FRUIT PRODUCTION OF SOME UNDERSTORY HARDWOODS

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The fruit of small trees, shrubs and vines which comprise the woody understory of southern forests is not adequately appreciated. Most deer studies, for instance, have stressed browse and acorns.

It appears that the aggregate production of fruit in the understory exceeds that of acorns per unit of basal area; and that the production of fruit may exceed that of usable browse.

Some 30 species of fruit have been recorded as used by East Texas deer and they apparently seek out and make full use of practically all species according to their availability. This is, doubtless, true of many other forest wildlife species.

Appraisals of the productivity and adaptability of each species are needed to achieve efficient wildlife production in southern forests. As silvicultural practices become more intensive, the need for this information will increase.

The small beginning on these appraisals that we have made in eastern Texas may serve to illustrate the potential of this part of the forest wildlife habitat.

Our objectives have been to learn something about fruit production, how to estimate it and to learn something of the factors which affect productivity.

METHODS

The study was initiated in the summer of 1958. Assistants were E. E. McDonald, Edward W. Hill, Charles A. Segelquist, Horace G. Gore, and John R. Akin. The selection of species for study was determined by the availability of the species and the presence of ripe fruit or green fruit large enough to count in the summer. Palatability was not a selection criteria.

The method of obtaining the data varied to some degree by species, but generally consisted of random selection among the fruiting trees of a population. Each plant studied had some fruit and each was in a fairly well-stocked pine-hardwood forest.

Each individual fruit was counted and, when necessary, the tree was felled. Basic measurements were diameter breast high (or 6 inches high for some shrubs), age, height, crown width, crown height, per cent overstory, and basal area on the one-tenth acre around the study tree. Samples of fruit were counted and weighed and some were submitted for chemical analysis. For species worked several months before maturity, such as dogwood, a series of marked limbs was used to determine the percentage of green fruit which later matured. The Statistical Laboratory of the Agricultural and Mechanical College of Texas determined correlations and multiple regressions.

The results for dogwood are presented in some detail as an example of the methods used.

FLOWERING DOGWOOD

All of the fruit on 26 flowering dogwood *(Cornus florida)* trees was counted, 15 in 1958 and 11 in 1959. The work was done in July and August, when fruit was large enough to count readily. All trees were in fully stocked stands of loblolly pine.

Study trees were selected at random, with two exceptions—multistem trees and those with no fruit were not used. The location of dogwood fruit is such that it was not practicable to count twigs for a fruit-twig ratio.

The means for all measurements taken are shown in Table 1. The samples for each year are comparable, as there was approximately the same fruit production each year. The differences in fruit-per-limb and in number of limbs was due to differences in methods of defining limbs.

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In 1958 the count was made just inside the green crown so each limb could be allotted to the low, mid, or top crown third. Although all fruits were counted on each tree, the count was recorded for only three limbs in each crown third. Crown location was ignored in 1959 and the limb count was made at the juncture with the main stem. Since the two variables (number of limbs and fruit-per-limb) are inversely related, inclusion of both tends to cancel bias in definition of limbs. The simpler method is to count limbs at the main stem.

Simple correlation tests were run each year for each variable against each other variable. Then multiple regressions were tested using all of the variables measured and fruit production. In 1958, two additional regressions were computed using two variables each. These were selected from inspection of the data as promising variables that might be usable in estimating fruit production.

In 1959, a program was used whereby the machine started with seven variables and automatically dropped one each time until on the sixth regression only the two best variables remained.

REGRESSIONS

For individual trees, an adequate sample of fruit-per-limb multiplied by the number of limbs will yield the total fruit. However, the means for groups of trees cannot be used in this manner and the use of a formula is necessary.

TABLE 1

MEANS OF DOGWOOD MEASUREMENTS TAKEN IN 1958 AND 1959

Variable	*1958*	*1959*
Number studied	15	11
Diameter in inches	3.99	3.59
Height in feet	25.87	22.3
Number of limbs	22.9	18.7
Fruit per limb	144.4	229.8
Fruit per tree	3,612.8	3,427.1
Per cent overstory	67.2	68.2
Basal area in feet per acre	120.7	...
Age in years	18	...
Years to grow last inch	7	...
Crown width in feet	.	15.6
Crown height in feet	.	15.3

All nine of the regressions run, Tables 2 and 3, were significant at the 0.01 or 0.05 levels. The best appears to be:

FRUIT=241.48(number of limbs)+12.87(fruit-per-limb)—3,831.59

This equation was developed from the 1959 data. When applied to the 1958 data it produced an estimate of 3,564 fruit per tree when the actual count was 3,613.

The two short equations from the 1958 data, Table 2, did not give satisfactory results when tried with the 1959 data. This was because the fruit-per-limb variable was measured differently each year. Where the number of limbs was included, as in the 1959 equations, the difference in methods of defining limbs did not agect the results.

Insofar as these two samples may be typical, it appears that the best method of estimating fruit production is to count the limbs on each tree and sample the fruit-per-limb on each tree. The key problem is to get an adequate sample of fruit-per-limb.

LIMB SAMPLING OF DOGWOOD

When dogwoods reach a diameter of about 1.5 inches, they start flowering and fruiting. Most of the fruit is located in the top of the crown. Trees of 3.5 inches in diameter have the fruit well distributed over the whole crown. Trees over 5 inches in diameter tend to have more fruit on the sides of the crown and less in the top. To sample a normal range of tree sizes, it appears that limbs from the middle portion of the crown-side are most representative.

Using the 1959 data, various sampling techniques were tested. The best sample of fruit-per-limb was attained by using one limb per tree. The limb used was the one nearest the middle of the crown which was of

TABLE 2.

MULTIPLE REGRESSIONS FOR 1958 DOGWOOD DATA

FRUIT (Y) = Ao	−931.54	−1,365.13	−521.79
+ DBH x	284.55	349.13	
+ Height x	−112.87		9.36
+ Number of limbs x	107.50		
+ Fruit per limb x	25.89	24.84	26.96
+ Per cent overstory x	8.17		
+ Basal area x	2.20		
+ Age x	−22.28		
+ Years to grow last inch x	−39.84		
SIGNIFICANCE OF R	**	**	**

near-average size. Thus, if a tree had 21 limbs the eleventh one was located, counting up from the lowest. Then the nearest limb of approximately average diameter was used for the sample count of fruit.

This gave an estimate 7 per cent above the actual, for this sample, with the sixth regression in Table 3. Using 2 or 3 limbs did not increase the accuracy of the estimate but all gave estimates within 10 per cent of the true mean.

It should be emphasized that this was a limited test of the method. It could not be tried on the 1958 data because limb counts were recorded for only 9 limbs on each tree.

The results suggest that sampling a larger number of trees would increase accuracy more than sampling additional limbs per tree.

Another factor worth noting is: The number of limbs per tree decreases as tree size increases. Larger trees have fewer limbs but larger limbs. This does not affect the equation because larger limbs also have more fruit.

In sampling groups of trees, it would be desirable to record (in addition to number of limbs and a count of fruit on one limb) the tree heights and diameters. This would permit a more complete description of the population studied and, with the height measurements, it would permit alternate computations using the equation with three variables, Table 3.

CORRELATIONS

Significant correlations are reported in Table 4. The only relationships which were significant both years were diameter and height, and total fruit and fruit-per-limb. Some especially interesting correlations are the negative ones indicated for overstory with total fruit, fruit-per-limb, and diameter. Although dogwood is shade tolerant, it appears that fruit increases as overstory decreases within the range studied under forest conditions. Since diameter also increased as overstory decreased, the effects of shade on fruiting may indirectly reflect competition in the stand.

Basal area around the study tree was not related to any of the variables except age. Since the timber stand was a young one, established on cutover longleaf site in the last 30 years, it was to be expected that the age of dogwoods would have a significant correlation with the amount of basal area. As more hardwoods and pines developed on the site, the age and basal area moved up together.

Twig length measurements varied considerably from crown top to bottom but there was little variation between trees. There did not appear to be any correlation with fruit production. It had been expected that there might be differences in tree vigor expressed in twig length which might agect fruit production.

PHENOLOGY

Dogwood is a dependable fruit producer. Surveys of the percentage of trees by diameter class having fruit are reported for four years in Table 5. Consistently better crops of fruit were produced in Trinity County than in Jasper and Newton Counties. For both areas 88 per cent or more of the trees 3.5 inches and larger were with fruit each year. Year-to-year differences were more pronounced in the smaller diameter classes.

TABLE 3.

MULTIPLE REGRESSIONS FOR 1959 DOGWOOD DATA

FRUIT(Y) =	Ao	−7,908.23	−6,860.98	−6,249.9	−4,370.63	−4,320.07	−3,831.59
+	DBH x	1,669.71	1,322.01				
+	Height x	1,175.70	639.72	633.98	112.17	29.61	
+	Crown height x	−801.08	−505.50	−530.71			
+	Crown Width x	−787.10	−487.43	−246.40	−101.06		
+	Per cent overstory x	−47.41					
+	Number limbs x	308.26	275.60	287.87	226.31	237.75	241.48
+	Fruit per limb x	5.40	6.85	9.79	12.49	12.50	12.87
SIGNIFICANCE OF R		**	**	**	*	*	*

TABLE 4.

SIGNIFICANT CORRELATIONS AMONG DOGWOOD VARIABLES MEASURED

Variables	*DBH*	*Height*	*Crown Height*	*Crown Width*	*Per Cent Overstory*	*Number Limbs*	*Fruit per Limb*	*Total Fruit*	*Age*	*Years Last Inch*	*Basal Area*
DBH		x*		**	xx−	x	xx	xx	xx	xx	
Height	x*		**	**	**	xx			x		
Crown Height		**			*						
Crown Width	**	**									
Per Cent Overstory	xx−	**	*				x−	x−		x	
Number Limbs	x										
Fruit per Limb	xx				x−			xx*	xx		
Total Fruit	xx				x−		xx*		xx		
Age	xx	x					xx	xx			x−
Years Last Inch	xx				x			xx			
Basal Area									x−		

x=1958 data
*=1959 data

x or *=significant at .05 level
xx or **=significant at .01 level
−= negative correlation

Counts of green fruit in July apparently may be taken as the approximate number that will mature. There was only a 2 per cent loss from June to August. Counts of acorns on some oak limbs decline as much as 95 per cent during the same period.

TABLE 5.

EXTENT OF DOGWOOD FRUITING BY DIAMETER CLASS, YEAR, AND LOCATION

				Diameter Class				
		Number		2	3	4	5	6 inches up
Location	Year	Checked		Percentage with Fruit				
Jasper-Newton	1958	222	0	36	68	88	87	100
Jasper-Newton	1959	235	4	67	94	94	93	100
Trinity County	1959	284	..	100	100	100	100	100
Jasper-Newton	1960	196	19	60	81	96	91	80
Trinity County	1960	40	..	83	100	100	100	100
Jasper-Newton	1961	115	44	95	96	94	100	100
Trinity County	1961	93	60	100	97	100	100	100

Dogwood flowering occurs in March and April. Ripening begins in September and some of the red fruit remains on the trees until January. Dogwood seeds have been found in deer pellets during the period November to February.

Until late in 1960, it appeared that the use of dogwood fruit by deer was relatively limited. It had occurred in four of 1,043 pellet groups collected from five ranges at all seasons beginning in 1956. Of course dogwood was not available when and where many of the collections were made.

In November and December, 1960, 34 of 35 pellet groups collected contained dogwood seed. These were from four deer in the 58-acre study pen at Kirbyville. There was no apparent reason for the sudden increase in use of dogwood fruit.

WEIGHT AND COMPOSITION

Two samples, each from several trees, averaged 1,083 ripe fruit per pound. The average production of 26 trees was 3.3 pounds. This is the equivalent of 37.9 pounds per square foot of basal area. One foot of basal area would be less than 1 per cent of the average forest stand, so dogwood produces well for the space occupied.

One sample of whole fruit from Jasper County was analyzed by the State Chemist, Dr. G. S. Fraps, with the following results for air dry basis with 15 per cent moisture content: (Freshly collected fruit contained 53 per cent water.)

> 5.49 per cent protein; 16.17 per cent fat; 24.64 per cent fiber; 4.96 per cent ash; 0.06 per cent phosphorus; and 1.10 per cent calcium.

As compared with 10 other fruits, dogwood is outstanding for its content of fat and calcium. Dogwood leaves and twigs contain 1.75 to 2.90 per cent calcium at the 15 per cent moisture level (Lay, 1957). Thus, dogwood litter contributes lime to the generally acid soils of southern forests.

OTHER SPECIES

Procedures similar to those for dogwood were reported more fully elsewhere (Lay, 1960) for six other species. A brief summary follows:

WHITE FRINGETREE

White fringetree *(Chionanthus virginicus)* is a shrub or small tree with delicate and drooping white flowers known locally as grandfather's gray beard. Not generally recognized is the fact that it produces date-like fruit used by deer and many other species.

Fruit ripens in July and is available until September. Deer, however, manage to obtain some as early as June and as late as November. There are 631 fruit per pound and the 41 trees studied produced 65 pounds per foot of basal area, Table 6.

Fruit is produced on twigs of the previous year. Production may be estimated for a group of trees using the means of diameter and fruit-per-100-twigs:

FRUIT=31.28 (diameter) + 1.242 (fruit-per-100-twigs)—158.78

Some variation in production occurs from year to year but no crop failures have been observed.

BEAUTYBERRY

Beautyberry or French mulberry *(Callicarpa americana)* is a common shade loving shrub with clusters of purple fruit which is adaptable to a wide range of site conditions.

Deer are fond of the fruit, some being eaten every month from July to March. The principal period of availability is August and September. Flowering occurs in May and June after all danger of frost; this may account for the consistency of production every year.

TABLE 6.

SUMMARY OF FRUIT PRODUCTION DATA FOR NINE SPECIES

Species	*Number Studied*	*Mean Diameter*	*Fruit per tree*		*Pounds per Foot Basal Area*	*Fruit per Pound*
			Number	*Pounds*		
Dogwood	26	4.0	3,500	3.3	37.9	1,083
Fringetree	41	1.75	692	1.1	65	631
French Mulberry	42	0.47	1,771	0.24	. . .	7,322
Blueberry Hawthorn	10	3.0	2,273	2.4	46	936
Flatwoods Plum	8	3.1	578	1.18	22.6	491
Sweetleaf	38	2.4	1,398	0.64	20	2,168
Kentucky Viburnum	51	0.87	415	0.08	. . .	5,000
Muscadine	1	2.4	8,827	53.8	. . .	164
Parsley Haw	2	2.0	5,191	1.5	. . .	3,446

The 42 plants studied averaged 3.8 feet high and 1,771 fruit per plant. This is a quarter pound of fresh fruit per plant, since there are 7,322 fruit per pound. Stands of 100 to 200 plants per acre occur and 25 to 50 pounds of fruit per acre may be produced.

For a group of fruiting plants, production may be estimated by measuring the diameter of the largest stem 6 inches above ground and by counting the fruit in one randomly selected cluster on each plant. Then:

FRUIT=7,720.44 (diameter) + 46.72 (fruit - per - cluster) - 3,298.71

BLUEBERRY HAWTHORN

Blueberry hawthorn *(Crataegus brachyacantha)* is known locally as blue haw because of the blue fruit produced in August and September. It is fairly common on the tighter soils of East Texas.

Deer (as well as many other species) make considerable use of this species and it is an especially valuable component of the habitat because it is one of the few species that produce fruit in late summer—a period that may be more critical on some deer ranges than winter.

Good to bumper crops were produced the last three years and it is thought to be a consistent producer. The group of 10 plants studied had means of 3.0 inches diameter, 2,273 fruit, and 2.4 pounds per tree. There are 936 fruit per pound. This is the equivalent of 46 pounds of fruit per foot of basal area.

For predicting fruit production, eight significant regressions were found. The most practicable for field use, significant at the .01 level, was:

FRUIT=127.26 (number limbs)+10.92 (fruit-per-limb)—1,992.21

In one test, with the same 10 trees, the use of one or two near-average size limbs in the middle of the crown side for each tree gave results within 4 per cent of the true mean.

Blue haw is a worthy occupant of understory forest space. It has a thin, open crown which produces little shade. It will grow under pines but more often it grows on marginal sites for pine. These may be open glades of tight soil which are excessively wet in winter and dry in summer ,a combination which limits pine regeneration whether blue haws are present or not.

FLATWOODS PLUM

Flatwoods or sloe plum *(Prunus umbellata)* fruits are relished by deer. The 8 trees studied averaged 3.1 inches in diameter, 13.2 feet in height, and produced 578 fruit per tree. This was 1.18 pounds per tree, since 491 fruit make a pound. This production is the equivalent of 22.6 pounds of fruit per foot of basal area. The study sample was too small for the development of a method of estimating fruit production.

Flowers appear in March and April and fruit ripens in July and August. This species grows on fairly moist upland pine sites but appears to offer little competition to pines. Its retention is desirable where there is concern for wildlife.

COMMON SWEETLEAF

Common sweetleaf *(Symplocos tinctoria)* is a small tree which occurs on the better quality pine-hardwood sites. It flowers in April and matures fruit to September to December which is used to some extent by deer and many other species.

The 38 trees studied averaged 2.4 inches in diameter and had 1,398 fruit. There are 2,168 fruit per pound and this is the equivalent of 20 pounds per foot of basal area, or 0.64 pounds per tree. Fruit develops on twigs of the previous year. The best method of estimating fruit production appears to be:

$$\text{FRUIT} = 981.50 \text{ (diameter)} + 2.91 \text{ (fruit-per-100-twigs)} - 1{,}895.98$$

KENTUCKY VIBURNUM

Kentucky viburnum *(Viburnum molle)* is a black haw which grows on fairly moist sites. It flowers from April to June and the terminal clusters of blue-black fruit ripen in July and August. Some fruit is available as late as November.

The fruit is sought by deer and the leaves and twigs are also highly palatable. Production of 51 plants studied was 415 fruit or about 0.08 pounds per plant, as there are about 5,000 fruit per pound. The plants averaged 0.87 inches in diameter at 6 inches above ground and 7.6 feet high.

A significant regression for estimating numbers of fruit on groups of plants was:

$$\text{FRUIT} = 469.75 \text{ (diameter)} + 4.017 \text{ (fruit - per - cluster)} - 75.04$$

Year-to-year production is reasonably constant and no crop failures have been noted. Other viburnums may be more productive and all should be recognized as sources of fruit as well as browse.

MUSCADINE GRAPE

The fruit on one large muscadine vine *(Vitis rotundifolia)* was counted with about four man days of effort. The vine was 2.4 inches in diameter and 17 years old. There were 8,827 fruit or 53.8 pounds at 164 per pound.

PARSLEY HAWTHORN

Two parsley haws *(Crataegus marshalli)* 1.5 and 2.5 inches in diameter produced 1.4 and 1.6 pounds of fruit.

DISCUSSION

For one 100-pound deer to 15 acres, the air-dry forage requirement is 61 pounds per acre per year. Summer production on two deer ranges in Texas was 200 and 350 pounds per acre green browse. The first was overstocked with deer and cattle and utilization of browse by deer was about 30 pounds green or 11 pounds air dry per acre per year. The second was moderately stocked with deer only and utilization was about 45 pounds green or 17 pounds air dry per acre. Much browse production is in unpalatable species and total utilization of more than 20 per cent of the supply causes some of the better quality species to decline. Usable deer browse supplies on these two ranges appeared to be far less than deer requirements.

If these levels of browse production and utilization are representative of southern forests, then the possible significance of the fruit crop may be recognized.

The air dry content of 11 species of fruit averaged 53 per cent of fresh weight. This compares favorably with browse which ranges from 25 per cent air dry in spring to 50 per cent in winter.

Goodrum (1959) reported that the average annual expected yield of fresh sound fallen acorns on a 14-inch tree, which is approximately one square foot of basal area, was 4.90 pounds for post oak, 6.59 pounds for white oak, 5.90 pounds for blackjack, 1.98 pounds for southern red oak, and 8.19 pounds for water oak. He estimated that for optimum populations of wildlife enough oaks are needed to produce 40.67 pounds per acre. This would be 5 to 20 feet of basal area.

These are average annual production figures, whereas the fruit production data are for the part of the population with some fruit. The variation in extent of fruiting from year to year would cause the average annual fruit production for the whole population to be somewhat lower than reported.

The species for which data are available produced from 20 to 65 pounds per square foot of basal area. Full stands of pine may have 10 to 15 feet of basal area of understory hardwoods. With the proper species and age classes, production of fruit could be several hundred pounds per acre.

Since most oaks require crown space in the canopy, comparable acorn production could not be achieved in the presence of full stands of pine. However, acorns are highly desirable on a wildlife range and they mature when they are most needed.

Much information is needed to fully evaluate the many species which produce fruit in southern forests: Which will produce the most in the least space? How may fruiting be stimulated? How may the more promising species be propagated and managed intensively? What are the relative nutritive values?

The data from Texas may have limited value elsewhere. Certainly it should be checked in other areas. The present objective will be accomplished if interest is stimulated in the fruit crop.

SUMMARY

1. The unique aspect of understory hardwoods is their ability to produce quantities of fruit without requiring canopy space in competition with pines.

2. Production of 20 to 65 pounds of fruit per square foot of basal area was found for five species. This compares with 2 to 8 pounds reported for oak species.

3. Fruit production may exceed that of usable deer browse.

4. Counts of fruit and equations for estimating fruit production are reported for several species.

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DEER HARVESTS FROM REFUGE AREAS IN MISSOURI

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This paper summarizes experiences and data derived during the reduction by hunting of deer populations on five refuge areas in Missouri. These harvests have provided us with our best information on actual densities of deer populations, a knowledge of which is basic to other facets of deer research.

Two of the refuges, Drury and Caney Mountain, are located in the southwestern Ozarks (Map 1). This region is characterized by cedar