Five-year growth response of a white spruce and balsam fir fertilization field trial in Cape Breton

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ABSTRACT

Diameter readings taken five growing seasons after the fertilization treatment of a young balsam fir stand with 448 kg/ha (400 lb/acre) of NPK fertilizer and of a semi-mature white spruce stand with 112 and 224 kg N/ha (100 and 200 lb N/acre) as urea indicate no marked increase in periodic basal area increment due to fertilization. However, fertilization increased the net basal area growth of the stands by reducing natural mortality.

RESUME

Les chiffres du diamètre relevés cinq périodes de végétation après la fertilisation d'un jeune peuplement de Sapin baumier [*Abies balsamea* (L.) Mill.] à l'engrais NPK à raison de 448 kg/ha (400 lbs/acre), et d'un peuplement d'Epinette blanche [*Picea glauca* (Moench) Voss] d'âge moyen à l'azote à raison de 112 et 224 kg/ha (100 et 200 lbs/acre), comme sources d'urée, n'indiquent pas d'augmentation marquée de l'accroissement périodique de la surface terrière du fait de la fertilisation. Toutefois la fertilisation a augmenté l'accroissement net de la surface terrière de ces peuplements en y réduisant la mortalité naturelle des arbres.

INTRODUCTION

In 1968 a forest fertilization field trial was initiated by the Pulp and Paper Research Institute of Canada (PPRIC) and Nova Scotia Forest Industries Ltd. to determine the growth response of balsam fir and white spruce to fertilizer applications. The company was responsible for the establishment and maintenance of the trial during the response period, while the Silvicultural Section of the Institute was responsible for the analysis and assessment of the response data. The Silvicultural Section was phased out in 1972 and the Canadian Forestry Service accepted responsibility for the assessment services that were formerly supplied by the Institute. The first remeasurement of the plots was carried out by staff of the Maritimes Forest Research Centre in 1973, five growing seasons after fertilization.

MATERIALS AND METHODS

During the winter and spring of 1968-1969, four experimental plots were established by Nova Scotia Forest Industries Ltd. in a 43-year-old old-field white spruce stand, and four in a dense 28-year-old balsam fir stand, located 2.4 km (1.5 miles) northeast of Ferguson Lake in Richmond County, Nova Scotia. The stands are located on opposite sides of a forest road, on stony well-drained soil of the Thom series overlying a parent material of grayish-brown sandy loam till derived largely from metamorphosed sedimentary rocks.

The trial was established according to the guidelines set out by the Institute for location, establishment, and fertilization of experimental plots. Circular 0.04 ha (0.10 acre) plots were used in the white spruce stand, and 0.02 ha (0.05 acre) plots in the balsam fir stand. All dead trees were cleared from each plot and piled at the perimeter. All the living trees in an inner 0.02 ha circle in the white spruce stand, and in an inner 0.005 ha circle in the balsam fir stand were numbered and measured at breast height to the nearest 0.025 cm.

Two plots in each stand were fertilized on May 20, 1969; the remaining plots were used as controls. The balsam fir stand was treated at the rate of 448 kg per hectare (400 lb/acre) with a premixed 19-19-19 granular fertilizer which was equivalent to 34 kg N, 13 kg P, and 29 kg K per hectare (or 76 lb N, 33 lb P, and 63 lb K per acre). One plot in the white spruce stand was treated with urea (45% N) at the rate of 112 kg N per hectare (100 lb N/acre) and the other plot received 224 kg N per hectare (200 lb N/acre). Breast height diameters of all trees were measured at the end of the growing season in 1973.

RESULTS

Summaries of the establishment and remeasurement data are shown in Tables 1 and 2.

Plot 1-2 in the white spruce stand (Table 1) has more stems per hectare than the other plots, but on a basal area basis the four plots were sufficiently uniform to permit treatment comparisons. The net basal area increase in the five-year interval was larger in the

Table 1. Plot establishment and remeasurement data - White Spruce stand, Barren Hill, Ferguson Lake. (Data present in S.I Units)

Treatment:	Control	Control	100 N*	200 N*
Block - Plot No.:	1-2	1-4	1-3	1-1
1969 measurement				
A. Live trees in 1969				
No. trees/ha (acre)	5483 (2220)	2668 (1080)	2568 (1040)	2946 (1200)
Basal area m^2/ha (ft^2/acre)	36.2 (157.8)	35.5 (154.4)	36.9 (160.9)	35.8 (156.0)
Average DBH cm (in)	8.81 (3.47)	12.32 (4.85)	12.83 (5.05)	11.84 (4.66)
B. Surviving trees in 1973**				
No. trees/ha (acre)	4248 (1720)	2124 (860)	2124 (860)	2741 (1110)
Basal area m^2/ha (ft^2/acre)	31.4 (137.0)	31.9 (139.1)	33.9 (147.5)	33.9 (147.7)
Average DBH cm (in)	9.42 (3.71)	13.31 (5.24)	13.66 (5.38)	12.04 (4.74)
1973 remeasurement				
C. Live trees				
No. trees/ha (acre)	4248 (1720)	2124 (860)	2124 (860)	2741 (1110)
Basal area m^2/ha (ft^2/acre)	34.8 (151.8)	35.7 (155.7)	37.8 (164.8)	37.4 (162.9)
Average DBH cm (in)	9.88 (3.89)	14.10 (5.55)	14.45 (5.69)	12.65 (4.98)
D. Dead trees				
No. trees/ha (acre)	1235 (500)	543 (220)	445 (180)	247 (100)
Basal area m^2/ha (ft^2/acre)	4.8 (20.8)	3.5 (15.3)	3.1 (13.4)	1.9 (8.2)
Average DBH cm (in)	6.76 (2.66)	8.38 (3.30)	1.39 (3.52)	9.47 (3.73)
Net change in plot (C-A)				
Basal area m^2/ha (ft^2/acre)	-1.4 (-6.0)	0.2 (1.3)	0.9 (3.9)	1.6 (6.9)
Average DBH cm (in)	1.07 (0.42)	1.78 (0.70)	1.63 (0.64)	1.07 (0.42)
Mortality (%)	23	20	17	8
Response on surviving trees only (C-B)				
Basal area m^2/ha (ft^2/acre)	3.4 (14.8)	3.8 (16.6)	3.9 (17.4)	3.5 (15.2)
Average DBH cm (in)	.46 (0.18)	.79 (0.31)	.79 (0.31)	.61 (0.24)
Periodic BAI (%)	10.8	11.9	11.6	10.3

* 112 & 224 kg N/ha (100 and 200 lbs N/acre) applied as urea.
** 1969 measurements based only on those trees alive in 1973.

fertilized plots than in the unfertilized plots. In fact, the denser of the two control plots showed a net loss of basal area growth during this period. Only small differences in periodic basal area increment on the surviving trees were noted between the control and treated plots. Apparently, the gain in net growth on the fertilized plots did not result from the extra wood grown due to fertilization, but from reduced tree mortality. Mortality was notably higher in the control plots, and the primary effect of treatment appears to be maintenance of trees that would otherwise have died.

The younger and denser balsam fir stand (Table 2) showed greater growth than the white spruce stand although a similar response pattern was apparent. The treatment was replicated in this trial, thus on the average the net basal area increased by 6.7% in the NPK treated plots, while the untreated plots increased by 2.8%. The basal area response on surviving trees differed slightly amounting to 18.4% and 17.9% for the fertilized and unfertilized trees, respectively. Again, the net growth of the fertilized plots was altered by tree mortality rather than by a fertilizer-induced growth response. Mortality within the replications was consistent during this response period and was lower in the fertilized plots than in the control plots (23.5% vs 31.5%).

DISCUSSION

In both stands, the 5-year periodic basal area increment of the surviving trees on the fertilized and unfertilized plots differed only slightly indicating no effective stimulation of radial growth due

Table 2. Plot establishment and remeasurement data - Balsam Fir, Barren Hill, Ferguson Lake. (Data presented in S.I. Units)

Treatment:	Control		Control		NPK*		NPK*	
Block - Plot No.:	2-2		2-4		2-3		2-1	
<u>1969 measurement</u>								
A. Live trees in 1969								
No. trees/ha (acre)	13239	(5360)	18574	(7520)	12844	(5200)	12250	(4960)
Basal area m^2/ha (ft^2/acre)	47.5	(206.8)	69.1	(301.2)	60.7	(264.5)	48.5	(211.2)
Average DBH cm (in)	7.12	(2.83)	7.26	(2.86)	7.75	(3.05)	7.29	(2.87)
B. Surviving trees in 1973**								
No. trees/ha (acre)	9090	(3680)	12646	(5120)	9682	(3920)	9485	(3840)
Basal area m^2/ha (ft^2/acre)	42.1	(183.6)	59.6	(259.5)	53.5	(233.1)	44.9	(195.8)
Average DBH cm (in)	7.19	(2.83)	7.26	(2.86)	7.75	(3.05)	7.29	(2.87)
<u>1973 remeasurement</u>								
C. Live trees								
No. trees/ha (acre)	9090	(3680)	12646	(5120)	9682	(3920)	9485	(3840)
Basal area m^2/ha (ft^2/acre)	50.0	(217.6)	69.9	(304.6)	62.8	(273.7)	53.7	(233.8)
Average DBH cm (in)	7.77	(3.06)	7.79	(3.07)	8.31	(3.27)	7.87	(3.10)
D. Dead trees								
No. trees/ha (acre)	4150	(1680)	5928	(2400)	3161	(1280)	2766	(1120)
Basal area m^2/ha (ft^2/acre)	5.3	(23.2)	9.6	(41.7)	7.2	(31.4)	3.5	(15.4)
Average DBH cm (in)	3.91	(1.54)	4.45	(1.75)	5.21	(2.05)	3.96	(1.56)
<u>Net change in plot (C-A)</u>								
Basal area m^2/ha (ft^2/acre)	2.5	(10.8)	0.8	(3.4)	2.1	(9.2)	5.2	(22.6)
Average DBH cm (in)	1.63	(0.64)	1.42	(0.56)	1.19	(0.47)	1.35	(0.53)
Mortality (%)	31		32		24		23	
<u>Response on surviving trees only (C-B)</u>								
Basal area m^2/ha (ft^2/acre)	7.9	(34.0)	10.3	(45.1)	9.3	(40.6)	8.8	(38.0)
Average DBH cm (in)	0.58	(0.23)	0.53	(0.21)	0.56	(0.22)	0.58	(0.23)
Periodic BAI (%)	18.8		17.3		17.4		19.6	

* 448 kg/ha (400lbs/acre) of 19-19-19 mixed fertilizer.

** 1969 remeasurements based only on those trees alive in 1973.

to the fertilizer treatment. A more detailed study of the stands is needed to explain the absence of any real growth response from fertilization. The trial may have been confounded by by the initial "cleaning" that took place prior to fertilization. In 1968 all the dead trees were cleared from the plots and piled at the perimeter. No records were kept of the number of trees removed when the plots were established. However, stump counts taken at time of remeasurement indicated that as many as 66% of the trees were presumed dead and were removed. The removal of such a large number of trees from the plots "opened up" the canopy, which probably elevated soil temperature and mineralization rates of nutrients in the forest floor and resulted in increased nutrient availability in the rooting zone (5, 7). The addition of fertilizers at a time when the trees are not subject to severe nutrient deficit may account for the lack of a noticeable fertilizer growth response.

Although no significant growth increases from fertilization were evident in this trial, the results are useful and pertinent to current silvicultural practices in Nova Scotia. The results can guide us in deciding where to fertilize. Young managed or spaced stands have often been considered as prime candidate areas for fertilization (6). Spacing reduces competition for the crop trees, and also exposes the forest floor to increased radiation and accelerated decomposition (5). Thus, for some time period after spacing the residual trees would grow under a diminished nutrient stress. In these circumstances it may be advisable not to fertilize juvenile stands immediately after spacing treatment, but after a suitable interval, or when crown closure occurs.

There has also been much speculation on the apparent self-thinning or spacing effect induced by the fertilization treatment of young, dense, natural stands (2, 3). Merchantable growth increments may be substantially increased by accelerating dominance in overstocked stands, thus concentrating growth on fewer stems per unit area. The combined response from accelerated natural thinning and enrichment induced by fertilizers may be large enough to consider aerial fertilization practices as an economic alternative to costly spacing operations which are time consuming and labour intensive. Reports have been positive on this type of response pattern with some coniferous species of the southern and western regions of the United States (1, 4, 8).

In prescribing the fertilizer treatments for this trial it was hoped that in addition to the extra growth response, fertilization would also "promote dominance in these over-crowded stands" (Swan[1]). In view of the greater shade tolerance of balsam fir, it may be more difficult to stimulate natural thinning in this tree species by fertilization than in the less tolerant pines in the South. We failed to detect an increased self-thinning response from the growth data; in fact mortality seemed to be reduced by fertilization. However, the acceleration of dominance is a long-term process in stand development and may not be accurately evaluated on a five-year basis. The next remeasurement in 1978 should give a more definite indication of this effect.

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