Early REPRODUCTION after seed-tree harvest cuttings in Appalachian hardwoods

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INFORMATION NEEDED

EVEN-AGED MANAGEMENT is gaining wide-acceptance in eastern hardwoods because it offers the promise of increased timber returns. Much of this increase results from the faster growth and higher value of the shade-intolerant or intermediate species that are perpetuated under this system. To obtain maximum benefit from even-aged management it is important that regeneration of the desired species be obtained promptly after the final harvest cutting. Information about the nature and timing of regeneration obtained from cuttings under various conditions is needed to facilitate the prescription of cutting methods or treatments that will accomplish this objective.

This report describes the quantity, origin, and species composition of the reproduction that was present 3 years after seed-tree harvest cuttings in Appalachian hardwood stands on the U. S. Forest Service's Fernow Experimental Forest near Parsons, West Virginia. This reproduction study was part of a much larger long-term study of three intensities of even-aged management on three site-quality classes.

STUDY AREAS AND METHODS

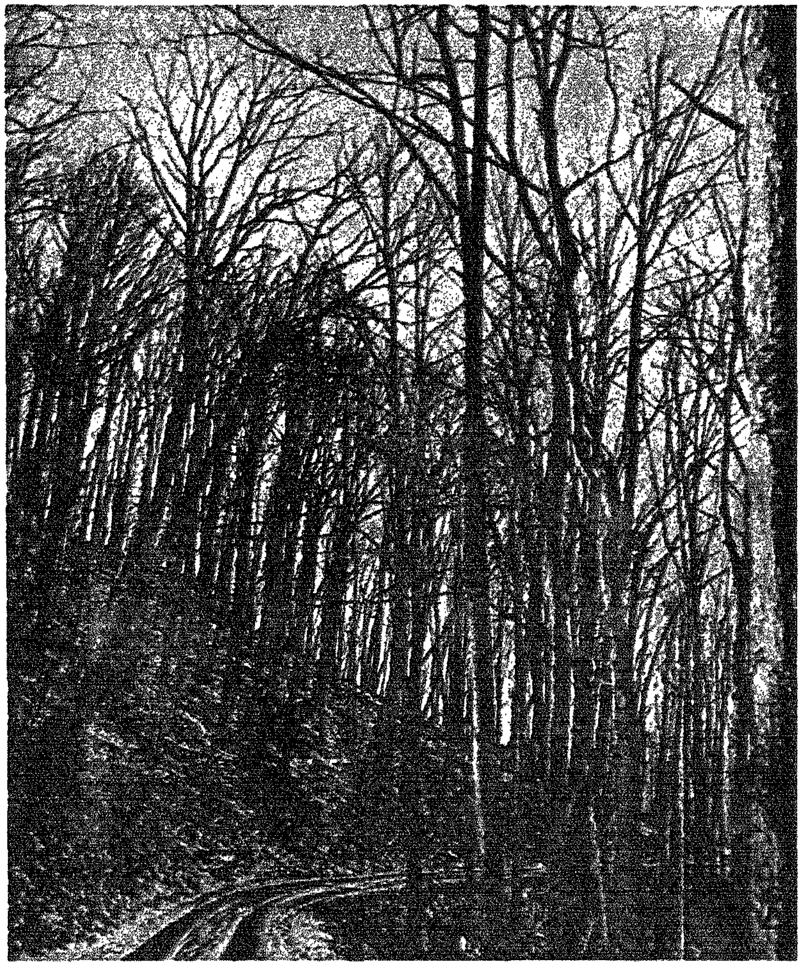
The study was carried out on nine compartments: three each on areas of site index 60, 70, and 80 (based on 10-foot oak site-index classes). These indexes characterize sites that are referred to respectively as fair, good, and excellent. The first compartment was established and cut in 1959 and the last one 3 years later. Eventually the areas will be subjected to treatment programs of different intensities, but at this date the only effective independent variables are site quality and the associated differences in species composition of the harvested stands and seed trees.

The same harvest-cutting procedure was used on all study areas. All trees over 5 inches d.b.h., except designated seed trees, were logged. Three growing seasons later, the seed trees were removed.

The original stands (fig. 1) were well stocked and had not been disturbed by cutting or fire for at least 35 years. All of them contained considerable sawtimber volume. The predominant or characteristic species were hickories, sugar maple, red oak, white ash, and black cherry on the excellent sities; yellow-poplar, red oak, hickories, chestnut oak, and white oak on the good sites; and chestnut oak, red oak, black gum, and white oak on the fair sites.

The number of seed trees left (fig. 2) after the initial logging depended on the site. On the lower site-quality areas we felt that more seed trees were needed to obtain adequate distribution of seed because of the greater proportions of the heavy-seeded oaks.

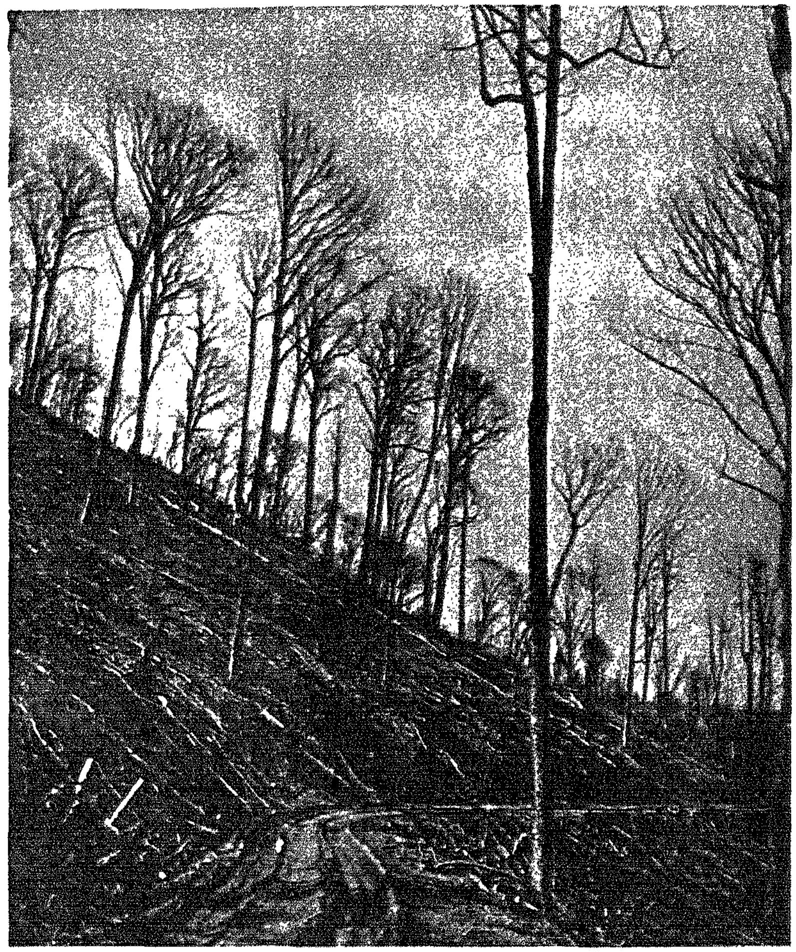
Figure 1.—Typical excellent-site stand before cutting.



By site-index classes we left the following numbers of trees per acre: site index 60 — 30 trees, site index 70 — 20 trees, and site index 80 — 10 trees.

A large proportion of the sawtimber trees on all the excellent sites and on one fair site and one good site were old-growth trees 90 to 100 years old (fig. 2). The sawtimber trees on the other sites were chiefly second growth, 55 to 60 years old, with a few old-growth residuals (fig. 3).

Figure 2.—Seed-tree stand left on one of the excellent sites.



To document closely the development of the new stands, we measured the reproduction before and after the harvest cuttings, and before and after seed-tree removal. Tallies were made by species, size class, and stem origin. Two size classes of reproduction were recognized: *small* (1 foot high to 1 inch d.b.h.) and *large* (1 inch to 5 inches d.b.h.). Small reproduction was sampled on milacre plots and large reproduction on 1/100-acre plots. Reproduction was tallied as seedlings or stump sprouts. The

Figure 3.—Typical fair-site stand before cutting.

seedling category included seedling sprouts, defined as stems arising from stumps less than 2 inches in diameter at ground line.

In the original stands the reproduction inventory in each compartment was done by sampling 1 percent of the area for the small stems and 10 percent of the area for the large stems. All reproduction tallies after the harvest cutting were made at 45 permanent sampling points in a 5-acre area in the center of each compartment.

RESULTS

Reproduction at the End of Three Growing Seasons

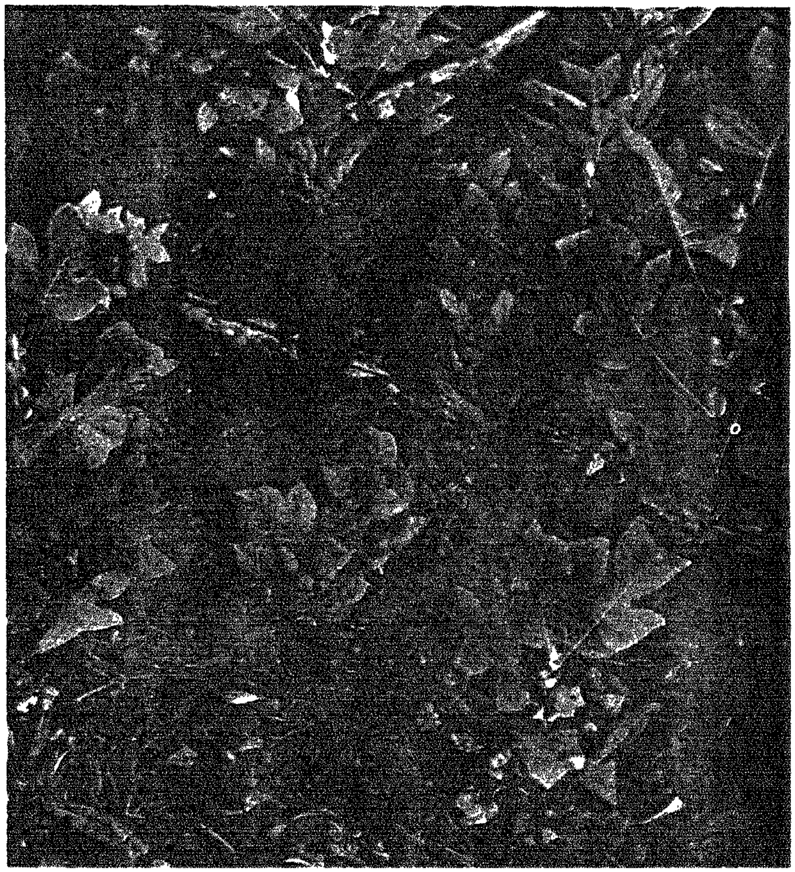
Abundance. — Small reproduction for all compartments ranged from 6,382 to 18,399 stems per acre and averaged 12,373 (table 1 and figs. 4 and 5). No significant difference in the total number of stems was detected among site classes at the 5-percent level. These results are in accord with those reported by Trimble and Hart (*1961*) in West Virginia and Roach (*1963*) in Ohio.

Table 1.—Small reproduction[1] at the end of three growing seasons

Compartment No.	Total stems per acre	Sprout stems per acre[2]	Sprouts	Five most numerous species, and number of stems per acre: First	Second	Third	Fourth	Fifth	Other species per acre	Millacres stocked with commercial species
	No.	*No.*	*Percent*						*No.*	*Percent*
						EXCELLENT SITE				
32	8,082	800	10	Sweet birch 3,330	Sugar maple 2,398	White ash 555	Yellow-poplar 466	Black cherry 222	1,111	91
33	18,399	1,528	8	Sweet birch 7,104	Sugar maple 5,305	White ash 2,620	Yellow-poplar 977	Black cherry 575	1,818	91
43	13,533	5,711	42[3]	Sugar maple 4,024	Black cherry 2,934	Yellow-poplar 2,422	White ash 1,022	Hickory 711	2,420	96
						GOOD SITE				
36	12,012	4,246	38	Sassafras 3,300	Yellow-poplar 2,002	Sugar maple 1,672	Black locust 946	Black gum 594	3,498	96
37	6,382	3,361	53	Sugar maple 1,749	Yellow-poplar 841	Red oak 840	White ash 750	Sassafras 431	1,771	91
39	12,154	2,377	20	Sugar maple 4,200	Yellow-poplar 2,800	Black cherry 1,444	Sweet birch 1,223	White ash 1,022	1,465	100
						FAIR SITE				
34	15,142	5,818	38	Sassafras 7,593	Chestnut oak 3,042	Red maple 2,064	Red oak 844	Sweet birch 710	889	93
35	13,185	4,640	35	Sassafras 4,928	Sweet birch 3,730	Red maple 1,798	Chestnut oak 533	Black locust 444	1,752	98
38	12,484	6,530	52	Sassafras 4,111	Chestnut oak 2,400	Sourwood 2,266	Red maple 1,598	Red oak 889	1,220	98

[1] Stems 1 foot high to 1 inch. d.b.h.
[2] Sprouts include root suckers of American beech and black locust.
[3] For this compartment only, sprout tallies included seedling sprouts.

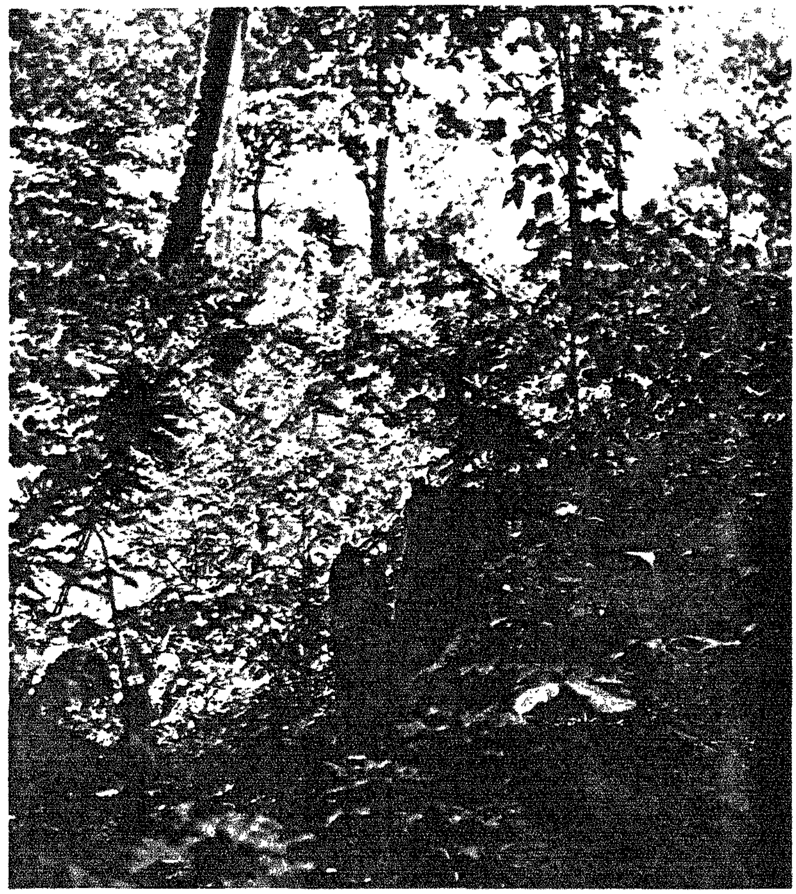
Figure 4.—Small reproduction on an excellent site 3 years after cutting.



Trimble and Hart reported over 10,000 stems of small reproduction per acre 5 years after clearcutting Appalachian hardwood stands; Roach reported 4,000 to 8,000 stems per acre after clearcutting upland hardwood stands in Ohio.

Of the total stems of small reproduction, 10 to 53 percent were of sprout origin (table 1). However, these figures tend to inflate the importance of sprouts because many sprouts may arise from a single stump. Our measurements also showed a higher percentage of sprouts on the good and fair sites than on the excellent sites. The range in percentage of sprout-origin stems

Figure 5.—Small reproduction on a good site 3 years after cutting.



concurs with the results reported earlier by Trimble and Hart (*1961*).

On the average, sugar maple was the most numerous species on the excellent and good sites, although it did not rank first in every instance. Sassafras was most numerous on the fair sites. Sweet birch ranked high on two of the excellent sites and on one fair site; yellow-poplar ranked second on all three good sites. Rankings of the top five species on each site are shown in table 1.

Most of the large reproduction stems were carryovers of advance reproduction that had survived the first harvest cutting; a few were fast-growing stump sprouts. The average number ranged from 107 per acre on the excellent sites to 208 on the fair sites. Being generally poor in form and few in number, most of these stems are undesirable elements in the new stand.

Distribution. — After 3 years, 91 to 100 percent of the milacres on all sites were stocked with one or more seedling or sprout stems of small reproduction (table 1). A large proportion of the milacres on the excellent and good sites were stocked with the desirable intolerant species — yellow-poplar, black cherry, and white ash — and with sugar maple (table 2). On the fair sites a majority of the milacres were stocked with sassafras; but chestnut oak, red oak, and other commercial species also were fairly well distributed. The ten top-ranking species in terms of stocked milacres are shown for each site in table 2.

The role of advance reproduction. — The quantity, species composition, and distribution of small reproduction on the ground before cutting differed markedly from that present 3 years later.

Advance small reproduction ranged from 1,200 to 4,500 stems per acre; 3 years after cutting the range was 6,382 to 18,399 stems per acre. This increase occurred despite severe damage to or destruction of 53 to 72 percent of the advance-growth stems during the initial harvest cuttings. Of course many of the stems damaged in logging undoubtedly resprouted from the base and formed part of the 3-year tally. Merz and Boyce (*1956*) have shown that such resprouting occurs with the oaks. Sterrett (*1915*) reported that white ash seedlings will resprout for 5 to 20 years under oak canopies and for 10 to 15 years under northern hardwood and yellow-poplar canopies. Resprouting of sugar maple and young black cherry seedlings has been observed on the Fernow Experimental Forest.

Sugar maple was the most abundant species in the small advance reproduction on the excellent and good sites, and sassafras was most abundant on the fair sites. Both species still retained these positions in the small reproduction 3 years after logging, but marked changes or regroupings occurred among the four next most numerous species (table 3). The changes were more pronounced on the excellent sites than on the good and fair sites.

Table 2.—Percentage of milacres stocked with commercial species of small reproduction at the end of 3 years (10 species with best stocking, per compartment)

Compartment No.	1 Species and % stocking	2 Species and % stocking	3 Species and % stocking	4 Species and % stocking	5 Species and % stocking	6 Species and % stocking	7 Species and % stocking	8 Species and % stocking	9 Species and % stocking	10 Species and % stocking
					EXCELLENT SITE					
32	Sugar maple 64	Sweet birch 44	Yellow-poplar 27	White ash 24	Black cherry 16	Hickory 16	Black locust 13	Elm 9	Red oak 7	Cucumber 7
33	Sweet birch 69	Sugar maple 67	Yellow-poplar 51	White ash 33	Elm 24	Butternut 20	Basswood 13	Red oak 11	Black cherry 7	Black locust 4
43	Yellow-poplar 64	Sugar maple 58	Black cherry 49	White ash 29	Hickory 27	Black locust 24	Sweet birch 9	Red oak 9	Elm 9	Red maple 4
					GOOD SITE					
36	Sassafras 58	Sugar maple 49	Yellow-poplar 33	Red oak 24	Hickory 16	Red maple 16	Chestnut oak 13	White ash 9	Sourwood 7	Black cherry 7
37	Sugar maple 44	White ash 40	Yellow-poplar 22	Sassafras 16	Red oak 11	Sweet birch 11	Chestnut oak 7	Hickory 7	Black gum 4	Elm 2
39	Yellow-poplar 67	Sugar maple 49	Black cherry 31	Sweet birch 31	White ash 27	Black locust 13	Hickory 11	Red maple 7	Red oak 4	Sassafras 4
					FAIR SITE					
34	Sassafras 62	Chestnut oak 20	Sweet birch 18	Red oak 18	Red maple 18	Sourwood 13	Yellow-poplar 11	Sugar maple 2	Black gum 2	— —
35	Sassafras 58	Sweet birch 40	Red maple 29	Red oak 20	Chestnut oak 13	Black gum 9	Black locust 7	Magnolia 4	Black locust 4	Sourwood 4
38	Sassafras 71	Red oak 31	Sourwood 27	Black gum 24	Chestnut oak 22	Cucumber 4	Sweet birch 4	Aspen 2	Scarlet oak 2	Red maple 2

Table 3.—Ranking of five most numerous species in the small advance reproduction and in the small reproduction 3 years after the cutting, (average by site).

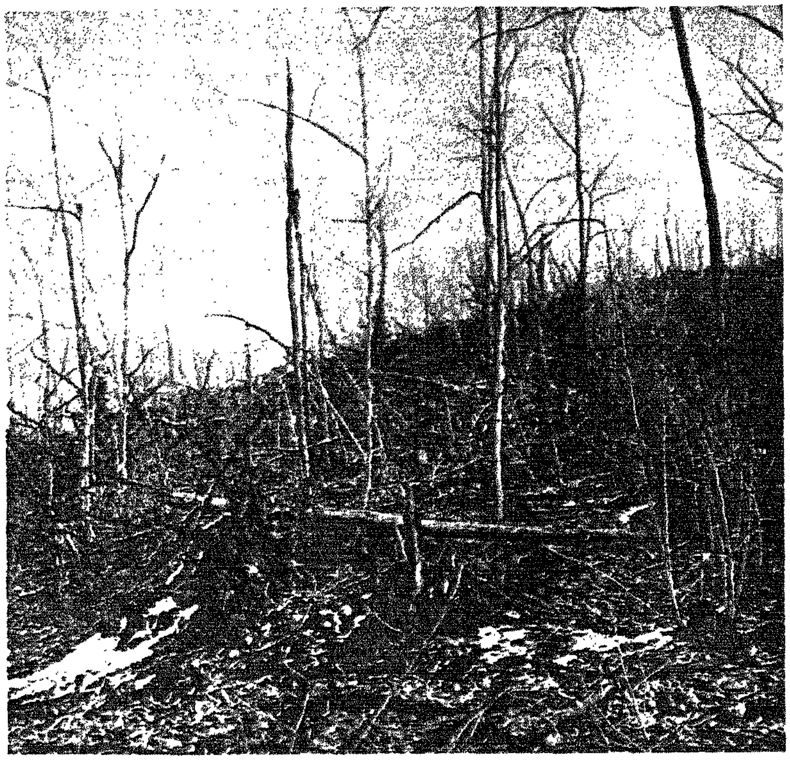
(1 foot high to 1 inch. d.b.h.)

Site quality	Rank	Advance reproduction	3 years after initial reproduction cut
	1	Sugar maple	Sugar maple
	2	Hophornbeam	Sweet birch
Excellent	3	Beech	White ash
	4	Basswood	Yellow-poplar
	5	Fraser magnolia	Black cherry
	1	Sugar maple	Sugar maple
	2	White ash	Yellow-poplar
Good	3	Red maple	Sassafras
	4	Red oak	White ash
	5	Black oak	Red oak
	1	Sassafras	Sassafras
	2	Chestnut oak	Red maple
Fair	3	Red maple	Chestnut oak
	4	Sugar maple	Sweet birch
	5	Black gum	Red oak

Before cutting, milacre stocking of the advance small reproduction for the excellent, good, and fair sites was 39, 75, and 85 percent respectively. After the first harvest cutting the respective milacre stockings averaged 27, 37, and 33 percent; 3 years later the figures were 93, 96, and 96 percent; and after seed-tree removal they were 87, 88, and 93 percent. These last figures undoubtedly were soon increased by the resprouting of damaged stems.

As mentioned previously, the larger stems of advanced reproduction are generally an undesirable component. They are usually made up of the less desirable species; they frequently have poor form; and their stocking is seldom dense enough for good quality growth (fig. 6). Many of them develop excessively large crowns and interfere with the development of smaller and more desirable stems. Although there is little published information to show that removal of these trees is economically justified,

Figure 6.—Large advance reproduction on the fair site after seed-tree removal.



most foresters who have studied their development recommend that they be eliminated when harvest cuts are made, or shortly after.

Other Considerations

Logging slash and herbaceous ground cover. — Both logging slash and heavy herbaceous ground cover can be detrimental to the establishment of desirable reproduction. In this study, detailed note was made of logging slash and casual observation was made of herbaceous ground cover.

After the first reproduction cutting, logging slash covered an average of 21 percent of the ground surface. Since pulpwood was harvested from this cutting as well as sawlogs, much of the heavier sawlog slash was utilized. After the seed-tree cutting — when no pulpwood was harvested except on compartment 38 — the average coverage by logging slash increased to 26 percent.

Our observations indicate that reproduction is reduced or at least delayed by the larger and denser slash piles until they have broken down, which occurs in 3 to 5 years. But we do not know to what extent this hinders the ultimate stocking and development of reproduction.

Only on two of the excellent-site compartments was there a heavy cover of herbaceous vegetation before the harvest cutting. As of 1966, this cover has persisted 5 years (fig. 7). Wood nettle (*Laportea canadensis*), pale snapweed (*Impatiens pallida*), black snakeroot (*Cimicifuga racemosa*), wild hydrangea (*Hydrangea*

Figure 7.—Heavy herbaceous growth on the excellent site 3 years after cutting.

arborescens), blackberry (*Rubus* sp.), and other high-site species blanket the area. Although the effect of this competition does not show up in the reproduction counts, the seedlings are shorter on these compartments than on the other high-site compartment. After 5 years, the new tree stand was just emerging from this layer. Only time will tell whether the reduction in early height growth will later be made up.

Seed trees. — Because of their sudden isolation from the protection afforded by a closed stand, seed trees retained after harvest cutting are subject to log-quality degrade by epicormic branching, and to losses from windthrow.

Epicormic branching. — Some epicormic branching was noted on several species left as seed trees on the better sites. These trees were dominants and codominants with good crowns — types of trees that are least susceptible to bole sprouting. During the 3 years the seed trees were standing, some epicormic branches developed on the first two logs of black cherry and basswood; there was no increase in epicormic branching on yellow-poplar and white ash. This is in line with results reported by Smith (*1966*).

Windthrow. — Some blowdown of seed trees occurred on the excellent-site compartments where only 10 seed trees per acre were left. Of a total of 470 seed trees on these three compartments, about 20 of them — ranging from 14 to 32 inches d.b.h. — were lost. High winds after heavy rains in February 1962 probably caused the blowdown. About equal numbers of basswood, red oak, white ash, and black cherry—the predominant seed trees species—were uprooted. Most of the damage occurred on a flat exposed ridge. No seed trees on the good and fair site compartments were blown down.

DISCUSSION

Our goal for regeneration in even-aged management is to obtain adequate stocking to desirable species during and shortly after the harvest cutting, or cuttings in the case of seed-tree and shelterwood systems. Our study demonstrated that this objective can be met, and it brought to light a number of pertinent facts concerning the process.

The important considerations are the quantity, distribution, and species composition of the reproduction that is present a short time after cutting. In our compartments the reproduction 3 years after harvest was satisfactory in all respects. There were more than enough well-distributed seedling and seedling-sprout stems to produce new stands of well-formed trees of desirable species if timely intermediate cuttings, such as weedings and thinnings, are carried out.

Species composition varied with site quality. Sugar maple was the predominant species on the excellent and good sites both before and 3 years after cutting, but such highly desirable intolerant species as yellow-poplar, black cherry, basswood, and white ash were abundant enough after cutting to form an important part of the new stands. Sassafras, a short-lived species, was prominent in the reproduction on the fair sites — both before and after cutting. However, the oaks and red maple were sufficiently numerous and well-distributed to stock the new stands if favored in intermediate cuttings.

Considering the abundance of reproduction stems, the damage caused by seed-tree removal was not important and therefore can generally be ignored.

Recent information about several species, notably yellow-poplar and white ash, has revealed that seeds stored in the duff can play a major role in regenerating new stands (*Clark 1962, Leak 1963, Sander 1966*). Black cherry probably falls in this same category; however, there is little published information about the relative importance of black cherry seed that has been stored in the duff. Advanced reproduction is also very important in the regeneration of certain species. Oaks that survive in the regeneration have been found to consist primarily of stump sprouts and new sprouts from advanced reproduction present under the old stand (*Sander 1966*). Thus there would seem to be little need to leave seed trees in situations where advanced reproduction is present or where seed of desired species can be expected in the duff.

Certain classes of vegetation present on the study areas 3 years after logging are potentially detrimental to the new stands. These include the scattered stems of large advance reproduction, which can be cheaply eliminated by basal spraying or injecting with herbicides. The other competitors, rhododendron and grapevines, are most prevalent on the better sites, and controlling them is costly. More work is needed to develop economically feasible control methods. Although briars and herbaceous plants may depress tree-seedling growth somewhat during the early years, expenditures for control of these plants probably would not ordinarily be justified.

Logging slash has not materially affected the establishment of new reproduction on the study areas. Under the heavier piles of brush, which in places completely covered areas of several square feet, reproduction has not come in. However, these spots occupy only a small part of the total area in any of the compartments, and they are scattered.

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