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CLEARCUTTING in Northern Hardwood Results after 30 Year

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CLEARCUTTING

in Northern Hardwoods: Results after 30 Years

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Common and Scientific Names
of Species Mentioned in this Paper

Paper birch	*Betula papyrifera* Marsh.
Yellow birch	*Betula alleghaniensis* Britton
Sugar maple	*Acer saccharum* Marsh.
Red maple	*Acer rubrum* L.
White ash	*Fraxinus americana* L.
Beech	*Fagus grandifolia* Ehrh.
Aspen	*Populus grandidentata* Michx. or *Populus tremuloides* Michx.
Pin cherry	*Prunus pensylvanica* L. or *Prunus virginiana* L.
Striped maple	*Acer pensylvanicum* L.
Raspberry, blackberry	*Rubus* sp.
Hemlock	*Tsuga canadensis* L.

A Case History

THE TREND toward even-aged management of hardwoods has developed more slowly in the northern hardwood type than in most other types. This is partly because several of the northern hardwood species are shade-tolerant and can be managed successfully on an uneven-aged basis. But even in this type there is an increasing awareness that timber returns may be greatest under some form of even-aged management that will maintain high proportions of the valuable intolerant and intermediate species.[1]

Numerous studies have shown that small patch or strip clearcuttings provide optimum conditions for establishment of paper and yellow birch—two of the most valuable northern hardwoods *(4, 5, 6, 7, 8, 11)*. The smaller openings seem especially desirable for yellow birch *(4, 6, 11)*. However, there are little data to show that the abudance of seedlings established in these small openings is needed. Some foresters feel that the smaller numbers of seedlings established in large clearcuttings are adequate to provide a fully stocked stand.

Unfortunately there have been few attempts to apply complete

[1] The values attached to resources other than timber also are important in the choice of management systems. The northern hardwood forests of New England have always had high recreation values; clearcuttings associated with even-aged management will not be appropriate in many areas where recreation is the primary resource.

clearcutting to northern hardwood forests. One notable exception is a 22-acre tract on the Bartlett Experimental Forest in New Hampshire. Jensen *(2)* has reported on the regeneration present 5 years after clearcutting on that tract. The regeneration there has now developed into a 30-year-old stand; and this stand provides a unique opportunity to examine the case history of a northern hardwood stand resulting from complete clearcutting.

Area Studied

The clearcutting took place in an old-growth northern hardwood stand composed primarily of beech (61 percent), yellow birch (15 percent), and sugar maple (15 percent).[2] There were also small amounts of red maple, white ash, and paper birch in the overstory. Basal area of the stand averaged 122 square feet per acre in trees 4.6 inches d.b.h. and larger. The advanced regeneration present was primarily sugar maple, beech, and striped maple (table 1).

The stand was located on a lower slope of 20 to 25 percent, at an elevation of about 1,100 feet. The aspect is northly. The soil is a Hermon stony, sandy loam—a well-drained podzol derived mainly from granite and granitic gneiss glacial till. The mor humus depth averaged about 3 inches over the study area. Site index for paper birch is estimated to be 70[3] on this area.

Clearcuttings were made on three plots of 5 acres each, plus an additional area of 7 acres. Cutting was done during the winters of 1933, 1934, and 1935, but much of the material was removed during the snow-free season. An average of 60 cords of split wood per acre was removed. All hardwoods 1.6 inches d.b.h. and larger and all conifers 4.6 inches d.b.h. and larger were cut except for a few of the larger white ash, which were left as seed trees. Advanced reproduction on about half of the area was mowed, but this had little effect on the reproduction *(3)*. All subsequent measurements were limited to the 15-acre area contained within the three plots.

[2] Percentages based on basal area in trees 4.6 inches d.b.h. and larger.
[3] Site index based on height of dominant and codominant paper birch at 25 years of age, using Curtis and Post curves *(1)* with a base age of 50 years.

Table 1. — *Reproduction and stand development*

Species	Advance reproduction		At 5 years		At 25 years		At 30 years [1]	
	Trees 1 foot high to 1.5 inches d.b.h.		Trees 1 foot high or higher		Trees 0.6 inch d.b.h. or larger		Trees 0.6 inch d.b.h. or larger	
	Stems per acre	*Percent*	*Stems per acre*	*Percent*	*Stems per acre*	*Percent*	*Stems per acre*	*Percent*
			TOLERANT					
Beech	3,321	26	6,485	19	1,032	25	786	30
Sugar maple	7,245	56	9,745	29	1,041	26	776	29
Striped maple	2,085	16	1,515	4	127	3	63	2
Conifers	82	1	30	(*)	58	1	49	2
			INTERMEDIATE					
Yellow birch	177	1	2,719	8	474	12	325	12
White ash	29	(*)	279	1	93	2	64	2
Red maple	—	—	278	1	176	4	112	4
			INTOLERANT					
Paper birch	—	—	3,296	10	401	10	294	11
Aspen	7	(*)	874	3	54	1	47	2
Pin cherry	—	—	8,204	25	636	16	168	6
All species	12,946	100	33,425	100	4,088	100	2,684	100

* Less than 0.5 percent.

[1] Because of slight differences in species composition among the 5 control plots used at age 30 and the entire 20 plots used at age 25, the figures presented here for 30 years have been adjusted to reflect the composition of all 20 plots.

Study Methods

The advanced regeneration present before cutting, and regeneration present 5 years after cutting were tallied by species and height classes on milacre sample plots. These data have been published previously *(2)*, but they are presented here in condensed form for comparison with the present stand. In 1959 and again in 1964, 100 percent tallies were taken of all trees present on twenty ¼-acre plots regularly spaced within the three original 5-acre plots. At the time of the 1959 tally, approximately 100 potential crop trees were selected on each ¼-acre plot; these trees were permanently marked and numbered, and detailed measurements were taken on a sample of 382 of them. The measurements include: diameter at breast height and at the top of the first log; merchantable height; total height; crown size, crown class, and crown vigor; clear length of bole; number and location of branches, epicormic branches, and bole defects; bole quality class; and others. These measurements permit detailed evaluation of individual tree development.

The potential crop trees were selected on the basis of: species (paper birch, yellow birch, white ash, and sugar maple were given preference, but red maple and beech were accepted where necessary); origin (seedlings were given preference over sprouts); crown class and size (large dominant and codominant trees were given preference, but some intermediates were accepted where necessary); and bole condition (clean, straight boles with a minimum of defects were given preference).

A sequential multiple comparison test as outlined by Snedecor *(9)* was used to test differences among species in the various crop-tree attributes.

A thinning study was established on the twenty ¼-acre plots in 1959, when the stand was 25 years old. Data shown in this paper for 1964 (30 years after cutting) are therefore based only on five plots used as controls in the thinning study. Data on stand structure and individual tree characteristics are presented from the 1959 data to permit averaging of all sample trees and to avoid inclusion of treatment effects.

Stand Development After Clearcutting

Advanced reproduction before cutting was composed almost entirely of tolerant species (table 1). Immediately after cutting, raspberries. blackberries, and other herbaceous species dominated the area; along with stump sprouts, root suckers, and weed species like pin cherry, they appeared to offer little promise for the future. However, within a few years seedlings of more valuable species began to emerge from the brush. At 5 years of age, aspen, pin cherry, and paper birch were dominant, and large numbers of more tolerant species had become apparent. Pin cherry was the most prominent species; it occurred in large numbers and was taller than all other species except aspen. Although aspen was not numerous over the entire area, it was important in some spots. Aspen occurred in clumps — originating primarily from root suckers—where it grew rapidly and sometimes excluded all other vegetation.

The short-lived pin cherry began to drop out of the stand after about 15 years. Although some pin cherry trees are still surviving at age 30, mortality is now high; nearly 75 percent of the pin cherry present in 1959 died before 1964. At 30 years of age aspen, paper birch, and white ash are the dominant species; and red maple, yellow birch, sugar maple, and beech are present as codominants or lower crown classes.

Table 2.—*Stand characteristics at 25 years of age*

Tolerance group	Number of trees		Basal area		Average d.b.h
	Number	*Percent*	*Square feet per acre*	*Percent*	*Inches*
Tolerants	2,257	55	25.4	26	1.3
Intermediates	743	18	17.9	18	1.8
Intolerants	1,091	27	55.9	56	2.7
Total	4,091	100	99.2	100	1.8

Intolerant and intermediate species have dominated the new stand from the start. They are the larger trees; they occupy much of the main crown canopy; and they represented 74 percent of the basal area at 25 years of age (table 2). However, in spite of their dominance, intolerant and intermediate species are not as numerous as tolerant species. Five years after cutting, four tolerant species comprised over half of the total number of stems. This proportion has increased gradually as the stand matured so that tolerant species account for 63 percent of the stems at 30 years of age (table 1).

Although this is an even-aged stand, it should be apparent from the discussion above that it is much more complex than the typical pure even-aged stand. The various species have markedly different growth rates, tolerances to shade and competition, and maturity ages. The crown canopy is not one narrow level but is nearly continuous from about 10 feet to 50 feet or more above ground. The slower growing tolerant species are often entirely beneath the main canopy of less-tolerant species. The diameter distribution of the stand has already assumed the inverse-J curve typical of uneven-aged stands (fig. 1).

If left to mature naturally, this stand will become increasingly similar to an uneven-aged stand. The short-lived pin cherry is already drying out; aspen can be expected to follow between 40 and 60 years of age; and paper birch will likewise mature by the time the stand reaches the 80-year mark. Red maple and white ash should survive past 100 years, but eventually they too will mature and the stand will then be dominated by the original, long-lived climax species—beech and sugar maple with small amounts of yellow birch. Any cutting in the stand to remove merchantable trees will hasten this process *(10)*.

The present stand is dense, and competition is severe. In 1959 there were over 4,000 stems 0.5 inches d.b.h. or larger per acre, and these stems represented 99 square feet of basal area. Mortality over the 5-year period 1959 to 1964 amounted to 35 percent of the number of stems. In spite of the high mortality, net growth during that 5-year period amounted to 2.2 square feet of basal area per acre per year, so that the present stand contains 110

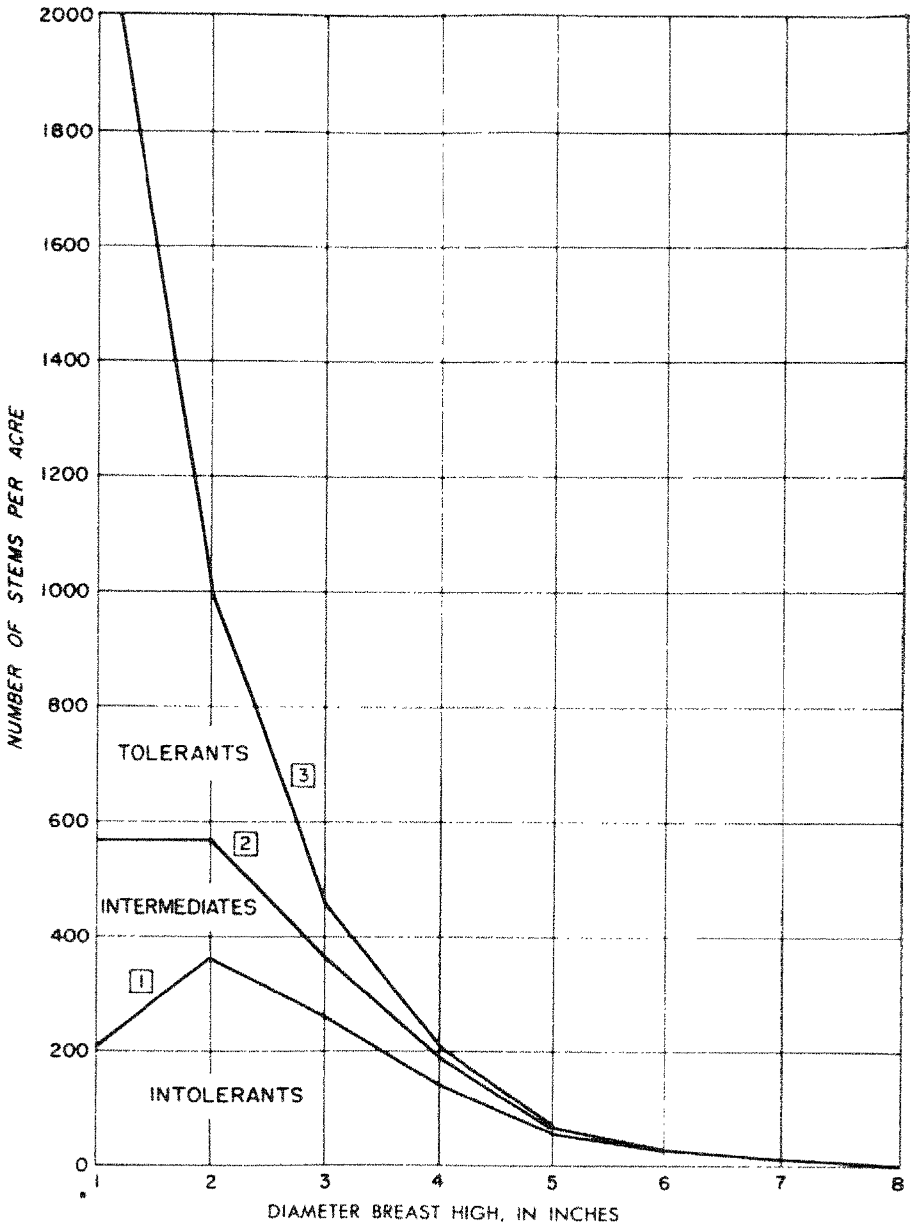

Figure 1.—Stand structure at 25 years of age. The curves are cumulative. That is, curve 1 represents intolerants only, curve 2 represents intolerants plus intermediates, and curve 3 represents all trees.

square feet per acre.[4] Growth on trees surviving the 5-year period was better than 4 square feet of basal area per acre per year. However, this growth is being spread over a large number of stems.

Characteristics of 25-Year-Old Trees

At 25 years of age, there was a sufficient number of desirable trees to permit selection of about 385 potential crop trees per acre. These trees represented 10 percent of the total number of stems and 30 percent of the basal area. About half of the potential crop trees were paper birch; the remainder were longer-lived species. A listing of potential crop tree characteristics is presented in table 3.

Based on the multiple comparison tests, the several species may be placed into groups representing similar qualities or sizes. Differences between the groups in the following discussion were statistically significant at the 0.05 level.

Paper birch had the largest average d.b.h. of all crop-tree species; white ash was second; yellow birch and red maple were third; and sugar maple and beech were fourth. Over the 25-year period, paper birch averaged 0.18 inches diameter growth per year, and sugar maple averaged 0.10 inches per year.

Paper birch and white ash were taller as a group than the other species. Red maple, yellow birch, and sugar maple were taller than beech. Paper birch averaged 1.7 feet of height growth per year as opposed to 1.3 feet per year for beech.

Crown size was expressed in four different ways. Differences among species in live crown length were not significant. But paper birch, white ash, and red maple had significantly larger crown areas and crown volumes than yellow birch, sugar maple, and beech. Crown ratio appears to be a poor measure of crown size: yellow birch and beech had larger crown ratios than the other four species, even though actual crown length was no

[4] For trees 4.6 inches d.b.h. or larger, basal area was 24 square feet per acre in 1959 and 52 square feet per acre in 1964.

Table 3.—*Characteristics of potential crop trees at 25 years of age*

Characteristic	Paper birch	White ash	Red maple	Yellow birch	Sugar maple	Beech	All crop trees
Trees per acre ....number..	169	31	21	67	73	24	385
Diameter at breast height ....inches..	4.4	3.9	3.5	3.2	2.8	2.7	3.7
Total height ....feet..	43	42	37	36	34	32	37*
Crown length ....feet..	22	21	20	21	19	18	20*
Crown ratio (length/total height) ....ratio..	.50	.50	.52	.57	.55	.58	.54*
Crown area projection ....square feet..	60	52	52	40	36	37	46*
Crown volume (area x length) ....cubic feet..	1,481	1,227	1,142	867	742	714	1,019*
Trees in dominant crown class ....percent..	33	20	9	0	0	2	10*
Trees in dominant and codominant crown class ...percent..	95	86	93	74	58	43	74*
Height to first branch ....feet..	16	10	9	12	11	10	12*
Height to first live branch ....feet..	21	21	17	15	15	14	17*
Branches on first log ....number..	0.2	0.3	0.8	2.0	2.0	3.5	1.5*
Epicormic branches on first log ....number..	0.0	0.0	0.4	2.5	2.8	4.6	1.8*
Trees with epicormic branches on first log ....percent..	0	0	5	41	43	62	27*
Grade 1 trees [1] ....percent..	38	30	14	10	5	5	17*
Grade 1 or 2 trees [1] ....percent..	66	46	32	29	32	13	37*
Average taper in 1964							
(d.b.h./diameter at 17 feet) ....ratio..	.81	.75	.80	.76	.79	.72	.77*
Current growth, 1959 to 1964—controls only							
D.b.h. increment per year ....inches..	.14	.16	.12	.09	.06	.07	.11
Height increment per year ....feet..	1.8	1.9	2.0	1.8	1.7	1.4	1.7*

* Based on equal numbers of each species—not actual distribution.

[1] See text for description of bole grades.

greater and crown area and crown volume were smaller than the other species.

Crown class is closely related to species, stem size, and crown size. Most of the paper birch, red maple, and white ash crop trees were dominant or codominant. About one-fourth of the yellow birch and one-half of the sugar maple and beech were intermediate or suppressed.

Bole quality may be expressed in many different ways. Paper birch and white ash had longer boles clear of live branches than the other species. It is interesting to note that the butt logs are nearly clear of branches by the time the stand reaches 25 years of age, or a diameter of 3.5 to 4.0 inches. However, epicormic branches are common, even in this dense stand, on yellow birch, sugar maple, and beech. About half of the trees of these species have epicormic branches. However, not a single epicormic branch was found on either paper birch or white ash. About 10 percent of the potential crop trees had forks below 25 feet, regardless of species.

An arbitrary grading system was used to rate the quality of the first log. Grade 1 permitted no live branches or epicormic branches, and only slight lean, crook, or sweep. Grade 2 permitted one live branch, up to five epicormic branches, and moderate crook and sweep if located so that a 12-foot log could still be obtained. Trees with more branches or epicormic branches or more severe defects were placed in grades 3 or 4.

On this basis, the larger and faster growing paper birch and white ash were of higher quality than the other species. Only 37 percent of the crop trees qualified for grade 1 or 2, indicating that branches and minor defects are common in this age class. However, only grade 4 trees have defects that appear serious enough at this time to prevent them from developing into high-quality sawlogs, and 95 percent of the potential crop trees qualified for grade 3 or better.

A comparison of current growth rates of the crop trees with average rates over the first 25 years reveal some important trends. Height growth continues to be good: the crop trees have, in fact, grown more rapidly in height during the last 5 years than they did the first 25 years. But increment of bole diameter has decreased over the last 5-year period. This may be indicative of the high stand density and competition.

Natural pruning is proceeding rapidly—at the rate of nearly 1.5 feet per year. Although this is desirable for stem quality, it indicates that the crown length is not increasing as the trees get larger. Proportionately shorter crown lengths may well be responsible for the reduction in bole growth that is already showing up.

Discussion

This case history demonstrates that vigorous new stands containing a high proportion of valuable species can be obtained by complete clearcutting in northern hardwoods (fig. 2). It does not suggest that such stands will always be obtained.

Some of the conditions at the time of this particular cutting are not very likely to be duplicated. Present-day markets will not permit utilization of small material such as occurred here. The absence of slash, the complete absence of residual trees, and the soil disturbance resulting from the removal of 60 cords per acre must have had a beneficial effect on the reproduction.

The cutting itself may not be entirely representative of large clearcuttings since it was spread over 3 years, and each year's cutting involved only about 7 acres. Furthermore, moisture conditions are favorable on this moderately steep north-facing slope. And although paper birch has become established in large numbers throughout the clearcut area, yellow birch of crop-tree quality is not so abundant nor so evenly distributed.

In some situations, smaller clearcuttings such as narow strips may be required to obtain the desired stocking, particularly where yellow birch is the primary species.[5] But in spite of these qualifications, clearcutting promises to be a practical and highly successful cutting method, once the conditions under which it will be successful are adequately defined.

In this study, the stand resulting from a complete clearcutting

[5] There are numerous second-growth stands in the northern hardwood area that resulted from commercial clearcuttings about 1880 to 1910. Some of these stands are poorly stocked with valuable species, and they offer much less promise than this study example.

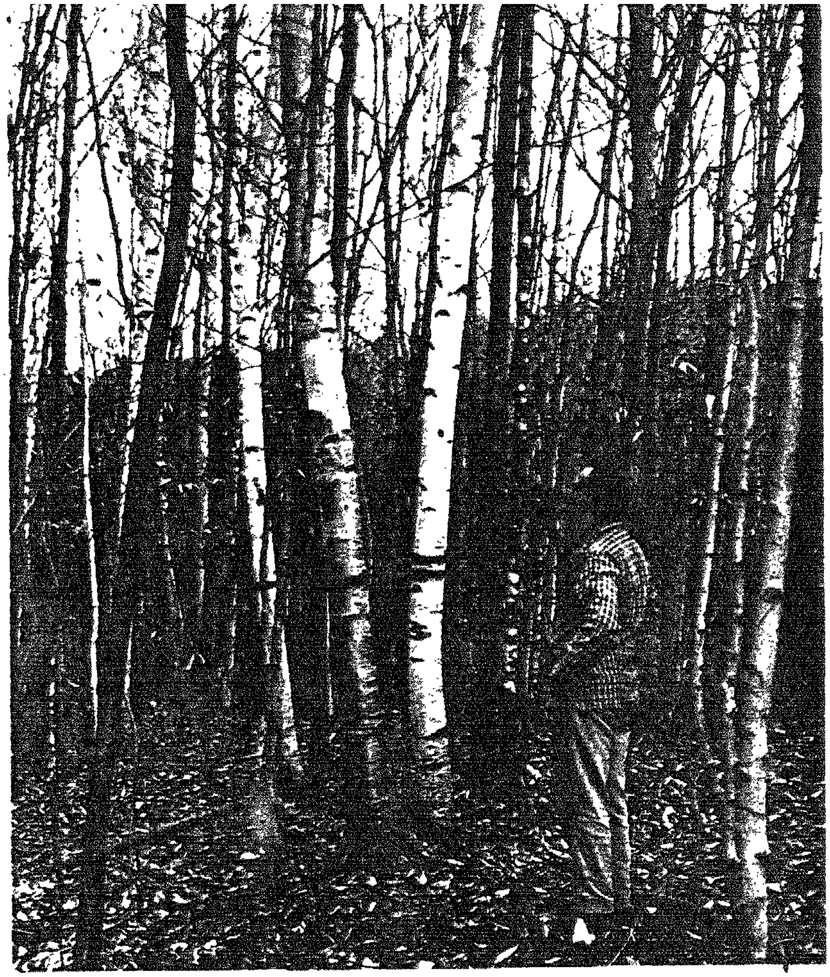

Figure 2.—A vigorous 25-year-old northern hardwood stand resulting from clearcutting.

has clearly satisfied the original objective—to obtain a high proportion of the valuable intolerant and intermediate species. It contains the stocking, the spatial distribution, and the growth rate required to produce high-quality hardwoods.

This complex stand offers both problems and opportunities for timber management. There are enough potential crop trees of promising quality to permit several management alternatives. It would be entirely possible to manage the stand purely for the fast-growing, short-lived paper birch, using a short rotation and attempting to regenerate the stand when the paper birch is cut. There are 169 well-distributed paper birch crop trees per acre—

enough to provide a well-stocked pure paper birch stand at maturity.

Similarly, it would seem possible to manage for a double harvest, first of paper birch and later of the longer-lived yellow birch, sugar maple, and white ash. This would require judicious thinning to bring both groups along concurrently in the early stages. A third alternative would be to utilize the less tolerant species as they mature, but to purposely encourage the uneven-aged development of the stand for management of tolerant species through individual tree selection cuttings.

Regardless of the alternative selected, early thinnings or weedings appear to be needed if the stand is to achieve maximum growth and quality. These treatments would concentrate growth on a small number of selected stems with high potential value, reducing the rotation length and increasing the value of the material harvested.

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