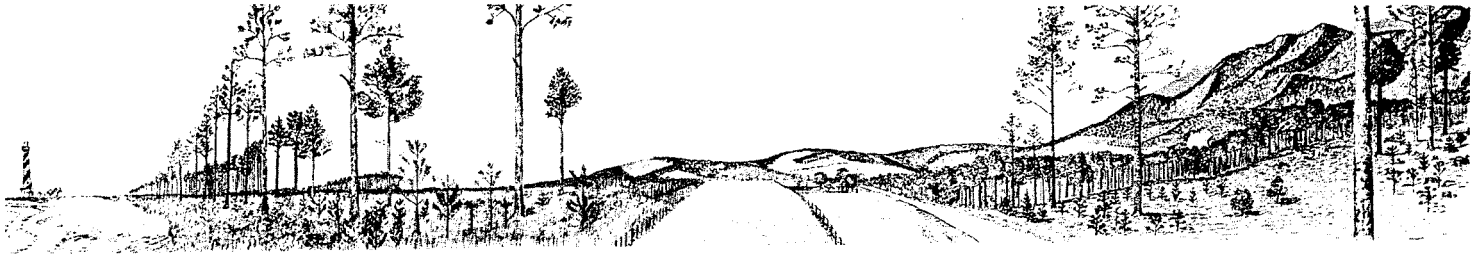

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SEED PRODUCTION IN SOUTHERN APPALACHIAN OAK STANDS

Abstract.--Acorn production in mixed oak stands of different densities varied considerably among stands, years, and species. Density had no effect on total acorn production. Although numerous acorns were initiated each year, the majority either failed to develop fully or were damaged by insects and animals.

The forest manager's ability to grow both timber and wildlife in the oak stands of the Southern Appalachians would be greatly enhanced if he could control or predict the quantity of acorns produced at a given time and place. At present too little is known about the factors which influence acorn production for him to do either.

In a previous study of acorn production in the Southern Appalachians, Downs and McQuilkin[1] sampled individual trees of five major species. They obtained information on acorn condition and relative rates of production among species. However, assessment of acorn production on a given area has been prohibited because of the difficulty in converting their sample data to total tree production and because of the lack of consistent correlation between total production and tree characteristics. More information is needed about the effects of site, stand, and climatic factors on acorn production.

The study reported here was designed to obtain quantitative information on acorn production per acre in mixed oak stands. The primary aim was to determine the effect of residual stand density on total acorn production. However, corollary information on species differences, acorn condition, and annual fluctuations may be as informative as the data on stand density.

METHODS

Six 2/3-acre plots were installed in mixed oak stands on the Bent Creek Experimental Forest in the summer of 1962. Although predominantly oak, species composition varied widely (table 1). At the time of installation, the stands were from 63 to 82 years old with approximately 100 square feet of basal area per acre. After one year of acorn collection, two plots were reduced to 66 square feet of basal area per acre, two were reduced to 33 square feet per acre, and two were retained intact as controls (table 2). All cutting was done from below in order to favor well-distributed, large-diameter oak trees.

[1]Downs, Albert A., and McQuilkin, William E. Seed production of Southern Appalachian oaks. J. Forest. 42: 913-920. 1944.

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Table 1.--Site and stand conditions before cutting

Plot number	Site index[1]	Stand age	Initial basal area	Initial basal area by species					
				Northern red oak	Black oak	Scarlet oak	White oak	Chestnut oak	Other species[2]
		Years	Sq. ft.	Percent					
1	60	68	93	0	10	61	1	23	5
2	63	63	98	4	1	4	49	34	8
3	73	71	98	0	8	4	69	0	19
4	74	79	115	10	52	3	9	14	12
5	63	82	95	0	17	61	9	0	13
6	72	72	108	13	21	2	0	46	18

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

[2]Other species include yellow-poplar, shortleaf pine, hickory, red maple, black locust, southern red oak, black cherry, and sourwood.

Table 2.--Site and stand conditions after cutting

Plot number	Basal area	Residual basal area by species					
		Northern red oak	Black oak	Scarlet oak	White oak	Chestnut oak	Other Species[1]
	Sq. ft.	Percent					
1	93	0	10	61	1	23	5
2	98	4	1	4	49	34	8
Average, high density	95.5	2	5.5	32.5	25	28.5	6.5
3	66	0	7	4	75	0	14
4	66	9	56	4	9	15	7
Average, medium density	66	4.5	31.5	4	42	7.5	10.5
5	33	0	12	67	9	0	12
6	33	41	0	4	0	54	1
Average, low density	33	20.5	6	35.5	4.5	27	6.5

[1]Other species include yellow-poplar, shortleaf pine, hickory, red maple, black locust, southern red oak, black cherry, and sourwood.

Seed production was estimated by catching the acorns in 1/10-milacre cardboard traps[2]; 24 traps were placed systematically in each plot. We collected acorns at 1- to 2-week intervals from mid-August until all seed were down. Trapped acorns were counted after being divided into four classes:

1. Well-developed, sound and undamaged
2. Well-developed, damaged by insects
3. Well-developed, but with other damage, primarily by birds and squirrels
4. Imperfectly developed, deformed or aborted

RESULTS

The data presented here summarize acorn production for the 5-year period from 1962 to 1966, the period encompassing the 1 year in undisturbed stands and the 4 years which followed cutting (table 3).

Acorn production.--The key word which describes acorn production in these mixed oak stands is variability. Average production of well-developed acorns (classes 1, 2, and 3) ranged from 6,600 per acre in 1964 to 94,600 per acre in 1966. Moreover, quantity varied greatly between plots in a single year. There was, however, no consistent relationship between acorn production and residual basal area. Following stand cutting in 1963, there appeared to be a trend of decreasing production with decreasing basal area. The seed years 1964 and 1965 were so uniformly poor on all plots that a comparison between plots during those years was meaningless. In 1966 the trend was reversed, with the low density plots producing the greatest number of acorns. In future years, as more data becomes available, a relationship between residual density and acorn production may be established. But it seems more likely at present that the diverse trends are due to variation in species composition between the plots.

Although the sampling scheme does not allow calculation of per acre production by species, a comparison of relative production by species is informative (fig. 1). Contrary to the findings of Downs and McQuilkin (see footnote 1), the red and white oak groups did not follow a common trend in production from year to year. Peak production in the white oaks occurred in 1963; peak production in the red oaks occurred in 1966. The random selection of the plots to be cut resulted in the white oaks being concentrated in the high density plots and the red oaks in the lower density plots (table 2). The differences in acorn production, therefore, did not result from differences in basal area between the plots but must have resulted primarily from differing production trends between the white and the red oak groups.

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[2]Klawitter, R. A., and Stubbs, Jack. A reliable oak seed trap. J. Forest. 59: 291-292. 1961.

Table 3.--Acorn production--5-year summary

Year and plot number		Well-developed			Aborted	Total
		Sound	Insect damage	Other damage		
		Thousands/acre				
1962	1	1.7	10.4	1.2	12.1	25.4
	2	8.8	42.5	1.2	38.8	91.3
	3	2.1	25.0	0.4	30.8	58.3
	4	9.2	22.9	3.3	11.2	46.7
	5	13.0	33.3	5.4	25.4	77.1
	6	10.8	15.0	8.3	9.6	43.8
Average		7.6	24.8	3.3	21.3	57.0
1963	1	4.6	21.2	0	9.6	35.4
	2	119.6	95.0	2.1	37.5	254.2
	3	67.5	92.9	1.2	55.0	216.7
	4	7.9	19.6	0.4	14.6	42.5
	5	8.4	23.5	0.9	24.5	57.3
	6	21.7	5.8	15.8	0	43.3
Average		38.3	43.0	3.4	23.5	108.2
1964	1	0.8	13.8	0	7.5	22.1
	2	1.2	3.3	0.8	0	5.4
	3	0.4	0.8	0.4	0.4	2.0
	4	1.2	4.6	2.1	13.8	21.7
	5	0.4	2.5	1.7	5.0	9.6
	6	0	4.6	0.8	2.1	7.5
Average		0.7	4.9	1.0	4.8	11.4
1965	1	0	0	0	0	0
	2	7.5	43.8	0	15.0	66.2
	3	10.4	42.1	1.2	20.0	73.8
	4	2.9	12.5	0.4	5.0	20.8
	5	0	0.8	0	17.9	18.8
	6	1.2	2.9	0	0.8	4.9
Average		3.7	17.0	0.3	9.8	30.8
1966	1	26.2	25.0	0.4	15.0	66.7
	2	5.4	5.8	0.4	4.6	16.2
	3	12.5	10.0	0.8	10.4	33.8
	4	86.7	17.5	1.7	24.2	130.0
	5	136.3	57.1	1.7	45.8	240.9
	6	145.4	34.2	0.4	60.0	240.0
Average		68.8	24.9	0.9	26.7	121.3

Acorn condition.--The quality of acorns produced is as important as the quantity produced. On the average, only two out of three acorns trapped were fully developed. As the total number of acorns increased, the percentage of acorns that developed fully also increased, ranging from 58 percent in the poorest year to 78 percent in the best year.

Of the acorns which developed fully, the number of sound and undamaged acorns (class 1) varied from 11 percent in 1964 to 73 percent in 1966. The percent of sound acorns was closely related to the number of well-developed acorns (fig. 2). In the poorest seed year (1964), when sound acorns averaged only 700 per acre, one plot had no sound acorns;

the maximum on any plot that year was 1,200 per acre. In the highly productive year (1966), sound acorns averaged 68,800 per acre, ranging up to 145,400.

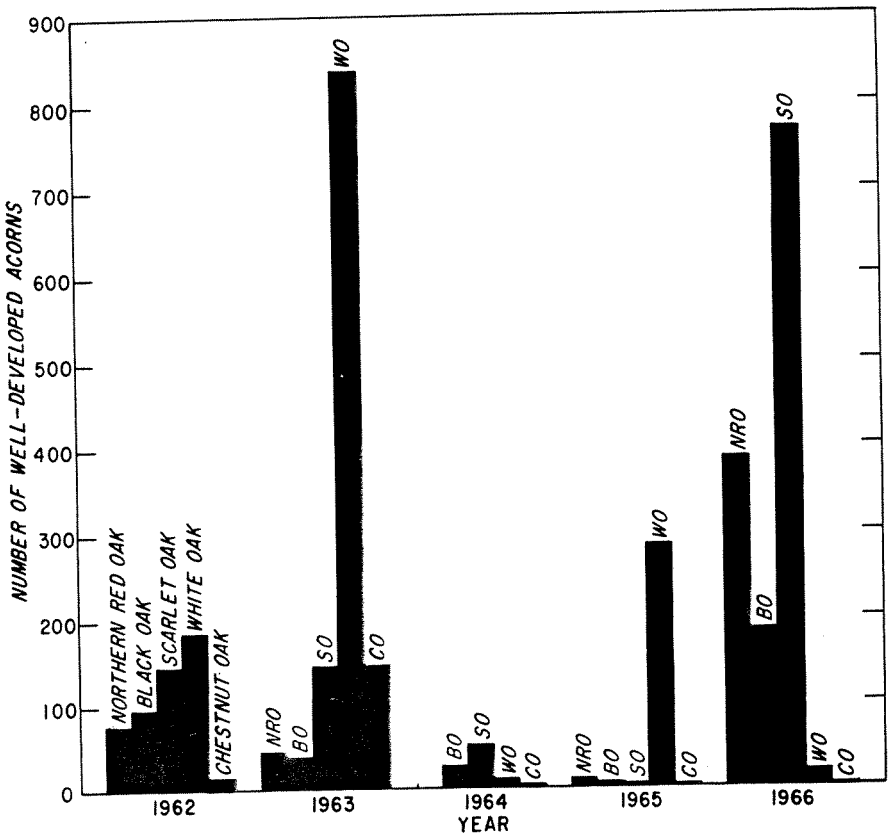

Figure 1.--Total yearly production of well-developed acorns by species.

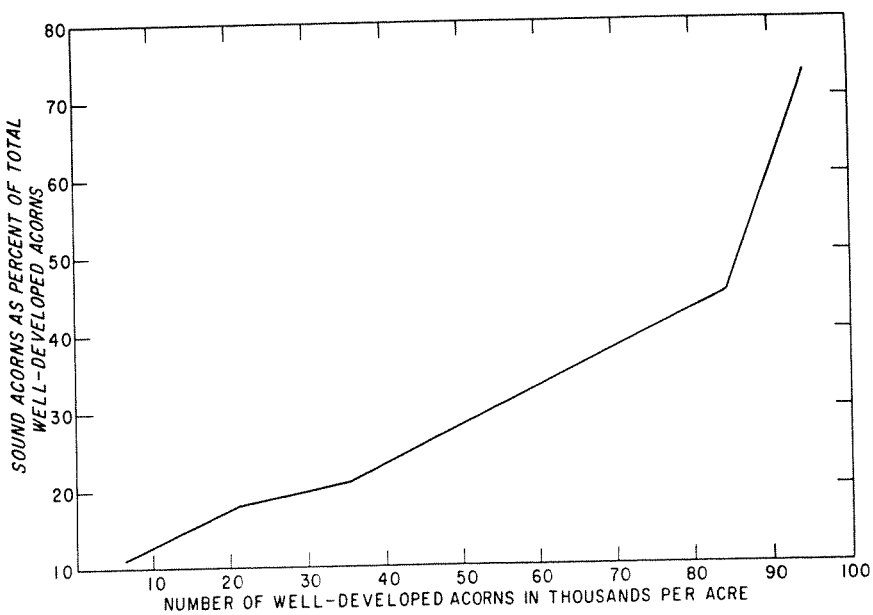

Figure 2.--Percent of sound, undamaged acorns in relation to crop size.

By far the greatest damage to well-developed acorns was caused by insects, primarily by weevils of the genus Curculio. The percentage of well-developed acorns infested with insects varied from year to year, ranging from 26 to 81 percent. Opinion as to the germinative capacity of insect-infested acorns seems to vary. However, observations by Korstian[3] indicate that only a very small percentage of weeviled acorns will produce normal seedlings.

In the present study, the well-developed acorns which were damaged by animals and birds averaged only 6 percent overall. This figure is deceptively small, however, because no evaluation was made of the acorns which were totally consumed or removed from the plots. Furthermore, the inroads made by deer and rodents, once the acorns are on the ground, are known to be extremely heavy.

Appreciable quantities of sound acorns reached the ground in only 2 of the 5 years: the white oaks produced heavily in 1963, and the red oaks produced heavily in 1966.

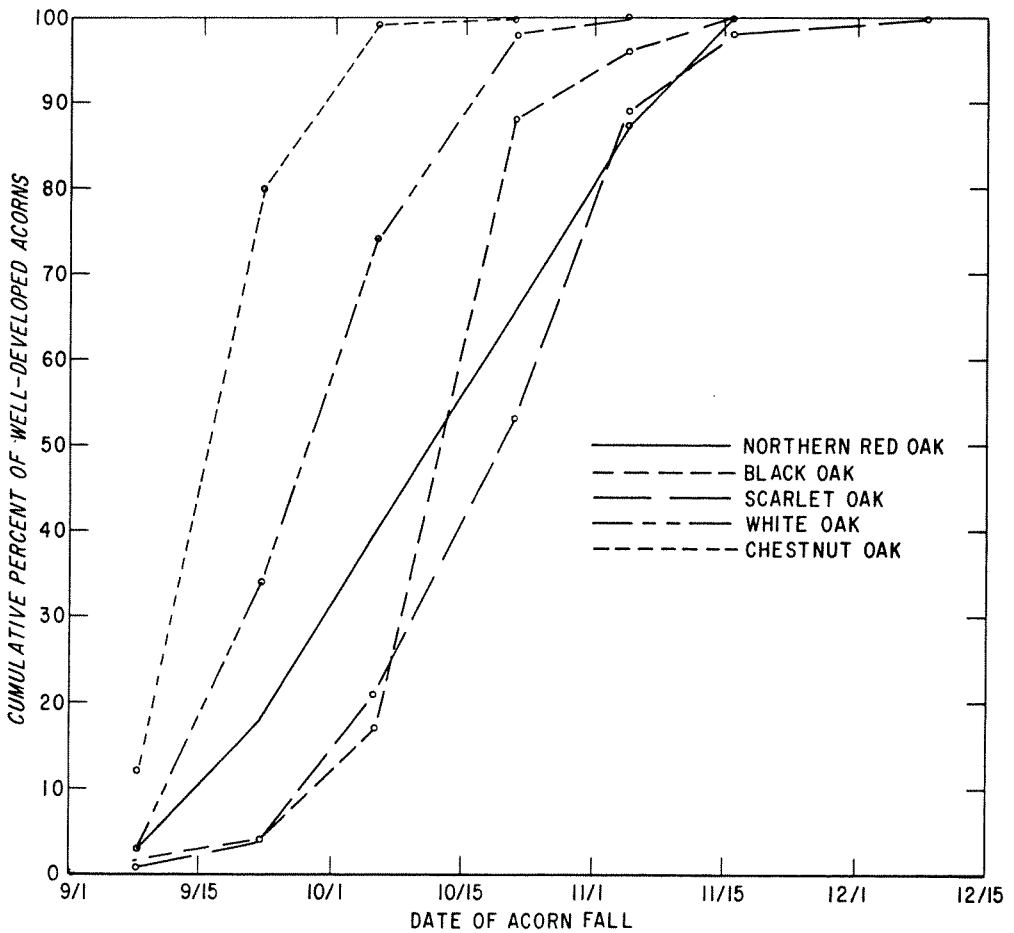

Figure 3.--Seasonal production of well-developed acorns.

[3]Korstian, C. F. Factors controlling germination and early survival in oaks. Yale Univ. Sch. Forest. Bull. 19, 115 pp. 1927.

Seasonal patterns of acorn fall.--After 5 years of collection, some definite patterns of acorn fall are evident. For all species, acorn fall begins about mid-August with the poorly developed or aborted acorns. By the time well-developed acorns begin to drop in early September, more than 50 percent of the aborted acorns are down.

The period during which well-developed acorns fall varies among species (fig. 3). The white oaks consistently shed their acorns earlier than do the red oaks. In the white oaks, the heaviest fall of acorns occurs between mid-September and mid-October. In the red oaks, seedfall extends into November, but the majority of acorns fall during the month of October. Virtually all seedfall is completed by mid-November, with occasional acorns shed as late as mid-December.

DISCUSSION

The area and the number of years sampled are too limited to justify sweeping generalizations about acorn production in the oak stands of the Southern Appalachians. However, a few points seem worthy of mention.

Acorn production varies tremendously from year to year, as it does within a single year between stands separated by only a short distance. Comparable variation can be expected over larger areas, and the enormous task of developing prediction techniques which would be widely applicable is apparent.

Oak species vary in their seasonal and annual production of seed; the principal difference is between the red and white oaks as groups. In view of the known phenological differences in flower and acorn development between the species groups, climatic factors appear to have a large influence on acorn production.

Stand density had no statistically demonstrable effect on acorn production. However, we know that neither cutting nor the failure to cut will eliminate crop failures, as evidenced by the 1964 seed year. It is also certain that a small residual basal area distributed in a few large trees can produce a bumper crop of acorns, as evidenced in 1966.

Perhaps the most significant observation made in the study is that large numbers of acorns were initiated on all the plots in each of the 5 years. In only one year (1964) did any plot fail to initiate at least 2,000 acorns per acre. But, after we eliminate those which failed to develop plus those that did develop but were subsequently damaged, very few acorns were left for regeneration except in bumper crop years. Possibly the greatest potential for increasing production of sound, viable acorns lies in control of the agents, particularly insects, which cause abortion and damage.

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