United States
Department of
Agriculture

Forest Service

**Southern Forest
Experiment Station**

New Orleans,
Louisiana

Research Paper
SO-183
September, 1982

Influence of Managed Pine Stands and Mixed Pine/Hardwood Stands on Well Being of Deer

Lowell K. Halls and Charles E. Boyd

SUMMARY

A 172-acre enclosure where all the hardwood trees were removed or deadened and a 167-acre enclosure where hardwoods comprised 25 percent of the tree basal area were each stocked in 1965 with 3 white-tailed deer (1 buck and 2 does). In 1963, before any timber cutting practices were imposed, tree basal area averaged 111 sq. ft. per acre and forage yields averaged 260 lbs. per acre. As a result of hardwood removal, timber thinnings and prescribed burns, the forage yields increased to 1,300 lbs. per acre in the pine enclosure and 870 lbs. per acre in the pine-hardwood enclosure. Timber stands were neither thinned nor prescribed burned after 1972 and forage yields decreased to 350 lbs per acre by 1978. No deer were harvested through 1966. Overwinter populations were kept to 10 per enclosure (1 deer per 17 acres) from 1967 through 1969 and 15 (1 deer per 11 acres) from 1970 through 1972 by harvesting surplus animals. From 1973 through 1976, deer were not harvested and the overwinter population leveled off at approximately 21 deer per enclosure (1 deer per 8 acres). Hunting and other losses reduced deer populations to 5 per enclosure by 1979. The weight, condition and productivity of deer were essentially the same in both enclosures. Fawn/doe ratios were 1.44 from 1966–1969, 1.17 from 1970–1972 and 0.88 from 1973–1976. Average live weight of harvested bucks ($\geq 2\frac{1}{2}$ years) was 128 lbs. from 1967 through 1972 and 90 lbs. in 1979.

Influence of Managed Pine Stands and Mixed Pine/Hardwood Stands on Well Being of Deer

Lowell K. Halls and Charles E. Boyd

INTRODUCTION

This study was initiated in 1963 to gain a better understanding of the interrelationships among white-tailed deer (*Odocoileus virginianus*), their food and cover and timber stand conditions in a shortleaf pine-loblolly pine-hardwood forest of East Texas. The specific objective was to find whether there were differences in deer productivity and condition between a timber tract managed exclusively for pines and a tract comprising a mixture of pines and hardwoods.

SITE DESCRIPTION

The study was conducted on an upland forest site at the Stephen F. Austin Experimental Forest, approximately 12 miles south of Nacogdoches, Tex. Most of the area had never been cultivated, and none of it farmed or grazed by livestock to any extent since 1940. At the time the enclosures were constructed in 1964, there had been no deer on the area for several years.

Vegetation Composition

The dominant tree species were shortleaf pine[1], loblolly pine, southern red oak, post oak, water oak, sweetgum, hickory and winged elm. The main understory woody species, including vines, were flowering dogwood, Alabama supplejack, poison-ivy, American beautyberry, yaupon, greenbriers, yellow jessamine and hawthorns. The most common herbaceous plants were longleaf uniola, panicums, sedges, rough buttonweed, partridgeberry, devil's grandmother, ironweed and yankeeweed.

Soils

Nine soil series were represented on the study area (table 1). Most of them are medium textured and have a somewhat restricted drainage. This group is typical of upland forest soils allocated primarily to growing pine timber in East Texas.

Climate

The summer is hot and humid and the winter mild. The mean maximum July temperature is 94°F and the mean minimum for January is 39°F. The average date for the last freeze in spring is March 15 and the first in fall is November 13. Growing season averages 243 days. The long-time mean annual precipitation is 48 inches, but during this study it averaged 44 inches. The highest annual rainfall was in 1968 and 1973 (66 inches) and the lowest in 1967 (32 inches). Rainfall was fairly evenly distributed throughout the year, but it varied widely among months, from none in October 1963 to 9.6 inches in June 1968.

EXPERIMENTAL PROCEDURES

In 1963, a timbered portion of the experimental forest was delineated and divided into 2 segments, one designated as the pine enclosure (172 acres) and the other as the pine-hardwood enclosure (167 acres). The timber along a 16-foot boundary line was removed to provide a right-of-way for an 8 ½-foot high deer proof fence which was constructed in the summer of 1964 (Halls et al. 1965).

Timber Inventory and Stand Treatment

Timber was inventoried initially in August 1963. Basal area of all trees 1 inch dbh and more was measured with a 10-factor prism at 101 locations systema-

[1]Scientific plant names are listed in the appendix.

Lowell K. Halls is Supervisory Range Scientist Southern Forest Experiment Station, Forest Service—USDA Nacogdoches, Texas. Charles E. Boyd is with Texas Parks and Wildlife Dept., Nacogdoches, Texas.

Study was partially financed by Federal Aid in Fish and Wildlife Restoration Funds under Texas Project W-91-R and W-109-R. Cooperating were the School of Forestry at Stephen F. Austin State University, Nacogdoches, Tex., and the Fish and Wildlife Service, U.S. Department of Interior. D. W. Lay, R. D. Oglesby and H. C. McAnally, Texas Parks and Wildlife Department, assisted in collection of field data.

Table 1.—*Soil series in the deer enclosures at the Stephen F. Austin Experimental forest*

Series name	Classification
Bernaldo-Besner complex, fine sandy	Glossic Paleudalfs
Iuka fine sandy loam	Aquic Udifluvents
Molville-Besner complex, fine sandy loam	Typic Glossaqualfs
Sacul fine sandy loam	Aquic Hapludults
Woden fine sandy loam	Typic Paleudalfs

tically spaced at 4-chain intervals throughout each enclosure. Repeat measurements were taken at the same locations in 1968, 1973 and 1978. Timber stands within each enclosure were delineated and mapped on the basis of age, density and composition of dominant trees. The dbh size-class designation for pine trees was 1.0 to 4.9 inches for saplings, 5.0 to 8.9 inches for poles and 9.0 inches and up for sawtimber. For hardwoods, the size class interval was 1.0 to 4.9 inches for saplings, 5.0 to 10.9 inches for poles and 11.0 inches and up for sawtimber. Pine tree basal area was converted to board-foot volume (International ¼-inch) of sawtimber by Grosenbaugh's (1952) formula.

Pine Enclosure—All merchantable hardwoods were harvested in 1964. Unmerchantable hardwoods (except dogwood) 2 inches dbh and larger were injected with undiluted 2, 4-D amine (4 pounds acid equivalent per gallon). An average of 306 stems, 31 sq. ft. basal area per acre, were treated. In 1965, all hardwoods untreated the previous year, including all dogwood stems 2 inches dbh and larger, were injected with 2, 4-D amine. The ingrowth of hardwood trees 1 inch dbh and larger were injected in 1969.

In 1967, approximately 60 acres were prescribed burned in January and 65 acres in late February. Approximately 20 acres were prescribed burned in February 1971.

In 1967 scattered merchantable pines were harvested on 35 acres along a creek bottom which had previously been dominated by hardwoods. The debris and unmerchantable trees were bulldozed into wind rows and burned in late fall in preparation for planting. This area was hand planted to loblolly pine seedlings at an 8 × 8 ft. spacing in February 1968.

In 1971, two 3½-acre strips were clearcut of all merchantable pines. In 1972, the stumps, non-commercial trees and shrubs on these strips were bulldozed and piled. Thereafter the strips were mowed annually in spring to keep down woody growth. In 1978, 10 large pines were removed as a salvage operation from an infestation of southern pine beetles.

Pine-hardwood Enclosure—In 1965, approximately 25 percent (11 sq. ft. basal area per acre) of the hardwood trees within the enclosure were injected with 2, 4-D amine. In 1966, the pine timber was thinned (1954 trees, or 308 MBF of sawtimber removed).

In 1967, approximately 115 acres were prescribe burned in January and 40 acres in February. Areas along drainages were excluded from fire. Twenty-five acres were prescribed burned again in February 1971.

In 1970, 35 acres were clearcut of all merchantable pines, but hardwood trees 4 inches dbh and larger were retained. All of the 35 acres except two 3½-acre strips were chopped with a Marden brush cutter and burned in December. Loblolly pine seedlings were hand planted on the site-prepared portion of the clearcut area at an 8 × 12 ft. spacing in February 1971. Approximately 4 percent of the standing hardwood trees (50 trees with a total basal area of 44 sq. ft.) died as a result of the burning and chopping treatment. The tree stumps, shrubs and non-commercial trees were bulldozed, piled and burned on the two 3½-acre strips in January 1972. Thereafter strips were mowed annually in spring to keep down woody growth. In 1976, 65 large pine trees were removed as a salvage operation from an infestation of southern pine beetles.

Forage Yields

Beginning in 1963, forage yields were sampled annually (except for 1972) in both enclosures during late summer and early fall at timber inventory sites. At each location three 3.1 × 3.1 sq. ft. quadrats were arranged within a 15-foot radius circle such that the same quadrat area was not sampled again for 8 years. On each quadrat, an estimate was made of the percentage by weight that each species or group of species comprised of the current season's growth of herbage and browse up to a height of 5 feet. The herbage and browse were then clipped and bagged separately and later dried at 160°F to a constant weight. Dry weight yields in pounds per acre for species and groups of species were calculated for each enclosure and for each timber stand.

Browse Utilization

Browse utilization was sampled bimonthly from September 1966 through July 1967 by the twig-count method (Halls, et al. 1970). From the fall of 1969 through the fall of 1978, utilization estimates were based on the number and length of twigs removed from current annual growth. Data were collected from 101 permanent 0.25-milacre quadrats located in a grid pattern in each enclosure. The number of twigs browsed was recorded by species in each quadrat during July (summer use), October (fall use) and early March (winter use). Tips of the browsed twigs were marked with paint so that they would not be counted in subsequent observations. Once a twig was browsed, it was seldom browsed again. A total twig count of each species on each quadrat was made in March just prior to spring greenup, and the average length of browsed

and unbrowsed twigs was recorded. The relative use by season was calculated by dividing the number of twigs browsed during a particular season by the number of twigs formed during the year. Yearlong utilization in percent was calculated by the formula:

$$\frac{\text{Length of unbrowsed twigs} - \text{Length of browsed twigs}}{\text{Length of unbrowsed twigs}} \times \frac{\text{Number of browsed twigs}}{\text{Total number of twigs}} \times 100$$

This system of measuring utilization indicated the relative preference of browse species, and for each species, the proportion of twigs eaten seasonally. The supposition was made that when deer consumed twigs they also ate the attached leaves, except for deciduous species in the winter. The data do not show the relative contribution of browse to the deers' total diet because the deer ate many other foods. Too, it is supposed that the deer frequently ate only the leaves, leaving no identifying mark on the twigs.

Additional information on deer diet was obtained by identifying the stomach contents of deer harvested and removed from the enclosures during 1968–1970.

Mast Yields

In 1963, acorns and other woody species fruits were sampled in 101 triangular traps (38 inches on each side, and 3 feet in height) systematically spaced at grid intersections in the pine-hardwood enclosure. In 1964, the number of traps was increased to 191. Number and oven dry weight of sound mature fruits were recorded annually at 2- to 4-week intervals from mid-September to mid-January through 1978.

Yield and Utilization of Understory Woody Plant Fruits

In both enclosures, the presence or absence of fruit was recorded for understory woody plant species from 1963 through 1975 on one hundred 0.01-acre circular plots located in a grid pattern at the same general location as the forage and timber sampling points. In addition, fruit yields were taken for American Beautyberry from 1963 through 1972; rusty blackhaw, 1967 and 1972; fringetree, 1963 through 1967 and 1972, and flowering dogwood, 1963 through 1968.

A qualitative assessment of fruits eaten by deer was made by examining 10 deer droppings monthly in each enclosure from April 1965 through December 1969, and from May 1973 through December 1975. No effort was made to quantify the amount of fruits eaten.

Deer Inventory and Condition Records

In the spring of 1965, a 2½ year old buck and two 2½ year old pregnant does were released into the pine enclosure, and a 2½ year old buck, a 2½ year old pregnant doe and a 1½ year old doe were released into the pine-hardwood enclosure.

Deer numbers were inventoried annually in late fall and winter by drive counts. Drivers would line up approximately 50 feet apart and walk abreast through each enclosure. Deer were tallied as they crossed a cleared strip, or as they broke back through the line. In addition, during late spring and early summer, track counts were made along dragged roads, and observations were made by spotlight checks and from observation towers to collect information on fawn survival, reproduction and condition.

In order to keep deer numbers at prescribed levels of stocking a specified number of deer were removed by shooting or trapping in the late fall or winter. As much as possible, overwinter deer populations were kept at 10 per enclosure from 1966 through 1969, and 15 per enclosure from 1970 through 1972. There were no scheduled removals of deer from 1973 through 1977, but several were removed in 1978 and in 1979 when the study was terminated. Body weight, age, antler dimensions on bucks (when available) and general condition were recorded for all removed deer. Necropsies were performed for dead deer at the early and late stage of the study.

RESULTS

Timber Stand Conditions

Pine Enclosure—In 1963, before any trees were cut, basal area averaged 112 sq. ft. per acre, 68 sq. ft. in pines and 44 sq. ft. in oaks and other hardwoods (table 2). Approximately 75 percent of the pine tree basal area was in the sawtimber size class. Hardwood tree basal area was fairly evenly spaced among size classes. Volume of pine sawtimber averaged 6,107 bd. ft. per acre.

Considerable difference existed among timber stands in total basal area and in stand composition.

Table 2.—*Tree basal area (sq. ft. per acre) by size classes in the pine enclosure, 1963 and 1978*

Kind of trees	Size class			Total
	Sawtimber	Poles	Saplings	
1963				
Pines	52	12	4	68
Oaks	9	7	3	19
Misc. hardwoods	5	7	13	25
Total	66	26	20	112
1978				
Pines	64	15	6	85
Oaks	0	0	5	5
Misc. hardwoods	0	1	9	10
Total	64	16	20	100

For example, total tree basal area ranged from 66 sq. ft. per acre to 145 sq. ft. per acre; and the hardwood component ranged from zero to 59 sq. ft. per acre.

As a result of timber harvests, chemical treatments, pine regeneration and growth of residual pines, the tree basal area and composition changed considerably among stands during the course of the study. The greatest change occurred in a stand along a creek bottom with a tree basal area of 105 sq. ft. per acre in 1963. Hardwoods comprised 56 percent of the dominant overstory. With hardwood removal in 1964 and the harvest of all merchantable pines in 1967, the tree basal area was reduced to zero. The area was planted to loblolly pines in 1968 and by 1973, the pine tree basal area had increased to 15 sq. ft. per acre. By 1978, basal area had reached 80 sq. ft. per acre, 55 sq. ft. in pines and 25 sq. ft. in hardwoods. Fifty-six percent of the pine basal area consisted of pole-size trees, whereas 93 percent of hardwood basal area was in sapling-size trees.

Substantial increases in pine tree basal area occurred in 7 stands. By 1978, all supported 86 sq. ft. or more per acre, of which 83 percent were sawtimber-sized trees. Hardwoods comprised 15 percent of the total tree basal area, 93 percent were in sapling-size trees. Decrease in pine tree basal area in one stand was a result of timber mortality from southern pine beetles.

For the entire enclosure, volume of pine sawtimber averaged 8,696 bd. ft. per acre in 1978, an increase of 2,589 bd. ft. per acre over the 1963 volume. Even though pines comprised nearly 100 percent of the overstory, the well-developed understory consisted mainly of woody vines and shrubs and sapling size hardwood trees.

Pine-hardwood Enclosure—In 1963, tree basal area averaged 110 sq. ft. per acre, 70 sq. ft. in pines and 40 sq. ft. in oaks and other hardwoods (table 3). Approximately 71 percent of the pine tree basal area was in the sawtimber-size class. Hardwood tree basal area was fairly evenly distributed among size classes.

Table 3.—*Tree basal area (sq. ft. per acre) by size classes in the pine-hardwood enclosure, 1963 and 1978*

Kind of trees	Size class			Total
	Sawtimber	Poles	Saplings	
1963				
Pines	50	12	8	70
Oaks	12	8	5	25
Misc. hardwoods	3	5	7	15
Total	65	25	20	110
1978				
Pines	50	13	9	72
Oaks	14	3	2	19
Misc. hardwoods	2	2	5	9
Total	66	18	16	100

Volume of pine sawtimber averaged 7,448 bd. ft. per acre in 1963. The injection of some hardwoods with 2, 4-D amine in 1965 and the pine timber thinning in 1966 reduced the tree basal area in the enclosure to approximately 70 sq. ft. per acre, 76 percent in pines and 24 percent in hardwoods. All stands were reduced when possible, to the same proportionate amount in total basal area.

Pine tree basal area was reduced to zero in 2 stands in 1970, but most of the pole and sawtimber-size hardwoods were left standing. The stands were planted to pines in 1971 and by 1978, the pine tree basal area had reached 46 sq. ft. per acre, with 72 percent of basal area in sapling-size trees. Hardwood tree basal area was 15 sq. ft. per acre in these stands, with 75 percent in sawtimber-size trees, 25 percent in sapling, and none in pole size trees.

For the remaining stands in 1978, the pine tree basal area ranged from 52 sq. ft. to 101 sq. ft. per acre. Approximately 70 percent of tree basal area was in sawtimber-size trees. Hardwood tree basal area ranged from 12 sq. ft. to 54 sq. ft. per acre, with approximately 55 percent in sawtimber size trees. For the entire enclosure, volume of pine sawtimber averaged 6,619 bd. ft. per acre. The decrease of 839 bd. ft. per acre since 1963 was a result of the thinning in 1966 and the pine clearcut of 2 stands. Midstory and understory consisted mainly of woody vines and shrubs and hardwood tree species in the sapling and pole size class.

Forage Yields

Pine Enclosure—Before any timber was cut in 1963, forage yields averaged 237 lbs. per acre—166 lbs. per acre of browse and 71 lbs. per acre of herbage (table 4). Yields of preferred browse species averaged 27 lbs. per acre—11 for evergreens and 16 for deciduous species. (Preference classification by species is given in the appendix.) Approximately ½ of the total browse consisted of low preference species. For the enclosure as a whole, the forage yields increased for several years after 1963 and peaked at 1,321 lbs. per acre in 1968. From 1969 through 1973, the yields remained fairly constant, but declined steadily thereafter to 359 lbs. per acre in 1978. Species contributing most were winged elm, trumpetcreeper, sweetgum, poison-ivy, greenbriers and longleaf uniola.

Changes in forage yields through the course of the study were closely related to timber stand conditions and treatments. Opening of the timber stand by removal of hardwoods in 1964 caused an immediate growth response of understory plants, and by 1965, the forage yields had more than doubled. The biggest increase was in herbaceous plants, mainly longleaf uniola.

The combination of hardwood removal in all stands, the harvest of scattered pines in one stand and the

Table 4.—*Forage yields (lbs per acre) in the pine enclosure, 1963 through 1978*

Class of forage	1963	1964	1965	1966	1967	1968	1969	1970	1971	1973	1974	1975	1976	1977	1978
Browse	166	149	212	229	307	472	454	650	513	539	341	317	306	169	188
High preference															
Evergreen	11	8	16	18	20	44	32	43	50	54	39	20	14	9	7
Deciduous	16	22	36	48	73	118	138	174	117	100	86	63	60	37	29
Medium preference															
Evergreen	2	2	7	15	9	21	29	39	29	35	16	16	9	7	5
Deciduous	55	57	66	74	89	158	117	200	142	162	97	104	123	58	74
Low preference															
Evergreen	16	6	9	6	14	16	14	36	57	24	20	20	10	6	8
Deciduous	66	54	80	70	104	115	124	158	118	164	83	94	90	52	65
Herbaceous	71	95	365	405	328	849	660	596	471	540	486	435	381	223	171
Grasses and grass-likes	61	75	296	336	279	552	508	433	374	421	388	366	288	192	139
Composites	4	10	37	17	25	199	91	103	64	66	69	35	47	16	18
Legumes	2	1	4	8	7	35	28	19	9	21	7	13	18	8	6
Miscellaneous	4	9	28	44	17	93	33	41	24	32	22	21	28	7	8
Total	237	244	577	634	635	1321	1114	1246	984	1079	827	752	687	392	359

prescribed burning in late winter of 1967 were largely responsible for the high yields in 1968. Composites increased proportionately greater than any other plant group, probably because of the soil disturbance associated with planting site preparation.

Because the timber stands were neither burned nor thinned after 1971, the overstory canopy became increasingly dense and shaded out many of the understory plants. Forage yields declined accordingly. Part of the forage decline was attributed to shrubs and small hardwood trees growing beyond the reach of deer (5 ft.). In the small clearcut strip which was mowed annually, forage yields consistently averaged over 2,000 lbs. per acre.

Forage yields in the harvested stand illustrate the extent to which forage conditions change in response to clearcutting, planting and the subsequent closing of the pine canopy (table 5). In the uncut stand (tree basal area of approximately 105 sq. ft. per acre), forage yields were 323 lbs. per acre. Browse made up 62 percent of the total. During the first growing season after site preparation and planting of pine seedlings, the forage yields increased to 2,059 lbs. per acre. Herbaceous species comprised 72 percent of the total yields, with annual composites predominating. Herbaceous yields decreased the next 3 years, mainly because of decline in annual composites and miscellaneous forbs, but the decrease in herbaceous yields was compensated by increases in browse yields. Total forage yields peaked the third growing season. Thereafter, as many of the browse plants grew above 5 feet in height and partially shaded out the herbaceous species and as the pine tree canopy closed in, the yields of all forage classes steadily declined to a low of 74 lbs. per acre the 11th growing season after site preparation.

Forage yields increased in response to prescribed burning and hardwood removal in mature stands and declined with exclusion of fire and cutting (fig. 1). In 1963, the tree basal area was 130 ft. sq. per acre and forage yields were 171 lbs. per acre. With the removal of hardwoods in 1964 and prescribed burning in 1967, forage yields increased to 1,466 lbs. per acre by 1968. Tree basal area was approximately 79 sq. ft. per acre. Thereafter, with the exclusion of fire and no timber cutting, the tree basal area increased to 111 sq. ft. per acre and forage yields declined to 156 lbs. per acre in 1978.

Pine-hardwood Enclosure—Total forage yields averaged 283 lbs. per acre in 1963, 180 pounds of browse and 103 pounds of herbage (table 6). Species contributing most were longleaf uniola, western ragweed, American beautyberry, flowering dogwood, yellow jessamine, greenbriers, winged elm, sweetgum and southern red oak. Yields of preferred browse averaged 56 lbs. per acre—12 lbs. for evergreens and 44 lbs. for deciduous species.

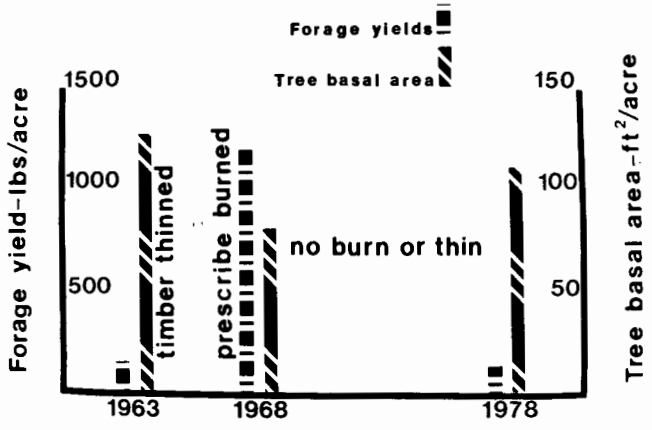


Figure 1.—*Forage yields increased when timber stands were thinned and prescribe burned, but decreased with the exclusion of fire and timber cutting.*

Table 5.—*Forage yields (lbs per acre) after a clearcut harvest of timber and site preparation*

Class of forage	Prior to cutting	Growing seasons after clearcut and site preparation										
		1	2	3	4	5	6	7	8	9	10	11
Browse	200	581	726	1096	841	...	524	220	249	132	51	52
Herbaceous						...						
Longleaf uniola	93	212	238	399	306	...	109	137	110	75	43	15
Panicums	8	207	218	151	134	...	95	54	10	17	0	0
Bluestems	0	10	24	37	91	...	40	1	0	0	0	0
Composites	7	584	341	324	131	...	78	33	1	14	0	0
Miscellaneous	15	465	208	205	156	...	119	23	19	53	10	7
Total	323	2059	1755	2212	1659	...	965	468	389	291	104	74

Table 6.—*Forage yields (lbs per acre) in pine-hardwood enclosure, 1963 through 1978*

Class of forage	1963	1964	1965	1966	1967	1968	1969	1970	1971	1973	1974	1975	1976	1977	1978
Browse	180	117	110	97	182	222	231	239	263	353	335	286	261	155	147
High preference															
Evergreen	12	7	6	6	15	27	17	16	12	13	22	8	10	6	4
Deciduous	44	22	21	26	48	57	56	47	60	60	70	46	35	21	15
Medium preference															
Evergreen	8	1	2	2	2	5	9	13	6	8	8	11	10	8	8
Deciduous	52	46	37	20	56	61	65	60	77	108	70	78	70	40	58
Low preference															
Evergreen	12	3	12	9	7	20	18	15	12	47	55	46	42	16	10
Deciduous	52	38	32	34	54	52	66	88	96	117	110	97	94	64	52
Herbaceous	103	66	76	170	249	354	347	249	347	516	439	366	242	144	112
Grasses and grass-likes	69	40	58	116	201	280	291	203	175	418	390	302	198	119	92
Composites	21	12	8	30	16	35	24	12	112	48	26	41	13	6	8
Legumes	3	7	2	6	12	16	14	7	19	19	6	7	6	2	4
Miscellaneous	10	7	8	18	20	23	18	28	41	31	17	16	25	17	8
Total	283	183	186	267	431	576	578	488	610	869	774	652	503	299	259

Forage yields remained low through 1965. Then, as a result of the partial hardwood removal in 1966, the pine timber thinning in 1967 and the prescribed burn in 1968, yields increased to nearly 600 lbs. per acre in 1968 and 1969. In 1970, herbage yields decreased or remained stable in all stands except one, which was clearcut. Mainly because of the increased forage growth in the clearcut, the average yields of browse and herbage in the enclosure increased to 869 lbs. per acre in 1973. Thereafter, the timber stands were not cut or prescribe burned, thus the crown cover increased, many of the browse plants grew beyond the reach of deer and the forage yield steadily decreased to 259 lbs. per acre by 1978.

In general, the per acre yields of preferred browse species averaged about 25 percent of the total browse yields and the deciduous species about 75 percent of the preferred species. The percentages were not appreciably affected by timber stand conditions and treatments.

Forage responses within each stand were closely related to timber stand density and the cutting and burning treatment. In 1963, when the tree basal area in one stand was 113 sq. ft. per acre the forage yields averaged 210 lbs. per acre. With a light timber thinning in 1965 and a prescribed burn in 1967, yields increased to 448 lbs. per acre by 1968. Tree basal area was approximately 80 sq. ft. per acre with 33 percent in hardwoods. By 1978, with no timber cutting or prescribed burns the tree basal area increased to 110 sq. ft. per acre with 30 percent in hardwoods and the forage yield declined to 140 lbs. per acre. Similar trends in forage yields and tree basal area were shown in a second stand.

Forage yields in the clearcut stand further illustrate the rapid change that results from timber removal and site preparation. Forage yields averaged 658 lbs. per acre in the uncut stand. In 1970, during the first growing season after the pine timber was cut but before the area was chopped and burned for site preparation, the total forage yield was 1,159 lbs. per acre. In 1971, after site preparation and planting, yields increased to 1,963 lbs. per acre. Yields peaked at 2,727 lbs. per acre in 1973, the third growing season after site prepara-

tion. Thereafter, as shrubs and small trees grew above 5 feet in height and the tree canopy began to close, forage yields declined to 568 lbs. per acre by 1978. Prior to site preparation the browse-herbage ratio was approximately 55:50 however, because of the great influx of herbaceous annuals the ratio changed to 24:76 in 1971. Browse yields continued to be less than herbage from 1976 through 1978 but at a ratio of approximately 40:60. The main browse species were blackberries and greenbriers, the dominant herbaceous species were bluestem and panic grasses and the composites.

Browse Utilization

Pine Enclosure—Because of the high variability in use among browse species, it was not possible to detect significant differences among years even though browse yields and deer stocking changed considerably from 1969 through 1977. On the average, 12 of the most commonly occurring species were browsed heavily (≥ 20%). Laurel and saw greenbriers, red mulberry, climbing dogbane, yellow jessamine and Alabama supplejack showed the heaviest use (table 7). Most of these high-use species were grazed relatively heavier in the summer and fall than in the winter. Conversely, the relative seasonal use of nearly all the low-use species was heavier in the fall and winter than in the summer.

Species that were utilized heaviest during the last 2 and 3 years of the study were flowering dogwood, red maple, common persimmon, shortleaf and loblolly pines, yaupon, and blackgum.

On the average, evergreen species such as laurel greenbrier, climbing dogbane, yellow jessamine, honeysuckle and yaupon were browsed more heavily in fall and winter than in the summer. There were no consistent relationships between degree of utilization and the frequency of occurrence or the number of observed twigs. About ½ of the species that occurred in at least 5 percent or more of the sample plots had an average utilization of 10 percent or greater.

Stomach analyses of deer collected during the winters of 1968, 1969 and 1970 indicated that browse constituted the major portion of the deer's winter diet. Yellow jessamine, greenbriers, honeysuckle, water oak and yaupon were the most heavily used forage species (table 8). These evergreen or semi-evergreen species constituted 65 percent to 85 percent of the stomach contents, and with the exception of water oak, were among the heavy utilization species recorded in the browse survey.

Pine-hardwood Enclosure—Utilization varied considerably among species and years regardless of the overall ranking in use (table 9). On the average, 11 of the commonly occurring species were heavily grazed (≥ 20%). Saw greenbrier and trumpetcreeper received the heaviest use (33%). Even among the heavily-used species, some of the plants would receive little or no use during certain seasons and years. Conversely, some plants of the species which were lightly used on the average were heavily browsed occasionally.

With very few exceptions, species which occurred on at least 5 percent of the plots and which showed 2 percent or more of use were eaten to some extent throughout the year. On the average, however, most of the heavily used species had the highest relative use in the spring and summer, and most of the lightly used species had the highest relative use in the winter. Thus deer extended their diet to include many of the least palatable species when food became scarce during the winter.

On the average, evergreen species such as yellow jessamine and honeysuckle were utilized most heavily during the winter. Although deer generally prefer evergreen browse species in winter, some species such as the pines are usually eaten only under stress conditions.

Because of the wide yearly variation in browse utilization, it was difficult to establish any consistent trend for all species. However, during the last 2 or 3 years of the study, the degree of utilization was considerably heavier than in previous years on the following low-utilization species: peppervine, American beautyberry, flowering dogwood, crossvine, shortleaf and loblolly pine, white oak and red maple.

The evergreens, yellow jessamine, yaupon and partridgeberry constituted the major portion of the contents of the deer stomach samples collected in the winter of 1969 and 1970 (table 8). Although pine needles are generally considered a low preference browse in 1970, they were found in 12 of the deer stomachs.

Mast Yields

Annual yields of sound mature mast in the pine-hardwood enclosure averaged only 9.9 lbs. per acre, ranging from 0.1 to 34.0 lbs. per acre (table 10). On the average, acorns comprised 55 percent of the total mast yields but this varied from a negligible amount to 96 percent of total yields. Southern red, water and post oaks produced 90 percent of the acorns. In the 2 years of heaviest mast yields, 1970 and 1973, pine seeds comprised 56 percent and 70 percent, respectively, of the total yields.

On the average, 56 percent of the fruit had fallen by November 8 and 95 percent by December 20. Fruit fall was earliest in the autumn when acorns were the dominant fruit crop and latest in the fall when pine seeds were most abundant.

Understory Woody Plant Fruit Yields and Utilization

Understory woody plants produced substantial amounts of fruits but the yields per plant and the proportion of plants bearing fruit varied considerably

Table 7.—*Occurrence and utilization of commonly occurring browse species in a pine enclosure, 1969–1977*

Species	Frequency of occurrence[1]	Observed twigs	Proportion of twigs grazed			Annual utilization	
			Summer	Fall	Winter	Mean	Range
	(%)	(N)	(%)	(%)	(%)	(%)	(%)
Heavy utilization (≥ 20%)							
Laurel greenbrier	7	85	25	59	16	41	14–73
Red mulberry	10	50	51	33	16	30	20–68
Climbing dogbane	16	114	26	35	39	29	16–42
Saw greenbrier	36	837	44	37	19	28	16–40
Yellow jessamine	44	838	15	46	39	28	16–50
Alabama supplejack	24	550	36	43	21	28	22–37
Trumpetcreeper	24	220	59	21	20	25	10–42
Cat greenbrier	22	207	36	42	22	24	16–32
Black cherry	...	...	...	...	...	...	...
Possumhaw	5	142	27	46	27	22	6–38
Honeysuckle	6	178	9	34	57	22	16–39
Common greenbrier	19	434	40	34	26	21	10–35
Blackberry	52	331	14	42	44	20	12–28
Moderate utilization (10–19%)							
Yaupon	5	739	10	11	79	14	7–32
St. Andrewscross	9	254	26	38	36	12	3–22
Devil's-walkingstick	5	6	0	22	78	12	0–31
Common sassafras	18	223	30	37	33	11	2–26
Shining sumac	10	35	51	33	16	10	0–22
Low utilization (< 10%)							
Rusty blackhaw	9	297	31	34	35	9	3–24
Tree sparkleberry	8	630	29	44	27	8	2–17
Winged elm	25	1456	47	27	26	8	4–16
Poison-ivy	52	600	23	28	49	7	2–14
Dogwood	9	592	26	41	33	7	2–17
American beautyberry	42	1224	6	52	42	7	1–10
Peppervine	9	67	42	3	55	7	2–18
Virginia creeper	35	96	30	67	3	6	0–36
Water oak	9	262	22	18	60	6	2–8
Red maple	6	48	11	38	51	5	0–23
Common persimmon	6	41	42	3	55	5	0–31
Loblolly pine	9	174	1	1	98	5	0–24
Shortleaf pine	18	113	0	2	98	4	0–26
Muscadine grape	38	685	12	28	60	4	1–9
Post oak	5	105	38	16	46	3	0–8
Summer grape	7	47	26	26	48	3	0–14
Sweetgum	19	548	5	40	55	2	0–4

[1]Relative occurrence on 101 0.25-milacre quadrats.

among plants, species and years (Lay 1979). For example, American beautyberry yields ranged from trace amounts to an estimated 54 lbs. per acre in the pine-hardwood enclosure and up to 68 lbs. per acre in the pine enclosure. On the average, 92 percent of the sampled plants bore fruit in 1964 but only 63 percent in 1975.

Fruit yields of flowering dogwood in the pine-hardwood enclosure ranged from 5 to 27 lbs. per acre. The frequency of fruiting ranged from 51 percent to 62 percent.

For rusty blackhaw, 7 percent of the plants in the pine enclosures and 8 percent of the plants in the pine-hardwood enclosures produced fruits from 1963 through 1969. The yields in 1967 averaged 5 lbs. per acre.

Fruit yields of fringetree ranged from 2 to 13 lbs. per acre. About ½ of the trees of 1 or more inches in diameter fruited each year, with production ranging from ½ to 2 lbs. per tree.

For all the above species, fruiting frequency and yields were directly related to diameter size of main stem. In this study, it appeared that the understory browse plants produced substantially more fruit than the overstory, even where the timber stand was 25 percent hardwoods.

The fruits of 24 species or species groups of woody plants and 24 herbaceous plant fruits were identified in deer pellets (table 11). On the average, 53 percent of the examined pellets in the pine enclosure and 84 percent of the pellets in the pine-hardwood enclosure contained seeds of woody plants. For herbaceous spe-

cies, the percentages were 24 and 20, respectively. American beautyberry was by far the most frequently ingested fruit in both enclosures. Next, in frequency of occurrence, were sumac and blackberries, and in the pine-hardwood enclosure, oak and dogwood fruits. The most frequently consumed herbaceous plant fruits were grasses, pokeweed and partridgeberry.

Frequency of occurrence of fruits in deer pellets was highest for each species during the time of year when the fruits matured, and least during February – April. For example, American beautyberry fruits were usually found in pellets from July through November, sumac from September through January, and partridgepea from July through December. On the other hand, the availability of fruits was rather short-lived (May and June) for most soft mast fruits such as blackberries. In some cases, the use of fruit extended after it had fallen to the ground. Occasionally there was no evidence of fruit consumption.

Deer Characteristics

Pine Enclosure—No deer were harvested in 1966, but from 1967 through February 1969, 13 animals (6 male fawns, 3 bucks and 4 does) or 27 percent population were removed each fall in order to keep the overwinter population at approximately 10 deer, 1 per 17 acres (table 12). One 6½ year old doe, 1 male fawn, 2 female fawns, and one 2½ year old buck were found dead from unknown causes. Because of an apparent scarcity of bucks, two 1½ year old bucks were added to the herd in the spring of 1968. During the 4-year period, 15 mature does (2 does ≥ 2½ years old in 1966, 3 does in 1967, 5 does in 1968 and 5 does in 1969) gave birth to 22 live and healthy fawns, an average ratio of 1.46 fawns per doe (table 13). Two of the fawns were unaccounted for during the winter census. One of the does that was placed in the enclosure in 1965 consistently dropped 2 fawns each spring but usually 1 died before winter.

From 1970 through 1972, when overwinter populations were 14–16 deer, approximately 1 per 11 acres, 8 animals or 16 percent of the fall population were removed (table 12). One mature buck, one 1½ year old buck, and 2 mature does were found dead. During this period 15 mature does (four does ≥ 2½ years old in 1970, 5 does in 1971 and 6 does in 1972) gave birth to 20 fawns, an average ratio of 1.33 fawns per doe (table 13). Four fawns and one 1½ year old doe were unaccounted for.

From 1973 through 1976 no deer were harvested (table 12). The overwinter population reached 29 in 1976, 1 deer per 6 acres. Thirty-seven does (8 does ≥ 2½ years old in 1973, 8 does in 1974, 10 does in 1975 and 11 does in 1976) produced 29 fawns, 0.78 fawns per doe (table 13). Seventeen of these fawns were unaccounted for in the winter census, indicating a high mortality rate during the summer and fall. One mature buck and 3 mature does were unaccounted for. One mature doe was found dead.

The overwintering population in 1977 and 1978 was 21 deer. Although there were some fawns dropped each year, the survival was poor and the small increment was counterbalanced by an unaccountable loss of older aged deer.

Table 8.—*Percentage content of stomachs collected from deer during the winter*

Food item	Pine enclosure			Pine-hardwood enclosure	
	1968 (n=3)[1]	1969 (n=6)	1970 (n=2)	1969 (n=4)	1970 (n=2)
Yellow jessamine	68	29	3	34	40
Yaupon	...	15	4	14	10
Greenbriers	8	21	42	1	5
Japanese honeysuckle	2	2	5	...	...
Water oak	3	7	4	1	5
Blueberry	2	3	7	...	...
Pine	...	1	...	1	12
Tree sparkleberry	...	...	...	2	...
Blackberry	2	...	...	...	...
Willow oak	2	...	...	...	...
Unidentified browse	9	5	21	11	17
Fungi	...	7	5	...	...
Fruits	...	1	7	7	...
Forbs	...	7	...	6	...
Partridgeberry	...	...	...	23	10
Grass	2	2	1	...	1
Total	100	100	100	100	100

[1]Number in parenthesis refer to number of deer stomachs sampled.

Table 9.—*Occurrence and utilization of commonly occurring browse species in the pine-hardwood enclosure, 1969–1977*

Species	Frequency of occurrence[1] (%)	Observed twigs (N)	Proportion of twigs grazed			Annual utilization	
			Summer (%)	Fall (%)	Winter (%)	Mean (%)	Range (%)
Heavy utilization (≥ 20%)							
Trumpetcreeper	9	86	66	20	14	33	16–51
Saw greenbrier	26	597	45	33	22	33	15–51
Climbing dogbane	13	77	41	28	31	30	10–55
Cat greenbrier	11	64	44	37	19	29	20–42
Black cherry	5	26	17	27	56	28	7–45
Yellow jessamine	43	637	26	34	40	28	16–40
Red mulberry	5	19	50	35	15	28	20–50
Common greenbrier	24	492	47	32	21	26	18–42
Alabama supplejack	24	458	42	34	24	23	15–33
Sugar hackberry	7	430	56	16	28	23	11–35
Water oak	9	161	43	21	36	20	5–36
Blackberry	32	200	14	33	53	20	13–28
Moderate utilization (10-19%)							
St. Andrewscross	10	140	39	40	21	17	9–37
Littlehip hawthorn	3	78	44	37	19	16	0–24
Common sassafras	8	37	33	22	45	16	2–33
Parsley hawthorn	3	39	39	25	36	14	0–25
Yaupon	3	17	10	54	36	14	0–38
Winged elm	23	1313	63	20	17	12	7–18
Possumhaw	7	643	42	31	17	12	8–22
Honeysuckle	3	139	7	33	60	11	4–27
Summer grape	28	42	26	13	61	11	0–31
Low utilization (< 10%)							
White ash	3	27	66	11	23	9	0–17
Peppervine	10	57	33	14	43	8	0–36
Shining sumac	8	59	34	33	34	7	0–16
American beautyberry	28	485	12	42	46	7	3–16
Devils'-walkingstick	3	4	77	0	23	7	0–25
Dogwood	20	414	28	31	41	6	2–14
Poison-ivy	42	307	48	13	39	6	2–13
Tree sparkleberry	15	1114	36	22	42	6	2–10
Rusty blackhaw	14	555	39	20	41	6	2–13
Crossvine	6	25	17	66	17	5	0–24
Willow oak	7	319	36	18	46	5	1–9
Carolina buckthorn	6	38	14	26	60	4	3–12
Shortleaf pine	28	256	16	11	73	3	0–9
Loblolly pine	21	255	24	0	76	3	0–6
White oak	10	171	10	19	71	3	0–14
Muscadine grape	28	552	14	26	60	3	0–9
Red maple	10	77	37	4	59	2	0–13
Virginia creeper	28	103	55	10	35	2	0–8
Post oak	10	53	10	19	71	2	0–8

[1]Relative occurrence on 100 0.25-milacre quadrats.

Table 10.—*Yields of mature, sound mast in pine-hardwood deer enclosure (oven-dry lbs/a)*

Kind of trees	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1978	Avg.
Oaks	4.0	2.1	1.6	0.1	17.5	0	12.5	7.6	3.1	6.1	7.5	6.1	1.6	1.3	11.7	5.5
Pines	.6	0	0	3.6	.4	.1	.4	12.8	.1	.1	23.7	0	.2	.4	0	2.8
Flowering dogwood	.2	.1	.2	.3	.2	0	0	.4	1.4	2.4	2.7	4.1	1.9	1.1	.4	1.0
Misc.	.2	.4	.1	.2	.1	0	.4	2.1	.2	.9	.1	.8	.7	.1	1.8	.6
Total	5.0	2.6	1.9	4.2	18.2	0.1	13.3	22.9	4.8	9.5	34.0	11.0	4.4	2.9	13.9	9.9

Table 11.—*Frequency of seed found in deer pellets, 1965–1969; 1973–1975*[1]

Plant species	Pine enclosure		Pine-hardwood enclosure	
	Mean (%)	Range (%)	Mean (%)	Range (%)
Woody plants				
American beautyberry	23	12–49	24	7–56
Shining sumac	6	2–14	12	0–24
Blackberries	8	3–23	7	3–10
Greenbriers	1	0–3	1	0–3
Oaks	tr[2]	...	13	0–28
Flowering dogwood	tr	...	3	0–7
Mexican plum	tr	...	2	0–8
Deciduous holly	1	0–11	1	0–9
Misc.[3]	4	0–17	6	0–16
Herbaceous plants				
Grasses	7	0–21	7	0–38
Pokeweed	7	0–20	3	0–5
Partridgeberry	5	0–22	6	0–22
Misc.[4]	4	0–18	6	0–33

[1]A total of 855 pellets examined in each enclosure.
[2]Less than 0.5 percent.
[3]Grape, St. Andrewscross, blueberry, poison-oak, Japanese honeysuckle, peppervine, Virginia willow, pine, yaupon, American elder, hawthorn, white fringetree, tree sparkleberry, honey locust, blackgum and Alabama supplejack.
[4]Sedge, nightshade, longleaf uniola, violet, showy partridgepea, rattlebox, tickclover, downy milkpea, lespedeza, butterflypea, yellow passion flower, prickly sida, bundleflower, heartwing sorrel, maypop passion flower, bigroot, morning glory, land swamp smartweed, rough buttonweed, flax and groundcherry.

Table 12.—*Deer removal and mortality by years, 1966–1979*

Years	Pine enclosure				Pine-hardwood enclosure			
	Removed (N)	Unaccountable loss (N)	Death loss (N)	Overwinter population (N)	Removed (N)	Unaccountable loss (N)	Death loss (N)	Overwinter population (N)
1966–1969	13	2	5	9–11	6	4	1	6–10
1970–1972	8	5	4	14–16	12	2	0	15–16
1973–1976	0	21	1	17–29	0	23	5	15–21
1977–1979	7	unknown	15	21–5	9	unknown	11	24–5
Total	28	28	25	...	27	29	17	

Table 13.—*Deer fecundity*

Years	Pine enclosure			Pine-hardwood enclosure		
	Does[1] (N)	Fawns[2] (N)	Fawns/doe (Ratio)	Does[1] (N)	Fawns[2] (N)	Fawns/doe (Ratio)
1966–1969	15	22	1.46	12	17	1.42
1970–1972	15	20	1.33	19	19	1.00
1973–1976	37	29	0.78	32	31	0.97
Total	67	71	1.06	63	67	1.06

[1]Breeding does ≥ 2½ years old.
[2]Fawns recorded live and healthy at birth or shortly after.

In August 1978 and February 1979, 7 deer were harvested in order to obtain information on herd condition and age structure. The harvest consisted of 6 bucks ranging in age from 3½ to 6½ years and one 4½ year old doe. The lack of fawns and 1½ year old deer was further evidence that the fawn increment had been neglible for at least 2 years. Including the above 7 harvested deer, the accountable death loss from June 1978 to December 1979 was 22 (11 bucks ≥ 2½ years old, 8 mature does, 2 female fawns and 1 male fawn). Part of the high death loss in 1979 was attributed to the harassment and wounding of deer by hunters. The known number of deer at the close of the study in March 1980 was 1 buck and 4 does.

During the course of the study, 28 deer (23 males and 5 females) were harvested, and 25 (11 males and 14 females) were found dead of unknown causes (table 14). The proportion of males to females was 64:36. Twenty-eight deer were unaccountably lost. From 1967 through 1972, when forage conditions were relatively good, fawn mortality was approximately 20 percent, but from 1973 through 1976, when populations were highest and forage yields were on a steady decline, the fawn mortality was approximately 54 percent.

The condition of deer was noticeably better during the early years of the study when stocking rates were relatively lower than during the later years when stocking rates were highest. From 1967 through 1972, all the removed deer except 1 were rated as good or in better condition; the average live weight of harvested mature bucks (≥ 2½ years) was 133 pounds with a range of 110 to 157 lbs (fig. 2). The average antler dimensions of these bucks were: circumference, 4⅛ in. (3½–4½ in.); spread, 15 in. (7–17 in.); and number of points 7.4 (1–9). In 1979 mature bucks removed in the winter averaged only 87 pounds liveweight with a range of 75–102 lbs. (fig. 2), and were classed as fair in condition. Although limited in number of samples, the weight and condition differences between years were also obvious for the mature does.

Pine-hardwood Enclosures—In 1965, one 1½ year old buck died but was replaced by a similar aged buck. No deer were harvested during 1966 and 1967. However, in 1968 and 1969, 6 deer (4 bucks and 2 fawns), 20 percent of fall population, were removed to keep the overwinter population at 10, 1 per 17 acres (table 12). During these years, one 2½ year old buck was found dead and 4 fawns were unaccounted for in the winter census. One mature buck not previously recorded was included in the 1978 census. Twelve breeding does (2 does ≥ 2½ years old in 1966, 3 does in 1967, 3 does in 1968 and 4 does in 1969) produced 17 fawns, an average ratio of 1.42 fawns per doe (table 13).

During 1970 through 1972, when overwinter populations were 14 to 16 deer, 1 deer per 11 acres, 12 deer or approximately 20 percent of fall population were removed (table 12). Two fawns were unaccounted for in winter census. During this period 19 does (6 does ≥ 2½ years old in 1970, 5 does in 1971, and 8 does in 1972) produced 19 fawns, an average ratio of 1.00 fawns per doe (table 13). No deer deaths were recorded during these years.

From 1973 through 1976, the winter population reached 21, 1 deer per 8 acres. Thirty-two does (9 does ≥ 2½ years old in 1973, 7 does in 1974, 8 does in 1975 and 8 does in 1976) produced 31 fawns, 0.97 fawn per doe (table 13). Sixteen of the fawns, two 1½ year old bucks, two 1½ year old does and 3 adult does were unaccounted for in the winter census (table 12). Three

Table 14.—*Deer harvest and loss from enclosures by age class and sex, 1965–1979*

Age class	Sex	Harvested deer (N)	Dead carcass (N)	Unaccountable losses (N)
Pine enclosure				
Fawn	Male	7	3	12
	Female	0	4	11
1½–2½	Male	7	4	0
	Female	4	1	1
3½+	Male	9	4	1
	Female	1	8	3
Total		28	25	28
Pine-hardwood enclosure				
Fawn	Male	2	2	11
	Female	4	1	10
1½–2½	Male	6	1	2
	Female	3	1	3
3½+	Male	8	6	0
	Female	4	6	3
Total		27	17	29

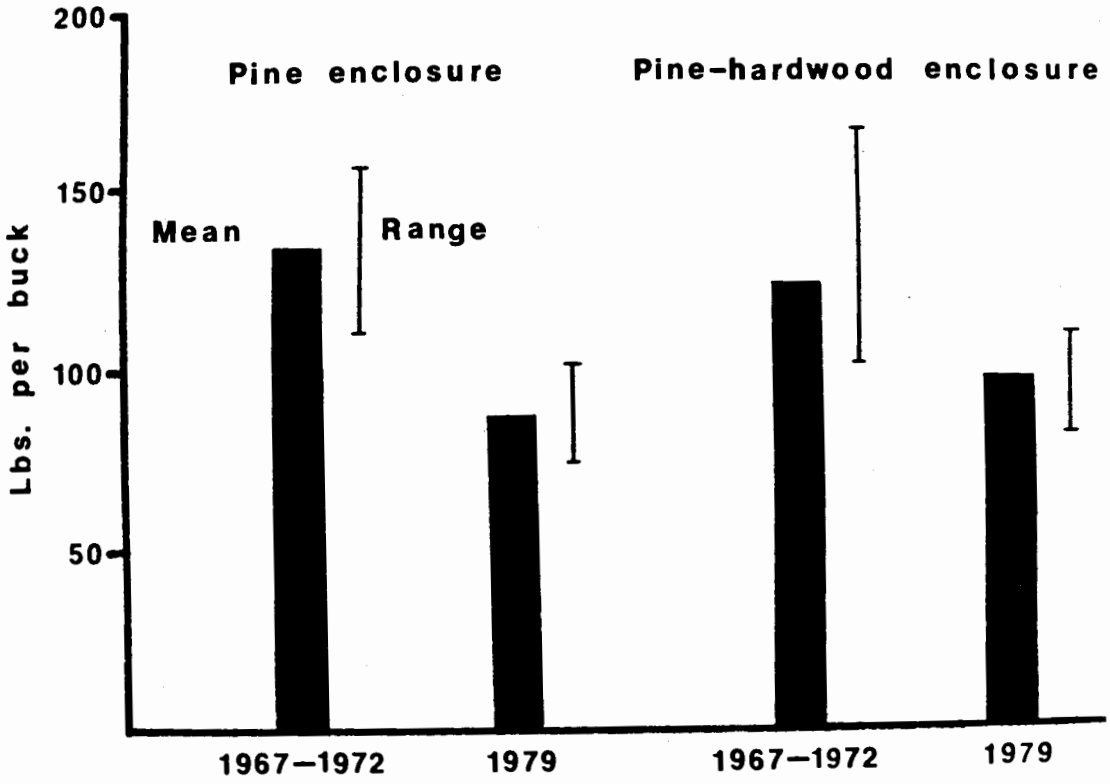


Figure 2.—*Live weight bucks (≥ 2 1/2 years old) removed from enclosures in winter.*

adult females, 1 adult male and 1 female fawn were found dead. Even though the birth rate was relatively high during these years, the population did not increase due to the high unaccountable loss.

The number of fawns dropped in 1977 was unknown, but at least 6 survived to bring the fall population up to 24, 1 per 7 acres.

In June 1978, 1 male fawn, one 6½ year old doe and one 4½ year old male were found dead. In August, 3 mature bucks and 1 mature doe were removed by hunting. From September 1978 through January 1979, 2 mature bucks, 1 mature doe and 1 male fawn were found dead. In late February and early March of 1979, 2 mature bucks, 2 mature does and 1 female fawn were removed. The overwinter population consisted of 10 deer—5 mature does and 5 mature bucks.

From June to October 1979, 2 mature bucks and 2 mature does were found dead and 1 mature buck was unaccounted for. No fawns were recorded this year, and the overwinter population (March 1980) consisted of 2 mature bucks and 3 mature does.

The high death loss of deer during the summers of 1978 and 1979 was attributed in part to the harassment and wounding of deer by hunters.

During the course of the study, 27 deer (16 males and 11 females) were harvested and 17 deer (9 males and 8 females) were found dead. Twenty-nine deer were unaccountably lost (table 14). From 1967 through 1972 fawn mortality was approximately 18 percent, but from 1973 through 1976 when populations were high and forage yields on the decline the fawn loss was 50 percent.

During the first few years of the study, the removed deer were rated good in condition and the average weight of a mature buck (≥ 2½ years old) in the winter was 124 pounds, a range of 102–168 lbs. (fig. 2). The average antler dimensions of these bucks were: circumference, 3¼ in. (2½–3¾ in.); spread, 12½ in. (8–18 in.), and number of points, 7 (6–8). In the winter of 1979, the average weight of 2 mature bucks that were removed was 97 lbs. (fig. 2). Both were in fair condition. Differences between years in weight and condition were also evident for the small sample of mature does.

Chemical analyses of stomach contents from deer killed in August 1978 revealed no deficiencies in crude protein, phosphorus and calcium. However, the BUN (blood urea nitrogen) values of 10 mg/dl or less were in the same general level as does fed a low nutritional diet in Michigan (Bahnak et al. 1979, Seal et al. 1972) and indicate a nutritional stress. Likewise, the BUN value was only 9 mg/100 dl for fawns fed a low protein diet in Virginia in comparison to 22 mg/dl for fawns on a high protein diet (Kirkpatrick et al. 1975).

Most of the deer collected throughout the study were free of any sign of disease or of heavy parasitism with the exception of ticks. Normal infection levels of *Gongylenema* spp. in the esophagus and *Haemonchus contortus* and *Setaria cervi* in the stomach were found in some deer in both enclosures.

DISCUSSION

In both enclosures the close relationships between forage yields and timber stand conditions were similar to other studies (Blair 1967, Blair and Feduccia 1977, Blair 1971, Blair and Enghardt 1976, Blair and Brunett 1976). The results illustrate the potential of well-stocked loblolly pine-shortleaf pine-hardwood forest to produce forage and indicate the extent to which the forest manager can schedule timber cutting and prescribed burning practices to maintain or increase forage yields.

In even-aged timber stands maximum yields of approximately 3,300 lbs. per acre are obtained the first 2 to 4 years after a clearcut harvest of timber (Stransky and Halls 1979). Clearcut areas will consistently produce 2,000 lbs. per acre of forage if woody stems are kept below 5 feet in height by mowing. However, most clearcut areas are regenerated to pines, and with exclusion from fire and cutting, woody stems soon grow to form an overstory canopy that is out of reach for deer and shades out most of the understory plants. Maximum yields of 2,212 lbs. per acre were obtained the third year after a clearcut. By the sixth growing season, yields were reduced by approximately ½. Only negligible amounts (74 lbs. per acre) of forage were available the 11th year after the clearcut. Closed canopy stands such as this will be practically devoid of forage for several years, i.e., until pines are of sufficient size to warrant a commercial harvest, either a clearcut or a thinning.

If the timber stands are carried through a sawtimber rotation of 65 to 70 years, the annual forage yields will likely average less than 300 lbs. per acre, in stands where the tree basal area is 110 sq. ft. per acre or more. However, the forage yields can be increased several fold by keeping the stands at a lesser density and by prescribed burning (Blair 1967, Blair and Enghardt 1976, Blair and Brunett 1976). A timber cutting cycle of 8 to 10 years and a prescribed burn at 3 to 5 year intervals would provide relatively high forage yields in stands managed primarily for timber products (Halls 1973). Too, as shown in this and other studies (Blair and Feduccia 1977, Schuster and Halls 1963), the forage yields will likely be higher in the upland pine-hardwood forests where the hardwood growth is curtailed.

Utilization data from browse surveys and the stomach and pellet analyses emphasize the fact that deer ingest a wide variety of food items in their seasonal diets. Although 20 to 25 species contributed the greater portion of the browse diet, nearly all species in both enclosures were eaten to some extent during the year. The relative amounts varied between enclosures, also the degree of utilization for a particular species ranged as much as 7 percent to 67 percent for laurel greenbrier, a heavily used species, and from zero to 24 percent for crossvine, a lightly used species. The species of browse and the degree of utilization differed to some extent from observations by Lay (1967) and Blair and Brunett (1980) but no more than would be expected considering the variation in time, stocking rates and vegetation compositions. The availability and utilization of a large number of plant species is of special significance nutritionally, since some plants are high in essential nutrients such as crude protein while others are low (Blair et al. 1977, Short 1971, Short and Epps 1976). Thus, the value of some sparse forage species may be much higher than indicated by their frequency of occurrence.

From the examination of deer pellets, it was quite obvious that fruit contributed substantially to the variety and amount of deer food in both enclosures. Also, measurements in the pine-hardwood enclosure indicated that the fruit yields of understory woody plants were greater than the yields from the overstory hardwood trees. For example, in 1968, the estimated 54 lbs. per acre yields of american beautyberry were nearly twice as great as the maximum yields of hard mast from all tree species in the pine-hardwood enclosure.

As with forage yields, the potential of understory browse plants to produce fruit is dependent primarily on timber stand conditions and management practices. In other studies (Halls and Alcaniz 1968), woody plants grown in the open produced several times more fruit than plants grown beneath a canopy of pine trees of approximately 70 sq. ft. basal area per acre. In clearcut areas (Stransky and Hall 1980), browse fruit yields averaged 115 lbs. per acre on control plots where woody plant growth was not restricted but by only 36 lbs. per acre the third year after a mechanical site preparation, when a high proportion of woody plants was destroyed. Timber management practices that favor the retention of browse for forage and fruit would be desirable from the standpoint of deer food production. On the other hand, the profuse growth of browse plants may restrict the early growth of pines (Cain and Mann 1980).

The results of this study indicate that, in forest areas with similar site conditions and of comparable stand density, there is little if any difference in the deer carrying capacity between habitats managed primarily for loblolly and shortleaf pines and habitats where hardwoods comprise up to 25 percent of the total tree basal area. Even though hardwood mast is a desirable component of deer diet, the mast yields in a pine-

hardwood forest may not be sufficient enough to noticeably improve deer health and productivity. During the first few years of this study the deer productivity rate of 1.4 fawns/mature doe was high in both enclosures and indicates that East Texas forests dominated by pole and sawtimber size trees have the potential to produce a relatively high number of deer each year provided that there is a well developed understory of shrubs, vines and small trees which are kept within reach of each deer.

The results also indicate that as long as ample food is available, at least 25 percent to 30 percent of the fall population can be harvested annually without reducing herd productivity and condition. This is considerably higher than the legal harvest rate of approximately 10 percent reported for majority of Texas deer ranges (Teer 1965).

The relatively small body weight and antler size, even when ample food was available, indicates that the pine-hardwood forests may be more suitable for the management of "quantity" rather than "quality" of deer, a system advocated for ranges where nutritional quality of food is relatively low (Short 1972).

The high proportion of male to female fawns (64:36) in the harvest and accountable loss may suggest that the mature females were under a nutritional stress even when the quantity of food was ample. Verme (1969) has shown that more males are likely to be produced when mature females are undernourished, whereas well fed and well nourished does are likely to produce more female than male fawns.

Results of this study emphasize the danger of "too many deer." When deer populations were not kept in check by a scheduled harvest, the reproductive rates fell off quicky and the death losses were high, especially for fawns. As shown by other studies, the recommended way to keep the herd numbers within its habitat capacity is to include does in the harvest schedule (Forbes et al. 1971, Gwynn 1976, Harlow and Jones 1965, Kellogg 1976, Lang and Wood 1976, Newsom et al. 1968, Noble 1974, Severinghaus and Darrow 1976 and Teer 1965). The number of does to harvest should, of course, depend on the reproduction rate of does, the sex-age ratio of the herd, and the habitat productivity and management objectives. When does are included in the harvest in the proper proportion, the manager can theoretically maintain total deer numbers and yield a high proportion of trophy bucks if deer reproduction rates are high (Short 1979). Such will likely be the case when ample food is available in habitats similar to those in this study.

In a general comparison of buck deer weights in this and other studies, it appears that when ample food is available in the pine forests of East Texas, the live weights of mature bucks would approach that of bucks grown in the pine-hardwood forests of Louisiana (Newsom et al. 1968) and in the Rio Grande Plains and Panhandle, the 2 areas of Texas with reportedly heaviest deer (Teer et al. 1965). However, with a high deer population and a restricted source of food, the weights of bucks in the East Texas pine forests would be similar to that in over-populated areas such as the Llano Basin and Edwards Plateau in Texas and less than that reported in Louisiana pine-hardwood forests. Even when ample food is available, it is likely that nutritional limitations in the forage (Short et al. 1975, Blair and Brunett 1977) could prevent buck deer from attaining their genetic potential in weight and antler development. An example of nutritional limitations was shown in Louisiana. Buck deer, fed a balanced ration, weighed 40 lbs. more and averaged 3 more antler points than similar aged bucks harvested in an upland pine-hardwood forest (Newsom et al. 1968).

The rapidly changing conditions in forage yields emphasize the unstable nature of the deer carrying capacity of upland forests in East Texas. Results of the study indicate that the stability and potential of the forest to produce the optimum number of deer depends primarily on a productive understory that is kept within reach of deer. This condition can best be achieved, either in pine or pine-hardwood timber stands, by periodic prescribed burns and by thinning the timber to keep the overhead canopy fairly open.

LITERATURE CITED

Bahnak, B. R., J. C. Holland, L. J. Verme, and J. J. Ozoga.
1979. Seasonal and nutritional effects of serum nitrogen constituents in white-tailed deer. J. Wildl. Manage. 43(2):454–460.

Blair, R. M.
1967. Deer forage in a loblolly pine plantation. J. Wildl. Manage. 31(3):432–437.

Blair, R. M.
1971. Forage production after hardwood control in a southern pine-hardwood stand. For. Sci. 17(3):279–284.

Blair, R. M., and L. E. Brunett.
1976. Phytosociological changes after timber harvest in a southern pine plantation. Ecology 57(1):18–32.

Blair, R. M., and L. E. Brunett.
1977. Deer habitat potential of pine-hardwood forests in Louisiana. South. For. Exp. Stn., New Orleans, La. 11 p. USDA For. Serv. Res. Pap. SO-136.

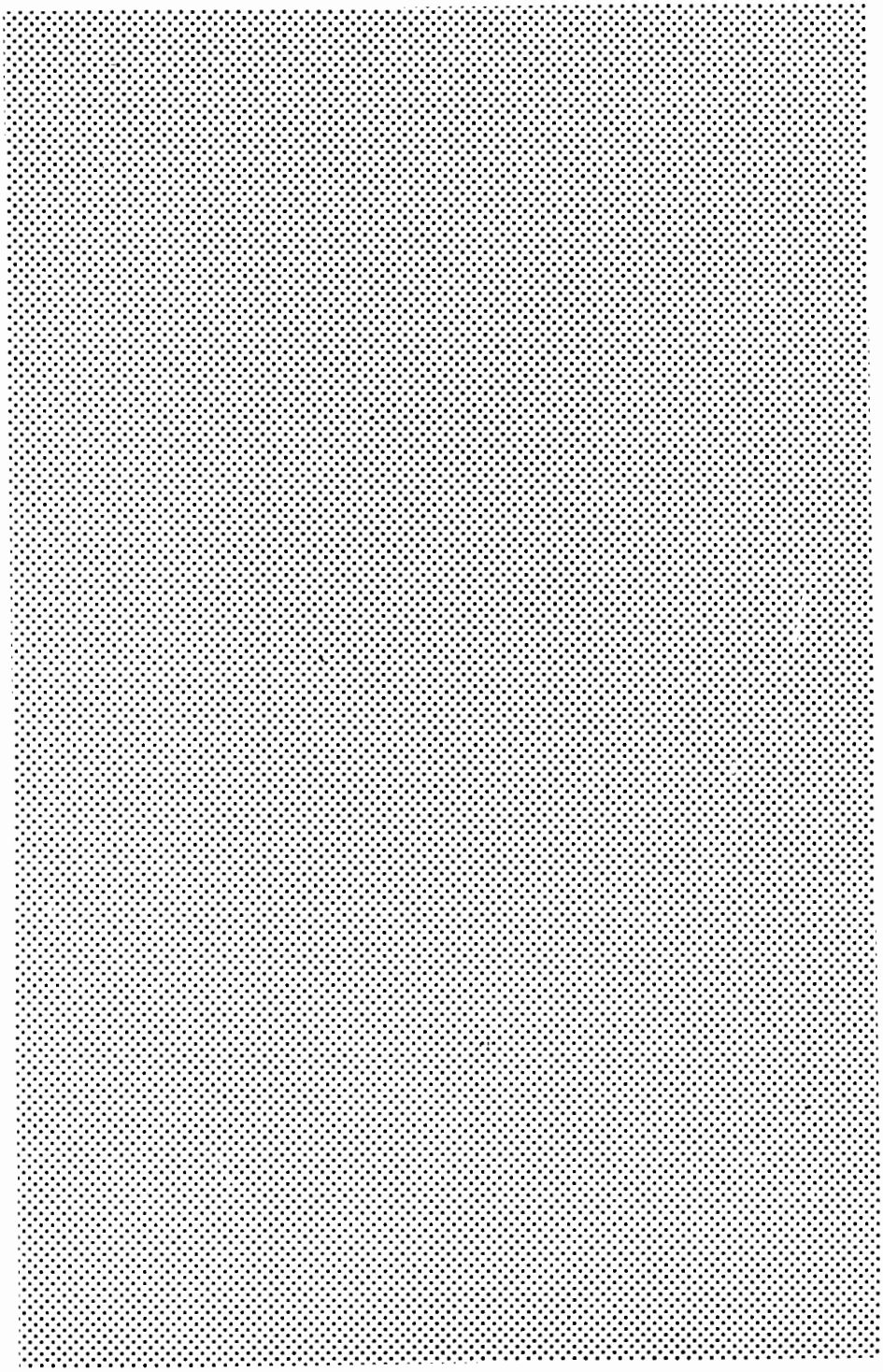
Blair, R. M., and L. E. Brunett.
1980. Seasonal browse use by deer in a southern pine-hardwood habitat. J. Wildl. Manage. 44(1):79–88

Blair, R. M., and H. G. Enghardt.
1976. Deer forage and overstory dynamics in a loblolly pine plantation. J. Range Manage. 29(2):104–108.

Blair, R. M., and D. P. Feduccia.
1977. Midstory hardwoods inhibit deer forage in loblolly pine plantations. J. Wildl. Manage. 41(4):677–684.
Blair, R. M., H. L. Short, and E. A. Epps, Jr.
1977. Seasonal nutrient yield and digestibility of deer forage from a young pine plantation. J. Wildl. Manage. 41(4):667–676.
Cain, M. D., and W. F. Mann, Jr.
1980. Annual brush control increases early growth of loblolly pine. South. J. Appl. For. 4(2):67–70.
Forbes, S. E., L. M. Lang, S. A. Liscinsky, and H. A. Roberts.
1971. The white-tailed deer in Pennsylvania. Penn. Game Comm. Res. Bull. 170. 40p.
Grosenbaugh, L. R.
1952. Plotless timber estimates-new, fast, easy. J. For. 50(1):32–37.
Gwynn, J. V.
1976. The Virginia deer management program. Paper read at the 12th Northeast Deer Study Group Meeting, Chicopee, Mass.
Halls, L. K.
1973. Managing deer habitat in loblolly-shortleaf pine forest. J. For. 71(12):752–757.
Halls, L. K., and R. Alcaniz.
1968. Browse plants yield best in forest openings. J. Wildl. Manage. 32(1):185–186.
Halls, L. K., C. E. Boyd, D. W. Lay, and P. D. Goodrum.
1965. Deer fence construction and costs. J. Wildl. Manage. 29(4):885–888
Halls, L. K., J. D. McCarty, and H. V. Wiant.
1970. Relative browsing of 16 species by deer. J. Range Manage. 23:146–147.
Harlow, R. F., and F. K. Jones, Jr.
1965. The white-tailed deer in Florida. Florida Game and Fresh Water Fish Comm. Tech. Bull. 9. 240p.
Kellogg, F. E.
1976. So you're not seeing deer now. Ark. Game and Fish 8(4):12–13.
Kirkpatrick, R. L., D. E. Buckland, W. A. Abler, P. F. Scanlon, and H. E. Burkhart.
1975. Energy and Protein influences on blood urea nitrogen of white-tailed deer fawns. J. Wildl. Manage. 39(4):692–698.
Lang, L. M., and G. W. Wood.
1976. Manipulation of the Pennsylvania deer herd. Wildl. Soc. Bull. 4(4):159–166.
Lay, D. W.
1967. Deer range appraisal in eastern Texas. J. Wildl. Manage. 31:426–432.
Lay, D. W.
1979. Fruiting in pine and pine-hardwood forests. Texas Parks and Wildlife Dept. Tech. Series 27. 34p.
Newson, J. D., H. L. Short, J. F. Fowler, and G. L. McCoy.
1968. Study shows effects of nutrition on growth of deer. Louisiana Agriculture 12(1):4–5.
Noble, R. E.
1974. Reproductive characteristics of Mississippi white-tailed deer. Miss. Game and Fish Comm., Jackson Miss. 58p.
Seal, U. S., L. J. Verme, J. J. Ozoga, and A. W. Erickson.
1972. Nutritional effects of thyroid activity and blood of white-tailed deer. J. Wildl. Manage. 36(4):1041–1052.
Severinghaus, C. W., and R. W. Darrow.
1976. The philosophy of deer management. The Conservationist (New York):18–19.
Short, H. L.
1971. Forage digestibility and diet of deer on southern upland range. J. Wildl. Manage. 35(4):698–706.
Short, H. L.
1972. Ecological framework for deer management. J. For. 70(4):200–203.
Short, H. L.
1979. Deer in Arizona and New Mexico: their ecology and a theory explaining recent population decreases. Gen. Tech. Rep. RM-70, Rocky Mountain Forest and Range Experiment Station, Forest Service, USDA. 25p.
Short, H. L., R. M. Blair, and E. A. Epps, Jr.
1975. Composition and digestibility of deer browse in southern forests. South. For. Exp. Stn., New Orleans, La. 10p. USDA For. Serv. Res. Pap. SO-111.
Short, H. L., and E. A. Epps, Jr.
1976. Nutrient quality and digestibility of seeds and fruits from southern forests. J. Wildl. Manage. 40(2):283–289.
Stransky, J. J. and L. K. Halls.
1979. Forage yield increased by clearcutting and site preparation. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildlife Agencies (1978)32:38–41.
Stransky, J. J., and L. K. Halls.
1980. Fruiting of woody plants affected by site preparation and prior land use. J. Wildl. Manage. 44(1):258–263.
Teer, J. G.
1965. Texas deer herd management. Texas Parks and Wildlife Department Bull. No. 44. 69p.
Teer, J. G., J. W. Thomas, and E. A. Walker.
1965. Ecology and management of white-tailed deer in the Llano Basin of Texas. Wildlife Monographs No. 15. 62p.
Verme, L. J.
1969. Reproductive patterns of white-tailed deer related to nutritional plane. J. Wildl. Manage. 33(4):881–887.

APPENDIX

Species and groups of plant species referred to in the text



Category	Scientific name	Common name
Grasses and grass-like plants	Andropogon sp.	Bluestems
	Carex sp.	Sedge
	Panicum sp.	Panicum
	Uniola sessiliflora	Longleaf uniola
Legumes	Cassia fasciculata	Showy partridgepea
	Centrosema virginianum	Butterflypea
	Crotalaria sp.	Rattlebox
	Desmodium sp.	Tickclover
	Desmanthus depressum	Bundle flower
	Galactia volubilis	Downy milk pea
	Lespedeza sp.	Lespedeza
Composites	Ambrosia psilostachya	Western ragweed
	Elephantopus tomentosus	Devil's grandmother
	Eupatorium compositifolium	Yankeeweed
	Vernonia texana	Ironweed
Miscellaneous forbs	Diodia teres	Rough buttonweed
	Ipomea pandurata	Bigroot morningglory
	Linum striatum	Flax
	Mitchella repens	Partridgeberry
	Passiflora lutea	Yellow passion flower
	P. incarnata	Maypop passion flower
	Physalis sp.	Groundcherry
	Polygonum hydropiperoides	Swamp smartweed
	Phytolacca americana	Pokeweed
	Rumex hastatalus	Heartwing sorrel
	Sida spinosa	Prickly sida
	Solanum sp.	Nightshade
	Viola sp.	Violet
Browse plants		
High preference		
Deciduous	Ascyrum hypercoides	St. Andrewscross
	Berchemia scandens	Alabama supplejack
	Fraxinus americana	White ash
	Rubus sp.	Blackberry
	Sassafras albidum	Sassafras
	Smilax bona-nox	Saw greenbrier
	S. glauca	Cat greenbrier
	S. rotundifolia	Common greenbrier
	S. smallii	Lanceleaf greenbrier
Evergreen		
	Gelsemium sempervirens	Yellow jessamine
	Ilex vomitoria	Yaupon
	Lonicera japonica	Japanese honeysuckle
	Smilax laurifolia	Laurel greenbrier
Medium preference		
Deciduous	Acer rubrum	Red maple
	Bignonia capreolata	Crossvine
	Callicarpa americana	American beautyberry
	Chionanthus virginicus	White fringetree
	Cornus florida	Flowering dogwood
	Crataegus sp.	Hawthorn
	C. marshallii	Parsley hawthorn
	C. spathulata	Littlehip hawthorn
	Ilex decidua	Possumhaw
	Morus rubra	Red mulberry
	Nyssa sylvatica	Blackgum
	Parthenocissus quinquefolia	Virginia creeper
	Quercus alba	White oak
	Q. phellos	Willow oak
	Rhus glabra	Smooth sumac
	R. radicans	Poison-ivy
	Sambucus canadensis	American elder
	Ulmus alata	Winged elm
	Viburnum rufidulum	Rusty blackhaw
	Vitis sp.	Grape
	V. aestivalis	Summer grape
	V. rotundifolia	Muscadine grape
Evergreen		
	Quercus nigra	Water oak
	Trachelospermum difforme	Climbing dogbane
Low preference		
Deciduous	Ampelopsis arborea	Peppervine
	Aralia spinosa	Devil's-walkingstick
	Campsis radicans	Trumpetcreeper
	Carya sp.	Hickory
	Celtis laevigata	Sugar hackberry
	Diospyros virginiana	Common persimmon
	Gleditsia triacanthos	Honeylocust
	Liquidambar styraciflua	Sweetgum
	Prunus mexicana	Mexican plum
	P. serotina	Black cherry
	Quercus falcata	Southern red oak
	Q. stellata	Post oak
	Rhamnus caroliniana	Carolina buckthorn
	Rhus copallina	Shining sumac
	Vaccinium sp.	Blueberry
Evergreen		
	Juniperus virginiana	Eastern redcedar
	Pinus echinata	Shortleaf pine
	P. taeda	Loblolly pine
	Vaccinium arboreum	Tree sparkleberry

HALLS, LOWELL K., and CHARLES E. BOYD.
1982. Influence of managed pine stands and mixed pine/hardwood stands on well being of deer, U.S. Dep. Agric. For. Serv. Res. Pap. SO-183, 18 p. South. For. Exp. Stn., New Orleans, La.

Effects of pine and pine-hardwood scenarios upon deer populations are compared. The timber stands also are taken through various stages, including no management. Tests were started in 1965 with a 172-acre enclosure and a 167-acre enclosure.