by
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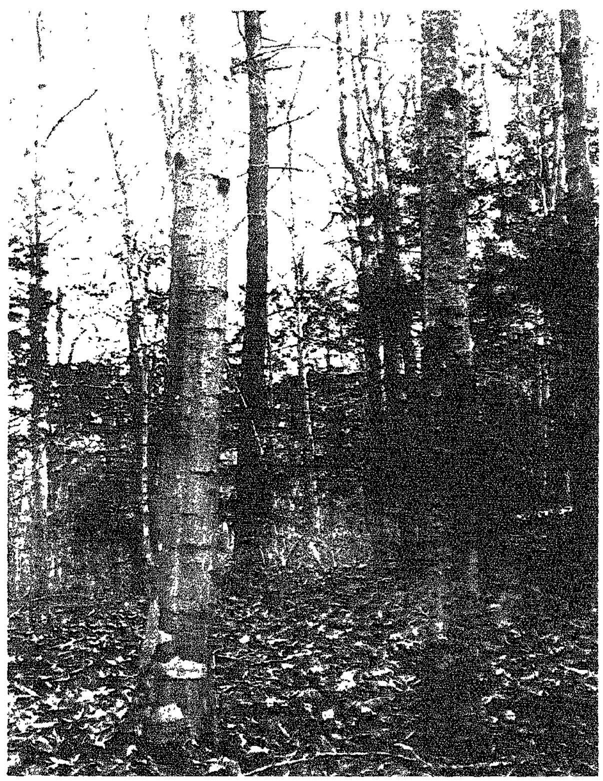
IMPACT OF BEECH BARK DISEASE ON UNEVEN-AGE MANAGEMENT OF A NORTHERN HARDWOOD FOREST (1952 to 1976)



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Abstract

A northern hardwood stand that had more than 50 percent of its total cubic foot volume in beech was managed under the single-tree selection system from 1952 to 1976. The peak of the killing stage of beech bark disease occurred during the early part of that period. The disease disrupted stand development, which led to a deficiency of large sawtimber trees and a lower butt-log quality. Two selection cuttings and two cultural treatments salvaged infected beech and improved the overall vigor of the residual growing stock, thereby minimizing the impact of the disease. Group selection cutting in combination with single-tree selection is recommended as an alternative where the objective is uneven-age management. The combination cuttings would help to regain control of stand development and increase the proportions of other highly valuable hardwoods—yellow birch, paper birch, and white ash.

INTRODUCTION

BEECH BARK DISEASE seriously affects American beech (*Fagus grandifolia* Ehrh.), a major component of northern hardwood forests in northeastern United States. Many infected beech trees are completely girdled by the disease and die in a few years. Others are only partially girdled and remain alive for many years, but in a weakened, defective condition. Yet some trees in the same stand remain free of disease (Fig. 1).

In the Northeast, the disease is caused principally by the fungus *Nectria coccinea* var. *faginata* Lohman, A. J. Wats, and Ayres that infects minute feeding wounds in the bark made by an insect, the beech scale, *Cryptococcus fagi* (Baer.) (Ehrlich 1934, Hepting 1971, Shigo 1970). At present, there are no practical measures for controlling the insect or disease where timber production is the primary objective.

Shigo (1972) separated the pattern of attack by the insect-disease complex into three stages: (1) the advance front, (2) the killing front, and (3) the aftermath zone. In the advance front, some beech scale can be found, but the disease is scarce. In the killing front, beech mortality is high over large areas. In the aftermath zone, beech that were apparently resistant are still thriving. Others may have all gradations of injury from a few small cankers to most of the stem killed.

Another scale insect, *Xylococculus betulae* (Perg.) Morrison, also causes defect on beech, especially in aftermatch zones (Shigo 1962). The roughened bark caused on beech bark by this insect is often mistaken for the bark injury that results from the beech bark disease.

Beech is used for a variety of products: furniture, plywood, dowels, shuttles, containers, and flooring. Beech is also an important pulpwood species. Then, too, beech makes excellent fuelwood. The wood burns steadily, gives off few sparks, and is highly desirable for fireplace use (Webber 1955). Beech nuts provide food for deer, bear, grouse, turkeys, and other wildlife, and the smooth, gray bark of a healthy beech makes the species esthetically appealing to tourist and hiker.

Figure 1.—The beech on the left has no bark disease; the one on the right has been killed by the disease. This suggests that certain trees have a natural resistance to the disease.

Because of these inherent values of beech, and the hazard of diseased trees in recreation areas, woodland owners and managers—and even the general public—have shown increased concern

Figure 2.—Uneven-aged northern hardwoods in the study area. Beech comprised 53 percent of the cubic-foot volume.

about the disease. Their concern is not only about beech kill, but also about the impact of the disease on woodland stand management. They want answers to: What is the effect on species composition, volume, and stand structure? How is stand growth and development affected? How is log grade changed?

The impact of the disease differs in different areas and, unfortunately, no single answer is available for all stands. Much depends on the proportion and age of beech in the stand before the disease attack, severity of the attack, and site conditions; the frequency of harvest cutting and cultural operations also have some influence.

A good clue to the impact of the disease and its implications has been provided by 24-year interim results from a long-term uneven-age management study begun in 1952 at the Bartlett Experimental Forest in the White Mountains of New Hampshire. The peak of the killing front of the disease occurred during the early part of the study. During later years, the study area was considered to be in the aftermath zone.

THE BARTLETT STUDY

The study area is 32 acres, situated on a northeasterly aspect, with a moderately steep midslope terrain, ranging in elevation from 1,100 to 1,300 feet. The soil is a well-drained glacial till (Hoyle 1973, Leak 1976).

In 1952, the timber was classified as uneven-aged (Fig. 2). A 100-percent tally of all live trees over 5.0 inches dbh (tallied by 2-inch dbh classes) showed 179 trees per acre containing 107 ft^2 of basal area or 2,487 gross ft^3. Beech was the predominant species; it comprised 53 percent of the cubic-foot volume. Other species were: sugar maple, 18 percent; paper birch, 11 percent; yellow birch, 11 percent; hemlock, 3 percent; red maple, 2 percent; red spruce, 1 percent; and white ash, 1 percent (Table 1).

Harvest cuttings were made in 1952 and 1975. The timber was marked under the single-tree selection system—using a 20- to 25-year cutting cycle (Eyre and Zilgitt 1953, Jensen 1943, Leak and Filip 1975). The immediate need in both operations was to salvage beech severely weakened by the bark disease. Because of the continual threat of bark disease, sugar maple and other commercial species were favored over beech in the residual stocking whenever feasible (Crosby and Bjorkbom 1958, Shigo 1972). The long-term goal is to develop a balanced diameter-class distribution among trees of acceptable vigor and quality to ensure sustained sawtimber yields. (Previous logging in the study area was done before 1900). In 1956 and 1963, cultural treatments were made to release sugar maple saplings overtopped by thickets of beech, and to kill culls or poor-quality trees of all species.

RESULTS

Species Composition and Volume

Although logging, cultural work, and mortality have removed a relatively high cubic-foot volume of beech from the stand, beech always remained a strong component. It accounted for 53 percent of the stand volume in inventories made in 1952 before the first harvest cutting, and again in 1976 after the second. However, actual beech volume decreased by 339 ft^3 per acre during the 24 years of management (Table 1).

Of the eight commercial species in the stand, sugar maple and hemlock had an actual and percentage increase in volume. Yellow birch and paper birch, on the other hand, decreased in actual and proportionate volume during the management period. The remaining species—red maple, white ash, and red spruce—decreased in actual volume, but the proportion of each in the stand did not change.

Growth and Development

Interim inventories were made in 1953 after the first harvest cutting, and 19 years later, in 1972, to measure growth response and development. Basal area per acre in trees over 5.0 inches dbh increased from 70 to 100 ft^2 per acre; and average annual production of 1.6 ft^2 per acre. If trees over 5.0 inches dbh that were girdled in the two cultural operations had been included, the average annual basal area production would have been 2.0 ft^2 per acre.

The adverse effect of beech bark disease on stand growth and development during the 19-year period became apparent from comparison between the study area and uncut growth plots. Data from fifty 1/4-acre growth plots in uncut northern hardwood stands at the Bartlett Experimental Forest served as a reasonable guide for comparing growth responses (Filip et al. 1960). Stand characteristics in the plots and study area were fairly similar.

Annual production in the uncut plots averaged only 0.6 ft^2 per acre compared to 1.6 ft^2 per acre in

Table 1.—Gross volume per acre and percentage, by species and inventory period in trees over 5.0 inches dbh, using 2-inch dbh classes

Species	Inventory			
	1952 (before first cut)		1976 (after second cut)	
	*ft*³	%	*ft*³	%
Beech	1,314	53	975	53
Sugar maple	453	18	494	27
Paper birch	274	11	6	[a]
Yellow birch	272	11	130	7
Hemlock	80	3	166	9
Red maple	46	2	44	2
Red spruce	32	1	28	1
White ash	16	1	13	1
Total	2,487	100	1,856	100

[a] Less than 1 percent.

the study area (Table 2). High mortality in the uncut plots accounted for most of the low production. Large-size beech killed by the bark disease accounted for a high proportion of the mortality.

During the period when growth was measured (1953 to 1972), 86 trees over 11.0 inches dbh died in the study area. Of this number, 51 trees—59 percent—were beech. According to our ocular estimate, practically all beech mortality was caused by the bark disease.

Hardwood Quality

Salvage cutting of infected and poor-risk trees in the two harvests, and removal of undesirable trees in the two cultural treatments upgraded the butt-log quality of hardwoods in the residual stand during the 24-year management period (Table 3). The proportion of high-quality logs (grades 1 and 2) increased by 13 percent. Log grades are closely correlated with grade specifications for standard hardwood lumber (Rast et al. 1973). Unfortunately, the continual degrading effects of the disease prevented greater stand improvement. Since beech represented over half of the growing stock volume, lowering of beech quality directly affected stand quality.

The degrading effects of the disease became more apparent when the quality of beech was compared to the combined quality of the other five hardwoods in the stand (Table 4). Although the proportion of beech in grades 1 and 2 remained unchanged in the inventories made in 1952 and 1976, the actual volume in these grades decreased by 49 ft^3 per acre. During the same inventory periods, the combined volume of the other five hardwoods in grades 1 and 2 increased by 92 ft^3 per acre, a proportionate stand increase of 27 percent.

Medium-quality logs (grade 3) in the other hardwoods decreased, but the proportionate decrease was less in beech: 22 percent versus 16 percent. The proportion of local-use or poor-quality logs in beech increased by 25 percent while in the other hardwoods it decreased by 2 percent.

Table 2.—Growth components in the study area and uncut stands in trees over 5.0 inches dbh (square feet/acre/year)

Stand	Production[a]	Accretion	Ingrowth	Mortality
Study area	1.6	1.3	0.6	0.3
Uncut	.6	1.7	.3	1.4

[a] Production equals accretion plus ingrowth minus mortality; it is the net change in basal area between two inventories (Gilbert 1954).

Table 3.—Quality of hardwood sawtimber trees, by butt-log grade, in trees over 11.0 inches dbh

Quality class	Inventory 1952 (before first cut)		Inventory 1976 (after second cut)	
	ft ³/acre	%	*ft ³/acre*	%
Factory logs				
Grades 1 and 2	443	29	486	42
Grade 3	762	50	365	31
Local-use logs[a]	209	14	309	26
Total merchantable	1,414	93	1,160	99
Unmerchantable	116	7	11	1
Total	1,530	100	1,171	100

[a] Also includes sawtimber-size trees suitable only for pulpwood.

Table 4.—Quality of beech sawtimber versus other hardwoods, by butt-log grade

Quality class	Beech				Other hardwoods[a]			
	1952		1976		1952		1976	
	ft³/acre	%	*ft³/acre*	%	*ft³/acre*	%	*ft³/acre*	%
Factory logs								
Grades 1 and 2	184	21	135	21	259	40	351	67
Grade 3	452	52	236	36	310	47	129	25
Local-use logs[b]	144	16	265	41	65	10	44	8
Total merchantable	780	89	636	98	634	97	524	100
Unmerchantable	94	11	11	2	22	3	0	0
Total	874	100	647	100	656	100	524	100

[a] Sugar maple, yellow birch, paper birch, red maple, and white ash.
[b] Also includes sawtimber-size trees suitable only for pulpwood.

Table 5.—Average number of trees per acre according to diameter distribution of all species, by inventory period and a distribution used as a management guide

Dbh (inches)	1952 (before first cut)	1976 (after second cut)	Management guide
6	46.6	42.2	45.3
8	37.6	31.2	30.2
10	35.1	21.8	20.1
12	27.8	16.7	13.4
14	17.0	12.2	8.9
16	8.5	8.6	6.0
18	2.9	3.8	4.0
20	1.8	1.7	2.7
22	.7	.8	1.8
24	.5	.2	1.2
26	.1		
28	.2		
30	.1		
Total	178.9	139.2	133.6
Basal area (ft^2/acre)	107.4	82.3	80.0

Stand Structure

In 1976, after 24 years of management, the diameter distribution departed a little from the distribution we used as a management guide (Table 5). The guide is a reasonable one for use in regulating the residual stand structure and yield in uneven-age management of northern hardwoods in New England (Filip 1977, Gilbert and Jensen 1958, Leak and Filip 1975). It is based on a q of 1.5 (the constant quotient between numbers of trees in successively smaller dbh classes).

Although the residual basal area of 82 ft^2 per acre in 1976 practically met our long-term objective of 80 ft^2, a 33 percent deficiency existed in numbers of trees 18 inches dbh and larger. Trees 18 inches dbh and larger have a comparatively high lumber-grade potential. Beech mortality and the need to salvage severely weakened beech was largely responsible for the deficiency. Some of the deficiency was also caused by the need to salvage other species, harvest mature trees, and improve the general vigor of the stand.

DISCUSSION

Interim results from this long-term study have helped to quantify some harmful effects of beech bark disease on timber production under uneven-age management in a northern hardwood stand having a high proportion of beech. Fairly high beech mortality and the need to salvage many beech to recover the volume of heavily diseased trees, was largely responsible for disrupting overall stand growth and development. An imbalance in diameter-class distribution resulted, particularly among sawtimber trees. The continual deficiency of healthly trees in the upper sizes affected the yield of high-quality logs.

However, slow but steady progress has been made toward lowering the stocking of beech and increasing the stocking and proportion of sugar maple, a highly valuable commercial species that is also esthetically appealing. Although an imbalance still exists in the current diameter distribution, when compared to the distribution set up as the long-term goal in this study, the increased sugar maple stocking is encouraging.

Since some beech still showed signs of infection by the bark disease, we cannot readily determine the effect this will have on mortality or log quality in future years. As of 1976, however, the stand was in better condition than in 1952 when the study was begun. By our timely salvage of heavily infected beech when the killing front of the disease hit the study area, and our cutting and cultural operations during the aftermath stage, we achieved some improvement in log quality, species composition, and general vigor of the residual stand.

RECOMMENDATIONS

Because of the continual lethal effects of beech bark disease (Houston 1975, Shigo 1972), forest managers should consider some general guidelines in uneven-age management for minimizing the impact of the disease on stand production. Until we have a better understanding of the disease, one or more of the following guidelines may be applicable, depending to some extent on the stage of the attack:

- Undertake timely harvests (perhaps 10 years apart or less) and cultural operations to keep timber losses at a minimum while improving overall stand conditions.
- Favor commercial species other than beech among the growing stock whenever feasible.
- Modify the management components—residual stocking, maximum tree size, and diameter distribution—if necessary, to fit stand conditions (Filip 1977, Leak and Filip 1975). For example, during one or more stand improvement cuttings, residual stocking may have to be lowered to about 60 or 70 ft^2 per acre, instead of only 80 ft^2 as done in our study. Maximum tree size for beech should probably be no larger than 16 or 18 inches dbh; other species, not over 20 or 22 inches. The growing of large, high-quality beech is complicated by the disease (Shigo 1970).
- Use a combination of group selection and single-tree selection cutting (Leak and Filip 1977). Group selection (stand openings of about 1/2 acre) could be used to harvest mature, overmature, or defective trees, and to increase the proportions of the highly valuable, light-demanding yellow birch, paper birch, and white ash. Single-tree selection would be applied between group selections to shape stand structure and salvage beech as needed.
- Where beech root suckers, hobblebush, and other unwanted stems are prevalent in group-selection cuttings, scarify the forest floor. This should help to remove much of the competing vegetation and prepare a mineral soil-humus seedbed favored by birch regeneration (Filip and Shirley 1968).
- Beech should not be completely discriminated against, particularly in disease aftermath zones. Some beech tend to have a natural resistance to the disease, or become only lightly infected.

Where beech predominates, a stand diagnosis may show that the timber tract would be severely understocked after removal of heavily infected or dying beech and other species of low potential quality. If the residual basal area of acceptable stems in an uneven-aged stand will fall below 40 ft^2 per acre in trees over 5.0 inches dbh, the possibility of regenerating a new stand under even-age management should be considered (Leak et al. 1969).

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