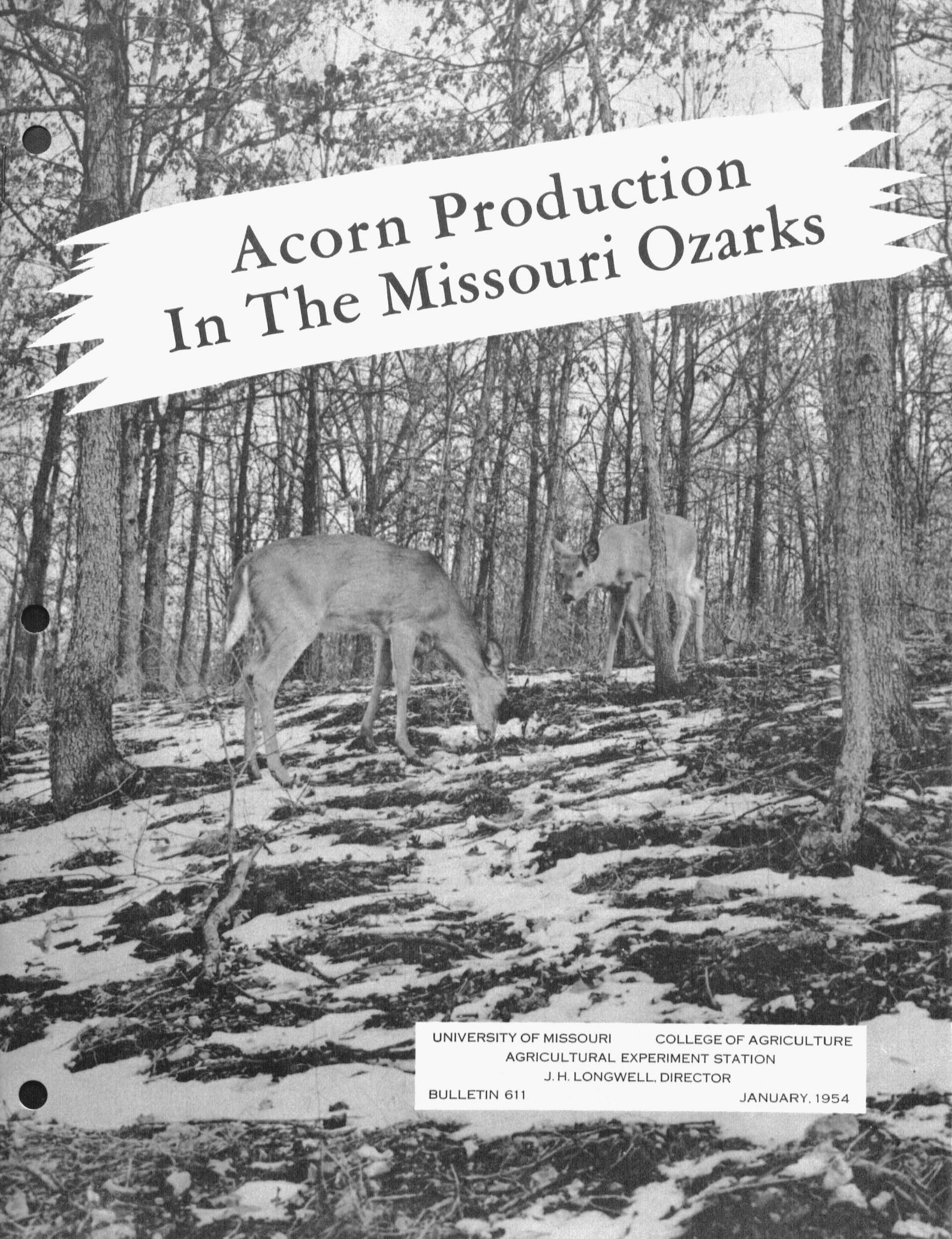

# Acorn Production In The Missouri Ozarks

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
J. H. LONGWELL, DIRECTOR
BULLETIN 611 JANUARY, 1954

## SUMMARY

An investigation of the annual variation in acorn production, the condition of acorns produced, and the relationship of tree characteristics to acorn production was conducted in three localities in the Missouri Ozarks. Species studied were black, blackjack, scarlet, post and white oaks. Data were collected from 1947 through 1952.

The results are summarized as follows:

1. Acorn production varied considerably from year to year without following a regular cycle; the longest interval between good seed years was four years. No general acorn-crop failure occurred.

2. The variability of acorn yields among trees was not consistently related to measurable tree characteristics, although large-crowned trees tended to produce more acorns than small-crowned trees.

3. Only a small proportion of acorns were mature and sound when collected in the autumn, mainly because many acorns failed to mature or were attacked by insects. The average number of sound, mature acorns per tree per year varied in one of the experimental stands from only 11 for post oak to 153 for white oak.

4. Mast-consuming wildlife species exhibited no apparent preference for any species of acorn.

Scarlet, black, and white oaks have an advantage over blackjack and post oaks in regeneration because of their more prolific production of viable acorns. Timber managers should study individual trees during a period of years so that good acorn producers may be spared from harvest in order to obtain an abundant seed crop for forest reproduction.

Apparently scarlet oak is unreliable as a mast species for wildlife management because of great annual fluctuation of its yield. As a rule, wildlife managers should attempt to maintain a variety of oak species and good acorn producers in the forest so that at least some acorns are available as food for mast-consuming wildlife species every year.



Report on Department of Forestry Research Project
Number 123, Entitled "Ecological Studies"

Research reported in this publication was supported, in part, by funds
from the Division of Forestry, Missouri Conservation Commission.

# Acorn Production In The Missouri Ozarks

PAUL Y. BURNS, DONALD M. CHRISTISEN,[1] AND J. M. NICHOLS

According to a recent survey of the forest resources of Missouri, the 17 million-acre Ozark region is 61 percent forested (King *et al.,* 1949). Most of the Ozark forest may be classified as oak type; various species of oaks compose 74 percent of the cubic volume. In managing oaks for timber production, it is desirable to obtain natural reproduction from seed produced by trees in the stand. Production of acorns of good quality in sufficient abundance to serve such uses as wildlife production also is important.

Acorns are rich in carbohydrate, fat and certain vitamins; they are an important source of food for many species of wildlife. Deer, squirrels, flying squirrels, chipmunks, mice, turkeys, ducks, quail, and other birds consume varying amounts of oak mast (cover picture). It is common practice to feed hogs on acorns, and cattle also eat them.

In deciding how much game a forest can support, game managers need to know how much food will be available. A knowledge of annual fluctuations in acorn abundance is therefore important.

It was the purpose of this investigation to determine the annual variations in acorn production of various oak species and of individual trees, to ascertain the condition of the acorns when produced, and to relate tree characteristics to seed production. Although the research is not complete, the information already assembled will be a preliminary guide to wildlife managers and foresters concerned with oak seed in the Ozark region.

## LOCATION AND DESCRIPTION OF EXPERIMENTAL AREAS

Acorns were collected in Butler, Dent, and Taney counties, located respectively in the southeastern, north-central, and southwestern sections of the Missouri Ozarks. The Missouri University Forest in Butler County, the Indian Trail State Forest and Wildlife Refuge in Dent County and the Drury Wildlife Refuge in Taney County served as study areas.

At the University Forest the stand was of medium density, and the site quality was average for Missouri oaks. The trees varied from 12 to 25 inches d.b.h.and from 35 to 80 years in age. At Indian Trail the stand was open as a result of past cuttings and fires (Fig. 1), the site quality was slightly below average for Missouri oaks, and there was more variation in diameter than at the University Forest. In Drury Wildlife Refuge stand conditions were similar to those at the University Forest.

## EXPERIMENTAL PROCEDURE

The major oak species at each area were chosen for study. White and black oaks were sampled at all three areas; scarlet oaks were sampled in Butler and Dent counties; post and blackjack oaks were sampled in Dent and Taney counties. The experiment was iniaiated in the latter counties in 1947, and in Butler County in 1948. Data were collected each year through 1952, except in Taney County, where the experiment was terminated at the end of 1948.

In the initial phase of the study, a satisfactory economical technique for sampling acorn production of a tree was sought. Under each of several trees, 12 to 16 seed traps were established. These were placed in a regular pattern beneath the crown of each tree to sample in all cardinal directions from the tree trunk to a point just beyond the crown perimeter. Traps were 3.3 feet square and 12 inches deep. They were covered with chicken-wire and had hardware-cloth bottoms

View of forest stand in Indian Trail Game Refuge, Dent County. The stand is not well stocked. Frequent fires and cuttings have reduced the crown canopy.

[1]Biologist, Pittman-Robertson Program, Missouri Conservation Commission.

An acorn trap is pictured in position under the crown of a white oak. The trap is 3.3 feet square. It is covered with chicken wire and has hardware-cloth bottom and sides.

and sides (Fig. 2). The traps were designed to exclude deer, squirrels, and birds; however, acorns in them were accessible to mice.

Sampling at the University Forest after the first year was done with four traps placed at random under each tree. During the period of seed fall, acorns were collected every two days. Five trees of each species were sampled in this stand. Observations of several characteristics such as silvicultural crown class, d.b.h., height, crown length, crown diameter, and radial growth were made for each tree.

In Dent County, one trap was established under the crown of each tree. Acorns were collected several times during the period of acorn drop. A total of 62 trees was sampled the first year; thereafter 87 were sampled until 1952, when the number was increased to 105. Tree characteristics were recorded. Sampling in Taney County was like that in Dent County with 43 trees being studied.

All acorns found in the traps were classified as to health conditions by inspection as follows:

1. Mature, well-developed, and sound acorns.
2. Mature acorns which showed signs of insect usage
3. Mature acorns which had been utilized by wildlife
4. Immature or deformed acorns

In 1947 and 1948, acorns in the first two categories collected in Dent County were weighed within 3 weeks of collection, in order to determine the average number of acorns equivalent to a weight of 1 pound.

## RESULTS

### Distribution or Pattern of Acorn Drop

Apparently the number of acorns caught per trap was independent of the trap's distance from the tree bole or of compass direction. Practically all acorns caught were found in traps directly under the crown—few acorns were distributed beyond the crown edges. Therefore the number of acorns produced per tree for a given year was computed by multiplying the number of acorns collected by the ratio of the area under the crown to the trap area.

### Seasonal Characteristics of Acorn Drop

Acorn fall gradually built up to a peak, tapering off similarly. In the Butler County stand, average date of peak fall was October 17 for black and white oaks, October 22 for scarlet oak. Acorn fall began about October 8 for all three species, ending October 30 for white oak, November 3 for black oak, and November 9 for scarlet oak. As a rule, 90 percent of the acorns dropped off in the first 8, 13, and 16 days for white, black, and scarlet oak, respectively.

Usually, acorn fall in Dent County began in late August, the early drop being primarily immature acorns. The average accumulation of acorns on November 1 was post oak 84 percent, white oak 95 percent, black and blackjack oaks 91 percent.

In years of heavy production, the period of acorn drop was slightly longer. High winds or heavy rainfall temporarily increased rate of fall, and the first killing frost accelerated acorn drop. Immature acorns fell from the trees earlier than mature ones.

## Abundance and Periodicity of Seed Production

The average number of mature, well-developed acorns produced per tree was computed for each year. Results are shown in Table 1.

TABLE 1 -- AVERAGE NUMBER OF MATURE ACORNS PER TREE IN THREE EXPERIMENTAL FOREST STANDS

| Year | Black Oak | Blackjack Oak | Scarlet Oak | Post Oak | White Oak |
|---|---|---|---|---|---|
| | | Butler County | | | |
| 1948 | 2000 | | 4400 | | 900 |
| 1949 | 100 | | 0 | | 0 |
| 1950 | 2900 | | 600 | | 700 |
| 1951 | 100 | | 0 | | 1800 |
| 1952 | 2500 | | 6800 | | 100 |
| Average | 1500 | | 2400 | | 700 |
| Standard error | 600 | | 1200 | | 300 |
| | | Dent County | | | |
| 1947 | 600 | 1100 | 0 | 300 | 500 |
| 1948 | 2200 | 1000 | 2300 | 200 | 900 |
| 1949 | 300 | 300 | 0 | 200 | 600 |
| 1950 | 200 | 300 | 0 | 300 | 1900 |
| 1951 | 300 | 200 | 100 | 200 | 900 |
| 1952 | 1900 | 1500 | no data | 300 | 1800 |
| Average | 900 | 700 | 500 | 200 | 1100 |
| Standard error | 200 | 100 | 300 | 100 | 400 |
| | | Taney County | | | |
| 1947 | 400 | 200 | | 300 | 1500 |
| 1948 | 1500 | 1100 | | 100 | 400 |

Individual trees varied considerably in production. Standard errors associated with the averages are large, indicating that to obtain a highly accurate estimate of the average number of acorns produced per tree, a great many trees must be sampled. In addition, because of the great variation in production from year to year, a long period of years is needed to obtain an accurate estimate of average annual production. In Taney County the study period was too short for estimation of average annual yield. In Dent County the lack of scarlet oak data for 1952 (observed by inspection to be a good year for scarlet oak) resulted in the computed average being low.

Differences between the Butler and Dent County averages in Table 1 were tested statistically. The results show no statistically significant differences at the 5 percent probability level between species, except for the significantly lower production in Dent County of post oak compared to other species.

An outstanding observation from Table 1 is the great fluctuation from year to year in average production, except in the case of post oak. This yearly variation is most pronounced in the case of scarlet oak. No clearly defined cycles of seed production are evident; however, it appears that abundant seed crops are produced at intervals shorter than five years. This result is also shown in data presented by Downs and McQuilkin (1944) for Appalachian oaks.

It is noteworthy that in the Indian Trail Forest in Dent County each species except scarlet oak produced some acorns each year. However, in the Butler County stand, all three species had failure or near-failure in 1949.

There was a tendency for a good seed year for one species to be also a good seed year for other species, and for a good year in one locality to be a good year in other localities. The years 1948 and 1952 were generally good seed years, and 1949 was generally poor.

## Relationship of Tree Characteristics to Acorn Production

There was great variability in acorn production among individual trees. For example, in Dent County the most prolific of the white oaks yielded an average of 7,700 acorns per year; the least prolific produced only 100. As a general rule, trees that produced abundantly in a given year also produced abundantly in other years. Poor producers also were consistent. Downs (1949), Cypert (1951), Smith (1929), and Wood (1934) also found some oaks to be inherently good acorn producers and others inherently poor.

It logically would be expected that trees of large size and vigorous growth rate should be the best seed producers. However, a graphical analysis of the relationship between acorn production and observable tree characteristics indicated that variation in seed production, due probably to hereditary differences, almost completely obscured variation due to tree size and growth rate.

The range of crown classes of trees sampled was small. Intermediate trees were not sufficiently abundant to be tested. A comparison was made between dominants and codominants, each species being treated separately. Differences between means were not statistically significant at the 5-percent level, but there was a slight tendency for dominants to yield more than codominants. Possibly a more extensive sampling would bring out more strongly the relationship of crown class to acorn production.

For each species, simple correlation coefficients were computed between number of mature acorns produced and d.b.h., height, crown length, radial wood growth, crown diameter, and crown surface area. The latter figure was computed from crown diameter and crown height, by assuming that the crown had the shape of a paraboloid. Practically all of the computed coefficients were small and statistically insignificant. Crown diameter had the highest degree of correlation; wide-crowned black, blackjack, and scarlet oaks tended to be more prolific than trees with smaller crowns.

Similar results were reported for post oak in Texas by Petrides *et al.* (1935). Trees with large crown surface area generally produced more abundantly than trees with small crowns. The relationships between acorn production and d.b.h., total height, and crown length were weak. Slight tendencies for large trees to be the best producers were evident. There was no apparent relationship between rate of radial growth and acorn production.

## Maturity of Acorns

A high proportion of acorns produced were immature. A few of the immature acorns were so small that they passed down through the ½-inch mesh hardware-cloth bottoms of the traps; thus the proportions calculated are probably somewhat lower than the actual amount. Table 2 shows the percentages of inspected acorns which were immature.

TABLE 2 -- PERCENTAGES OF IMMATURE ACORNS IN THREE EXPERIMENTAL AREAS

| County | Black Oak | Blackjack Oak | Scarlet Oak | Post Oak | White Oak |
|---|---|---|---|---|---|
| Bulter | 10 | | 23 | | 6 |
| Dent | 38 | 46 | 31 | 56 | 27 |
| Taney | 25 | 31 | | 51 | 17 |

It is noteworthy that more than half the post oak seed failed to mature. In the Butler County stand (Table 2), the proportion of immature acorns is probably relatively low because immature acorns began falling before the traps were put into position. In good seed years the proportion of immature acorns was somewhat lower than in poor seed years.

Table 3 shows the proportion of mature acorns classified into condition categories.

TABLE 3 -- PERCENTAGE OF MATURE ACORNS IN EACH CONDITION CLASS

| Condition Class | Black Oak | Blackjack Oak | Scarlet Oak | Post Oak | White Oak |
|---|---|---|---|---|---|
| | | Butler County | | | |
| Sound | 41 | | 42 | | 19 |
| Insect usage | 46 | | 48 | | 59 |
| Wildlife usage | 13 | | 10 | | 22 |
| | | Dent County | | | |
| Sound | 16 | 14 | 14 | 5 | 14 |
| Insect usage | 72 | 71 | 70 | 87 | 72 |
| Wildlife usage | 12 | 15 | 16 | 8 | 14 |
| | | Taney County | | | |
| Sound | 32 | 21 | | 12 | 32 |
| Insect usage | 61 | 60 | | 80 | 57 |
| Wildlife usage | 7 | 19 | | 8 | 11 |

## Insect Usage

An extremely high proportion of seed was damaged by insects. Insect usage apparently was greater in Missouri than in the Appalachians, where Downs and McQuilkin (1944) reported that 30 percent of the mature acorns had been attacked by insects. About 67 percent of acorns were infested with insects in 1937 on the Clark National Forest in the Missouri Ozarks (Kautz and Liming, 1939).

The greatest degree of worminess was in post oak, with over 80 percent insect usage, and the other species averaged more than 50 percent wormy. In years of abundant seed production, insect damage was somewhat less.

The species of insects causing the damage were not determined. Downs and McQuilkin (1944) reported that nut weevils appeared to cause the greatest amount of insect damage, and Korstian (1927) found three main groups of insects attacking acorns in North Carolina—nut weevils, moth larvae, and gall-forming Cynipids.

## Wildlife Usage

The usage of acorns by wildlife, shown in Table 3, occurred before acorn collection in the fall. Subsequent utilization of acorns lying on the ground during the winter undoubtedly would be much greater.

The main source of wildlife usage of trapped acorns probably came from squirrels and birds removing acorns from trees and allowing pieces to fall into the traps; mice also could have eaten acorns after climbing over the trap sides. Cypert and Webster (1948) estimated that about 12 percent of acorns produced by water and willow oaks were removed from the trees by birds and never reached the ground.

Table 3 shows that the percentages of acorns used by wildlife were low, ranging from 7 to 22. Acorns of the white oak group (white and post oaks) are reputedly sweeter than those of the black oak group and would be expected to be preferred by wildlife. The outstanding difference in chemical composition between these groups is that the acorns of black oak contain a much higher percentage of fat than those of white oak (Korstian, 1927; King and McClure, 1944). However, data collected in the present investigation do not bring out consistent species preferences. A similar conclusion was reached by Downs and McQuilkin (1944).

Wildlife usage was proportionally greater in poor seed years than in good ones. In abundant seed years wildlife usage was below 7 percent for all three species in the Butler County stand.

The size of the annual acorn yield caused squirrel production to fluctuate in the Missouri Ozarks. The relationship of acorn production to squirrel abundance is shown in the following table.

An average hunting-success figure of one squirrel per gun-hour, with young-of-the-year making up half or better than half the total bag, indicates good squirrel production.

| Year | Acorn abundance Dent County | No. Squirrels Killed In Mo. Ozark Plateau per Gun-Hour | Percentage of Young Squirrels Taken |
|---|---|---|---|
| 1947 | fair | 1.2 | 59.3 |
| 1948 | good | 1.1 | 59.3 |
| 1949 | poor | 1.4 | 59.5 |
| 1950 | fair | 0.7 | 47.5 |
| 1951 | good | 0.9 | 48.9 |
| 1952 | good | 1.0 | 55.7 |

[1]Squirrel data obtained from hunter-cooperators of Missouri Conservation Commission.

The effect of either good or poor acorn crops was reflected in the squirrel population of the following year. An abundance of acorns occurring in 1948 insured a good carry-over of breeding stock in good physical condition, resulting in high squirrel production the ensuing year, 1949. A poor acorn yield in 1949 affected the number and breeding condition of squirrels adversely, causing poor production in 1950.

### Production of Sound, Mature Acorns

It may be assumed that a high proportion of mature, sound acorns was viable; seeding tests under natural forest conditions showed that over 60 percent of the white, black, and scarlet oak acorns germinated. Table 3 shows that less than half the mature acorns were sound when collected. In the Dent County stand, the proportion was less than 20 percent. Post oak produced few sound acorns.

In years of abundant seed production, the proportion of sound acorns was somewhat higher than average in the case of the black oak group, and about average for the other oaks.

In the Dent County stand, which contained all five species, the average number of sound, mature acorns produced per tree was as follows:

| Species | Number of Sound Acorns per Tree Average All Years | Best Year for Each Species |
|---|---|---|
| Black Oak | 149 | 815 |
| Blackjack Oak | 91 | 186 |
| Scarlet Oak | 68 | 1360 |
| Post Oak | 11 | 15 |
| White Oak | 153 | 362 |

### Weights of Mature Acorns

During the storage period before weighing, acorns lost some moisture; thus, the observed weights are smaller than the fresh weights would be. However, the results indicate approximately the number of acorns of each species equivalent to one pound.

Sound acorns weighed appreciably more than insect-infested acorns. Because of the importance of sound acorns as wildlife food, their weights are presented in the following table.

| Species | Average number of sound acorns per pound |
|---|---|
| Black Oak | 236 |
| Blackjack 0ak | 404 |
| Scarlet Oak | 202 |
| Post Oak | 441 |
| White Oak | 118 |

Dalke (1953) obtained somewhat similar results with acorns collected in 1938 from the Dent County forest, with the exception that scarlet oak acorns were heavier than white oak acorns.

## CONCLUSIONS

The following conclusions from this study, supported by a review of the literature, have important implications for forest management to produce timber and wildlife crops.

1. Abundant seed crops are not produced every year. There is great variation from year to year, which does not follow a regular cycle. For any species, the longest interval between good seed years was four years. Scarlet oak was the most erratic of the species studied.

2. General acorn crop failure of all species is unlikely.

3. There is great variation among individuals in ability to produce acorns. Although trees with large crowns tend to produce more acorns than small-crowned trees, the variability among trees in the dominant and codominant crown classes is not consistently related to measurable tree characteristics.

4. A high proportion of acorns fail to mature.

5. A large proportion of mature acorns are damaged by insects (over 50 percent in this investigation); post oak acorns are especially wormy.

6. Only a small proportion of acorns were sound and mature when collected in the autumn. The average number of sound, mature acorns produced per tree varied from only 11 for post oak to 153 for white oak. Although only moderately abundant on the average, in a good seed year scarlet oak was the most prolific species of those studied.

7. The effect of either good or poor acorn crops is reflected in the squirrel population of the following year.

8. Preferences of wildlife for one species of acorn over another are not outstanding.

These conclusions have definite implications for forest management, although the measures taken by the forest manager may be different, depending on whether the desired forest crop is sawtimber, wildlife, or both. Species not desirable for timber may be desirable for the food which they produce for wildlife.

### Timber Management

Probably the occasional year of abundant seed production is of great importance in providing reproduction; in other years few viable acorns are available because of insect and wildlife depredation. Scarlet, black, and white oaks, because of their more prolific production of viable acorns, have an advantage over blackjack and post oaks in regeneration. Post oak, with only 15 sound acorns per tree in its best year of record, is especially weak in this regard. Post oak and white oak acorns germinate in the fall, however, and thus are less subject to animal attack before germinating than are acorns of the black oak group, which do not germinate until spring. Wildlife consumption is probably a limiting factor in regeneration in poor seed years; in good seed years, wildlife does not consume all sound acorns, and squirrels may even aid regeneration by leaving buried acorns to germinate.

In order to obtain the maximum production of acorns, individual trees should be studied during a period of years so that the good producers are left for seed trees when cuttings are made. In reproduction cuttings where the forest manager is not able to study individual trees over a period of years, trees with large crowns should be left as seed producers.

### Wildlife Management

A good food species from the standpoint of wildlife management is one that produces abundantly every year. None of the species studied met these qualifications. Post oak was a consistent but low producer; the other species, although abundant producers in some years, occasionally produced small crops. Scarlet oak appears to be especially erratic and unreliable as a mast species; a wildlife population dependent on scarlet oak acorns would fluctuate greatly.

The production per acre of acorns suitable for wildlife consumption can be estimated. Assuming that mature acorns not used by insects are available, and that the stand consists of 20 seed-bearing trees per acre, evenly distributed among the five species studied, the average number of acorns available for food would be approximately 4000 per acre per year, representing a weight of 20 pounds. Computations based on data presented by Dalke (1953) show that in 1938 the Indian Trail Forest produced approximately 5600 mature acorns per acre suitable for food. The occasional poor seed year, however, is of critical importance for mast-consuming species. The poorest year in the Indian Trail Forest was 1949. In that year the assumed stand had a production of only 2,200 acorns per acre available for food, equivalent to a weight of 11 pounds.

Individual trees which have good production records (or, lacking records, trees with large crowns) should be spared in timber harvests. This practice will increase mast production per acre.

Wildlife managers should attempt to maintain a variety of oak species in stands like those studied so that mast failures will be unlikely. Generally, it is not in the best interest of wildlife production to encourage an oak stand of a single species. A variety of oak species tends to stabilize the food supply and likewise the wildlife populations dependent upon this source of food.

## LITERATURE CITED


Cypert, Eugene. 1951. *Suggestions for the Management of Oak Forests for Mast Production.* Mimeog. paper presented at Southeastern Assoc. Game and Fish Commissioners' Conference, Edgewater Park, Miss.

Cypert, Eugene, and B. S. Webster. 1948. *Yield and Use by Wildlife of Acorns of Water and Willow Oaks.* Jour. Wildlife Management 12:227-231.

Dalke, Paul D. 1953. *Yield of Seeds and Mast in Second Growth Hardwood Forest, South-central Missouri.* Jour. Wildlife Management 17:378-382.

Downs, A. A. 1949. *Trees and Food from Acorns.* In: *Trees,* Yearbook of Agriculture, 1949, pp. 571-573.

Downs, A. A., and W. E. McQuilkin. 1944. *Seed Production of Southern Appalachian Oaks.* Jour. Forestry 42:913-920.

Kautz, L. G., and F. G. Liming. 1939. *Notes on the 1937 and 1938 Acorn Crop in the Missouri Ozarks.* Jour. Forestry 37:904.

King, D. B., E. V. Roberts, and R. K. Winters. 1949. *Forest Resources and Industries of Missouri.* University of Missouri Agricultural Experiment Station, Res. Bul. 452, 89 pp.

King, Thomas R., and H. E. McClure. 1944. *Chemical Composition of Some American Wild Feedstuffs.* Jour. Agric. Research 69:33-46.

Korstian, C. F. 1927. *Factors Controlling Germination and Early Survival in Oaks.* Yale School of Forestry Bull. 19. 115 pp.

Petrides, G. A., Paul Parmalee, and J. E. Wood. 1953. *Acorn Production in East Texas.* Jour. Wildlife Management 17:380-382.

Smith, J. R. 1929. *Tree Crops: a Permanent Agriculture.* Harcourt, Brace and Co., New York. 333 pp.

Wood, A. M. 1934. *A Brief Record of Seed Productivity for Chestnut Oak in Southern New Jersey.* Jour. Forestry 32:1014-1016.