) for a medium site at age 70.

Both the cordwood rotation chart (Johnston 1977) and the mean and current annual increment data (tables 4 and 5) show that the stand, regardless of treatment, is past the recommended rotation and could be harvested (fig. 1). The 800 trees/acre treatment has only 15 trees/acre that are <3.5 in. d.b.h.; the check plots have 330 unmerchantable trees/acre.

Cumulative diameter distribution (fig. 2) compares by treatment how the trees grew from the initial study installation in 1954 to 1992. The 800 trees/acre plots had no ingrowth trees; the check plots from 1953 to 1973 had 930. During the next 19 years (1974-1992), 790 of those trees died.

Actual basal area vs. age shows a near linear relationship, but the predicted basal area is curvilinear (fig. 3). Clearly, Perala's (1971) growth model, developed almost entirely from older natural stands, does not estimate growth well for younger stands.

CONCLUSIONS

Black spruce growing on an average site responded to thinning, achieving greater diameter growth and about 10-percent greater yield than unthinned black spruce over a 40-year period. Additional analyses would be required to determine if putting in 2 to 3 workforce days/acre to gain 3.8 cords on 257 fewer crop trees is economically efficient.

LITERATURE CITED

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Table 3.—*Merchantable volume of black spruce treatment (trees >3.5 in. d.b.h.)*

Treatment	Cubic feet/acre[1]				Cords/acre[2]			
	1953	1967	1973	1992	1953	1967	1973	1992
800	190	1,377	2,009	3,251	2.1	14.9	21.6	34.8
1,300	116	1,339	2,066	3,585	1.0	11.9	18.7	33.6
Checks	171	1,018	1,799	3,369	1.8	9.8	17.0	31.0

[1]*Using equation 3 (Perala 1971).*
[2]*Using equation 4 (Perala 1971).*

Table 4.—*Black spruce mean and current annual increment (trees >3.5 in. d.b.h.)*

	Cords/acre/year						
	MAI				CAI		
Treatment	29[1]	43	49	68	37	46	59
800 trees/acre	0.07	0.35	0.44	0.51	0.91	1.12	0.69
1,300 trees/acre	.03	.28	.38	.49	.78	1.13	.78
Checks	.06	.23	.35	.46	.57	1.20	.74

[1]*Age (years)*

Table 5.—*Black spruce mean d.b.h. and current annual volume growth 1954-1967, 1968-1973, and 1974-1992*

Treatment	Mean d.b.h. growth/year (inches)						Mean current annual volume growth (d.b.h. > 3.5 in.)					
	All trees			Trees > 3.5 in. d.b.h.			Cubic feet/acre			Cords/acre		
	54-67	68-73	74-92	54-67	68-73	74-92	54-67	68-73	74-92	54-67	68-73	74-92
800 trees/acre	0.133	0.102	0.077	0.038	0.058	0.065	84.8	105.3	65.4	0.91	1.12	0.69
1,300 trees/acre	.111	.083	.077	.004	.043	.047	87.4	121.2	79.9	.78	1.13	.78
Checks	.050	.047	.081	.024	-.003	.050	60.5	130.2	89.5	.57	1.20	.74

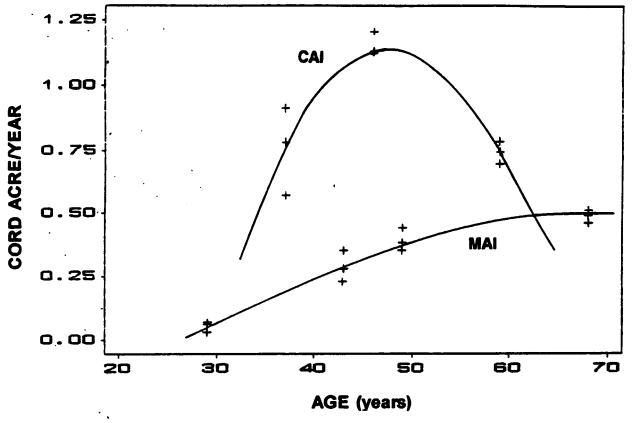

Figure 1.—*Black spruce mean and current annual increment by cords/acre/year for trees >3.5 inches d.b.h.*

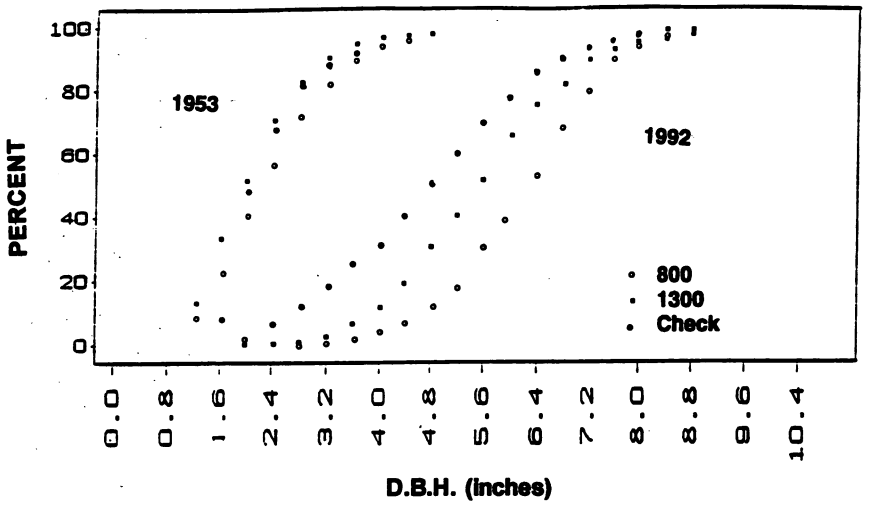

Figure 2.—*Black spruce cumulative d.b.h. distribution - 1953 and 1992.*

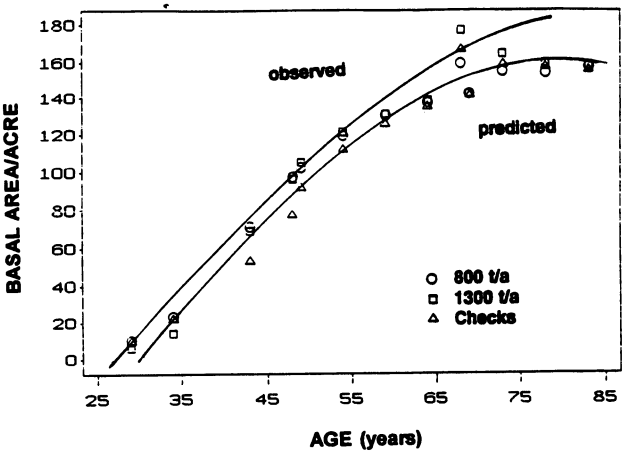

Figure 3.—*Black spruce observed and predicted (Equation 7, Perala 1971) basal area over time.*

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