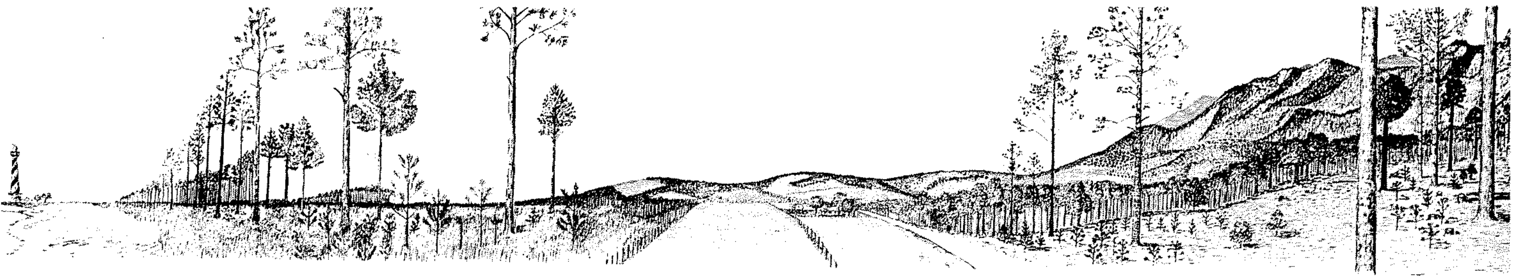

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TWELVE-YEAR ACORN YIELD IN SOUTHERN APPALACHIAN OAKS

Abstract.--A 12-year sample from Southern Appalachian oak stands showed acorns to be a valuable though inconsistent source of wildlife food. At least moderate amounts of acorns were produced in 9 of the years, with 4 years being exceptionally good. In 3 of the years, acorn production was very low. There were distinct differences in the production of acorns by the five species involved. Northern red and white oaks were superior to scarlet, black, and chestnut oaks in amount and consistency of production. "Bumper" crops were produced every 4 years by white oak and every 5 years by northern red oak.

Keywords: *Quercus rubra*, *Q. alba*, *Q. coccinea*, *Q. velutina*, *Q. prinus*.

The value of acorns for many species of wildlife is well recognized. In fact, management programs for some species are predicated on maintaining specified acreages in oak trees of mast-bearing age (Dellinger 1970). On the other hand, the underlying theme of most reports on acorn production has been the great variability and uncertainty of production among trees, species, places, and years (Downs and McQuilken 1944; Burns and others 1954; Christisen 1955; Sharp 1958; Collins 1961; Tryon and Carvell 1962; Beck and Olson 1968; Goodrum and others 1971). Is it realistic to assume that oak forests can be managed to produce acorns as a major source of wildlife food? A 12-year record of acorn production provided an opportunity to examine this question for one area in the Southern Appalachians.

STUDY AREA

Acorn yields were measured from 1962 to 1973 on the Bent Creek Experimental Forest in western North Carolina. The study area was located at an elevation of about 2,500 feet and included a variety of topographic conditions. Middle slopes, coves, and ridge tops were represented, along with east, south, and west exposures. The study area was covered by a contiguous block of essentially even-aged oak forest that varied in site quality and species composition because of the varying topography. Oak species included northern red (*Quercus rubra* L.), black (*Q. velutina* Lam.), scarlet (*Q. coccinea* Muenschh.), white (*Q. alba* L.), and chestnut (*Q. prinus* L.).

Southeastern Forest Experiment Station - Asheville, North Carolina
U.S. Department of Agriculture - Forest Service

On the basis of site quality, stand age, tree size and condition, and species diversity, the sample area seemed very favorable for acorn production. Under a system of even-aged management, such stands would have to furnish the bulk of acorn production for any given management unit.

METHODS

Acorn yields were sampled on six 2/3-acre study plots. Acorns were collected in twenty-four 1/10-milacre traps (Klawitter and Stubbs 1961) placed systematically in each of the six plots. Collections were made weekly to biweekly from mid-August until all acorns were down. Well-developed acorns were classified as sound or insect-infested on the basis of cutting tests. Fresh weight of well-developed acorns of each species was estimated by applying conversion factors developed by the USDA Forest Service (1974, p. 699) to the acorn count.

During the first year of collection, tree basal area averaged 100 square feet per acre on all six plots. After 1 year, four of the plots were thinned to different densities as part of a study on acorn production and seedling establishment. Two plots remained unthinned. Site and stand conditions before and after thinning are shown for each plot in table 1.

Table 1.--Stand and site conditions in plots of mixed oaks before and immediately after thinning

Plot No.	Site index[1]	Age	Basal area						
			Northern red oak	Black oak	Scarlet oak	White oak	Chestnut oak	Other species	Plot total
	ft	years	ft²/acre						
			BEFORE THINNING						
1	60	68	0	9.3	56.7	0.9	21.4	4.6	92.9
2	63	63	3.9	1.0	3.9	48.0	33.3	7.9	98.0
3	73	71	0	7.8	3.9	67.6	0	18.6	97.9
4	74	79	11.5	59.8	3.4	10.4	16.1	13.8	115.0
5	63	82	0	16.2	58.0	8.6	0	12.4	95.2
6	72	72	14.0	14.0	2.2	0	49.7	17.4	99.3
			AFTER THINNING						
1			0	9.3	56.7	.9	21.4	4.6	92.9
2			3.9	1.0	3.9	48.0	33.3	7.9	98.0
3			0	4.6	2.6	49.5	0	9.2	65.9
4			5.9	37.0	2.6	5.9	9.9	4.6	65.9
5			0	4.0	22.1	3.0	0	4.0	33.1
6			13.5	0	1.3	0	17.8	.3	32.9

[1]Computed from Olson (1959).

Confounding of residual stand density with site quality and species composition obscured any effect of thinning on acorn production. I therefore considered the data as a composite sample. Number of trees by diameter class and species for the six plots combined are shown in table 2.

Table 2.--Numbers of overstory trees by species and diameter class before and immediately after thinning (composite of all six plots)

Species	Thinning status	Diameter class (inches)									Total
		8	10	12	14	16	18	20	22	24	
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Northern red oak	Before	1	1	2	1	1	2	2	1	1	12
	After	-	1	1	1	1	2	2	1	1	10
Black oak	Before	12	14	6	6	9	3	5	2	--	57
	After	9	7	4	2	5	3	3	2	--	35
Scarlet oak	Before	19	12	16	15	7	4	1	--	--	74
	After	16	10	16	13	4	4	1	--	--	64
White oak	Before	27	18	7	5	11	5	3	3	2	81
	After	8	14	6	4	9	5	3	3	2	54
Chestnut oak	Before	19	16	9	4	6	5	3	4	1	67
	After	12	15	5	3	4	2	3	4	1	49

RESULTS AND DISCUSSION

Yearly acorn production for the 12-year period averaged 289 pounds per acre for all species combined (table 3). Yields were well above average for 1963, 1966, 1967, and 1971. In 3 years--1964, 1968, and 1973--production was very low to nonexistent. In the other 5 years, production was below average, although substantial quantities of acorns were available. In 3 out of 4 years, yield exceeded 76 pounds per acre.

The complementary effect of the red and white oak groups and the importance of species mixtures were evident. The white oak group provided the greatest percentage of the acorns in 1963, 1965, 1967, and 1969, and the red oak group provided the greatest percentage in 1966, 1970, and 1972. In 1962 and again in 1971, both groups provided about equal amounts. Both groups failed for the most part in 1964, 1968, and 1973. Thus, although the species mixture did not eliminate failure completely, it did prevent at least 3 other years of failure that would have occurred had only one of the groups been present.

An average of 35 percent of the acorns produced was infested by insects, primarily weevils, and was at least partially unavailable for wildlife. The

Table 3.--Twelve-year production of well-developed acorns by species

Year	Northern red oak		Black oak		Scarlet oak		White oak		Chestnut oak		Total	
	Total	Sound	Total	Sound	Total	Sound	Total	Sound	Total	Sound	Total	Sound
	lb/acre	%	lb/acre	%	lb/acre	%	lb/acre	%	lb/acre	%	lb/acre	%
1962	51.6	64	27.2	33	42.2	31	84.8	14	10.5	33	216.3	36
1963	29.1	32	11.1	8	42.5	17	387.5	48	100.0	81	570.2	51
1964	--	--	8.0	28	15.0	21	5.1	44	1.4	0	29.5	25
1965	7.3	17	1.4	21	.5	50	131.0	18	.7	0	140.9	19
1966	255.2	84	52.7	75	227.1	68	9.2	61	.7	0	544.9	77
1967	23.2	40	26.9	46	42.6	38	683.8	78	236.2	94	1,012.7	79
1968	--	--	1.8	61	--	--	4.8	89	--	--	6.6	80
1969	5.9	21	--	--	--	--	113.4	54	1.6	0	120.9	51
1970	69.5	57	18.2	33	43.3	26	6.0	54	.7	0	137.7	46
1971	166.5	73	27.4	61	90.3	58	305.5	75	23.6	53	613.3	70
1972	16.5	64	17.3	59	32.1	63	8.4	84	1.4	50	75.7	64
1973	--	--	--	--	--	--	2.6	29	--	--	2.6	29
Total	624.8	70	192.0	51	535.6	52	1,742.1	61	376.8	85	3,471.3	--
Average	52		16		45		145		31		289	65

portion infested varied by species and the total size of the crop, as was true in other studies of acorn production in Southern Appalachian oaks (Downs and McQuilkin 1944, Beck and Olson 1968). Insects infested only 29 percent of the well-developed acorns in the 4 above-average years and 67 percent in the poorest seed years. Chestnut and northern red oaks had the smallest percentage of insect damage, followed by white, black, and scarlet oaks, in that order.

Production varied considerably by species. The various species did not contribute acorns in proportion to their presence in the stands. For example, northern red oak constituted only 6 percent of the basal area but contributed 18 percent of the acorns. In terms of average production per square foot of basal area for the 12-year period, northern red oak was the most productive, followed in order by white, scarlet, chestnut, and black oaks (table 4). Northern red and white oaks were vastly superior to the other three species in average yield. These two species produced several "bumper" crops that pulled their averages up; they were also more consistent than the other members of their groups. White oak outproduced chestnut oak in every year, and northern red oak outproduced both scarlet and black oaks in all years except 1964, 1968, and 1973. In those years, total production for all species was so low as to make species comparisons meaningless.

Table 4.--Twelve-year production of well-developed acorns by species

Year	Northern red oak	Black oak	Scarlet oak	White oak	Chestnut oak
			lb/ft^2		
1962	14.6	1.7	2.7	3.1	0.7
1963	7.9	1.2	3.4	24.4	8.3
1964	0	.8	1.1	.2	.1
1965	1.8	.1	0	7.9	0
1966	62.2	5.4	15.4	.6	0
1967	5.5	2.8	2.9	39.8	17.6
1968	0	.2	0	.2	0
1969	1.3	0	0	6.4	.1
1970	15.1	1.8	2.7	.2	0
1971	34.7	2.8	5.6	16.5	1.6
1972	3.4	1.9	2.1	.4	.1
1973	0	0	0	.1	0
12-year average	12.2	1.6	3.0	8.3	2.4

The ranking by species was about as would be expected from other studies. However, the substantial superiority of northern red and white oaks was not expected. As a partial check on these data, I applied Downs' (1944) figures for yield by tree diameter class to the diameter distributions on the sample plots (table 5). Production of black and chestnut oak acorns on the study plots was very close to that predicted from Downs' data. Scarlet oak production was about one-third less than predicted. White oak produced nearly twice the predicted amount, and northern red oak yielded 2.5 times the predicted amount.

Northern red oak was represented by comparatively few trees concentrated on the heavily thinned plots. Its yield could have been unduly influenced by one or a few superior acorn producers or some thinning effect. Thus, the observed production may have been greater than will occur on the average. On the other hand, white oak was represented by a comparatively large sample spread across a range of diameters and residual densities. Furthermore, the relative yields of white and northern red oaks in this study paralleled those noted in West Virginia, where northern red oak outproduced white oak by a substantial margin (Tryon and Carvell 1962).

Table 5.--Comparison of average acorn yields observed and those predicted by applying data from Downs (1944)[1]

Species	Predicted	Observed
	lb/ft^2 of basal area	
Northern red oak	4.7	12.2
Black oak	1.8	1.6
Scarlet oak	4.4	3.0
White oak	4.3	8.3
Chestnut oak	2.4	2.4

[1] Downs' (1944) data on production by diameter class were applied to the diameter distributions in the sample plots.

Except for the sharp drop in 1973, white oak produced a sizable crop every other year (table 3). As predicted by Downs and McQuilkin (1944), it produced above-average or "bumper" crops at 4-year intervals. According to the cyclic pattern of the previous 11 years, production should have been at least moderate in 1973. The sharp drop that occurred that year may have been due to a late freeze on May 18, when a temperature of 29° F was recorded at Bent Creek. The only other year with a freeze after mid-May was 1968; temperature dropped to 32° F on May 22, and an almost complete acorn failure was recorded that year.

Cycles of production were less apparent for northern red oak. There did appear to be a 5-year interval for "bumper" yields, with 2 years of failure and 2 years of moderate yield intervening. Scarlet and black oaks exhibited trends that were generally like that for northern red oak. Chestnut oak followed the trend of white oak for the most part, although yields were more erratic.

SUMMARY AND CONCLUSIONS

During the 12-year study, the mixed oak stands sampled clearly provided a major, though not completely dependable, source of wildlife food. Each acre produced an average of 289 pounds of well-developed acorns annually. Acorn yields were over 500 pounds per acre for 4 of the 12 years, over 75 pounds per acre for 9 years, and below 30 pounds per acre for 3 years. It is perhaps noteworthy that really poor years did not occur consecutively. Each of the 3 poorest years was bracketed by fairly productive ones.

On the average, insects damaged one-third of the total production, and in poor years nearly two-thirds of the well-developed acorns were infested. The total impact of the insects on available food supply is not clear. Many species of wildlife apparently consume insect-infested acorns for at least a few weeks after acorn fall; thus, the infested acorns were not a complete loss. Perhaps the most important impact was the reduction in the quantity of acorns potentially available in late winter and early spring.

In managing Southern Appalachian oaks for acorn production, close attention must be paid to species composition, both because of the wide difference in productive capacity of the species and because of the complementary effect of the red and white oak groups. In this study, northern red and white oaks paid the highest dividend in acorn yield per square foot of basal area or space occupied. These species produced several "bumper" crops as well as consistently outproducing the other members of their groups in poor years. Thus, one must carefully consider species composition when talking about yields per unit area. However, no species should be favored to the exclusion of the others. Black, scarlet, and chestnut oaks added measurably to the overall production. And in one year, 1964, black and scarlet oaks kept a very poor year from being a complete failure. The five species included in this study tend to segregate by site quality, further emphasizing the need to maintain a variety of species over a range of sites in order to minimize crop failures.

It is always risky to predict production from year to year. However, production of northern red and white oaks apparently follows a definite pattern. Cycles of "bumper" yields, in particular, were evident in this study and are in general agreement with previous studies.

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Multipliers to convert from English to metric units:

m	=	3.281	x	ft
ha	=	2.471	x	acre
kg/ha	=	1.121	x	lb/acre
m^2/ha	=	0.230	x	ft^2/acre
kg/m^2	=	4.883	x	lb/ft^2

Donald E. Beck, Principal Silviculturist
Asheville, North Carolina