cause some serious thinking by the members of our profession. We certainly do not offer this as the solution to all our problems but as a starting point from which we may be able to move into a positive approach to our farm game program.

Respectfully submitted,
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THE EFFECT OF STAND DENSITY ON THE ACORN PRODUCTION OF TURKEY OAKS[1]

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17th Annual Conference
Southeastern Association of Game and Fish Commissioners
Hot Springs, Arkansas
September 30, October 1 - 2, 1963

ACKNOWLEDGMENTS

Statistical procedures used in analyzing the oak tree orchard data were suggested by Dr. Joseph Sutton, Professor of Psychology, Stetson University, DeLand, Florida. The authors gratefully acknowledge the editorial assistance given by Dr. Stephen L. Beckwith, Professor of Wildlife Management, University of Florida, Gainesville, Florida, and Mr. Lovett E. Williams, Wildlife Biologist, Florida Game and Fresh Water Fish Commission, Lake City, Florida. Data on the characteristics of good and poor acorn producing turkey oaks were compiled by Wildlife Biologist A. Gordon Spratt, Ocala, Florida. This project was originally designed by Donald D. Strode, U. S. Forest Service, Asheville, North Carolina.

The longleaf pine-turkey oak *(Pinus palustris-Quercus laevis*)* association occupies a considerable land area in north and central Florida, particularly inland. Some of Florida's densest deer populations are located in this type of habitat. Turkey oak is dominant when pine has been removed and burning is infrequent, while pine is common where burning is frequent. Several other trees which are often locally abundant include bluejack *(Quercus cinerea)*, liveoak *(Quercus virginiana)*, and post-oak *(Quercus stellata)*. Turkey oaks are not only the most common oaks, but contribute a greater quantity of mast for wildlife than the others. Understory vegetation consists primarily of wiregrasses *(Aristida* spp.), gopher-apple *(Geobalanus oblongifolius)*, huckleberry *(Vaccinium myrsinites)*, dog-fennel *(Eupatorium* spp.), and legumes.

The principal soil type in this association is the Norfolk series. The surface is typically a grey, fine sand with a yellow subsoil. The soil is well-drained, slightly acid, and usually free of lime. The water table is normally lower than four feet from the surface.

This type of land with its rolling topography, park-like appearance, and good drainage is particularly suited to real estate development.

[1] A contribution of Pittman-Robertson Federal Aid Project W-41-R.
* Plant names follow Small. Lit. cited.

Where it is owned by pulpwood companies, it is rapidly being cleared of oaks and planted to slash pine *(Pinus elliottii)*. In an attempt to establish recommendations for landowners interested in maintaining some oaks for wildlife, a study was conducted during the fall of 1956 through the fall of 1962 which attempted to measure the acorn yield of turkey oaks as related to thinning practices. The primary objective was to determine the effect of various degrees of thinning turkey oak stands on the acorn-bearing ability of the remaining trees.

TECHNIQUES USED

In a dense 20-acre stand of turkey oaks (averaging between 150 and 160 stems per acre) on the north end of the Ocala National Forest, Marion County, Florida, four acres were thinned to 80 stems per acre, four acres to 40 stems per acre, and four acres to 15 stems per acre. An eight-acre control plot had an average of 153 oaks per acre (Figure 1). Each plot was replicated one time. Forty trees were selected for study, ten in each thinning category and ten in the control plot. Sample trees were more than 5.5" D.B.H. and ranged in age from 35-41 years. They were randomly selected whereby the tree that met the necessary requirements nearest to a predetermined location was chosen.

Trees were numbered 1-10 (control plot), 11-20 (80 stems per acre), 21-30 (40 stems per acre), and 31-40 (15 stems per acre). During the first five years of the study one 3.0' x 3.0' acorn trap was placed below each oak. For the last two years two traps were located beneath each sample tree. Traps were placed on 2" x 2" posts approximately 30" above the ground in such a manner as to sample representative portions of the crown. The bottoms of the traps were covered with ¼-inch mesh hardware and the tops with 2-inch mesh poultry wire.

All traps were visited twice a month from November through February at which time acorns were counted, weighed to the nearest gram, and separated into the following categories: (1) sound, (2) unsound, and (3) immature. Seasonal acorn yield per oak was estimated according to the following formula:

$$\text{Total acorns per tree} = \frac{\text{Number of acorns collected x tree crown area}}{\text{Total acorn trap area}}$$

FINDINGS

Over the seven-year study period sample oaks in the 90 per cent thinned area produced the highest average yield of acorns (533 per tree); those in the 50 per cent thinned area produced the second largest quantity (449 per tree); trees in the 75 per cent thinned plot were third (260 per tree); and oaks in the control plot produced the smallest number of acorns (236 per tree) (Table 4). However, on a per-acre basis, the unthinned plot produced the greatest quantity of acorns (36,108), followed by the 50 per cent thinned area (35,920), with the 75 per cent thinned area third (10,400), and the 90 per cent thinned plot last (7,995). (Table 4.)

Turkey oak number one, in the control plot, produced more than twice as many acorns as the other nine study trees combined during the first year of the study (Table 4).

A greater number of study oaks on the plots thinned to 50 per cent and 90 per cent, over the seven-year study, were from the beginning consistently higher producers than those oaks selected on the control plot or the plot thinned to 75 per cent (Table 1).

Bartlett's Test for Homogeniety of Variance, Snedecor (1956), revealed that an "Analysis of variance" could not be performed with the acorn data. This strongly suggests that stand manipulation (thinning) was ineffective and that the existing differences in acorn production might be due to individual variation between the selected oaks. Acorn production of individual trees varied irregularly, by years, within each treatment. Certain trees led in production regardless of stand treatment. Collins (1961) observed over a ten-year period that oaks in Louisiana were consistent in their production. Collins (*op. cit.*) and

the present study both suggest that inheritance or some other difficult to observe factor may play an important part in the acorn-bearing capacity of individual trees.

Thinning apparently had little effect on the acorn production of the selected study trees. It is possible that a mature stand of turkey oaks of 150-160 trees per acre is not sufficiently dense for shade to be an influencing factor on the acorn production. If good producers are retained thinning might produce a net beneficial effect by increasing ground cover.

Thirty turkey oaks with an acorn-bearing capacity of 1,100 acorns per tree would equal the projected seven-year average, for the control plot (153 oaks per acre).

Frequency of cucurlionid weevils in the acorns varied from 36.9 per cent in 1962 to 81.2 per cent in 1960 (Table 3).

D.B.H. measurements of the study oaks were made immediately after selection and again at the termination of the study. The greater

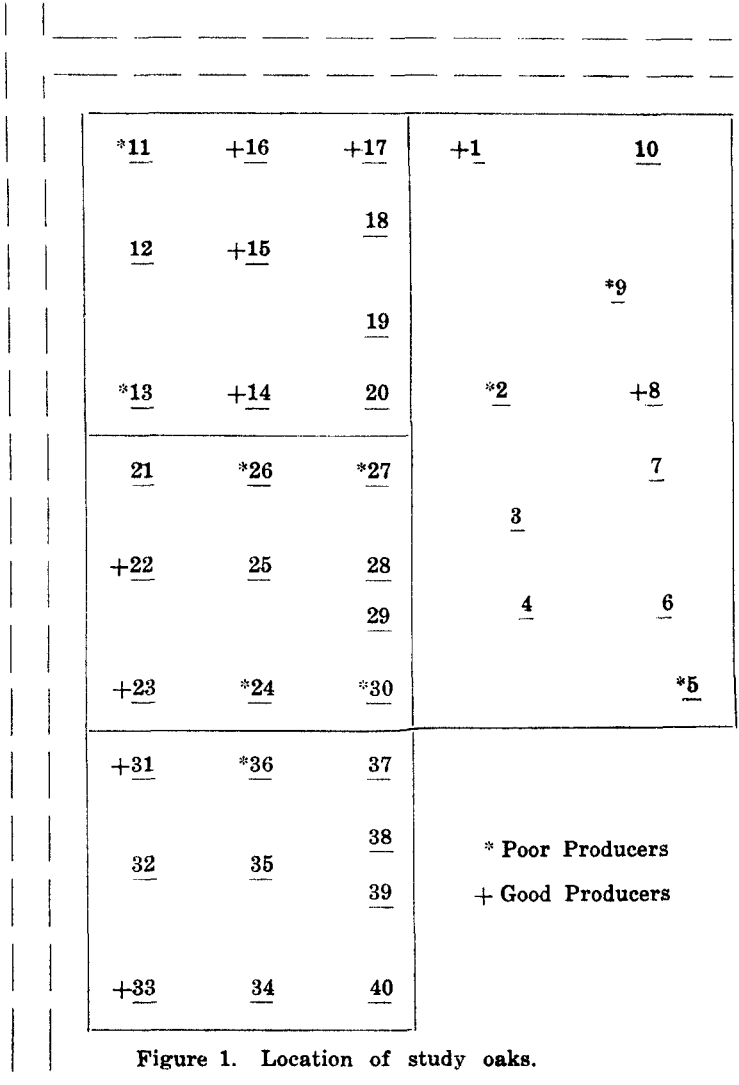

Figure 1. Location of study oaks.

the degree of thinning, the greater the D.B.H. growth. (Table 5.) Apparently, growth was proportional to the degree of thinning.

In an attempt to discover why some of the study oaks were consistently good producers and others were poor, the ten best and ten poorest were compared as to D.B.H., total height of tree, crown size, proximity to other trees, and age. Measurements are summarized in Table 7. Standard forestry equipment was used and included a Swedish increment borer, a Forest Service hypsometer, and a diameter tape. Measurements were nearly the same between the good and poor producers with the exception of ground covered in area by the crown in square feet The ten best acorn producing oaks averaged 41 per cent larger in crown size than the ten poorest producing oaks. This concurs with the Louisiana study by Collins (*op. cit.*). Other factors which appeared to influence acorn production were the degree of shading (those oaks *extremely* shaded were generally poor producers), and whether the tree had been severely injured or had heart rot. Age did

TABLE 1. TURKEY OAK ACORN PRODUCTION PER TREE. 1956-57 TO 1962-63

No.	56-57	57-58	58-59	59-60	60-61	61-62	62-63	
+ 1	5,449	1,227	0	514	134	161	223	
* 2	78	18	0	9	17	4	13	Control
3	308	342	0	291	52	17	86	Plot
4	490	176	0	13	0	0	0	
* 5	169	13	0	63	0	0	31	153
6	324	246	0	26	131	18	74	trees/
7	150	113	0	51	100	19	63	acre
+ 8	782	402	0	379	201	11	335	
* 9	114	88	0	9	35	0	52	
10	246	89	0	134	0	0	212	
*11	97	9	0	43	9	22	22	
12	1,164	359	0	325	205	68	171	50%
*13	172	28	0	36	33	8	3	thinned
+14	1,176	140	0	700	448	98	322	
+15	3,350	2,188	0	201	1,228	860	1,407	80
+16	1,280	690	0	1,230	301	75	841	trees/
+17	650	667	0	838	342	60	316	acre
18	298	70	0	61	149	35	123	
19	759	134	0	268	156	33	167	
20	1,183	469	0	201	290	33	367	
21	308	102	0	462	171	77	85	
+22	1,677	86	0	325	222	188	778	75%
+23	1,677	86	0	137	188	51	410	thinned
*24	513	112	0	89	44	22	78	
25	513	410	0	0	154	205	380	40
*26	75	25	0	100	25	87	94	trees/
*27	134	67	0	0	0	22	67	acre
28	163	150	0	1,318	841	62	75	
29	804	855	0	445	52	26	17	
*30	448	112	0	0	0	14	28	
+31	1,535	1,360	0	3,209	1,255	175	2,407	
32	1,471	445	0	68	17	26	43	90%
+33	890	86	0	2,498	804	0	1,290	thinned
34	67	470	0	588	178	44	111	
35	376	393	0	1,334	342	60	70	15
*36	975	171	0	68	34	43	9	trees/
37	1,044	0	0	1,574	308	17	650	acre
38	558	357	0	625	0	0	234	
39	1,249	616	0	308	308	9	51	
40	462	222	0	564	0	0	59	

+ Good Producers (10) * Poor Producers (10)

TABLE 2. NUMBER AND POUNDS OF ACORNS PRODUCED. 1956-1962

	Total Number Acorns Produced per 10 Oaks				Average Number Acorns per 10 Oaks			
Year	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40
1956	8,110	10,129	6,312	8,627	811	1,013	631	863
1957	2,714	4,754	2,005	4,138	271	475	200	413
1958			T O T A L	M A S T	F A I L U R E			
1959	1,489	3,903	2,876	10,806	148	390	287	1,080
1960	670	3,161	1,697	3,246	67	316	169	324
1961	230	1,292	755	274	23	129	75	27
1962	1,089	3,739	2,012	4,924	108.9	373.9	201.2	492.4

	Total Weight Acorns per 10 Oaks (Pounds)				Average Weight Acorns per 10 Oaks (Pounds)			
Year	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40
1956	65.3	81.6	50.8	69.5	6.53	8.16	5.08	6.95
1957	10.3	25.1	7.1	18.6	1.03	2.51	0.71	1.86
1958			T O T A L	M A S T	F A I L U R E			
1959	5.6	20.6	11.0	48.6	0.56	2.06	1.10	4.86
1960	2.5	16.7	6.5	14.6	0.25	1.67	0.65	1.46
1961	0.87	6.8	2.8	1.2	0.08	0.68	0.28	0.12
1962	4.1	19.8	7.9	22.1	0.41	1.98	0.79	2.21

	Total Number Acorns Per Acre				Total Weight Acorns Per Acre (Pounds)			
Year	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40	153 T/A 1-10	80 T/A 11-20	40 T/A 21-30	15 T/A 31-40
1956	124,083	81,040	25,240	12,945	999.0	653.0	203.0	104.0
1957	41,463	38,000	8,000	6,195	158.0	201.0	31.0	27.9
1958			T O T A L	M A S T	F A I L U R E			
1959	21,644	31,200	11,480	16,200	82.6	169.0	44.0	73.0
1960	10,151	25,280	6,760	4,860	38.7	134.0	27.0	22.0
1961	2,519	10,320	3,000	405	9.1	54.6	11.5	1.8
1962	16,677	29,920	8,040	7,380	63.7	159.0	30.8	33.2

Oaks	Ave. Sq. Ft. Crown
1-10 (153 T/A)	133
11-20 (80 T/A)	148
21-30 (40 T/A)	165
31-40 (15 T/A)	179

T/A = Trees per Acre

Table 3. Per Cent of acorns insect infested.

Year	Control	50% Thinned	75% Thinned	90% Thinned	Average
1956	61.7	44.2	68.8	50.6	56.3
1957	63.7	52.2	60.4	72.7	62.2
1959	76.9	34.5	32.5	27.8	42.9
1960	87.0	81.1	83.0	74.0	81.2
1961	100.0	92.0	28.8	97.0	79.4
1962	34.0	36.8	36.7	40.4	36.9

Table 4. Acorn production for a 7-year period as related to extent of thinning, Ocala National Forest, 1956-1962.

Extent of Thinning (%)	Number of Oaks Per Acre	ACORN PRODUCTION Ave. No. Acorns Per Tree (1956-1962)	ACORN PRODUCTION Ave. No. Acorns Per Acre (1956-1962)
Control	153	236	36,108
50	80	449	35,920
75	40	260	10,400
90	15	533	7,995

not seem to influence the variation of acorn production among the study trees.

The present study revealed that stand density up to 153 turkey oaks per acre had a minimum influence on acorn production of individual trees and strongly implies that a mature, unthinned stand of 150 oaks per acre may be thinned up to 50 per cent without significantly reducing acorn production, when the best producers are selected.

A survey of the acorn bearing potential of individual oaks should be conducted prior to an oak thinning program if oaks are to be saved for wildlife.

The better mast producers were found in the present study to have the following characteristics:

(1) large crown area, at least 200 square feet,
(2) D.B.H.* at least 7.0 inches,
(3) height to lowest branch (3" in diameter) not over 22 feet,
(4) Freedom from severe injury and heart rot.**

In conclusion, when there is some reason for removing turkey oaks in a mature stand of 150-160 trees per acre, it can be done without a pronounced reduction in mast yield, provided most of the best producers are left. To select the best producers an acorn survey should be conducted on the stand for at least a one-year period. Most wildlife species will benefit from selective thinning of turkey oak stands because of the increase that will occur in the different species of forbs and woody plants. Many of these plants will be maintained by a 3 or 4-year controlled burning program which may be started a year or so after thinning has been accomplished, Harlow and Bielling (1961).

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Table 5. Average diameter breast height growth of turkey oak trees during the 7-year study period (inches).

Date of Measurement	Control	50 Per Cent Thinned	75 Per Cent Thinned	90 Per Cent Thinned
9-13-56	6.19	6.50	6.49	6.70
11-15-62	6.40	6.80	6.92	7.65
Growth increase	0.21	0.30	0.43	0.95

Table 6. Average grams weight per acorn over the 7-year study period.

Year	Tree Numbers	Weight
1956	1-40	3.65
1957-1962	1-10	1.73
1957-1962	11-20	2.40
1957-1962	21-30	1.74
1957-1962	31-40	2.04

* Approximately four and one-half feet above ground.
** Injured trees may be temporarily stimulated to produce a heavy acorn crop for one year.

Table 7. Physical comparison of the ten best and ten poorest acorn producing turkey oaks which were selected for the oak tree orchard elimination study.

	GOOD PRODUCERS										
Tree Number Quercus laevis	*1*	*8*	*14*	*15*	*16*	*17*	*22*	*23*	*31*	*33*	*Ave.*
Ground Area Covered by Crown in Square Feet	346	254	290	177	213	254	346	254	397	397	292.8
D.B.H. in inches	6.6	6.4	7.6	6.5	6.8	7.2	8.0	7.0	8.5	9.7	7.4
Height to lowest branch 3 inches in diameter or larger	13	18	22	18	12	12	15	12	10	17	14.9
Age in years	31	39	42	30	38	42	45	39	41	36	38.3
Radial wood growth for 5 years in inches	0.50	0.34	0.50	0.69	0.44	0.38	0.50	0.63	0.50	1.59	0.6
Radial wood growth for 10 years in inches	1.00	0.66	0.75	1.05	0.75	0.56	0.75	1.00	0.88	2.02	0.9
Total height in feet to nearest foot	25	31	41	38	31	32	33	33	36	41	34.1
Crown density rating *	2	2	2	3	2	2	2	2	2	2	2.1
Proximity of Nearest Tree											
PINE											
Height in feet	——	——	——	——	——	——	——	——	——	15	15
Distance in feet	——	——	——	——	——	——	——	——	——	3	3
D.B.H. in inches	——	——	——	——	——	——	——	——	——	3.0	3.0
OAK											
Height in feet	——	——	——	——	——	——	——	——	——	——	——
Distance in feet	——	——	——	——	——	——	——	——	——	——	——
D.B.H. in inches	——	——	——	——	——	——	——	——	——	——	——

*1 — Dense
2 — Average
3 — Poor

Table 7 (continued)

POOR PRODUCERS

Tree Number Quercus laevis	*2*	*5*	*9*	*11*	*13*	*24*	*26*	*27*	*36*	*30*	*Ave.*
Ground Area Covered by Crown in Square Feet	82	82	82	177	82	254	177	254	177	346	171.3
D.B.H. in inches	6.2	7.2	6.5	6.3	6.6	8.4	6.7	8.2	6.9	8.3	7.13
Height to lowest branch 3 inches in diameter or larger	15	18	28	13	27	23	13	20	15	15	18.7
Age in years	42	48	36	33	37	49	42	40	24	45	39.6
Radial wood growth for 5 years in inches	0.38	0.35	0.44	0.25	0.44	0.84	0.56	0.53	0.88	0.63	0.53
Radial wood growth for 10 years in inches	0.56	0.56	0.75	0.63	0.75	1.63	0.91	0.91	1.41	0.88	0.90
Total height in feet to nearest foot	37	31	35	30	37	40	31	35	29	32	33.7
Crown density rating *	3	2	2	2	2	2	3	3	3	3	2.3
Proximity of Nearest Tree											
PINE											
Height in feet	55	——	——	——	——	——	——	8	13	12	22
Distance in feet	10	——	——	——	——	——	——	4	15	3	8
D.B.H. in inches	12.9	——	——	——	——	——	——	1.0	2.0	1.7	7.0
OAK											
Height in feet	22	——	20	——	——	——	——	——	——	——	21
Distance in feet	5.5	——	3.0	——	——	——	——	——	——	——	4.3
D.B.H. in inches	5.0	——	4.0	——	——	——	——	——	——	——	4.5

*1 — Dense
2 — Average
3 — Poor