Regeneration of Birch

and associated hardwoods after patch cutting

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by David A. Marquis

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NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
RALPH W. MARQUIS, DIRECTOR

The Author

DAVID A. MARQUIS received a Bachelor of Science degree in forestry from the Pennsylvania State University in 1955 and a Master's degree from Yale University in 1963. Since joining the staff of the Northeastern Forest Experiment Station in Laconia, New Hampshire, in 1957, he has studied problems of regeneration and thinning in northern hardwoods.

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IN 1958 a series of birch-regeneration studies was begun on the Bartlett Experimental Forest in New Hampshire. These studies have dealt with the environmental factors that affect birch regeneration—chiefly light exposure, soil moisture and soil temperature, and seedbed conditions. In brief, it has been found that germination of birch seeds is best under conditions of high soil moisture and moderate soil temperature. These conditions occur most often on mineral soil seedbeds and in locations shaded from direct sunlight. Height growth, however, is better on organic seedbeds and in direct sunlight *(3)*. To find out how important these and other factors are in actual practice, a survey was made of the amount, distribution, and size of reproduction in several 3-year-old patch cuttings.

Area and Methods

In August 1958, two series of patch cuttings were made. In the first area, known as compartment 45, 8 rectangular patches were cut, each measuring 4.0 by 1.7 chains (2/3 acre). Compartment 45 lies at an elevation of about 950 feet on a gentle northerly slope. The timber is primarily second-growth northern hardwoods dating from heavy cuttings 70 to 90 years ago. The other series consisted of 12 circular patches, varying in size from 0.1 to 0.3 acre, in an area known as compartment 31. This compartment lies at an elevation of 1,700 to 1,900 feet on a steep northerly slope. The timber here is typical old-growth northern hardwood, never having been heavily cut.

All merchantable material was cut and skidded in tree lengths from the patches, using an HD-5 tractor and arch. All other trees down to 2 inches d.b.h. were cut and left on the ground.

Seed crops in 1958 for the birches of major interest were rated as heavy for paper birch *(Betula papyrifera)* and medium for yellow birch *(B. alleghaniensis)*.

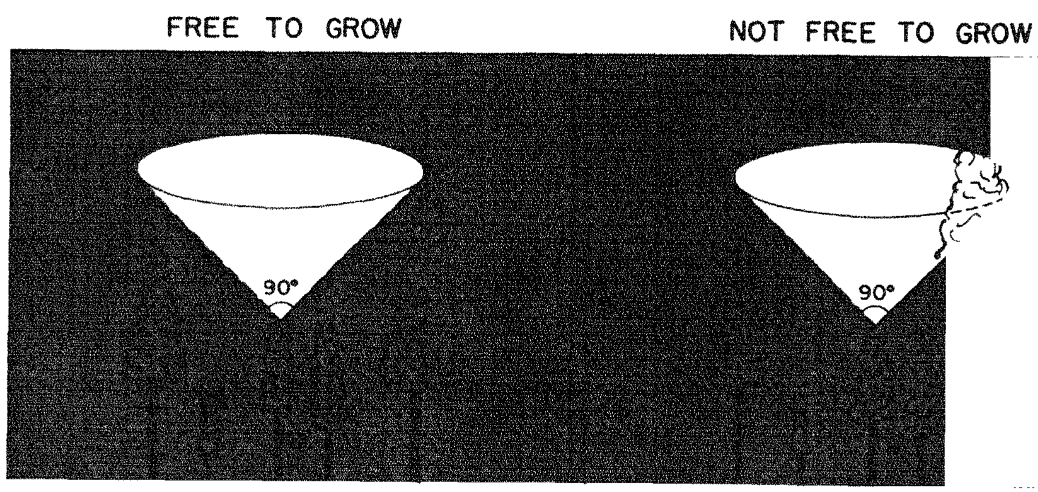

Figure 1.—An imaginary 90-degree cone was used to determine the classification of a tree as free-to-grow or not-free-to-grow.

A survey of the reproduction was made on both series of patches 3 years later, in the fall of 1961. Circular milacre plots were taken at 25-foot intervals on grid lines 25 feet apart. The starting point and direction of the first line in each patch, and the starting point on each line, were selected at random. Maps that had been drawn at the time of logging to show skidtrails, slash piles, and other pertinent features were used in conjunction with ground observations to classify seedbed conditions on each sample milacre. Four conditions were recognized:

1. **Skidroads**: skidroads and trails on which mineral soil had been exposed on at least 50 percent of the area.
2. **Disturbed**: areas disturbed by logging but with mineral soil exposed on less than 50 percent of the area.
3. **Undisturbed**: areas undisturbed by logging.
4. **Slash piles**: tree tops and slash in piles originally 4 feet or more high.

All reproduction on each milacre was tallied by species[1] and origin (seedlings, sprouts, or root suckers). Then the milacre was divided into quarters and the dominant (tallest) stem on each quarter was recorded by species, origin, height, and whether or not it was free to grow. If this stem was not a birch, the origin and height of the tallest birch were also recorded on that 1/4-milacre. A stem was considered free to grow if an imaginary inverted cone of 90° angle could be placed on its terminal and not intercept the foliage of another seedling or sprout (fig. 1). This arbitrary system worked well for identifying the stems that were tall enough in

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SPECIES TALLIED[1]

Common name	Scientific name
Paper birch	*Betula papyrifera* Marsh
Yellow birch	*Betula alleghaniensis* Britton
Sugar maple	*Acer saccharum* Marsh
Beech	*Fagus grandifolia* Ehrh.
Red maple	*Acer rubrum* L.
White ash	*Fraxinus americana* L.
Pin cherry	*Prunus pensylvanica* L.
	Prunus virginiana L.
Striped maple	*Acer pensylvanicum* L.
Raspberry	*Rubus* sp.
Others not included above	

relation to their neighbors to receive direct light. A total of 286 milacres was sampled.

Analysis of variance was used to test the significance of differences in stocking and height due to seedbed and compartment. Because an unequal number of milacres was sampled for each seedbed, the approximate method for computation of sums of squares with unequal frequencies was used *(4)*.

Results and Discussion

STOCKING

Regeneration was abundant in all patches: all space except the larger slash piles was stocked with some type of vegetation. Yellow and paper birch seedlings combined were more numerous than any other species: they made up nearly half of the total reproduction. Other merchantable species were also present. But in spite of their abundance, seedling stems of merchantable species were

Table 1.—Stocking in 3-year-old patch cuttings, by seedbed condition, in percent of 1/4-milacres stocked

Condition	Any woody species	Dominant merchantable species	Dominant merchantable species of seedling origin	Dominant birch	Free-to-grow birch	Any birch
			COMPARTMENT 45			
Skidroad	100	12	9	10	9	97
Disturbed	100	5	3	1	3	96
Undisturbed	100	13	5	3	2	68
Slash	86	25	20	4	4	30
All seedbeds	98	14	8	4	4	67
			COMPARTMENT 31			
Skidroad	100	39	22	18	35	91
Disturbed	100	37	22	5	12	95
Undisturbed	100	53	22	3	9	47
Slash	83	43	20	3	0	17
All seedbeds	99	46	22	9	16	60

dominant on only 8 to 22 percent of the ¼-milacres (table 1). Undesirable stems such as pin cherry, striped maple, aspen, raspberry, maple sprouts, and beech root suckers were dominant on most of the area. The larger pin cherry, aspen, and striped maple had reached heights of 10 to 12 feet and base diameters of 1 inch or more, and in some places they grew so profusely as to exclude all other species.

Table 2.—Stocking in patch cuttings, by species and seedbed condition—all trees

Species	Skidroad		Disturbed		Undisturbed		Slashpile	
	M stems per acre	*(%)*	*M stems per acre*	*(%)*	*M stems per acre*	*(%)*	*M stems per acre*	*(%)*
COMPARTMENT 45								
Paper birch	104.0	(37)	65.8	(37)	17.0	(13)	3.2	(6)
Yellow birch	63.0	(23)	14.8	(8)	9.7	(8)	1.6	(3)
Sugar maple	3.8	(1)	2.1	(1)	7.1	(6)	4.9	(9)
Beech	4.4	(2)	7.1	(4)	6.0	(5)	2.9	(5)
Red maple	7.3	(3)	5.3	(3)	4.5	(4)	2.3	(4)
White ash	3.4	(1)	2.2	(1)	1.8	(1)	1.3	(2)
Pin cherry	23.7	(9)	21.8	(12)	23.5	(18)	11.4	(21)
Striped maple	.1	(—)	.9	(1)	2.2	(2)	1.6	(3)
Raspberry	61.2	(22)	46.6	(26)	40.8	(32)	15.6	(29)
Aspen	1.4	(1)	.6	(—)	1.0	(1)	.0	(—)
Other	5.2	(1)	10.9	(7)	13.2	(10)	9.6	(18)
Total	277.4	(100)	178.2	(100)	126.8	(100)	54.5	(100)
COMPARTMENT 31								
Paper birch	56.8	(20)	24.7	(14)	5.9	(6)	.7	(3)
Yellow birch	88.3	(32)	23.8	(13)	4.0	(4)	.1	(1)
Sugar maple	11.1	(10)	23.0	(13)	35.9	(37)	6.7	(21)
Beech	11.1	(4)	8.9	(5)	13.0	(13)	6.4	(25)
Red maple	3.0	(1)	3.1	(2)	1.0	(2)	.9	(4)
White ash	5.1	(2)	5.4	(3)	1.9	(2)	—	(—)
Pin cherry	5.0	(2)	7.7	(4)	9.0	(9)	4.7	(18)
Striped maple	3.0	(1)	3.1	(2)	5.0	(5)	1.2	(5)
Raspberry	61.0	(22)	49.4	(28)	15.8	(16)	6.7	(21)
Aspen	1.7	(1)	.8	(—)	—	(—)	—	(—)
Others	15.5	(5)	28.2	(16)	5.9	(6)	.8	(2)
Total	278.8	(100)	178.1	(100)	98.1	(100)	25.3	(100)

Effects of Seedbed

Differences in birch stocking due to seedbed were highly significant. Skidroads contained several times as many birch seedlings as did the disturbed seedbeds, and these in turn contained several times as many as the undisturbed seedbeds (table 2). Birch seedlings were in a dominant position in significant numbers only on the skidroads (table 3). The distribution of birch seedlings was also much better on skidroads and disturbed seedbeds; nearly all plots of these seedbeds contained some birch, whereas more than half of the undisturbed (including slash) plots did not contain a single birch seedling (table 1). The concentration of birch seedlings in and around the skidroads was clearly evident upon casual observation.

Birch stocking in the skidroads averaged 3½ to 4 seedlings per square foot. Undisturbed surface, which occupied two-thirds to three-fourths of the patch areas, contained only 1 seedling in every 2 to 5 square feet. Obviously the scarification that occurred during logging greatly increased the stocking of birch. The effect of scarification would have been even more sharply revealed if the seed supply or weather conditions had been less favorable than they were during the year that the patches were cut.

The distribution of other species by seedbeds is shown in tables 2 and 3. Raspberry was the only species except the birches that showed significantly higher stocking on the skidroads and disturbed seedbeds. Differences among seedbeds for the other species were small and nonsignificant, except that there were fewer stems of all species in the slash piles than elsewhere.

Differences between Compartments

Compartment 45 had more paper birch and pin cherry, and less sugar maple, beech, and striped maple than compartment 31 (table 2). These differences were significant. The most noticeable differences were in the dominant stems (table 3). In compartment 45, pin cherry far outranked all other species: it occurred in such large numbers and grew so rapidly that it was dominant on nearly two-thirds of all plots. In compartment 31, pin cherry was a relatively minor component; instead, striped maple and beech root suckers were most often dominant.

Table 3.—Stocking in patch cuttings, by species and seedbed condition, in percent—dominant stems

Species	Skidroad	Disturbed	Undisturbed	Slashpile	All seedbeds
		COMPARTMENT 45			
Paper birch	8	1	2	4	4
Yellow birch	2	—	—	1	1
Sugar maple	—	—	2	9	2
Beech	2	6	8	4	6
Other merchantable species	—	—	2	8	2
Pin cherry	64	69	61	39	58
Striped maple	1	7	7	5	6
Raspberry	20	16	13	18	16
Other	3	1	5	12	5
Total	100	100	100	100	100
		COMPARTMENT 31			
Paper birch	13	5	1	3	5
Yellow birch	4	—	3	—	3
Sugar maple	3	7	17	13	12
Beech	16	23	28	27	24
Other merchantable species	3	2	4	—	3
Pin cherry	2	10	7	23	7
Striped maple	16	25	26	17	23
Raspberry	43	20	9	16	19
Other	—	8	5	1	4
Total	100	100	100	100	100

These differences between compartments 45 and 31 are typical of those observed between other second-growth and old-growth areas. Successful regeneration has frequently been reported after cuttings in old-growth timber *(1, 2)*. Seedlings of maple, birch, and other valuable species become established in large enough numbers to produce a satisfactory stand. Similar cuttings in second-growth are less satisfactory because pin cherry, red maple sprouts, and other undesirable stems dominate the new stand *(5)*. The present compartments conform to this general pattern.

An important point to note here is that the lack of dominant birch in the second-growth compartment 45 was not due to failure of birch seedlings to get established. There were many more birch seedlings in compartment 45 than in compartment 31. Yet twice as many plots were stocked with dominant birch and three times as many were stocked with dominant merchantable species of seedling origin in compartment 31 as in compartment 45. The aggressive competition from pin cherry and the lack of advance reproduction of sugar maple and beech appear to be responsible for the less favorable situation in compartment 45.

Origin

Origin of regeneration is important because it affects initial growth rate and ultimate quality of the tree. In general, sprouts and root suckers are undesirable. Most of the maple sprouts in these patches were eliminated 1 year after the cutting by basal spraying with herbicide. In spite of this treatment, sprouts and root suckers are an important component of the reproduction.

The proportions of all tallied stems of merchantable species that were of vegetative origin are shown in table 4. Note that proportionately more sprouts and root suckers were dominant than seedlings of the same species. For example, only 2 percent of the sugar maples in compartment 31 were sprouts; yet 26 percent of the sugar maples in a dominant position were sprouts. A similar situation prevailed in the other species.

Table 4.—Origin of stocking in patch cuttings: percentage of tallest stems that were of vegetative origin

Species	Compartment 45		Compartment 31	
	All stems	Dominant stems	All stems	Dominant stems
Paper birch	1	12	—	—
Yellow birch	—	—	1	15
Sugar maple	1	6	2	26
Beech	50	88	50	84
Other merchantable	2	33	3	33
All merchantable species	5	41	7	53

Table 5.—Proportions of paper birch and yellow birch in three categories of stems, in percent

Category	Compartment 45		Compartment 31	
	Paper birch	Yellow birch	Paper birch	Yellow birch
All birch stems	68	32	43	57
Tallest birches—all 1/4-milacres	76	24	59	41
Tallest birches—birch-dominated 1/4-milacres	86	14	62	38

Experience has shown that elimination of maple sprouts (particularly red maple) is desirable; otherwise these unwanted stems will outgrow and eventually suppress all other trees within a sizeable area. Beech root suckers, which are more difficult to treat with basal sprays, also may be troublesome when they are as numerous as they were in compartment 31.

Data on origin of weed species are not shown in table 4. It was originally assumed that all of these species originated from seed, and this certainly was true of the pin cherry and raspberry. However, only a few of the aspen started from seed. This species appeared in quantity only in patches where it had been present before the cutting, and here all the larger aspen stems examined were found to be root suckers.

Striped maple was in certain respects the most surprising of the four weed species. Although of seed origin, most stems were at least 10 years old. They apparently had become established before the cutting and had managed to survive in the dense shade without making much growth. Once provided with full sunlight, however, they began growing at the rate of 2 or 3 feet a year. Examination of adjacent uncut areas confirmed the presence of many suppressed striped maple seedlings.

Paper Birch versus Yellow Birch

There were more paper birch than yellow birch in compartment 45, but the reverse was true in compartment 31. This almost certainly was due to differences in the seed sources. However, paper birch does appear to be better able to compete than yellow birch. Even in compartment 31, where yellow birch was more prevalent, paper birch was more often dominant (table 5).

HEIGHT GROWTH

The birches were generally among the shortest stems, averaging less than 3 feet tall. Raspberry averaged about 3 feet, and beech and sugar maple ranged between 3 and 4 feet. Pin cherry and striped maple were the tallest species, averaging about 6 feet.

Seedbed-Growth Relationships

The tallest seedlings were found in the undisturbed areas, and the smallest ones in the skidroads and slash piles (table 6). These differences were statistically significant. In an earlier study *(3)*,

Table 6.—Mean heights in feet, by species and seedbed condition, based on dominant stems by 1/4-milacre sub-plots

Species	Skidroad	Disturbed	Undisturbed	Slash	$\bar{x}$
		COMPARTMENT 45			
Paper birch	2.3	2.4	4.1	2.8	3.0
Yellow birch	2.6	—	1.0	1.1	1.8
Sugar maple	3.2	3.9	3.8	3.2	3.3
Beech	3.2	3.9	3.8	3.2	3.7
Other merchantable	—	5.0	2.6	3.0	3.1
Pin cherry	5.5	5.9	6.2	4.9	5.9
Striped maple	3.3	3.8	4.1	4.2	4.0
Raspberry	3.1	2.9	3.1	2.5	2.9
Other	1.9	5.0	6.9	2.4	2.4
$\bar{x}$	4.5	5.1	5.3	3.7	
		COMPARTMENT 31			
Paper birch	2.0	1.6	2.0	0.4	1.9
Yellow birch	1.8	—	3.6	—	2.9
Sugar maple	2.7	4.6	3.9	4.3	3.8
Beech	2.3	2.6	3.2	2.5	3.0
Other merchantable	2.7	1.8	3.4	—	3.2
Pin cherry	3.0	2.2	2.3	2.9	2.3
Striped maple	4.4	6.3	6.4	6.3	6.0
Raspberry	3.1	3.2	2.8	2.9	3.0
Other	—	4.0	2.8	—	3.0
$\bar{x}$	3.0	3.8	4.0	3.5	

growth on mineral soil seedbeds was found to be less than on organic seedbeds, apparently due to higher nutrient levels in the organic matter. Lower nutrients may be one reason for the poorer growth in the skidroads. Other possible reasons are the greater number of stems on the skidroads, which may depress the growth rate, or heavier deer browsing.

Poor growth in the slash piles may be a result of slower restocking (younger seedlings) in these areas. Although it has sometimes been suggested that slash minimizes deer browsing, this seems relatively unimportant in these cuttings, particularly in reference to the birches, because so few birch seedlings became established in the slash.

Growth in compartment 45 was significantly better than in compartment 31, average heights being 1 to 1½ feet greater. The reasons for this difference are uncertain; site, elevation, and size of cut patches are factors that may have had some differential effects on growth.

Would Weeding Help?

There is much controversy over the effects of weed tree competition. Some foresters feel that this competition does little or no harm. Some even feel that it is beneficial by reducing deer damage and encouraging rapid natural pruning. Others feel that pin cherry in particular may limit birch regeneration where the cherry occurs in large numbers.

By the end of the first growing season it was apparent that pin cherry and raspberry competition would be severe in compartment 45. To get some evidence on the effects of this competition, an exploratory weeding was done in two of the patches during June

Table 7.—Quarter-milacres containing free-to-grow birch, compartment 45, in percent

Condition	Not weeded	Weeded
Skidroad	9	41
Disturbed	3	50
Undisturbed	2	9
Slash	4	—

of the second year. All pin cherry and raspberry seedlings were removed (pulled out by the roots) in half of each of the two patches. The areas thus weeded were tallied and summarized separately.

Some of the results of the weeding are shown in table 7. Removal of pin cherry in particular left many more birch seedlings in a free-to-grow position. Whether or not this treatment will affect the ultimate growth or survival of the released seedlings cannot be determined yet. But if the competition is as severe as it appears, weeding would help.

Summary

Patch cuttings of 1/10 to 2/3 acre were made in both second-growth and old-growth northern hardwood stands and were examined 3 years later for the amount and kind of reproduction that was developing. The data demonstrated that such small clearcuttings can be used successfully to regenerate the highly desirable paper and yellow birches. Seedlings of both species became established in large numbers in all patches.

Seedbed condition was the most important factor affecting early birch establishment. Seedlings were much more numerous where mineral soil had been exposed in skidroads and other disturbed areas than in areas that had not been disturbed by logging. However, seedling growth was best in the undisturbed areas, presumably because of the greater supply of nutrients in the organic soil layers.

Competition from weed species and from sprouts and root suckers of commercial species was important in limiting the number of birch seedlings able to attain a free-to-grow position. Such competition was particularly severe in the second-growth stand. In general, birch seedlings on disturbed seedbeds were in a better competitive position than those on undisturbed seedbeds.

A small experimental weeding in two patches showed the possibilities of such treatment for releasing overtopped birch seedlings, at least temporarily, from suppression by faster growing competitors.

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