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EFFECTS OF CROWN RELEASE AND FERTILIZER ON SMALL SAW LOG-SIZED YELLOW BIRCH

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Sternitzke (1974) reported that yellow birch (*Betula alleghaniensis* Britton) sawtimber removals exceed growth and that the volume of birch growing stock declined 33 percent in the United States since 1963. These factors, combined with the slow growth rate of birch in unmanaged stands, has caused serious shortages in saw and veneer logs required by industry. The quickest improvement in the current situation can probably be made by increasing growth and volume production on potentially high value small saw log-sized trees in such stands. This study was established in 1971 to test crown release and fertilizer treatments aimed at doing exactly that.

Forty-five study trees were selected from a 65-year-old even-aged stand, which is located on the Argonne Experimental Forest in northeastern Wisconsin. Yellow birch comprised about 46 percent of the 348 trees per acre that were 2.6 inches d.b.h. and larger.[1] This proportion is four times higher than was commonly found in northern hardwood types of the Lake States (Eyre and Zillgitt 1953). The stand had 102 saw log-sized trees (9.6 inches d.b.h. and larger) per acre; 80 percent of which were under 13.5 inches. Saw log-sized birch trees occupied codominant crown positions and ranged from 8 to 22 feet shorter than the dominant trees largely of other species.

Nine groups of 5 similar trees were selected for the study, making a total of 45 study trees. All of these trees were codominants and well spaced apart. The five individual trees within each selected group for treatment comparisons were well matched as to breast height diameter (d.b.h.), height, stem characteristics, crown size, and density.[2]

Five treatments were randomly applied to one of the five individual trees within each group. These treatments were four intensities of crown release: 5-foot, two-tree, single-tree, no release, and another single-tree release treatment with fertilizer applied one season later. This provided for nine individual tree replications of each of the five treatments.

Before leaf-out in early May 1971, all crown release thinning was done. Only the most important crown competitor(s) was cut in the single-tree and two-tree treatments. For the 5-foot treatment, all trees whose crowns were within 5 feet of the study tree's crown perimeter were cut. This involved cutting from 5 to 11 trees per study tree (average was 8). About 50 percent of the cut trees were important competitors, the remaining were less important intermediate or suppressed trees.

The next spring, 9 of the 18 single-tree released trees were fertilized. This was done be broadcasting N, P, and K fertilizer using a cyclone seeder on a circular plot (0.01 acre) around each assigned tree (11.78 foot radius).[3]

More details of special measurements taken and methods used are given in Appendices II and III.

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[1]*See Appendix I for percent of trees 2.6 inches d.b.h. and larger by basal area as well as for other stand conditions before treatments were applied including soil and weather conditions.*

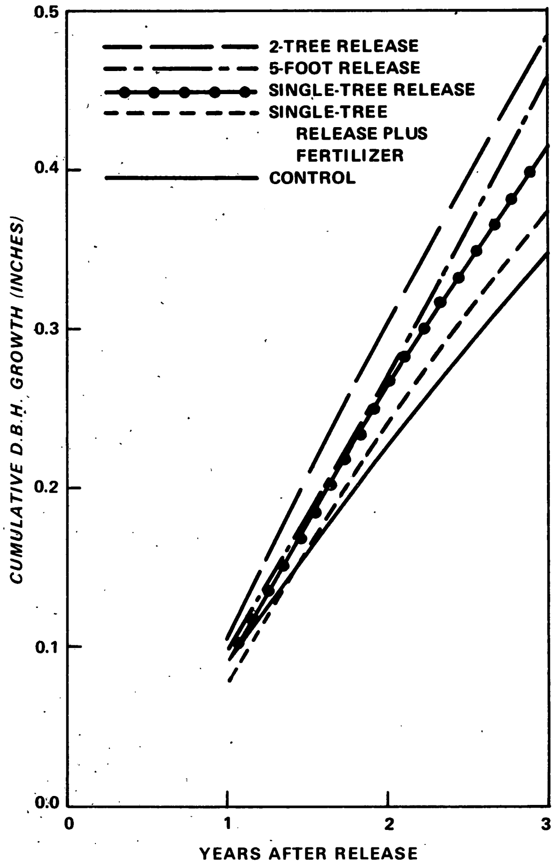
[2]*Initial overall averages for the 45 trees were as follows: height, 73 feet; crown length, 31 feet; crown diameter, 20 feet; and d.b.h., 10.4 inches (range 8.7 to 12.8 inches). Only one of the five-tree groups was under (9.6 inches d.b.h.).*

[3]*Each nutrient was applied at 100 pounds per acre (elemental basis).*

DIAMETER GROWTH RESPONSE TO RELEASE

Diameter growth of all saw log-sized trees gradually increased during the 3-year period following crown release. The amount of growth was generally related to the degree of release (fig. 1). However, well-defined trends were not apparent until after the second growing season following release; statistical differences in annual diameter growth rate did not become significant (0.05 level) until after the third growing season. There were no significant differences in growth rate between the control, single-tree release, and the single-tree release plus fertilizer treatments. During the 3-year period, trees released 5-feet beyond the crown perimeter and those released from two competitors outgrew the unreleased trees by 42 percent and 50 percent, respectively, as shown in the following tabulation:

Figure 1.--*Mean cumulative diameter growth by treatments and years after release.*



Crown release	*Three-year diameter growth* (inches)
No release (control)	0.35 a[4]
Single-tree plus fertilizer	0.37 ab
Single-tree	0.41 abc
5-foot	0.45 bc
Two-tree	0.48 c

Part of the increase in diameter growth was probably related to the gradual buildup in crown size and density as well as to the additional growing space. Increases in crown width and effective crown area, brought about by greater lateral branch elongation in released than unreleased trees, appeared to be the most important factors in crown buildup.

Change in foliage density was not as apparent in this study as observed in pole-size trees over the same period of time (Erdmann and Peterson 1972). The vigorous growth of epicormic sprouts that quickly filled-in the crowns of released pole-sized trees was nearly absent in these small saw logs. Differences in crown length caused by height growth and retention of lower branches did not appear to influence diameter growth of the saw log-sized trees.

BOLE QUALITY

Butt logs of study trees were graded (Hanks 1971): 67 percent of the selected trees qualified as grade 3 at the beginning of the study. Only 11 percent were large enough in diameter and free of defects to be assigned grade 2. The remaining trees were below minimum size for any tree grade. Merchantable log height (to a variable top diameter of not less than 8.0 inches) ranged from one-half to one and one-half logs, averaging only one log. However, all study trees were estimated to have a height potential of at least two 16-foot logs. Thirty-one percent appeared to have a two and one-half-log potential and 13 percent a three-log potential; further development was restricted by crown breakup caused by forking, limbiness, or excessively large limbs. About

[4]*Values followed by same letter in a column are not significantly different (0.05 level) using Duncan's New Multiple Range Test.*

two-thirds of the study trees had forks, all of which occurred at or above 29 feet on the bole.

So far, sapsucker feeding activity has occurred only on exposed birch trees that are growing along the edges of roadways and larger openings within the study area. Birdpeck and epicormic branching have not been problems associated with crown release on trees released up to 5 feet beyond their crown perimeters. Sunscald also has not proven to be a problem associated with release.

RESPONSE TO FERTILIZATION

Fertilization responses were determined by comparing the growth of single-tree released only with single-tree released plus fertilized trees in each of the nine sample groups. Broadcast fertilization with N, P, and K had no significant influence on diameter growth during the 2-year period following application. Growth of fertilized trees during the season of application exceeded that of the nonfertilized released controls by 5 percent. During the second growing season, however, fertilized trees grew slightly less than those not fertilized.

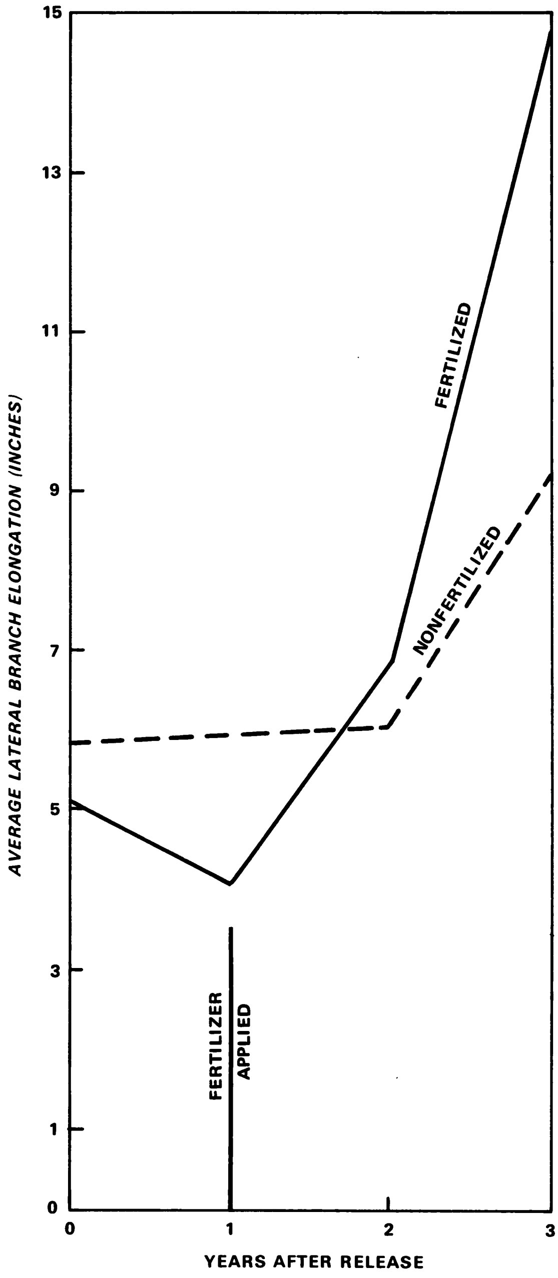
Fertilization increased lateral branch elongation in the upper, free-growing part of birch crowns.[5] The difference in annual branch elongation between fertilized and nonfertilized trees became apparent at the end of the first growing season following fertilizer application (fig. 2). However, differences first became significantly greater ("t" at 0.05 level) for the nine fertilized trees after the second growing season. Average growth per shoot was 10 inches more for fertilized than nonfertilized trees.

Foliage density was not noticeably improved by fertilization (see Appendix II for foliage density rating procedure). However, the fertilized trees probably had more leaves on the longer lateral shoots produced after fertilization because the number of leaves on a shoot and its length are positively correlated.[6]

[5]*Annual lateral branch elongation was measured to the nearest ½ inch on clipped branch tips in 1972 and 1973. Measurements of lateral branch growth were made on branches between terminal bud scars from the branch tip toward the bole.*

[6]*F. T. Metzger. Unpublished data on file at the Northern Hardwoods Laboratory, Marquette, Michigan.*

Figure 2.--*Effect of fertilization when applied 1 year after release on mean annual lateral branch elongation of single-tree released birches.*



Although there was no change in diameter growth rate, foliar analyses showed that the uptake of P and K was promoted by fertilization (see Appendix III). Both the percent concentration and absolute amount (or total content) of P and K in leaves of fertilized trees were significantly higher during the growing season during which fertilizer was applied than the season before application (table 1). In August 1973, two growing seasons after fertilization, absolute amounts (milligrams per leaf basis) of P and K in foliage of fertilized trees dropped to prefertilizer treatment levels. There were significantly lower absolute amounts of Ca and Mg in leaves of individual trees one season after fertilization than one season before fertilization. Average total content of these elements per leaf were not different in fertilized and nonfertilized trees after the second season following fertilization (table 2).

Leaf percentage values were not reliable indicators of the nutrient status of the leaves; similar results were also reported for birch (Hoyle 1965). For example, the percentages of P and K in fertilized tree foliage were significantly higher in 1973, the season after fertilization, than in 1972, the season of fertilization. These results could lead one to incorrectly conclude that nutrient uptake was greater one season after fertilizer application when, in fact, absolute content of elements per leaf was actually significantly lower (table 1). The significantly higher P and K percentage values resulted from significantly lower fertilized tree leaf weights in 1973 than in 1972. One other noticeable effect of fertilization during the first 2 years was that foliage in crowns of fertilized trees remained green after the other trees had turned yellow.

MANAGEMENT IMPLICATIONS

Early results indicate that previously untended 65-year-old codominant yellow birch trees will respond to crown release but the increase in diameter growth rate will occur

Table 1.--*Change in the average composition of single-tree released plus fertilized birch foliage from one growing season before to two seasons after fertilization*[1]

Sampling time	N	P	K	Ca	Mg
		Percent dry leaf weight			
Season before fertilization	2.14	[2]0.24c	0.74c	1.18b	0.36a
Season of fertilization	([3])	.31b	1.31b	1.05b	.35a
Season after fertilization	2.80	.45a	1.47a	1.49a	.36a
		Milligrams per leaf			
Season before fertilization	5.64	0.66b	1.98b	3.24a	0.99a
Season of fertilization	([3])	.82a	3.46a	2.93a	.95a
Season after fertilization	2.66	.44b	1.45b	1.43b	.34b

[1]Foliage was collected in August (1-10) of 1971, 1972, and 1973 from the nine single-tree released plus fertilized trees.

[2]Values followed by the same letter in a column are not significantly different (0.05 level) using Duncan's New Multiple Range Test.

[3]Nitrogen analyses were not made in 1972.

Table 2.--*Average concentrations and absolute amounts of elements in birch foliage by treatments after fertilizer application*

Treatment	N	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
		Percent dryweight						*ppm*			
Released only	[1]2.70a	0.34b	1.14b	1.63a	0.41a	59a	118a	240a	9a	955b	82a
Released plus fertilized	2.80a	.46a	1.47a	1.49a	.36b	56a	123a	241a	9a	1,326a	80a
		Milligrams per leaf						*Micrograms per leaf*			
Released only	3.71a	.46a	1.60a	2.08a	0.56a	81	157	334	12	1,462	109
Released plus fertilized	2.66a	.44a	1.45a	1.43a	.34a	51	117	106	9	1,202	82

[1]Values followed by the same letter in a column are not significantly different (0.05 level) using Duncan's New Multiple Range Test.

gradually. Adjustments of the crown to the increased growing space and to change in density apparently require about 3 years before significant diameter growth becomes apparent. Release by removing two important competitors has shown the most response immediately following treatment. Although the response to the 5-foot release treatment, which removed twice as many important competitors, was similar, the greater growing space does suggest longer benefits.

In the Lake States there are about 8 million acres of immature second-growth northern hardwood stands under 75 years of age. Most are dense, unmanaged, even-aged stands that developed after heavy commercial cutting. Potentially valuable yellow birch trees growing under these conditions need to be crown released to assure their survival and stimulate growth. In this study, residual basal area density around individual widely spaced saw log trees averaging 10.4 inches d.b.h. in the 5-foot and two-tree release treatments averaged 84 and 109 square feet per acre, respectively.[7] If crown thinnings like these were applied under stand conditions, released crop trees normally would not be spaced so far apart. Thus for a stand (includes all trees in the main overstory canopy) of the same diameter, a residual basal area stocking level as low as 80 square feet would still be considered acceptable under Lake States conditions; a slightly lower level of about 75 square feet is recommended in the Northeast (Leak *et al.* 1969).

In structured stands under uneven-aged management, yellow birch saw log-sized trees should receive special attention during marking so that potentially high value trees will be released from at least two important competitors. These practices should encourage and maintain yellow birch in future stands to increase the growing stock and stimulate the development of larger trees required for industrial usage.

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[7] *Basal area density, a commonly used measure of stand stocking levels, was measured within 26.3 foot radius (1/20-acre plot) of the released trees center at d.b.h.*

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APPENDIX I

Trees 2.6 inches or larger averaged 152 square feet of basal area. Yellow birch trees made up nearly 37 percent of the basal area; sugar maple (*Acer saccharum* Marsh.) 18 percent; hemlock (*Tsuga canadensis* (L.) Carr) 18 percent; basswood (*Tilia americana* L.) 9 percent; white ash (*Fraxinus americana* L.) 8 percent; American elm (*Ulmus americana* L.) 5 percent; and white birch (*Betula paperifera* Marsh.), red maple (*Acer rubrum* L.), black ash (*Fraxinus nigra* Marsh.), and northern red oak (*Quercus rubra* L.) combined 5 percent.

The site indices based on stem analysis were 60 feet at 50 years for yellow birch and sugar maple and at least 5 feet greater at 50 years for basswood and white ash.

The study area is located on a level to gently rolling ridgetop, at an elevation of 1,750 feet. Soils classify as coarse loamy Alfic Fragiorthod primarily of the Iron River series although some areas have thin sand and gravel layers in the substratum that classify as Stambaugh. Effective rooting depth averages about 19 inches with a pH of about 5.3 within this upper layer.

Small boulders are common on the surface and throughout the profile. During the growing season, precipitation averages about 20 inches, but short dry periods are not uncommon.

APPENDIX II

Foliage density was rated after full leaf development each year. Foliage ratings were based on the average percent of the main stem within the tree's live crown that was obscured by foliage when viewed from two sides at one tree-length distance as follows: dense (87.5 or more), medium to dense (75 to 87.5), medium (62.5 to 75), fair to medium (50 to 62.5), fair (37.5 to 50), and poor (37.5 or less).

APPENDIX III

Each year foliage samples were collected from single-tree released fertilized and non-fertilized birch trees during the first week in August as recommended by Hoyle (1965). A sample of 25 to 68 mature sun leaves was taken from fully exposed upper branches on the south side of the crown at each occasion. Leaf samples were dried at 70° C, ground in a Wiley mill to pass a 20-mesh screen, and analyzed for nutrient concentrations. Total nitrogen was determined using a semimicro-Kjeldahl method (Bremner 1965); P, K, Ca, Fe, Al, Cu, Zn, B, and Mn determinations were made on dry-ashed (470° C for 4 to 5 hours) samples on the emission spectograph. These were made in 1971 and 1972 under the guidance of Donald R. Christenson, Associate Professor, Crop and Science Department, Michigan State University, East Lansing, Michigan. In 1973 these analyses were made by the Crop Research Laboratory, University of Minnesota. Paired t-tests were made to compare differences on foliage composition for each element between sample means.

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