Development of a Southern Appalachian Hardwood Stand After Clearcutting

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ABSTRACT. A mixed hardwood stand composed of 53% oak (Quercus *spp.), 33% yellow-poplar (*Liriodendron tulipifera *L.), and 14% other species, was clearcut in 1963. Twenty years later a developing, even-aged stand of predominantly sprout origin is dominated by yellow-poplar, black locust* (Robinia pseudoacacia *L.), red maple (*Acer rubrum *L.), and sweet birch (*Betula lenta *L.). The oaks are a minor and decreasing component.*

This and other studies suggest that clearcuts on good sites in the Southern Appalachians will be dominated by aggressive intolerant species— mainly yellow-poplar. If a larger oak component is desired, measures to ensure strong advance reproduction and lessen competition from prolific sprouters such as red maple will be necessary.

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Clearcutting, in which harvest of all commercial trees is followed by felling of all residual material, is a widely accepted and successful method of naturally regenerating Southern Appalachian hardwoods on a variety of sites. There are, however, still-unanswered questions about long-terms trends in species composition, distribution of desirable stems, and management needs in the developing stands. This report documents and discusses development of a hardwood stand for the first 20 years after clearcutting a high-quality cove stand of mixed species composition.

METHODS

The stand harvested in 1963 was located on the Bent Creek Experimental Forest near Asheville, NC. The study site is a large, open cove bisected by a small north-south stream. Most of the 46-ac stand has an easterly aspect and is of high productivity with site index for yellow-poplar in excess of 100 (base age 50). On the westerly facing slope (about 10% of the area), the site quality is 5 to 10 ft lower. The study area has a research history dating back to 1936, when it was subdivided into fifty 1-acre plots as part of a harvest cutting study. At that time 5 treatments were replicated 10 times on the 1-ac plots. The treatments ranged from no cutting to a diameter cut in which all trees above 14 in were removed. The original plot boundaries have been retained, and the plots are identified by number. However, no effects of the relatively mild treatments applied in 1936 could be detected in the current regeneration (McGee and Hooper 1970, 1975).

Sawtimber averaged 7,000 bd. ft. (Int. ¼-in rule) in 25 trees/ac. The sawtimber was primarily yellow-poplar (33%), northern red oak (*Q. rubra* L.) (27%), and chestnut oak-white oak (*Q. prunus* L.-*Q. alba* L.) (26%). About 10 cords of pulpwood/ac were removed in trees 5 to 10 in. dbh. The 102 pulpwood-size trees/ac were dominated by miscellaneous species such as red maple, with yellow-poplar and the oaks each contributing about 20%. After the commercial logging, al1 residual trees more than 4.5. ft tal1 were felled with chain saws.

Fifty permanent plots ¼-ac in size were established before harvest to monitor stand development. Reproduction less than 4.5 ft tal1 was tallied before harvest and after 2 growing seasons. At stand ages 5, 10, 15, and 20, stems more than 4.5 ft tal1 were tallied by species and origin and whether they were overtopped or free to grow (FTG). Thus, judgment was based on whether or not the tree was overtopped by competitors. Also, at age 20 al1 stems were tallied by species and 1-in diameter class. A subsample of the 200 tallest trees/ac was measured for height at each 5-year interval.

RESULTS AND DISCUSSION

Early Reproduction

Advance reproduction 1 year before clearcutting was typical of many cove stands (Table 1). Small seedlings of al1 species, including the intolerants such as yellow-poplar, were present in large quantities. Oaks in particular were numerous, with more than 5,400/ac. Red maple seedlings were profuse but mostly very small-the majority only a few inches tall.

Table 1. Number of seedlings at preharvest and two years after clearcutting.[1]

Species	1963	1965
Yellow-poplar	520	5,632
Northern red oak	1,623	408
Black oak	83	19
Chestnut and white oaks	3,745	1,126
Sweet birch	83	1,544
Black iocust	83	777
Red maple	11,851	3,690
Misc-I[2]	478	408
Misc-II[3]	1,165	1,922
	19,631	18,526

[1] Less than 4.5 ft tall.
[2] Desirable timber species including hemlock (*Tsuga canadensrs* L.), ash (*Fraxinus americana* L.), Fraser magnolia (*Magnolia fraseri* Walt.), black cherry (*Prunus serotina* Ehrh.), hickory (*Carya* spp.), and basswood (*Tilia americana* L.).
[3] Tolerant understory species including witch-hazel (*Hamamelis virginiana* L.), sourwood (*Oxydendrum arboreum* L.), sassafras (*Sassafras albidum*), blackgum (*Nyssa sylvatica* Marsh.), and dogwood (*Cornus florida* L.).

Two growing seasons after harvest, the number of stems present had changed very little, but the species composition had shifted dramatically. The most noticeable increase was in yellow-poplar and sweet birch, both of which produce numerous seed that remain viable in the forest floor for up to 8 years and germinate profusely under proper conditions. Black locust from root sprouts had also increased substantially, but thousands of the small red maple seedlings died on exposure. The oak species also exhibited a marked decline, with only 28% of the preharvest number present after 2 years. Nearly 4,000 seedlings/ac of oak species died in the first 2 years of competition with the tangle of weeds, vines, and trees.

Stand Development

Both FTG and total number of stems have declined over time (Table 2). From age 5 to age 20, the total number declined by 43%, and FTG declined by 63% as individual stem size and degree of competition increased. Decline in FTG stems was most rapid between the 5th and 10th years as crowns closed and dominance was expressed. The slight increase in FTG between the 10th and 15th year is attributed to the grapevine treatment at age 13. Mortality was greatest between the 10th and 15th years; more than half of the total mortality took place in that 5-year period after stand closure took place and intertree competition intensified.

Four species along with the miscellaneous group of tolerant understory species (Misc-II) have dominated the stand for the first 20 years (Table 3). At age 5, sweet birch and locust accounted for 51% of FTG stems and, together with yellow-poplar and tolerant understory species, make up 81% of FTG stems. Over the period of 15 years, locust has about held its own, sweet birch has steadily declined, yellow-poplar has steadily increased, and the tolerant understory species have become an inconsequential part of the dominant stand. Added to these trends, red maple has become a significant part of the dominant stand.

Current Stand

Species Dominance. Distribution by species and size class at age 20 is shown in Table 4. When size of stems is considered as well as number, the degree that yellow-poplar dominates the stand is even more obvious. Yellow-poplar makes up 44% of stand basal area and 80% of al1 stems more than 8.0 in dbh (Figure 1). Yellow-poplar accounts for 37% of the tallest 200 stems/ac with an average height of 60 ft. Locust is a somewhat distant second with 19% of basal area and 11% of stems more than 8.0 in dbh. Locust accounts for 27% of the tallest stems but averages only 50 ft tall. Red maple remains a fairly strong third in percentage of basal area. It contributes only 5% of the tallest stems, but those are relatively tall, second only to yellow-poplar. The declining status of sweet birch is very evident. While still present in very large numbers it constitutes only 7% of basal area, and stems among the 200 largest average only 51 ft tall.

The poor position of oaks in general and northern red oak in particular is evident from the size distribution (Table 4). Oaks contribute less than 4% of stand basal area; northern red oak is less than 1%. Oaks account for less than 7% of the tallest trees, and northern red oak is not among them. Miscellaneous timber species (Misc-I) remain a small but consistent component of the stand. Miscellaneous nontimber species (Misc-II) are present in relatively large numbers but have been relegated to understory status.

Origin of Stems. The importance of sprouts in reproduction of hardwood stands is illustrated in Table 5. Sprouts were important from an early age, and by age 20 accounted for nearly three-fourths of al1 FTG stems. With the

Table 2. Number of stems per acre more than 4.5 ft tall, by species at five-year intervals.

Species	Age 5			Age 10			Age 15			Age 20		
	FTG	SUPR	Total	FTG	SUPR	Total	FTC	SUPR	Total	FTG	SUPR	Total
Yellow-poplar	142	204	346	84	279	363	99	132	231	116	71	187
Northern red oak	32	40	72	10	44	54	13	24	37	4	21	25
Black oak	2	3	5	2	3	5	1	3	4	1	2	3
Chestnut and white oaks	44	57	101	17	80	98	21	20	41	16	13	29
Sweet birch	261	742	1,003	68	853	921	80	429	509	48	291	339
Red maple	62	27	89	34	48	82	43	120	163	62	104	166
Black locust	247	122	369	105	91	196	95	31	126	81	6	87
Misc-I	57	49	106	21	100	121	30	98	128	28	123	151
Misc-II	159	239	398	38	319	357	56	338	394	15	415	430
Total	1,006	1,483	2,489	379	1,818	2,197	438	1,195	1,633	371	1,064	1,417

FTG, free to grow; SUPR, suppressed; Misc-I, desirable timber species including hemlock, ash, Fraser magnolia, black cherry, hickory, and basswood; Misc-II, tolerant understory species including witch-hazel, sourwood, sassafras, blackgum, and dogwood.

Table 3. Species trends indicated by percentage of number of free-to-grow stems, by five-year intervals.

Species	Age 5	Age 10	Age 15	Age 20
Yellow-poplar	14	22	23	31
Northern red oak	3	3	3	1
Black oak	1	1	1	1
Chestnut and white oaks	4	4	5	4
Sweet birch	26	18	18	13
Red maple	6	9	10	17
Black locust	25	28	22	22
Misc-I[1]	6	6	7	8
Misc-II[2]	16	10	12	4
	100	100	100	100

[1] Desirable timber species including hemlock, ash, Fraser magnolia, black cherry, hickory, and basswood.
[2] Tolerant understory species including witch-hazel, sourwood, sassafras, blackgum, and dogwood.

exception of yellow-poplar and sweet birch, almost al1 FTG stems were of sprout origin. Only those two species produced any appreciable number of seedlings or seedling sprouts that were a part of the dominant stand at age 20. Both these species produce large, frequent seed crops and store seed in the forest floor that is able to germinate and grow when given proper light, temperature, and moisture. In addition, seedlings of both species are able to grow rapidly in height from an early age.

Red maple is a particularly prolific sprouter even from relatively large stumps. Sprout clumps of red maple self-thin very slowly and occupy considerable ground area to the exclusion of other species (Figure 2). At age 20 there were 36 sprout clumps per acre with 3 or more surviving stems per clump.

Grapevines

At each stand examination, the extent of grapevines on each 1/40-ac plot was evaluated in three categories: heavy-40% or more of plot affected; moderate—20–40% affected; light—>20% affected. At age 5, grapevine was heavy on 22% of plots, moderate on 1 1%, and light to absent on 67%. By stand age 10, the presence of grapevines had increased to heavy on 52% of plots, with moderate presence on an additional 30%. Many trees were severely damaged by vines; some areas as large as 1/4-ac or more were completely occupied by vines, which left little chance for any tree development. Trimble and Tryon (1979) and Smith (1984) have summarized the devastating effects of grapevines in young stands on high-quality sites and recommended control methods. Based on their work we undertook control of grapevines at stand age 13 by cutting al1 vines that extended into the crown canopy. The control effort was partially successful-at the 15th year, grapevines were still moderate to heavy on 27% of the plots. Most of the vines in the canopy at age 15 appeared to be those that were missed in the control operation and continued to spread through the tree crowns.

Table 4. Number of stems per acre at age 20, by species.

Species	dbh (in) 1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Yellow-poplar	26	27	18	23	14	19	11	17	13	12	2	3	2	187
Northern red oak	13	5	3	2	1	1	—	—	—	—	—	—	—	2.5
Black oak	1	—	1	—	—	—	—	—	—	1	—	—	—	3
Chestnut and white oaks	1	9	3	8	4	—	2	2	—	—	—	—	—	29
Sweet birch	162	78	51	27	16	2	2	1	—	—	—	—	—	339
Black locust	—	—	6	21	19	23	11	3	2	1	1	—	—	87
Red maple	27	42	35	29	19	8	3	3	—	—	—	-	-	166
Misc-I[1]	62	39	22	17	8	1	1	1	—	—	—	—	—	151
Misc-II[2]	227	162	26	11	4	—	—	—	—	—	—	—	—	430
Total	519	362	165	138	85	54	30	27	15	14	3	3	2	1,417

[1] Includes hemlock, ash, Fraser magnolia, black cherry, hickory, and basswood.
[2] Includes witch-hazel, soutwood, sassairas, blackgum, and dogwood.

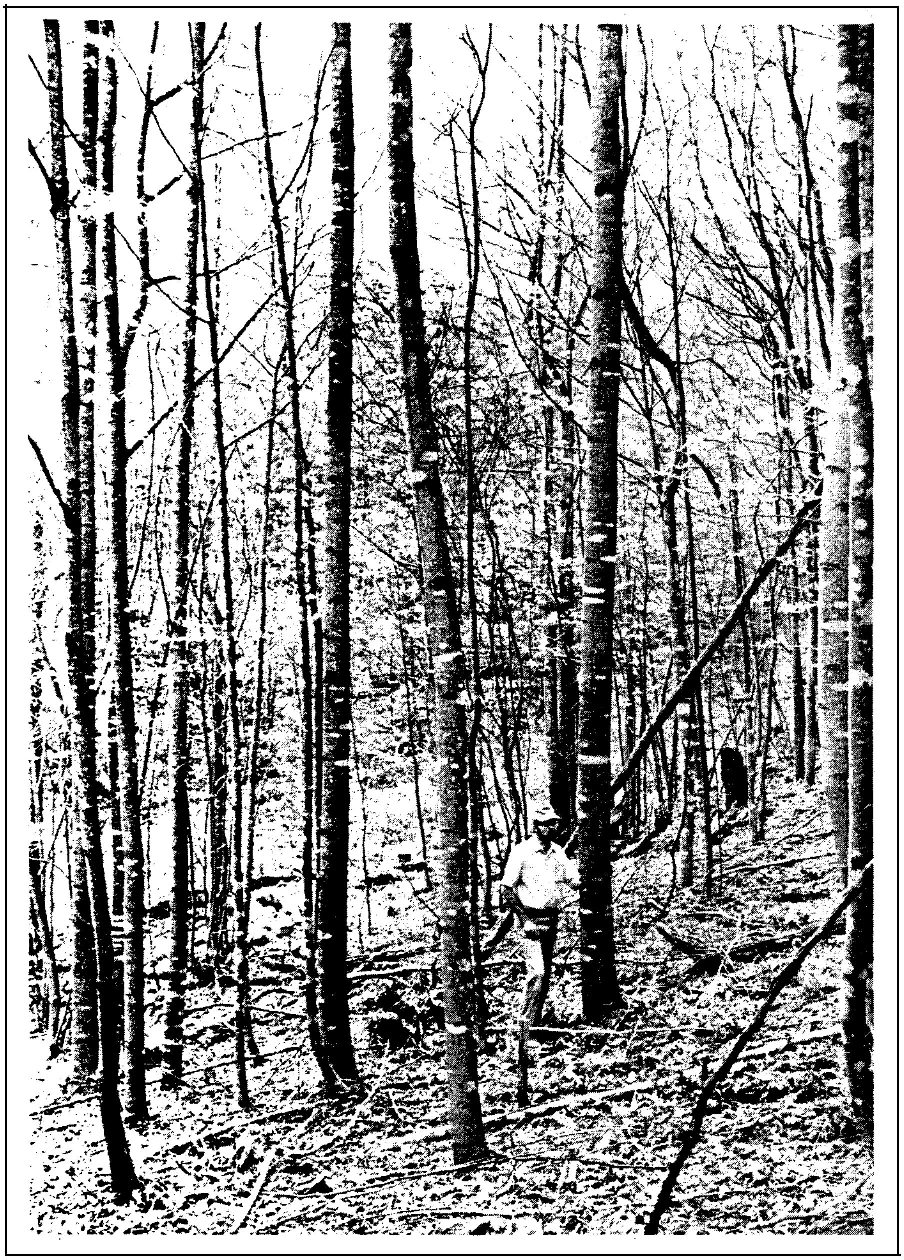

Figure 1. Yellow-poplar is the dominant tree species at stand *age* 20.

DISCUSSION

Commercial clearcutting followed by felling of residuals has resulted in a well-stocked stand of cove hardwoods at age 20. The current stand is largely of sprout origin and is dominated by yellow-poplar, black locust, red maple, and sweet birch. Based on past trends and comparative growth rates of saplings and polesize trees, yellow-poplar will assume increasing dominance in the stand over time. Most other species, including the miscellaneous desirable timber species, might be expected to occupy a position similar to the one they held in the previous stand. Oaks are the main exception. They seem to be destined to occupy a far less significant position than they did previously. The position of northern red oak, which constituted 25% of volume in the previous stand, has deteriorated with each passing year until at age 20 only 4 stems/ac are FTG, and these individuals are 10–15 ft shorter than their neighbors although most are sprout origin. The more than 5,400 small oak seedlings/ac in the preharvest stand have not been a factor for dominance at all. One could argue, as did Oliver (1978) in New England, that the few survivors will be able to hang on for long periods and assume dominance later in the rotation as their competitors begin to slow down in height growth. In this instance, however, the major competition will be from yellow-poplar, which can sustain growth for long periods and maintain dominance well beyond any reasonable rotation age for timber production. We expect to see further deterioration in the position of oak in the stand.

If one considers cultural operations to encourage oak development, the trends of oak numbers and relative position in the stand are instructive. A relatively large number of northern red oak were present at age 5, and about half were in a reasonably competitive position. After age 5, numbers of FTG and total survivors were reduced by about one-third during each 5-year period to age 20. It would seem logical to enter the stand at an early age before red oak numbers are depleted if enhanced development of oak is desired. Release of crop trees at an early age in seedling-sapling stands, however, has not proven effective in other studies. Released

Table 5. Sprouts as a percentage of free-to-grow stems, by species.

Species	Age 5	Age 10	Age 15	Age 20
Yellow-poplar	44	44	45	41
Black locust[1]	100	100	100	100
Sweet birch	13	26	48	54
Red maple	94	88	100	100
Northern red oak	38	30	54	75
Black oak	1	1	1	1
Chestnut and white oaks	55	52	48	78
Misc-I	60	45	83	90
Misc-II	85	87	89	100
Weighted avg.	60	66	71	74

[1] Includes both root and stump sprouts.

Figure 2. Red maple sprout clumps have poor potential and exclude more valuable species.

trees, especially of oak species, have responded slowly and have been overtopped by sprouts from cut trees and crown expansion of nearby competitors (Trimble 1973, 1974). Even when kept FTG by annual release, northern red oak on good sites grows much slower than its competitors when they start on an even footing. After 12 years, released red oak seedlings were 16 ft tal1 compared with 22 and 29 ft for black cherry and yellow-poplar (Smith 1983). Smith also found that development of clear bole was very slow for the released seedlings.

The pattern of stand development and species trends detailed here is typical of those observed on cove and lower moist slopes throughout the Southern Appalachians. The prolific seeders and vigorous sprouters with rapid height growth-epitomized by yellow-poplar- tend to dominate. Such stands appear capable of developing through the seedling-sapling stage quite satisfactorily without cultural treatment, except for special problems such as those caused by vines. In fact, for best growth and quality development, it may be necessary to maintain closed stands until desired clear length of bole has been obtained (Carvell 1983, Holsoe 1947). Less prolific reproducers and slower growers, such as the oaks, do not compete well unless given a head start in the form of large advance reproduction or small diameter stumps that sprout vigorously. On good-quality sites with sawtimber rotations, numbers of small oak trees that sprout readily are likely to be low. Advance seedlings are also usually very small—less than 1 ft tall. If less competitive species such as the highly valuable northern red oak are desired on these high-quality sites, it will probably be necessary to take steps to encourage development of large advance reproduction—perhaps of sapling size or larger—that can compete on an equal footing. Preharvest use of herbicides to eliminate or reduce some of the competition from prolific sprouters such as red maple may also be effective in promoting growth of the less competitive species (Loftis 1978, 1983). ☐

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