An Appraisal of

EARLY REPRODUCTION

after Cutting in Northern Appalachian Hardwood Stands

by
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The Questions

HOW shall I cut to get reproduction? What kind of reproduction will I get if I cut the way I am planning to? All foresters have asked themselves these questions. To help supply some answers to these questions for the northern Appalachian hardwood area, the authors have summarized and analyzed before- and after-cutting reproduction data collected over a period of 10 years on the Fernow Experimental Forest near Parsons, West Virginia.

Almost any kind of cutting in sawtimber stands of Appalachian hardwoods will be followed by abundant reproduction of tree species of some kind. At least, that is true according to reproduction surveys made 5 to 10 years after cuttings on the Fernow Forest. These surveys show also that quality of the site and severity of the cut influence the amount, distribution, and species composition of the reproduction.

These surveys reflect only short-time effects. Not until the present seedlings and saplings have reached poletimber size will we have a clear picture of how cutting affects stand regeneration.

The Study Areas

The forest stands on all the areas studied were first logged between 1905 and 1910. In some locations the cutting approached a clearcut; in less accessible stands it was a light high-grading. When research cuttings were started on the Experimental Forest in 1949, the stands were composed mainly of three classes of trees above 5 inches d.b.h.: (1) second-growth Appalachian hardwoods, 40 to 45 years old; (2) old residual trees left from the original cutting; and (3) a scattering of pole-size trees that had come up in openings created by the death of the chestnut around 1930. The stands were characteristically uneven-aged and well-stocked, and they had not been burned for at least 35 years.

Three site classes were represented in the study areas: excellent hardwood sites, good hardwood sites, and fair hardwood sites. These correspond to oak site indexes 80, 70, and 60 respectively.[1]

Characteristic species composition on the study areas by site classes are as follows, with species listed roughly in the order of their abundance: (1) site index 80—sugar maple, yellow-poplar, beech, white ash, black cherry, basswood, red oak, hickory; (2) site index 70—sugar maple, red oak, red maple, beech, black cherry, chestnut oak, hickory, yellow-poplar; and (3) site index 60—chestnut oak, red oak, white oak, red maple, sugar maple, black gum, sassafras (at lower elevations), and black cherry (at higher elevations).

The research cuttings ranged from very light selection cuts, in which as little as 15 percent of the cubic volume was removed, to commercial clearcuttings in which as much as 95 percent of the volume was removed. Before cutting, stand volumes ranged from 1,600 to 3,800 cubic feet per acre on individual cutting areas. (Averages by sites and cutting-intensity classes are shown in table 1.)

[1]Schnur, G, Luther. Yield, stand, and volume table for even-aged upland oak forests. U.S. Dept. Agr. Tech. Bull. 560. 80 pp., illus. 1937.

Table 1.—Acreages, original cubic volumes, and intensities of cutting on study areas

Original volume per acre* (cubic feet)	Cubic volume cut	Area cut**
	Percent	Acres
Excellent sites:		
3,700	Over 75	12
3,400	51-75	5
3,200	26-50	110
2,700	0-25	16
Good sites:		
2,500	Over 75	48
2,600	51-75	45
2,600	26-50	200
2,100	***0-25	24
Fair sites:		
--	Over 75	0
2,400	51-75	30
2,800	26-50	53
2,000	0-25	5

*In trees over 5 inches d.b.h. to a 4-inch top.

**These are total acreage figures for the respective categories. In most cases they are summations of several separate cutting areas.

***Very light frequent cuttings in farm woods over the 5-year period.

Survey Methods

Surveys were made before logging and 5 years afterward on temporary, evenly-spaced plots along grid lines covering each area under study. No attempt was made in after-logging surveys to remeasure the same plots that had been used before.

Two size classes of reproduction were measured. One class consisted of stems ranging from 1 foot tall to 1.0 inch in diameter at breast height. This class will be referred to as *small* reproduction. The second class comprised stems from 1.0 to 5.0 inches d.b.h. This class will be referred to as *large* reproduction. At each sampling point, small reproduction was measured on a milacre and large reproduction on a 1/100-acre plot. The intensity of sampling varied as follows: for small reproduction from ¼ percent on some areas to 1 percent on others; for large reproduction from 2½ percent on some areas to 10 percent on others.

Table 2.—Tree species recorded in survey, grouped by desirability classes[1]

DESIRABLE SPECIES -- GOOD LUMBER TREES[2]			
Red oak	--Quercus rubra	Black cherry	--Prunus serotina
White oak	--Quercus alba	Cucumber	--Magnolia acuminata
Sugar maple	--Acer saccharum	White ash	--Fraxinus americana
Red maple	--Acer rubrum	Basswood	--Tilia americana
Yellow poplar	--Liriodendron tulipifera		
OTHER COMMERCIAL SPECIES[3]			
Blackgum	--Nyssa sylvatica	Sassafras	--Sassafras albidum
Beech	--Fagus grandifolia	Sweet birch	--Betula lenta
Fraser magnolia	--Magnolia fraseri	Butternut	--Juglans cinerea
Hickory	--Carya spp.	Black locust	--Robinia pseudoacacia
Yellow birch	--Betula alleghaniensis	Elm	--Ulmus americana
Sourwood	--Oxydendrum arboreum	Aspen	--Populus grandidentata
Eastern hophornbeam	--Ostrya virginiana		--Populus tremuloides
NONCOMMERCIAL SPECIES			
Pin cherry	--Prunus pensylvanica	Serviceberry	--Amelanchier arborea
Striped maple	--Acer pensylvanicum	Scrub oak	--Quercus ilicifolia
Flowering dogwood	--Cornus florida	Mountain maple	--Acer spicatum
American hornbeam	--Carpinus caroliniana		

[1]This desirability classification of reproduction was based on local market conditions during the 1950's. It does not necessarily apply in all categories to other areas or other periods.

[2]These trees have market value for lumber, and they grow large enough and are sufficiently free from defect to produce factory logs.

[3]These trees either have little or no value in the area for lumber, or they seldom grow to sawtimber size, or they normally are too defective to produce lumber.

Only commercial species were recorded in these surveys. This group includes all the desirable lumber species plus others for which there are ready markets for such products as pulpwood, mine timbers, and industrial blocking. Among these product species are sassafras, black gum, hickory, eastern hornbeam, and beech. Weed species such as blue beech, dogwood, pin cherry, and striped maple were not included as commercial species even though some of them are harvested in product sales. (Table 2 shows the tree species in each of the three categories.)

Results of The Study

REPRODUCTION BEFORE CUTTING

Consideration of the reproduction present before logging is pertinent since much of it will survive logging, particularly in selection cuts, and may make up a considerable part of the future stand.

Abundance and Distribution

Before cutting, most stands contained reproduction of commercial species (fig. 1.). In general, there appeared to be an inverse relationship between the abundance of small reproduction and site quality (table 3). On excellent sites the stocking of small reproduction ran from 200 to 2,500 stems per acre. However, sizable areas often were found on which small reproduction was very scarce (fig. 2). Fair sites had 1,500 to 5,000 stems per acre. Good sites were intermediate between the excellent and fair sites in numbers of small reproduction. The tendency for abundance of small stems to be greater on the poorer sites probably can be attributed to lower densities of overstory there than on the better sites.

Large reproduction was considerably less abundant than the small stems, and it was present in about the same numbers on all three site classes (table 3).

The percentage of sampled milacres that were stocked with at least one stem of commercial species was used as a measure of the distribution of stocking. Distribution data were taken only for the small reproduction class. Distribution, like abundance, increased as site quality declined. On the excellent sites, average milacre stocking was 59 percent; on the fair sites it was 79 percent (table 3).

The data on distribution indicate that reproduction generally is not very well distributed in uncut sawtimber stands on good sites, even though it may be plentiful on a per-acre basis. Most of the reproduction on these sites tends to be concentrated under the scattered natural openings in the canopy.

Figure 1.—Heavy sugar maple reproduction in an old-growth stand containing many old sugar maple trees.

Figure 2.—Dearth of reproduction under a 50-year old stand of Appalachian hardwoods on a good site. Herbaceous plants—mostly nettles—carpet the forest floor.

Species Composition

There was some correlation of species with site quality (table 3). On the excellent and good sites sugar maple made up 30 to 50 percent of the stems in both classes of reproduction. Beech was strongly entrenched in second place in both classes.

In the small reproduction class, sassafras was in third place, comprising 8 percent of the stems on both excellent and good sites.

In the large reproduction class, black birch was in third place on the two better sites. Evidently sassafras is less tolerant than black birch and loses out on these sites before it grows into the large reproduction class. Red maple was a weak, but consistent, component of both reproduction classes on the excellent and good sites.

Species composition on the fair sites differed considerably from that on the other two sites. In addition, there was a pronounced difference in the order of species occurrence between small and large reproduction (table 3). Sassafras and chestnut

Table 3.—Reproduction before logging—commercial species

Site quality	Stems per acre (average) No.	Milacres stocked, percent	Five most abundant species				
			1	2	3	4	5
			SMALL REPRODUCTION (1 foot high to 1 inch d.b.h.)				
Excellent	1,300	59	Sugar maple 42%	Beech 32%	Sassafras 8%	Red maple 4%	Hophornbeam 3%
Good	2,100	72	Sugar maple 52%	Beech 25%	Sassafras 8%	Hickory 4%	Red maple 3%
Fair	3,400	79	Sassafras 33%	Chestnut oak 19%	Sugar maple 14%	Red oak 9%	Red maple 8%
Site quality	Stems per acre (average) No.		Five most abundant species				
			1	2	3	4	5
			LARGE REPRODUCTION (1 to 5 inches d.b.h.)				
Excellent	410		Sugar maple 31%	Beech 28%	Black birch 13%	Red maple 10%	White ash 4%
Good	410		Sugar maple 40%	Beech 21%	Black birch 12%	Red maple 7%	Red oak 4%
Fair	430		Red maple 26%	Sugar maple 12%	Red oak 11%	Beech 9%	Chestnut oak 9%

oak were the two most abundant species in the small reproduction class but were scarcely represented in the large class (chestnut oak ranked fifth and sassafras had disappeared). Sugar maple and red maple were third and fifth respectively in the small reproduction, yet in the large reproduction they ranked first and second. The sassafras and the chestnut oak evidently die out, whereas many of the more tolerant maples survive and eventually grow into the large class.

There seemed to be a relationship between occurrence of some species and elevation. Elevations of the surveyed areas ranged from about 1,800 to 3,500 feet. Sassafras in particular was markedly more abundant on fair sites at lower elevations than on areas of comparable site quality near the upper range of elevation.

REPRODUCTION 5 YEARS AFTER CUTTING

Response of reproduction to cutting is an extremely complex phenomenon that is influenced by many factors. The data reported here were collected on an area sampling basis, with few measurements taken to correlate reproduction with conditions at any one spot. Hence only the grosser factors, that is, those relating to an entire sampling area, can logically be discussed in connection with the reproduction found on it.

Abundance and Distribution

The effect of cutting almost always was to increase the amount of small reproduction by several hundred percent. Except in two areas of farm woods, where very light annual cuts were made, the 5-year stem counts of small reproduction ran from nearly 6,000 to nearly 17,000 per acre (table 4). In general, the heavier cuts resulted in heavier stands of reproduction and in higher percentages of stems of sprout origin.

The data show no obvious relationship between site quality and number of stems of small reproduction (table 4). Nor, apparently, is there a relationship between site quality and percentage of sprouts. However, the study results do not prove an absence of these relationships; generalized as the survey was, the results can

Table 4.—Small reproduction of the five most numerous species 5 years after logging, by site class and severity of cutting

(In percentage of total stems)

Percent of cubic volume cut	Total No. of commercial stems per acre	Distribution of five most numerous species										Percent sprouts	Percent milacres stocked, all commercial species
		1		2		3		4		5			
		Species	Percent	Species	Percent	Species	Percent	Species	Percent	Species	Percent		
EXCELLENT SITES													
Over 75	9,500	Yellow-poplar	34	Sugar maple	18	Beech	14	Black cherry	13	Black birch	6	28	88
51-75	16,600	Sugar maple	48	Yellow-poplar	21	Black cherry	7	Black birch	6	Hickory	5	7	100
26-50	6,900	Sugar maple	48	Black cherry	13	Yellow-poplar	9	Beech	5	Black locust	4	17	84
0-25	5,700	Sugar maple	64	Beech	18	Black cherry	4	Yellow-poplar	4	Hickory	3	*3	88
GOOD SITES													
Over 75	10,600	Sugar maple	36	Beech	14	Black birch	9	Black cherry	7	Sassafras	6	20	95
51-75	8,400	Sugar maple	48	Black birch	15	Black cherry	6	White ash	5	Yellow-poplar, beech	4	17	93
26-50	8,100	Sugar maple	45	Sassafras	9	Red oak	7	Black cherry	6	Beech	5	12	88
**0-25	1,800	Sassafras	43	Sugar maple	25	Beech	22	Basswood	3	Black gum	2	(***)	53
FAIR SITES													
Over 75	--	--		--		--		--		--		--	--
51-75	6,800	Sugar maple	43	Red oak	13	Black birch	10	Beech	10	Black cherry	8	31	90
26-50	9,400	Sugar maple	42	Red maple	16	Black cherry	11	Red oak	10	Chestnut oak	5	13	100
0-25	7,200	Sassafras	35	Sugar maple	16	Red maple	9	Red oak	7	Black gum	6	17	93

*Only 2.6 acres included in sprout tally.

**Farm woods where very light annual cuttings were made over the 5-year period.

***Tally not classified into seedlings and sprouts.

Table 5.—Large reproduction of the five most numerous species 5 years after logging, by site class and severity of cutting

(In percentage of total stems)

Percent of cubic volume cut	Total No. of commercial stems per acre	Distribution of five most numerous species										Percent sprouts
		1		2		3		4		5		
		Species	Percent	Species	Percent	Species	Percent	Species	Percent	Species	Percent	
EXCELLENT SITES												
Over 75	183	Yellow-poplar	34	Sugar maple	27	Black locust	16	Basswood	16	Beech	4	55
51-75	304	Sugar maple	46	Black cherry	14	Yellow-poplar	12	Black locust	11	Hornbeam	5	26
26-50	311	Sugar maple	54	Beech	18	Black birch	5	Red maple	4	Hornbeam	3	8
0-25	328	Sugar maple	32	Beech	30	Red maple	17	Hornbeam	8	Black birch	4	*6
GOOD SITES												
Over 75	419	Sugar maple	19	Beech	19	Black locust	16	Red oak	7	Red maple	7	27
51-75	394	Sugar maple	42	Beech	13	Black locust	8	Hornbeam	6	Red maple	5	10
26-50	335	Sugar maple	39	Red maple	16	Beech	14	Black birch	4	Red oak	4	9
0-25	357	Beech	26	Black birch	18	Red maple	14	Sugar maple	13	Yellow-birch	8	(**)
FAIR SITES												
Over 75	--	--		--		--		--		--		--
51-75	315	Sugar maple	49	Beech	21	Red maple	7	Hornbeam	7	Black birch	5	14
26-50	268	Sugar maple	38	Red maple	18	Beech	15	Frazer magnolia	6	Black birch, cucumber	3	18
0-25	375	Beech	23	Red maple	19	Sugar maple	13	Black birch	10	Hickory	7	7

*Only 2.5 acres included in sprout tally.

**Tally not classified into seedlings and sprouts.

be expected to show only those relationships that are strong and definite.

A definite relationship existed between severity of the cut and percentage of stems of sprout origin. On a clearcut excellent site (represented by one 12-acre commercial clearcut), 55 percent of the large reproduction was of sprout origin; in less heavily cut areas (less than 50 percent of the volume removed), fewer than 10 percent of the large stems were sprouts. On the clearcut area many sprouts had grown to over 1 inch in diameter in 5 years (fig. 3).

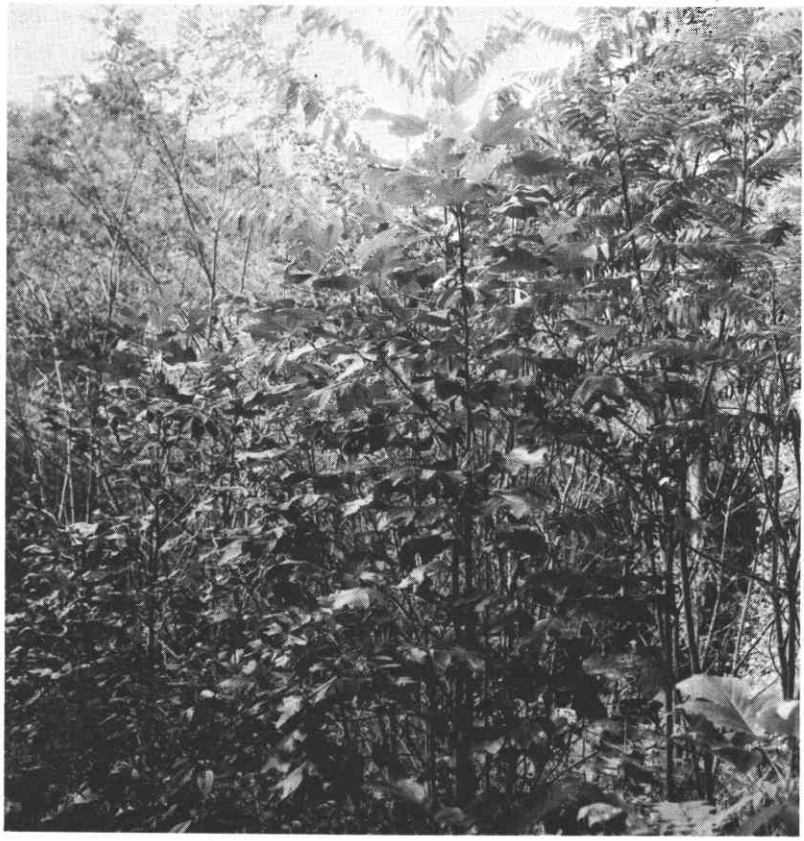

Figure 3.—Five years after clearcutting, this area has many stems of yellow-poplar, black locust, and black cherry of sprout origin that were over 1 inch d.b.h. Sumac in right foreground.

The percentage of milacres stocked (table 4) shows the distribution of small reproduction of all commercial species. Compared to before-cutting conditions, the distributions had improved after almost all intensities of cutting. They were generally good in all site and cutting classes except the lightest-cut category on the good site, which is represented by the two above-mentioned very lightly cut woodlots.

Five years after cutting, fewer stems were found in the 1 to 5 inch d.b.h. class than before cutting (table 5). This reduction in numbers probably can be attributed largely to logging damage. Such damage increases with increasing amounts of timber removed, and tends to mask the normal positive relationship between amount of reproduction and severity of cut—at least during the first 5 years.

Species Composition

The effect of site upon the composition of after-logging reproduction shows up strongly for certain species. For example, yellow-poplar was abundant after heavy cutting on excellent sites but very sparse or absent on fair sites (table 4). Sassafras was not among the five most numerous species on excellent sites but was a strong component on fair and good sites at the lower elevations, particularly after light cutting (fig. 4). Oak reproduction, practically absent on the excellent sites, showed up on the good sites, and was moderately plentiful on the fair sites.

Black cherry was found on all three sites and, though generally more numerous after heavy cutting, often was present also after light cutting, expecially in openings. Sugar maple was plentiful on all sites after all degrees of cutting; red maple was most prevalent on fair sites. In the two heavier cutting classes, black birch was a consistent component of the small reproduction on all three sites.

Beech may have increased a little in actual numbers on the excellent sites, but all in all, this species declined in relative abundance after cutting.

Large reproduction did not differ greatly from small reproduction in distribution. Sugar maple was the number one species

Figure 4.—Typical sassafras reproduction on a fair site after light cutting. Site index for oak is 60. Area was selectively cut 3 years before photograph was taken.

among large reproduction in most situations (table 5). Beech was a stronger component than among small reproduction, particularly on the fair sites. Black locust, which was never one of the five most numerous species in the small reproduction, often was represented in the large class by root sprouts or suckers in the heavier-cut areas on excellent and good sites. Being both fast-growing and intolerant, locust sprouts were either in the large reproduction class or dead at the end of 5 years. Red maple was more prominent on all sites in the large than in the small reproduction.

In a few stands reproduction was classified as occurring *in the open* or *under canopy*. *Openings* meant simply that no overhead shade was present; *under canopy* meant that the spot was under, or was shaded during most of the day by, an overstory. The limited

amount of data that were taken for this generalized classification reflect definite differences in reproduction.

Much more small reproduction of commercial species occurred in the openings than under canopy (from one-third more stems to several times as many) on all sites and under all degrees of cutting intensity. Intolerant species showed greater differences than tolerant species. On the better sites, where yellow-poplar and black cherry seed trees were present in the original and residual stands, openings contained 5 to 10 times as many yellow-poplar stems (fig. 5) and 2 to 3 times as many black cherry stems per acre as occurred under canopy.

Figure 5.—Yellow-poplar reproduction in an opening created by selective cutting 7 years ago.

Since most of the large reproduction found after 5 years in these partially cut stands was present before cutting, it was influenced much less than the small class by after-cutting canopy conditions. No trends related to canopy were discerned in the large reproduction in either total number of stems or species composition.

REPRODUCTION 10 YEARS AFTER CUTTING

The reproduction present 10 years after cutting is undoubtedly a better indication of ultimate reproduction composition and adequacy than that present after 5 years. Moreover, a comparison of 10-year data with 5-year data from the same cuttings gives evidence of how reliable 5-year data are for presaging future conditions of stocking. In our study, both 5- and 10-year data are available only from four 5-acre plots that were cut in 1949. Reproduction was tallied also on a 5-acre uncut check plot. The discussion to follow is based upon surveys of these five plots.

The five plots all were on an excellent site, and the stands before cutting were reasonably similar and uniform, with all the more important species well represented throughout the cutting area.

Each of four plots was cut to a different standard in 1949. Percentages of total cubic volumes removed at that time in trees 5 inches d.b.h. and larger were as follows: clearcut—95 percent; diameter-limit cut—62 percent; extensive selection cut (restricted to trees 11 inches d.b.h. and larger)— 50 percent; intensive selection cut (among all trees 5 inches d.b.h. and larger)— 47 percent.

Abundance and Distribution

In conformity with the general trend on all cuttings, numbers of stems of both small and large reproduction on these plots were positively correlated after 5 years with percentage of cut (table 6). Where 95 percent of the volume had been removed, over 10,000 stems of small reproduction and about 450 stems of large reproduction per acre were present. In the area of 47-percent removal, the figures were 7,500 and 210 respectively. The small reproduc-

tion was well distributed on all plots, with 81 to 100 percent of the sample milacres stocked.

Ten years after cutting, the picture had changed considerably. The quantity of small reproduction now was greatest in the selectively cut plots; it had dropped in the clearcut to less than 6,000 per acre (table 6). Large reproduction had increased in all areas but especially on the clearcut plot. On the heavily cut areas, many stems tallied as small reproduction at 5 years no doubt had grown into the large class in 10 years. Probably fewer small stems grew into this class on the selectively-cut areas because of the greater overstory competition. On the heavier-cut areas, dense sapling stands of sumac and pin cherry had developed in 10 years, in addition to the sapling stems of commercial species; competition from these stands unquestionably militated against establishment and survival of small reproduction. Selectively cut plots, with their uneven canopies and fewer saplings, appeared at the

Table 6.—Commercial species: reproduction 5 and 10 years after logging in a well-stocked sawtimber stand on an excellent site, by intensity of cut

(Commercial species only)

Intensity of cut	Cubic volume cut	Original cubic volume per acre*	Small reproduction			Large reproduction	
			Per-acre	Distribution**	Sprouts	Per-acre	Sprouts
	Percent	Cubic feet	No.	Percent	Percent	No.	Percent
			5-YEAR MEASUREMENTS				
Clearcut	95	2,380	10,130	100	--	450	--
Diameter-limit	62	2,510	10,060	81	--	340	--
Extensive selection cut	50	2,680	8,130	87	--	290	--
Intensive selection cut	47	2,700	7,500	88	--	210	--
			10-YEAR MEASUREMENTS				
Clearcut	--	--	5,820	92	23	760	36
Diameter-limit	--	--	5,850	88	20	490	23
Extensive selection cut	--	--	9,690	100	13	500	11
Intensive selection cut	--	--	8,330	98	10	330	9
Check plot	0	3,102	‡880	48	†48	410	10

*In trees over 5.0 inches d.b.h. Includes live culls.

**Percentage of milacres stocked with at least one stem.

†Beech root suckers account for a large part of the sprouting; also sprouts from dying sugar maple saplings. Heavy deer damage on this plot.

‡No natural openings in this small plot.

10-year point to be a more favorable environment for small reproduction.

At 10 years, small reproduction still was well distributed on all plots, and on the selection cuttings was even somewhat better distributed than at 5 years. With reference to sprouting, the same relationship held at 10 years as at 5 years: the heavier the cut, the greater the percentage of sprout origin.

Large reproduction on the uncut control plot was present in numbers roughly comparable to those on cut plots, but small reproduction was much more sparsely represented than on cut plots (table 6). Thus it was again demonstrated, as in the general summaries (tables 3 and 4), that cuttings tend to be followed by a substantial surge of small reproduction. In contrast to the usual correlation of sprouts with cutting intensity, almost half the small stems on the control plot were sprouts. These had originated mostly from the bases of dying sugar maple saplings and as suckers from beech roots.

Table 7.—Desirable species: reproduction 5 and 10 years after logging in a well-stocked sawtimber stand on an excellent site, by intensity of cut

(Desirable species only)

Intensity of cut	Cubic volume cut	Original cubic volume per acre*	Small reproduction			Large reproduction	
			Per-acre	Distribution**	Sprouts	Per-acre	Sprouts
	Percent	Cubic feet	No.	Percent	Percent	No.	Percent
			5-YEAR MEASUREMENTS				
Clearcut	95	2,377	7,533	100	--	160	--
Diameter-limit	62	2,510	7,188	75	--	253	--
Extensive selection cut	50	2,676	6,933	87	--	203	--
Intensive selection cut	47	2,703	5,938	75	--	175	--
			10-YEAR MEASUREMENTS				
Clearcut	--	--	4,776	90	23	412	45
Diameter-limit	--	--	4,708	88	18	312	47
Extensive selection cut	--	--	8,020	94	11	365	10
Intensive selection cut	--	--	6,688	90	11	252	10
Check Plot	0	3,102	‡438	21	†43	244	11

*In trees over 5.0 inches d.b.h. Includes live culls.

**Percentage of milacres stocked with at least one stem.

†Sprouts from dying sugar maple saplings account for most of this sprouting.

‡No natural openings in this small plot.

Table 8.—Species composition 10 years after cutting

(Percentages of 5 leading commercial species)*

Cutting intensity and size of reproduction	1	2	3	4	5
Clearcut:					
Small reproduction	Sugar maple 45%	Yellow-poplar 19%	Beech 9%	Black cherry 7%	White ash 6%
Large reproduction	Black locust 30%	Sugar maple 23%	Yellow-poplar 15%	White ash, beech, Red oak 5%	Hickory, sassafras 4%
Diameter-limit:					
Small reproduction	Sugar maple 50%	Yellow-poplar 22%	Beech 7%	Hickory 6%	White ash, black cherry 3%
Large reproduction	Sugar maple 34%	Black locust 22%	Yellow-poplar 15%	Basswood 9%	Hickory 7%
Extensive selection:					
Small reproduction	Sugar maple 43%	White ash 16%	Yellow-poplar 13%	Black cherry 9%	Beech 7%
Large reproduction	Sugar maple 55%	Beech 10%	Black locust 9%	Yellow-poplar 8%	Hickory 5%
Intensive selection:					
Small reproduction	Sugar maple 40%	Yellow-poplar 21%	White ash 14%	Hickory 8%	Beech 7%
Large reproduction	Sugar maple 58%	Beech 16%	Yellow-poplar 13%	Black birch, hornbeam 4%	Red oak, red maple 2%
Control:**					
Small reproduction	Sugar maple 50%	Beech 39%	Hickory 7%	Basswood, white ash 2%	--
Large reproduction	Sugar maple 47%	Beech 33%	Basswood 6%	Hickory 5%	Red oak 2%

*Where several species are listed in a category, the percentage occurrence applies to each.

**Measurement taken at time of 10-year measurements on cutting areas. This control area is nearby and comparable to the cutting plots in site and in species composition of the overstory.

Species Composition

Since most of the profit from timber management is derived from the desirable species, reproduction of this species group in relation to cutting intensity was of special interest, so it was analyzed separately (table 7). It was found that the same general relationships prevail among the segregate of desirable species as among all commercial species; the relationships, for the most part, merely were expressed in somewhat smaller numbers (compare tables 6 and 7).

Species composition of the reproduction at 10 years after cutting, especially that of the large class, probably indicates the approximate composition of the next stand (unless modified by weedings or intermediate cuttings). The five most abundant species for each size class and cutting intensity are shown in table 8. Because of differences in tolerance among species, a relationship between severity of cut and species composition of reproduction was expected, and was evident in the data, notably in a stronger representation of intolerants on the more heavily cut plots.

Assuming that species positions have become fairly well stabilized at 10 years, sugar maple is destined to predominate in the future on all plots. On the clearcut and diameter-limit plots, black locust and yellow-poplar promise to be strong secondary components. Other highly desirable species such as red oak, white ash, black cherry, and basswood, which made up 10 to 15 percent of the large reproduction on the heavily cut areas, also apparently will be well represented in the future stands.

On the selectively cut areas, sugar maple made up over half of the large reproduction, with beech poorly represented in second place. There was a good representation of desirable less-tolerant species (15 to 30 percent). Through improvement cuttings, a number of these saplings could be developed into crop trees; without such help, many of them probably would die out, leaving sugar maple in almost complete possession of the sites.

Summary

Reproduction surveys were made before and 5 and 10 years after several intensities of cutting in sawtimber stands. These stands were growing on excellent, good, and fair sites. Numbers, distribution, and species composition of the reproduction were related to site and to intensity of cutting.

BEFORE CUTTING

Most stands before cutting contained appreciable amounts of reproduction of commercial species in both small (1 foot tall to

1 inch d.b.h.) and large (between 1 and 5 inches d.b.h.) reproduction classes.

Small reproduction was more abundant and better distributed on the fair sites than on the better sites.

Sugar maple and beech were the most numerous species on the two better sites in both reproduction classes. On the fair sites, sassafras and chestnut oak predominated among the small reproduction but gave way to red and sugar maples in the large reproduction.

AFTER CUTTING

The surveys made 5 years after cutting showed that:

- The number of small reproduction stems increased several hundred percent after cutting. This increase was, in general, positively correlated with severity of cut.
- Percentages of sprout growth in the reproduction were higher after the heavier than after the lighter cuts.
- The heavier cuts favored higher proportions of intolerant species.
- Site quality influenced species composition of the reproduction. Noteworthy examples: yellow-poplar was abundant on heavily cut areas on excellent sites but rare on fair sites; oaks were rare on excellent sites, sparingly present on good sites, and moderately plentiful on fair sites.
- Sugar maple was the most numerous species on all sites and following all degrees of cutting except: (1) on excellent sites following clearcuttings, where yellow-poplar was more numerous, (2) on very lightly cut areas on good and fair sites at lower elevations, where beech was most numerous in the large reproduction and sassafras in the small reproduction.
- The number of large-reproduction stems, on the average, was slightly smaller than before cutting, probably because of logging damage.

- A number of sprout stems of intolerant species on the clearcut areas grew into the large reproduction class in 5 years.
- On partially cut areas small reproduction of intolerants was relatively much more abundant in openings than under canopy.

At 10 years after cuttings on excellent sites, the reproduction picture was considerably different than at 5 years. Large reproduction had increased greatly, particularly on a clearcut plot. Small reproduction, which at 5 years was most abundant on heavily cut areas, now was most abundant on areas that had been selectively cut.

Conclusions

Results of the reproduction surveys support the following tentative conclusions with reference to hardwood stands in the northern Appalachians (supporting data are weakest for the poorer sites, strongest for sites of index 75 or better for oaks):

- Reproduction of commercial species will come in abundantly on all sites after any method of cutting.
- Cuttings that remove 75 percent or more of the sawtimber volume will be followed by new stands in which up to one-half of the stems are of intolerant species. On excellent sites, yellow-poplar and black locust often will be the predominant intolerants; sugar maple will be the major tolerant species. A high proportion of the dominant stems in the reproduction after heavy cuttings will be of sprout origin.
- Light selection cuttings on the better sites favor reproduction of tolerant species—chiefly sugar maple, with lesser amounts of beech. Intolerant species will be only sparingly represented. Under group-selection cuttings, somewhat more intolerants such as yellow-poplar, white ash, and black cherry will become established. With appropriate stand-improvement measures, selected stems of these desirable species then could be maintained, along with sugar maple, as crop trees in the next stand.