United States
Department of
Agriculture

Forest Service

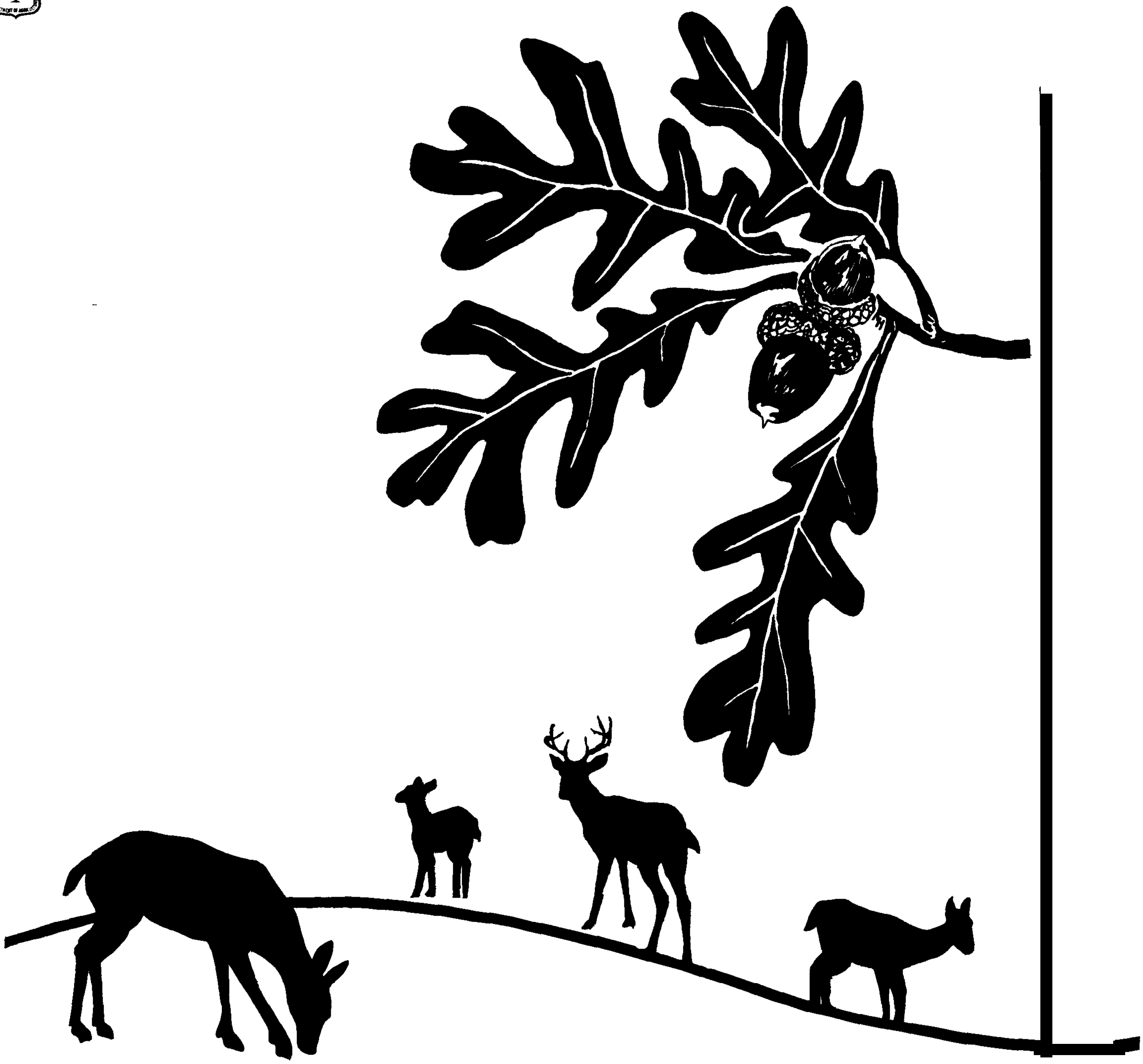
**Southern Forest
Experiment Station**

New Orleans,
Louisiana

Research Paper
SO-259

Deer Habitat in the Ozark Forests of Arkansas

Mitchell J. Rogers, Lowell K. Halls, and James G. Dickson



SUMMARY

Two enclosures of 590 and 675 acres were constructed and stocked with white-tailed deer *(Odocoileus virginianus)* to determine the deer carrying capacity of an Ozark mountain forest and to evaluate the impact of winter food plots on deer survival and productivity. Deer diets varied considerably within and among years, and they were closely related to habitat type and availability of acorns. Before food plots were established, the deer carrying capacity averaged only one deer per 45 to 100 acres, mainly because of a lack of high-quality, native forage during winter. Capacity was somewhat higher in the enclosure where cedar glades were more prevalent. Fawn production and winter survival of adult deer fluctuated widely and were positively correlated with acorn yields. After openings were established in the forest and planted with elbon rye (*Secale cereale*), ladino clover (*Trifolium repens*), and Japanese honeysuckle (*Lonicera japonica*), the carrying capacity increased to one deer per 21 acres, and population levels remained fairly stable from year to year. Food plots seemed beneficial only during years of low mast yields. Even with access to high-quality forage, the deer populations were limited by a low fawn survival rate due to predation, disease, parasites, and other unknown factors.

November 1990

Deer Habitat in the Ozark Forests of Arkansas

Mitchell J. Rogers, Lowell K. Halls, and James G. Dickson

INTRODUCTION

The Ozark mountain range comprises approximately 5.2 million acres in northern Arkansas. The wooded valleys and hills and the rivers and lakes have long provided a haven for sportsmen and recreationists. White-tailed deer (*Odocoileus virginianus)* have historically been a popular attraction, but their numbers have fluctuated widely due to the impacts of farming, timber cutting, hunting, disease, parasites, and poor nutrition.

In 1926, it was estimated that there were only 35 deer on the 173,000-acre Sylamore Ranger District of the Ozark National Forest (Donaldson and others 1951). In 1927 and 1928, two Federal refuges were established on the district. Intensive protection and predator control helped to reestablish the deer herd. In 1944, 463 deer were harvested on the Sylamore Ranger District (Segelquist and others 1969), and in 1945 the area was considered seriously overpopulated with deer (Alexander 1954). The dense overhead canopy of the young developing forest limited the production of understory vegetation (Halls and Crawford 1960). The exclusion of fire from planted pines in old fields further reduced range productivity. By 1950, the declining forage supply and high deer populations caused heavy overbrowsing and die-offs (Donaldson and others 1951). Deer populations remained depressed into the 1960's; for example, only 49 deer were harvested in 1967.

In an effort to resolve the situation, the Arkansas Game and Fish Commission; the Fish and Wildlife Service (Pittman-Robertson project W-53-R), U.S. Department of the Interior; and the Southern Forest Experiment Station, Forest Service, U.S. Department of Agriculture initiated a long-term investigation in north Arkansas. The study objectives were: (1) to determine the deer carrying capacity of Ozark highland forests under the present management system, (2) to explore the possibility of increasing deer numbers by improved management practices, and (3) to determine factors influencing deer condition and productivity.

The objective of the first 8 years of the study, 1959 to 1967, was to determine deer carrying capacity under existing forest management practices. The second phase, from 1968 to 1977, sought to determine if deer numbers could be increased by establishing improved food plots in the Caney enclosure.

METHODS

Area Description

The area was considered typical of Ozark highland forests in topography, soils, and timber stand conditions. In general, the area was deeply dissected by small streams, narrow valleys, and narrow, rounded ridges. Elevations ranged from 400 to 1,020 ft. Slopes ranged up to 60 percent but usually averaged from 30 to 40 percent.

The soil on ridges and upper slopes was extremely rocky. Chert fragments made up 30 to 75 percent of the total volume. Soils on lower slopes, benches, and floodplains were generally sandy to silty clay loams with a few rock fragments. Water-holding capacity decreased from streambottoms to the ridges.

On the average, annual precipitation was about 44 inches, with approximately 24 inches of rainfall during the warm months. Dry periods were frequent, and the mean temperature was 37 °F in January and 81 °F in July.

For this study, two 9-foot-high fenced enclosures were constructed at the Sylamore Experimental Forest, a part of the Ozark-St. Francis National Forest on the Springfield Plateau in northern Arkansas. The Caney enclosure contained 590 acres, and the nearby Big Spring enclosure contained 675 acres. Fence construction was completed in 1962.

Each enclosure contained four main forest types: upland hardwood, upland pine-hardwood, cedar glade, and streambottom hardwood. In the Big Spring enclosure there was also a transitional pine-hardwood forest type. The principal hardwood trees were white oak

Mitchell J. Rogers was previously biologist at the Arkansas Game and Fish Commission, Little Rock, AR, and is presently at Ducks Unlimited, Fifty Six, AR; Lowell K. Halls is wildlife biologist (retired); and James G. Dickson is research wildlife biologist at the U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Nacogdoches, TX.

(*Quercus alba*), black oak (*Q. velutina*), hickories (*Carya* spp.), and black cherry (*Prunus serotina*). Shortleaf pine (*Pinus echinata*) was dominant in the pine-hardwood stands. There had been no timber cutting in recent years, and many timber stands were largely mixtures of various size and age classes, with only a few acres of even-aged hardwood pole stands. Overstory canopies were heavy and continuous in all types except the cedar glade, where small noncommercial trees predominated.

Procedures

Deer Data

All the deer in both enclosures (36 in Caney and 30 in Big Spring) were removed by hunting and trapping in 1962. Between April and November 1963, the Caney enclosure was restocked with 8 does and 2 bucks, and the Big Spring enclosure was restocked with 10 does and 1 buck.

Deer were counted each March and December by a line-drive census using 70 to 130 drivers spaced 60 to 120 feet apart (Segelquist and others 1969). Additional census data were obtained from 1968 to 1977 in the Caneyenclosure by direct observation from raised platforms.

During the course of the study, deer were added or removed from the enclosures to maintain desired population levels and to collect data on animal condition, productivity, and internal parasites. Several adult deer and young fawns were fitted with motion-sensitive, lithium-powered transmitters in an effort to identify specific mortality factors.

Necropsies were performed by personnel from the Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, on 7 of the original deer population in 1962 and on a total of 10 additional deer in 1967, 1971, and 1978. A helminth parasite analysis was performed on 11 deer by personnel from the University of Arkansas, Department of Zoology, in 1975.

Vegetation Measurements

Each August, current-year annual growth to a height of 5 ft was estimated on about 125 permanent and 30 temporary 6.2-ft^2 plots systematically spaced throughout each enclosure using double-sampling procedures (Wilm and others 1944). Forage production on the temporary plots was estimated and then clipped and weighed for use as a correction factor for forage estimates on the permanent plots. Data are expressed on an ovendry basis.

Winter forage availability was estimated on plots each March from 1965 through 1972 with the same technique used to estimate summer forage. Winter browse included the previous season's twig growth of deciduous species and twigs and leaves of evergreens.

Forage utilization was estimated each August and March in conjunction with forage yield measurements. Summer utilization data were estimates of the weight of forage removed, and the winter utilization data were estimates of the percentage of growing stems browsed. Rumen contents of deer killed for population control and necropsy were also examined to determine food habits. Fecal pellets were collected regularly from January 1966 through January 1968 and examined for mast. Transects used to sample pellet groups were randomly located in each of the main forest types, and all pellet groups were counted each season from the fall of 1966 through the summer of 1969 to determine seasonal habitat preference. Because utilization is governed to some extent by relative abundance of plants, an importance value was calculated by multiplying the frequency of occurrence of plants along specified transects by their frequency of utilization.

Mast yields were sampled each fall by placing two 55-gal, open-top barrels at 99 randomly located points throughout each enclosure. Acorns and other fruits that fell into the barrels were counted and converted to an ovendry yield.

In February 1968 four food plots, ranging in size from 1.7 to 5.7 acres, were established in the Caney enclosure by bulldozing and disking. Approximately half of each plot was planted with Japanese honeysuckle (*Lonicera japonica*), and the other half was seeded annually with a mixture of elbon rye (*Secale cereale*) and ladino clover (*Trifolium repens*). Food plots in 1968 consisted of 3.7 acres of rye and clover and 6.0 acres of honeysuckle. The acreage of rye and clover was increased to 7.6 acres in 1969 and maintained at that level for the duration of the study. Production and utilization of rye and clover were estimated in midwinter and late winter 1968 through 1977 using 10 caged and 10 uncaged 3.1-ft^2 quadrats. Honeysuckle data were collected in August and March 1969 through 1977 by clipping a portion of randomly located plants and by comparing weights of caged and uncaged plants. Honeysuckle plants were mowed to about a 30-inch height to control woody invaders. All plots were limed at 1.5 tons/acre in April 1968. The rye-clover plots were fertilized annually with 10-20-20 (N-P-K) fertilizer, and the honeysuckle plots were fertilized with approximately 100 lb/acre of 30-0-O (N-P-K) fertilizer.

Some commonly used native species and forages grown on food plots were collected for nutritive analyses in the summer of 1969 and the spring of 1971 and analyzed for crude proteins, calcium, and phosphorus (Association of Official Agricultural Chemists 1960).

Cell wall contents, acid detergent fiber, and acid detergent liquor were determined (Van Soest 1967), and in vitro digestibility was determined using bovine rumen liquor and pepsin (Tilley and Terry 1963). Native forage samples consisted of leaves and stems of cool season grasses, sedges, and forbs, as well as the terminal end of browse twigs with attached leaves.

Woody measurement plots were established 6 feet from the center of each forage plot. The basal area of each tree species was recorded by l-inch diameter classes. Cover of understory woody vegetation up to a height of 5 feet was recorded from eight clusters of point-loop transects.[1]

RESULTS

Caney Enclosure

Woody Plants

Hardwood saplings predominated in the upland hardwood and upland pine-hardwood forest types (table 1). Pole stocking (trees in the 5.0- to 9.0-inch d.b.h. class) was densest in upland hardwoods. Sawtimber stocking (trees >9.0-inch d.b.h.) was greatest in the streambottom hardwood forest type. Pines were represented mainly in the upland pine-hardwood type and to some extent in the cedar glade type.

The understory cover estimate for the enclosure from plot samples was less than 21 percent. Flowering dogwood (*Cornus florida*) made up 16 percent of the total browse cover; common deerberry (*Vaccinium stamineum*) and lowbush blueberry (*V. vacillans*), 13 percent; several species of oaks, 14 percent; hickory, 6 percent; lindera (*Lindera benzoin*), 8 percent; tree huckleberry (*V. arboreum*), 5 percent; and blackgum (*Nyssa sylvatica*), 5 percent. Twenty-two other species were recorded, but none comprised more than 4 percent of the total cover.

[1]Parker, Kenneth W. 1953. A method for measuring trend in range condition on national forest ranges. Forest Service, USDA, Administrative Studies (Condition & Trend). 26 p. Plus form. Unpublished mimeo.

Forage and Mast Yields

Growing season yield of native vegetation averaged 115 lb/acre, ranging from 78 to 139 lb/acre (table 2). Preferred browse comprised 48 percent of total yields; nonpreferred browse, 38 percent; forbs and ferns, 18 percent; and grass and grasslike plants, 11 percent. The yields were very consistent among years, except in 1974 and 1976, when yields increased as a result of tree canopy openings caused by a tornado in 1974. Cedar glade was the most productive habitat (192 lb/acre) followed by streambottom hardwood (138 lb/acre), upland pine-hardwood (96 lb/acre), and upland hardwood (73 lb/acre). Yields of preferred browse were highest in the upland pine-hardwood, and the herbaceous plants were most productive in the relatively open cedar glade.

Table 1.—*Tree basal area in the Caney deer enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

	Forest types				
	Upland hardwood	Upland pine-hardwood	Cedar glade	Streambottom hardwood	All types combined
	Feet²/acre				
Hardwood					
Sapling*	52	43	29	28	45
Pole†	36	13	21	19	26
Sawtimber‡	18	15	16	44	19
Total hardwood	106	71	66	91	90
Pine					
Sapling	0	5	0	0	2
Pole	0	5	0	0	2
Sawtimber	1	17	10	0	7
Total pine	1	27	10	0	11
Total timber	107	98	76	91	101

* Trees 1.0 to 4.9 inches in d.b.h.
† Trees 5.0 to 9.0 inches in d.b.h.
‡ Trees >9.0 inches in d.b.h.

Table 2.—*Summer yields and winter availability of native forage in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

Vegetation class	Summer		Winter	
	Average	Range of values	Average	Range of values
	Pounds/acre			
Grass and grasslike plants	10	5-20	1	o-1
Forbs	12	4-20	0	0
Ferns	6	3-10	2	o-4
Preferred browse	41	29-73	8	4-13
Nonpreferred browse	38	26-41	5	3-6
Total	109	78-139	16	8-18

Available winter forage averaged only 14 lb/acre with ≥90 percent consisting of twigs from deciduous woody plants. Green forage was practically nonexistent.

Mast yields fluctuated widely by year, ranging from a low of 3 lb/acre in 1968 to 482 lb/acre in 1960 (table 3). On the average, white oak produced more acorns than black oak, but black oak was more consistent, producing some acorns each year. There were no regular cycles of high or low acorn production. White oak acorn yields exceeded 134 lb/acre in 5 out of 19 years, but only once in 2 consecutive years. Yields were <5 lb/acre for 7 years, and white oak produced no acorns in 3 years.

Yields of white and black oaks appeared to be operating independently of each other. In some years the yields were high for both species, but frequently the yields of both species were low. At other times the yield was high for one and low for the other.

Acorn yields were highest in the upland hardwoods (184 lb/acre) where stocking of ma&bearing oaks was greatest. The upland pine-hardwood type was second with 96 lb/acre. This habitat occurred on the south- and we&facing slopes where pines comprised much of the stand. Production was lowest in the cedar glades (17 lb/acre) due to low hardwood densities. Acorn yields in streambottom hardwoods were quite variable, varying from zero to 55 lb/acre. No acorns were produced in 13 out of 19 years in this forest type.

Mast yields from species other than oaks averaged 10 lb/acre, but varied from zero in 1968 to 35 lb/acre in 1960 (table 3). Those with the highest yields were dogwood, grape (*Vitis* spp.), and blackgum. Lesser production was noted for sassafras (*Sassafras albidum),* black cherry, smooth sumac (*Rhus glabra*), shining sumac (*R. copallina*), and chinkapin (*Castanea ozarkensis*). Average production of non-oak mast was greatest in streambottom hardwoods, at 34 lb/acre, with grape being the main producer in this forest type. Upland hardwoods produced an average of 14 lb/acre, mainly from dogwood and grape. Upland pine-hardwoods produced 5 lb/acre and cedar glade produced < 1 lb/acre.

Deer Food and Feeding Habits

Dogwood and lowbush blueberry were the most important browse species eaten by deer in late winter (table 4). Species of lesser importance as browse were eastern redcedar (*Juniperus virginiana*), New Jersey tea (*Ceonothus americanus),* hophornbeam (*Ostrya virginiana*), common deerberry, and red maple (*Acer rubrum*). There was no deer utilization of black and white oak, blackgum, farkleberry (*Vaccinium arboreum*), greenbriar (*Smilax* spp.), sassafras, or winged elm (*Ulmus alata*).

Grasses and sedges constituted 39 percent of the stomach contents of five deer killed in March 1967 (table 5). Only a moderate amount of acorns was recorded because they were fairly sparse at this time of year, and those eaten were either partially decomposed or damaged by insect larvae. Consumption of normally unpalatable items such as dead oak leaves, dry twigs, and eastern redcedar suggested a scarcity of palatable food for the deer. In general, it appeared that items eaten by deer during the winter were more closely related to availability than to preference.

Forbs and red maple had the highest importance rating of plants eaten by deer during the summer (table 6), followed by blackgum, sassafras, dogwood, lowbush blueberry, poison-ivy (*Toxicodendron radicans*), and hackberry (*Celtis occident&s).* White oak, hickory, greenbriar, grape, and white ash (*Fraxinus americana*) were not utilized by deer. The relatively low importance values indicated that most browse plants were not being utilized by deer and that ample food was available during the summer.

Pellet count surveys were used to test for seasonal habitat preferences. During the spring when herbage and browse were most succulent, deer used all types of habitat to some extent. Use was fairly evenly divided among habitat types during the summer and was not related to mast yields. In the fall when acorns were available, deer concentrated in the upland hardwood and streambottom hardwood forest types where mast was most abundant. These forest types received heavi-

Table 3.-*Mast production in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

Year	Oak				Non-oak				
	White	Black	Other*	**Total**	Flowering dogwood	**Blackgum**	Grape	**Misc.**†	**Total**
	------	------	------	------	- *Pounds/acre* ------				------
1959	135	2	‡	137	13	‡	‡	1	14
1960	415	31	1	447	11	‡	24	‡	35
1961	‡	69	‡	69	18	‡	2	‡	20
1962	8	22	‡	30	4	‡	3	‡	7
1963	11	4	‡	15	3	‡	1	‡	4
1964	4	5	‡	9	‡	‡	1	‡	1
1965	230	24	10	264	2	1	6	‡	9
1966	‡	14	1	15		1	‡	‡	1
1967	395	10	11	406	15	4	4	‡	23
1968	‡	3	‡	3	‡	‡	‡	‡	‡
1969	27	5	1	33	4	‡	1	1	6
1970	5	5	‡	10	‡	1	‡	‡	1
1971	60	107	2	169	1	‡	4	‡	5
1972	1	48	1	50	‡	1	‡	‡	1
1973	2	14	11	27	2	‡	2	‡	4
1974	300	12	5	317	2	3	1	‡	6
1975	2	1	‡	3	5	1	12	‡	18
1976	114	125	4	243	25	‡	1	‡	26
1977	37	160	9	206	1	‡	2	3	6
Average	92	35	3	129	6	1	3	‡	10

* Northern red oak (*Quercus rubra*), post oak (*Q. stellata*), chinkapin oak, (*Q. muehlenbergii*).
† Black cherry, smooth sumac, shining sumac, chinkapin, sassafras.
‡ Less than ½ lb/acre.

Table 4.—*Frequency of occurrence and utilization and the importance rating of browse forage in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest, March 1965*

Species	Frequency of occurrence	Frequency of utilization	Importance rating
	------	*Percent*	------
Dogwood	37	33	12.21
Lowbush blueberry	41	23	9.43
Eastern redcedar	2	50	1.00
New Jersey tea	4	14	0.56
Hophornbeam	7	8	0.56
Common deerberry	9	6	0.54
Red maple	4	13	0.52
Blackgum	2	0	0
Black oak	14	0	0
Farkleberry	4	0	0
Greenbriar	2	0	0
Sassafras	6	0	0
Winged elm	2	0	0
White oak	27	0	0

Table 5.—*Percent composition of stomach contents of five deer from the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest, March 1967*

Stomach contents	Percent
Grasses and sedges	39
Acorns	19
Unidentified	12
Unidentified browse	7
Low blueberry	6
Forbs	6
Dogwood	4
Dead oak leaves	4
Eastern redcedar	3
Total	100

Table 6.-Occurrence and *utilization frequencies* and *the importance rating of forage in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest, August 1965*

Species	Frequency of occurrence	Frequency of utilization	Importance rating
	------------------ *Percent* ------------------		
Forbs	63	9	5.67
Red maple	29	11	3.19
Blackgum	11	15	1.65
Sassafras	38	4	1.52
Dogwood	48	2	0.96
Lowbush blueberry	46	2	0.92
Poison-ivy	7	12	0.84
Hackberry	4	20	0.60
White oak	51	0	0
Hickory	35	0	0
Greenbriar	7	0	0
Grape	11	0	0
White ash	6	0	0

est use in the fall, even when mast yields were low. As the acorn availability decreased during the winter, deer concentrated in the cedar glade where evergreen browse and green herbage was more prevalent. Winter use in the glade was high regardless of mast yields but higher yet in low mast years. During the winter of 1966-67, when mast yields were low, pellet groups were only found in cedar glade.

Improved Forage

Yields of rye and clover from 1968-77 ranged from 1,062 lb/acre to 3,860 lb/acre (table 7). Utilization varied directly with the availability of mast. During winters of high mast production, utilization of rye and clover ranged from 11 to 18 percent. During winters of low mast production, their utilization ranged from 39 to 98 percent of the total production. Deer utilized mast and native forage in early winter and increased their use of rye and clover later in the winter as native foods decreased in availability. The relative contribution of rye and clover to the deer's diet in a low mast year was further illustrated when these two species comprised 96 percent of the stomach contents from five deer killed in March 1971.

Production of honeysuckle was light from 1969-72 due to the immaturity of plants (table 7), but yields averaged 2,922 lb/acre during the last 5 years (1973-77). In 1970-71, leaves of immature honeysuckle plants averaged 143 lb/acre. During the same period, native green forages preferred by deer produced 2 lb/acre. Thus, 1 acre of honeysuckle produced as much green winter forage as 70 acres of the undisturbed forest (Segelquist and others 1972).

Utilization of honeysuckle was limited mainly to the winter period and was inversely correlated with fall mast yields. Honeysuckle seemed especially important to deer during periods of ice and snow storms when many acorns were covered.

Nutritional Analysis

Crude Protein.-Crude protein content of honeysuckle leaves ranged from 11 to 16 percent (table 8) and was consistently above the 6- to 'I-percent levels suggested for mature deer maintenance (French and others 1955). On the other hand, twigs of honeysuckle were frequently below maintenance protein levels and often had the lowest protein levels of all forages tested. Crude protein content of rye and clover ranged from 9- to 39-percent. Except for the spring of 1970 when samples were collected after rye had matured, these values were above the 13- to Is-percent levels suggested as optimum for deer growth (French and others 1955) and were significantly higher than all other forages.

Except for dogwood twigs, the native species were generally at or above the deer maintenance levels, but native species seldom contained adequate protein for optimum growth of young deer. Protein content of dogwood leaves ranged from 7 to 13 percent.

Protein content was highest when plants were actively growing; thus, honeysuckle, dogwood, low panic grasses (*Panicum* spp.), and pussytoes (*Antennaria plantaginifolia*) were highest in this nutrient in the spring, and rye and clover were highest in the fall and winter.

Calcium.-Dogwood was usually higher than any other species in calcium content, ranging from 1.3 to 4.5 percent (table 9), considerably above the 0.45 percent calcium requirement needed to support growth and skeletal development of weaned fawns (Ulrey and others 1973). This high calcium content is characteristic of dogwood foliage (Fowells 1965). All forages contained adequate levels of calcium for maintenance, and, except for honeysuckle twigs and panic grasses, were sufficient for good antler development (Magruder and others 1957). In general, the calcium levels were highest during fall and winter months; this may possibly be related to rainfall patterns.

Phosphorus.-The phosphorus content of honeysuckle leaves and rye and clover foliage was consistently higher than that for native forage (table 10). As a rule, phosphorus content was below deer maintenance levels (0.25 percent) for all forages except the rye and clover, and this class of forage contained adequate phosphorus for best antler development only during the fall after antler growth is essentially complete.

Calcium-to-phosphorus ratios seldom fell within the recommended range of 1:1 to 2:1 for livestock. The ratio was generally highest for dogwood leaves and twigs and eastern redcedar (10:1 to 40:1) and lowest in rye and clover and twigs (<7:1) for all seasons.

Table 7.—*Yield and utilization of improved forage plants in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

Year	Elbon rye and ladino clover		Japanese honeysuckle	
	Yield	Utilization	Yield	Utilization
	Pounds/acre	*Percent*	*Pounds/acre*	*Percent*
1968-69	1,980	98		†
1969-70	1,678	56	67	95
1970-71	1,303	57	239	61
1971-72	1,824	17	750	3
1972-73	1,062	12	2,181	5
1973-74	1,625	11	2,833	22
1974-75	2,226	18	2,583	0
1975-76	2,063	39	3,532	13
1976-77	3,860	*	3,482	5

* Late collection after elbon rye had gone to seed.
† No data.

Table 8.—*Crude protein content of native and improved forages*

Forage item	1969 to 1970				1970 to 1971			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	Percent of ovendry weight							
- Japanese honeysuckle								
Leaves	11	13	14	16	13	15	12	16
Twigs	5	5	5	7	5	6	5	8
Elbon rye and ladino clover	16	39	20	9	24	31	25	18
Flowering dogwood								
Leaves	8	7	10	13	10	8	9	12
Twigs	4	5	8	5	4	6	6	6
Eastern redcedar	7	7	8	8	7	8	9	6
Panic grasses	9	7	10	11	9	8	10	15
Pussytoes	6	7	7	8	8	8	9	10

Table 9.-*Calcium content of native and improved forages*

Forage item	1969		1970 to 1971			
	Summer	Fall	Summer	Fall	Winter	Spring
	Percent of ovendry weight					
Japanese honeysuckle						
Leaves	1.6	1.5	*	1.1	1.5	1.4
Twigs	0.5	0.5	0.4	0.6	0.7	0.6
Elbon rye and ladino clover	1.3	1.1	1.1	0.9	0.7	0.9
Flowering dogwood						
Leaves	3.2	2.9	2.5	3.2	4.5	1.3
Twigs	2.1	1.4	2.1	3.2	2.6	2.0
Eastern redcedar	1.5	2.3	1.6	1.7	2.9	2.0
Panic grasses	0.5	0.7	0.5	0.8	0.6	0.6
Pussytoes	1.6	1.1	1.1	1.5	2.1	1.2

* No data

Table 10.—*Phosphorus content of native and improved fomges*

Forage item	1969 to 1970				1970 to 1971			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	Percent of ovendry weight							
Japanese honeysuckle								
Leaves	0.21	0.28	0.23	0.28	0.23	0.21	0.18	0.16
Twigs	0.20	0.09	0.09	0.17	0.18	0.14	0.10	0.13
Elbon rye and ladino clover	0.20	0.74	0.45	0.32	0.42	0.59	0.43	0.16
Flowering dogwood								
Leaves	0.13	0.14	0.12	0.26	0.14	0.12	0.17	0.08
Twigs	0.11	0.10	0.14	0.14	0.11	0.10	0.11	0.10
Eastern redcedar	0.13	0.15	0.14	0.14	0.16	0.15	0.14	0.05
Panic grasses	0.12	0.11	0.16	*	0.13	0.08	0.14	0.10
Pussytoes	0.15	0.15	0.11	0.19	0.19	0.14	0.13	0.10

* No data.

Table 1 1.—*Dry matter digestibility of native and improved forages*

Forage item	1969 to 1970				1970 to 1971			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	Percent							
Japanese honeysuckle								
Leaves	90	88	92	90	89	91	91	92
Twigs	41	29	30	46	40	38	36	56
Elbon rye and ladino clover	80	94	89	60	82	95	93	80
Flowering dogwood								
Leaves	87	87	91	88	87	88	87	88
Twigs	57	56	69	68	*	69	69	75
Eastern redcedar	71	69	78	78	75	76	78	76
Panic grasses	61	50	62	68	56	56	60	75
Pussytoes	88	79	89	88	85	86	87	89

* No data.

Forage Digestibility.-As determined by the in vitro, nylon bag, dry matter digestion technique (Tilley and Terry 1963), honeysuckle leaves were the most highly digestible (88 to 92 percent) of all forages tested, except during both fall seasons and one winter season when rye and clover forages were highest (table 11). Dogwood leaves were generally the most digestible of the native forages, and honeysuckle twigs were the least digestible of improved forage items. Twigs of woody plants were consistently much less digestible than the leaves. The digestibility values for dogwood and honeysuckle leaves were generally slightly higher than those reported in other studies (Short and others 1975).

Deer Responses

Population Changes 1963–67.—Twenty-nine adult deer and seven fawns were removed from the enclosure between March and November 1962 by live trapping and hunting. The enclosure was restocked with eight does and two bucks between April and June 1963 (table 12), but one buck died shortly after restocking. The recruitment (annual production minus mortality) of fawns in the spring of 1963 was seven.

The Caney enclosure was not censused for deer in the fall of 1963. The census in March 1964 recorded 16 deer. A fall census was not made in 1964. Four deer were shot during the winter of 1964-65 to keep deer numbers at a prescribed level. Five deer were counted in the census of March 1965. A census error was suspected so a recount was made in April. Six deer were counted. A subsequent search revealed three deer carcasses, and it was assumed that a major die-off had occurred during the previous winter when mast yields were low. There were no surviving fawns in the enclosure during the summer of 1965. Nine deer were restocked over the summer of 1965 to bring populations up to the desired level. The 1965 fall census of 16 indicated restocked deer had survived and that 1 fawn had been added by recruitment.

All deer survived the winter 1965-66. There were no recorded losses over summer. The fall census of 23 deer indicated recruitment of 7 fawns. In the spring of 1967, five deer were removed and necropsied, and one

Table 12.—*Deer population changes in the Caney enclosure, located on the Sylamore Ranger District of the Ozark National Forest, 1963-67*

Year	Data source	Number of deer
1963	Stocked	10
	Recruitment	7
	Unexplained losses	1
	Removed	0
1964	Spring census	16
	Recruitment	Unknown
	Unexplained losses	6
	Removed	4
	Stocked	0
	Fall census	No census
1965	Spring census	6
	Recruitment	1
	Unexplained losses	0
	Removed	0
	Stocked	9
	Fall census	16
1966	Spring census	16
	Recruitment	7
	Unexplained losses	0
	Removed	0
	Stocked	0
	Fall census	23
1967	Spring census	9
	Recruitment	0
	Unexplained losses	8
	Removed	6
	Stocked	0
	Fall census	14'

* Includes deer removed for necropsy March l-3,1967.

deer was crippled and presumed dead. Immediately following the necropsy work, a census drive recorded only nine deer, and the finding of five carcasses indicated that another die-off had occurred during the winter of 1966-67, another winter of low mast availability. All nine deer survived the summer of 1967, but there was no recruitment.

These study results indicated that the Caney enclosure would support one deer per 45-to-100 acres on a sustained basis. It was apparent that deer populations would build up in excess of that density during periods of average or above-average mast production, but deer would die off during periods of mast scarcity.

Population Changes 1968–77.—Nine deer were recorded in the Caney enclosure in 1968 when improved food plots were established (table 13). Five adult does were added during the summer. The fall census of 1968 showed a population of 23 deer, 9 of which were fawns.

During the winter of 1968-69, rye and clover were available to deer on the improved food plots, but mast production was the lowest recorded in the study. The extra heavy utilization of the rye and clover (98 percent, table 7) indicated that deer were short of food. Eight deer died during the winter, but 15 survived. In comparison, only six had survived the 1964-65 winter under similar food conditions but without food plots.

The fall 1969 census revealed a recruitment of 11 fawns. In contrast, no fawns were born or survived following the winter die-offs of 1964-65 and 1966-67 when no supplemental forage was available.

Twenty-two of the 26 deer present in the fall of 1969 survived over winter. Two deer jumped out of the enclosure during the fall 1969 census drive, and two deer were killed by bobcats. A moderate crop of mast (39 lb/acre) and the availability of improved forage was probably responsible for this high overwinter survival.

The fall 1970 census resulted in conflicting counts of 20 to 24 deer. Six fawns were positively identified during the fall, indicating that adult mortality equaled or possibly exceeded recruitment during the summer and fall. No carcasses were found. Escapes from the pen, poaching, or other unknown factors could have been responsible for the adult mortality.

Twelve live deer were counted in the spring of 1971. However, it was assumed that 21 deer survived the winter because 7 deer were removed for the disease and parasite study, 1 deer was wounded and presumed dead, and 1 deer was killed during the census when it ran into a tree. These last two deer were added to the removal data (table 13). Even though mast production was very low in 1970-71 (11 lb/acre), the yields of native and supplemental forage were adequate for winter survival of all deer.

The fall 1971 count of 14 deer represented a recruitment of 4 deer. Two old bucks were found dead from apparently natural causes. High mast yields enabled all deer to survive the winter and resulted in limited utilization of improved forages and undetectable use of native forage.

The fall 1972 count of 18 deer indicated a recruitment of 4 deer over the spring count. One deer was lost to unknown factors over winter even though mast production in the fall was relatively good (51 lb/acre).

Recruitment was good in the summer of 1973 with eight deer added to the population. Twenty-four deer survived the winter of 1973-74, and one was lost to unknown factors. The survival rate was high even though mast production was only 31 lb/acre, and utilization of cultivated forages was fairly light. High use of honeysuckle was noted during a period of snow and ice coverage.

A tornado damaged approximately 40 percent of the study area in the spring of 1974. Twenty-eight deer were counted in the fall, an increase of four over the spring count. Since eight fawns had been observed in late June 1974, it was obvious that some mature deer died or escaped after the tornado damaged the fences.

Because of high mast production in the fall of 1974 (323 lb/acre), use of cultivated forages was light even

Table 13.—*Deer population changes in the Caney enclosure, located on the Sylamore Ranger Disrict of the Ozark National Forest following food plot establishment, 1968-77*

Year	Data Source	Number of deer	Year	Data Source	Number of deer
1968	Spring census	9	1973	Spring census	17
	Known reproduction	9		Known reproduction	8
	Known mortality	0		Known mortality	
	Removed	0		Removed	0
	Stocked	5		Recruitment	8
	Recruitment	9		Fall census	25
	Fall census	23			
1969	Spring census	15	1974	Spring census	24
	Known reproduction	11		Known reproduction	8
	Known mortality	8		Known mortality	1
	Removed	0		Removed	0
	Recruitment	11		Recruitment	4
	Fall census	26		Fall census	28
1970	Spring census	22	1975	Spring census	28
	Known reproduction	6		Known reproduction	10
	Known mortality	2		Known mortality	13
	Removed	0		Removed	0
	Recruitment	±2		Recruitment	0
	Fall census	20–24†		Fall census	27
1971	Spring census	21*	1976	Spring census	22
	Known reproduction	4		Known reproduction	9
	Known mortality	2		Known mortality	11
	Removed	9		Removed	0
	Recruitment	4		Recruitment	0
	Fall census	14		Fall census	21
1972	Spring census	14	1977	Spring census	18
	Known reproduction	4		Known reproduction	11
	Known mortality	0		Known mortality	13
	Removed	0		Removed	0
	Recruitment	4		Recruitment	2
	Fall census	18		Fall census	20

* Includes deer removed for necropsy.
† Conflicting counts.

though the population of deer was the highest attained during the study. All deer survived the winter.

Seven newborn fawns in the enclosure and two outside in the wildlife management area were captured by hand and equipped with radio transmitters in the spring of 1975. All the instrumented fawns in the enclosure were either killed by predators or died during the summer. One fawn outside the enclosure died during the summer; the other survived for 5 months. Two adult bucks were killed during live-trapping operations, and one doe was found dead from apparently accidental causes. The net herd reduction during the summer was one deer; thus, a minimum of two 1975 fawns survived to 6 months.

Five deer were lost during the winter of 1975-76. Three had been killed by poachers, and a radio-equipped buck was found dead with his front leg and shoulder through the radio transmitter collar. The other loss was unexplained. During this winter, utilization of improved forages was relatively high, 39 percent for rye and clover and 13 percent for honeysuckle. Improved forage crops eaten by deer totaled almost 9,000 ovendry pounds, the highest utilization during the study. Food plots compensated for the low mast yields (22 lb/acre), and no deer losses were attributed to food shortages.

Twenty-one deer were counted in the fall of 1976, one less than in the spring. One adult doe was found dead from apparent gunshot wounds. Eight newborn fawns were equipped with transmitters; seven of these died or were killed by predators before reaching 6 weeks of age. The radio signal from one fawn was lost after 20 days. When all deer were removed from the enclosure at the end of the study, there were no deer from the 1976 fawn class, which verified the high fawn mortality of 1976. This was the second year in a row that mortality exceeded reproduction.

Eighteen deer survived the winter of 1976-77. Three adult deer carcasses accounted for all missing deer. These losses were not attributed to lack of nutritious food because mast production was 269 lb/acre, and utilization of improved forage crops was extremely low. Eight fawns that were captured and radio equipped during the spring either died or were killed by predators.

All 20 deer in the enclosure were removed by shooting from January through March of 1978. Age structure of these deer indicated a fawn survival of two from the 1977 fawn class, none from the 1976 fawn class, and two from the 1975 fawn class. Thus, only four fawns survived to adulthood during the period from 1975 to 1978. Reproductive potential as determined from necropsy analysis averaged 1.54 fetuses per breeding-age doe with a range of 1.34 to 1.86. Thus, fawn survival was only a small percentage of the potential production.

These results indicated that the deer carrying capacity of the enclosure with food plots was one deer per 21 to 33 acres, compared to one deer per 45 to 100 acres without supplemental forage. The average fall population without supplemental food plots was 13 deer (1 deer per 46 acres), whereas the average was 23 deer (1 deer per 26 acres) when supplemental food plots were available. Deer removed for necropsy were counted as surviving deer. Based on this evaluation, the number of deer available to the hunter in the fall was increased by 77 percent when supplemental food plots were available to augment fluctuating mast supplies.

Mortality factors.-A concerted effort to isolate mortality factors began with the capture of fawns in 1975. Twenty-five fawns were captured, 18 in the enclosure and 7 in the adjacent wildlife management area. Motion-sensitive transmitters were attached to fawns captured in 1975, and a heat-sensing function was added to transmitter units in 1976 and 1977. The combination of motion- and temperature-sensing functions was effective in determining when mortality occurred.

The majority of captured fawns was found in light understory in open hardwood and pine-hardwood timber stands. Most fawns were found bedded in the open at the base of trees, occasionally in dead or blown-down tree tops, and usually in slight depressions in the ground. A few were observed in heavy cover on food plots.

Fawns were never located in the same place on 2 consecutive days. One set of twin fawns was captured less than 1 hour after birth. Each fawn was found in a separate location the night after being fitted with transmitters. The fawns were not located together again, although they were never more than 300 yards apart for the 15 days they were monitored. The dam was never more than 300 yards from one of the twins, but she was seldom in direct contact with the fawns except during nursing and grooming periods. She would groom and nurse the twins and change their locations daily, usually in early morning and late afternoon. Typically, fawns were relatively inactive during the first 2 to 3 weeks of life. Activity, size of range, and the amount of time spent with the dam increased with age.

None of the 18 radio-equipped fawns survived inside the enclosure, and only 2 of 7 were known to have survived outside the enclosure. Predators killed 18, 2 starved, 2 died from accidents, 1 died from disease, and 2 were unaccounted for.

Of the predator kills, 13 were due to coyotes and 5 to bobcats. Predator-killed fawns averaged 14 days of age with a range of 8 to 61 days. The two deaths from starvation occurred at the ages of 14 and 17 days and were the result of abandonment by does. The abandoned fawns were inactive in one location for 2 to 5 days and then moved at random for 0.4 to 1 mile before dying. It appeared that one predator-related death occurred to a fawn near death from starvation.

An effort in 1977 to control predators by trapping was of little consequence because only one coyote was caught. Observation data indicated that the enclosure may have served as a portion of the home range for approximately three coyotes and two bobcats.

Necropsy of 14 fawns indicated 1 case of disease. Acute interstitial pneumonia with hemorrhagic disease was suspected.

Causes of adult deer mortality were investigated in 1975-77 by attaching motion-sensitive radio transmitters to 16 adults. Three died or were killed by poaching, accident, or predation, and one died when a leg became entangled in the radio collar. Nine of the transmitters failed due to antenna breakage, and one failed because of internal malfunctions. Seven additional deaths were recorded for adult deer not fitted with transmitters: three by poachers, two by deer traps, and two by undetermined causes.

Herd Behavior.-Generally, adult bucks were less active than other age or sex classes of deer in all seasons except fall. Adult males traveled, bedded, and fed in groups of two to six individuals. Usually these groups were made up of the same deer. These male groups began to disperse in October, and individual activity increased to a peak during the main breeding period of October 29 to November 6. At this time, adult bucks moved almost constantly throughout the enclosure. Adult males, generally active at night, were highly active during daylight hours only during the breeding period and regrouped after the breeding season. Yearling bucks were not as structured in their activities and frequently fed and traveled with adult doe family groups.

Adult does generally associated with their female offspring. One group consisted of an old doe with her young of the year, her 3-year-old daughter with her young of the year, and a yearling female. Adult does spent up to 75 percent of their time in selected high-use areas. There was some intermix between female family groups and bucks in late winter and spring. Adult females were somewhat more active during the breeding period, but much less than bucks, and were seldom found outside their core areas. Doe groups broke up during late spring with the pregnant does usually traveling and bedding alone until their newborn fawns were old enough to travel. Doe-fawn groups began to re-form in midsummer and remained basically intact the remainder of the year.

Internal Parasites.--Five of the 19 deer removed at the termination of the study (January-February 1978) were necropsied by personnel from the Southeastern Cooperative Wildlife Disease unit of the University of Georgia. Adult meningeal worms (*Parelaphostronglyus tenuis)* and their larvae were found in all five deer, but they were not associated with significant tissue damage. Abomasal helminth counts ranged from zero to 43 per deer for *Ostertagia mossi* and 60 to 571 for *Skrjabinagia spp.* These low levels indicated that food supplies were adequate for the period preceding collection.

Abdominal worms (*Seteria yehi*), gullet worms (*Gongylonema pulchrum*), and intestinal worms (*Capillaria bovis*) were of little importance at the low levels encountered. Blood and muscle protozoans (*Theileria cervi* and *Sarcocystis sp.*) were present, but neither parasite was a significant mortality factory. Arthropod parasites were at a level commonly encountered on deer in the Southeast.

Based on these results it was concluded in this study that deer mortality was not parasite induced. The abomasal parasite count indicated a deer population below the nutritional carrying capacity of the range (Eve and Kellogg 1977). Similar conclusions were drawn from necropsies performed on five deer collected from the surrounding wildlife management area.

Genetics.-An indication of genetic problems from inbreeding in the confined deer herd was suggested by liver and kidney examinations with horizontal starch gel electrophoresis (Price and others 1979). The average individual heterozygosity, ranging from 2.3 to 4.7 percent, was much lower for deer within the enclosure than for white-tailed deer in other parts of the range. Low genetic variability of the deer population may have been associated with the low herd productivity and high fawn mortality in the latter stage of the study.

Big Spring Enclosure

Woody Plants

Timber stands were largely a mixture of many size and age classes, with only a few acres of even-aged hardwood stands. Tree basal area ranged from 83 to 92 ft^2/acre for all forest types except the cedar glade, where it averaged 68 ft^2/acre (table 14). Overstory canopies were heavy and continuous for all types except the glade. Hardwood saplings were dominant in all types except in the transitional pine-hardwood type where pole size timber predominated. Streambottom hardwoods had the highest basal area of sawtimber. Pines were a major component of the timber overstory only in the upland pine-hardwood and transitional pine-hardwood stands.

Understory browse cover ranged from 14 percent in upland hardwood to 31 percent in the pine-hardwood stands. Species contributing most to cover were eastern redcedar, lowbush blueberry, grape, greenbriers, white oak, and American elm (*Ulmus americana*).

Summer Forage Yields

Summer forage yields averaged 179 lb/acre and varied from 128 to 516 lb/acre (table 15). Yields tended to be lowest in growing seasons with below average rainfall and generally increased with improved moisture availability. The high forage yields in 1975 were a direct response to the opening up of the canopy by the 1974 tornado. Opening of the stands reflects the extent to which forage yields may be increased through timber-cutting practices, which have been recommended for oak-hickory forests (Torgerson and Porath 1984).

Grasses, sedges (*Carex* spp.), forbs, and ferns accounted for 31 percent of the average yield, and browse for 69 percent. Composites, legumes, and mints made up the bulk of the forbs, while panic grasses and bluestems were the most common grasses. About half the browse was classified as preferred by deer. Dogwood, lowbush blueberry, and common deerberry were the most abundant species of preferred browse. Oaks and hickories were the dominant of nonpreferred species.

Winter Forage Availability

Winter forage was scarce, ranging from 14 to 103 lb/acre (table 16). Deciduous browse twigs made up about 90 percent of the total winter vegetation. Preferred green forage, consisting primarily of panic grasses, sedges, pussytoes, and eastern redcedar averaged only about 3 lb/acre. The relatively high yields in 1976 were a result of the 1974 tornado.

Mast Yields

Mast yields averaged 73 lb/acre but ranged from 3 to 206 lb (table 16). Acorns made up 86 percent of all mast. White oak acorns were most abundant, followed by black, northern red, blackjack (*Q. marilandica*), and

Table 14.—*Tree basal area in the Big Spring deer enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

	Forest types					
	Upland hardwood	Upland pine-hardwood	Cedar glade	Streambottom hardwood	Transitional pine-hardwood	All types combined
	Feet²/acre					
Hardwood						
Sapling	34	30	30	32	16	31
Pole	33	12	13	25	30	24
Sawtimber	23	12	18	30	18	21
Total hardwood	90	54	61	87	64	76
Pine						
Sapling	0	8	1	1	2	2
Pole	0	2	2	1	6	1
Sawtimber	1	19	4	3	12	7
Total pine	1	29	7	5	20	10
Total timber	91	83	68	92	84	86

Table 15.—*Summer forage yields in the Big Spring enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

Date	Grasses and grasslike plants	Forbs and ferns	Preferred browse	Nonpreferred browse	Total vegetation
	Pounds/acre				
1963	20	13	50	67	150
1964	14	14	44	56	128
1965	28	33	50	59	170
1966	23	24	53	45	145
1967	22	15	40	47	128
1968	22	15	45	50	132
1969	23	19	51	47	140
1970	15	18	49	54	136
1971	*	*	*	*	*
1972	19	21	54	61	155
1973	26	29	66	62	183
1974	*	*	*	*	*
1975	65	138	142	171	516
Average	25	31	58	65	179

* No data.

chinkapin oaks. Fruit of the dogwood, grape, blackgum, and sassafras made up 14 percent of the mast.

Acorn yields were less than 20 lb/acre for 4 years and greater than 100 lb/acre for 4 years. White oak was the most erratic major mast producer. No white oak acorns were produced for 4 years and less than 5 lb/acre another 4 years. Some black oak acorns were produced every year, but less than 9 lb/acre were produced 6 years.

The upland hardwood forest type produced the most mast (114 lb/acre), followed by the upland pine-hardwood type (79 lb/acre), the streambottom hardwood type, (59 lb/acre), and the dry cedar glade (25 lb/acre).

Deer Food and Feeding Habits

Deer diets varied widely between seasons. Based on forage utilization estimates and stomach contents, deer ate forbs, grasses, sedges, mushrooms, and the succulent portions of browse during spring and summer. During these seasons deer used all forest types as indicated by pellet group counts.

Deer diets during fall and winter varied largely with mast availability. When plentiful, mast made up almost the entire diet, and deer concentrated in the most heavily wooded forest types. Grapes were heavily used as soon as they began to drop. When acorn crops were low, all mast was soon expended, and deer turned to green winter forages such as eastern redcedar,

Table 16.-Winter *fomge availability and mast yields in Big Spring enclosure, located on the Sylamore Ranger District of the Ozark National Forest*

Year	Winter forage availability				Mast yields		
	Grasses and grasslike plants	Forbs and ferns	Browse	Total	Acorns	Other	Total
	Pounds/acre						
1963			*	*	5	6	11
1964		*	*	*	23	5	28
1965	*	*	13	14	149	9	158
1966	2	2	17	21	44	1	45
1967	1	1	14	16	190	16	206
1968	2	0	16	17	3	0	3
1969	1	1	18	19	45	3	48
1970	1	1	19	21	9	0	9
1971	2	3	20	25	*	*	*
1972	*	*	*	*	51	3	54
1973	3	4	14	21	23	13	36
1974	2	4	23	29	*	*	*
1975	*	*	*	*	4	26	30
1976	*	*	103	103	113	32	145
1977		*	*	*	160	21	181
Average	1	2	26	29	63	10	73

*No data.

panic grasses, pussytoes, and sedges. At these times, deer concentrated on the glade, where these forages were most abundant. However, the scarcity of green forage forced deer to eat considerable amounts of deciduous browse twigs and dead deciduous browse leaves during periods of extreme mast shortage. Chemical analyses of the most commonly eaten winter forages indicated that the most sought after forages had the highest nutritional content (Segelquist and others 1973).

Deer Responses 1963 Through 1971

In 1963, the enclosure was stocked with 10 does and 1 buck (table 17). From 1963 through 1971, 32 deer were known to have been born in the enclosure (19 females and 13 males). The total number of deer stocked and born was 29 does and 14 bucks. Seventeen does and 10 bucks were shot or trapped and removed, and 2 does and 1 buck were found dead. The remaining 10 does and 3 bucks apparently died or escaped from the enclosure because their remains were never found.

Productivity of the deer herd was extremely low through 1971. Based on the number of does ≥2 years old present each spring and a fawning rate of 1.57 fawns per doe as determined from fetal counts, at least 67 fawns should have been born. Records were obtained on only 32 deer born in the enclosure. These figures illustrate the disparity between expected and observed herd productivity.

Deer conditions ranged from poor to good depending upon the time of year and quantity and quality of available food. Deer captured in traps during the spring and summer were all in fair-to-good condition. Some large bucks taken from the enclosure during periods of mast scarcity in late winter were in poor condition. Deer were never found starving, but they were in poorer shape after mast shortages and were presumably more susceptible to other environmental stresses.

Deer were hosts to a number of internal and external parasites, but only those of the protostrongylid group were present in significant numbers. Adult meningeal worms were present in most deer, and their larvae were present in the lungs of all deer examined. Unidentified protostrongylid larvae were found in the lungs of deer. Parasitologic and physiologic data indicated that protostrongylid larvae, interacting with other factors, may have affected deer herd health at some times.

Poaching, predation, and escapes are unaccountable factors that may have affected deer numbers. One deer was shot and killed by a poacher, but its ear tag was ultimately recovered. A bobcat killed one yearling buck.

Based on the information collected from 1963 to 1971, the 675-acre enclosure was capable of supporting 10 to 13 deer or 1 deer per 50 to 70 acres. It appeared that the carrying capacity was determined by the scarcity of winter foods, which at times could have been compounded by parasitism.

Table 17.—*Deer population changes in the Big Spring enclosure, located on the Sylamore Ranger District of the Ozark National Forest, 1963-71*

Date	Data	Number of deer
1963	Stocked	11
	Recruitment	5
	Fall population	16
1964	Spring population	16
	Recruitment	7
	Shot	5
	Losses	2
	Fall population	23
1965	Spring population	16
	Recruitment	2
	Trapped and removed	2
	Fall population	16
1966	Spring population	16
	Recruitment	5
	Shot	5
	Fall population	21
1967	Spring population	16
	Recruitment	5
	Killed in drive	1
	Losses	7
	Fall population	21
1968	Spring population	13
	Recruitment	1
	Losses	4
	Fall population	14
1969	Spring population	10
	Recruitment	6
	Losses	4
	Fall population	16
1970	Spring population	12
	Recruitment	0
	Losses	0
	Shot	7
	Fall population	11
1971	Spring population	4
	Recruitment	1
	Shot	5

DISCUSSION

Study results indicate that the deer carrying capacity of Ozark upland forests is generally low and dependent on several factors that fluctuate within and among years. Food availability is the most obvious limiting factor and can be manipulated to some extent by management practices. As shown in this study, the 90 to 145 lb/acre of available forage during the growing season seems adequate to support a moderate population of deer. But 85 percent or more of this forage is unavailable to deer during the critical winter period, and most is deciduous, low-quality browse. Thus, on the basis of native forage yields, the heavily wooded Ozark forests are limited in their potential to support an overwinter population that may accrue during the summer.

Native forage availability is also governed by habitat types and logging activity. For example, the Big Spring enclosure, with its 311 acres of cedar glade and streambottom hardwoods, consistently produced more native forage than the Caney enclosure, with only 42 acres of these high forage producing types. Green winter forage production in the Big Spring enclosure was three times greater than in the Caney enclosure due to cedar glade acreage (Segelquist and others 1969). Also, tree basal area in the Big Spring enclosure was only 86 ft^2/acre compared to 101 ft^2/acre in the Caney enclosure.

Forage yields are unlikely to change much from year to year as long as timber stand conditions remain fairly stable. The extent to which timber alterations may influence forage yields was shown by the threefold increase of forage yields in the Big Spring enclosure during the growing season after the tornado blew down many of the larger trees. Presumably the deer-carrying capacity would be increased with a greater availability of forage, particularly during the winter, but the extent is not predictable from the results of this study.

The deer carrying capacity of Ozark forests such as the ones in this study is about one deer per 45 to 100 acres when the deer subsist solely on native forage. The more glade forest types, the greater the capacity.

The problem of forage sparsity is further accentuated by the low nutritional quality. Although the protein content of most native species tested was adequate for deer maintenance most of the year, it seldom reached a level needed for the optimum growth of young deer. The phosphorus level was inadequate in all cases, even for body maintenance, and the calcium-to-phosphorus ratio was much higher than recommended.

The availability of mast, which consists mainly of acorns, adds a potentially large, although highly erratic, dimension to the deer carrying capacity. Deer populations in both enclosures fluctuated drastically according to mast availability. Mast yields during 1964-65 were 11 and 28 lb/acre in the Caney and Big Spring enclosures, respectively. During the 1964-65 winter, deer numbers in Caney declined from one per 33 acres to one per 100 acres and in Big Spring from one deer per 38 acres to one per 42 acres. During the winter of 1966-67 with mast yields of 16 pounds per acre, deer in the Caney enclosure declined from one deer per 28 acres to one per 40 acres. In the Big Spring enclosure with mast yields at 45 lb/acre, the overwinter population remained at one deer per 31 acres.

The negative repercussion of meager acorn crops on mature deer was further accentuated by low fawn survival the following spring.. For example, after the winters of 1964-65 and 1966-67, no fawns survived in the Caney enclosure, and there was only a **13-percent** increase of deer numbers in the Big Spring enclosure. Usually the deer populations fluctuated less in the Big Spring than in the Caney enclosure-probably because of greater winter forage availability and because mast yields were more consistent in the Big Spring enclosure.

The fact that the overwinter carrying capacity and the reproductive rate of deer fluctuate highly in relation to mast availability poses difficult problems in the harvest strategy of deer. Data from this study suggest that special attention be given to an assessment of expected mast yields prior to the fall hunting season. If mast yields, particularly acorns, are low, extra hunting effort should be exerted to reduce the **over**wintering deer population. Under low mast conditions, winter survival would be low, and those surviving would experience a poor reproductive success the following spring. On the other hand, if herd numbers were reduced at or below carrying capacity in the fall, the surviving adult does would be more likely to go through the winter in reasonably good shape and produce healthy fawns the following spring and summer. Other studies have also shown the importance of adult doe nutrition on fawn survival (Verme 1977, **Logan** 1973).

When acorn yields are moderate to high, there is less need to impose a heavy harvest strategy. But here again, a deer herd maintained at or below the carrying capacity will likely experience high reproductive rates (McCullough 1984).

As visualized in the planning stages of this study, a practical possibility for increasing the deer carrying capacity of Ozark forests and ameliorating or cushioning the effects of highly fluctuating mast yields would be to establish food plots that consistently produce high-quality food during winter, the most critical part of the year. Efforts to do so in the Caney closure were successful.

The fir&year forage yields on food plots established in 1968 were low and not sufficient to fully compensate for the low yields of native forage and mast. As a result of this general food scarcity, utilization of native and improved forage was high. Eight adult deer died, and deer numbers declined from one deer per 26 acres to one deer per 40 acres. However, this was a significantly higher carryover than the one deer per 100 acres that survived the winter of 1964-65 when no food plots were available.

Deer that survived the 1968-69 winter produced 11 fawns the following summer, and the fall population in 1969 was 1 deer per 23 acres. This was the only significant reproduction recorded following any winter **die**-off during the study. After the acreage of food plots was expanded in 1969 and became fully productive, the overwinter populations became fairly stable at one deer per 21 acres. This was almost double that of one deer per 46 acres prior to food plot establishment.

Where food plots are needed to compensate for a deficiency in winter feed, it should be recognized that food plots will be of less importance when acorn yields are high. During such times, deer eat little else other than acorns until the acorn supply is exhausted. Thus, an assessment of acorn production should be made each fall before time and money are expended to plant and fertilize annual crops that will be utilized lightly by deer.

Even though adult deer were not suffering from a lack of nutritious food after the food plots were established, mortality still occurred. The cause was not always obvious. Old age, poaching, predation, accident, and unknown natural causes were often involved.

When food plots were available, it appeared that low fawn survival was the major factor limiting the population. Fawns were usually born at or very near the expected rate (as determined from prenatal fetal counts), but they seldom survived 6 months. Of the 18 fawns outfitted with radio transmitters in 1975 and 1978, 77 percent were killed by predators, 6 percent died from starvation, 11 percent had equipment loss or failure, and 6 percent died from disease. Although most of this mortality was associated with predators, it is believed that predators were mainly the removal mechanism and that genetic or other unidentified factors were involved with this mortality.

The study results emphasize several important facts pertinent to deer and habitat management in the Ozarks. Sparsity of high-quality native foods during the winter and highly variable mast yields combine with disease, parasites, and predators to restrict **over**winter deer populations to a low level. Scarcity of quality forage can be alleviated to a large extent by timber-cutting practices (Torgerson and Porath 1984) and by establishing high-quality food plots. Even so, the populations may be curtailed by low fawn survival resulting from predation, disease, parasites, and other possibly interacting factors, such as genetics.

LITERATURE CITED

Alexander, Harold E. 1954. Deer problems. Little Rock, AR Arkansas Game and Fish Commission, Federal Aid Publication. [Not paged].

Association of Official Agricultural Chemists. 1960. Official methods of analysis. 9th ed. Washington, DC: Association of Official Agricultural Chemists. 832 p.

Donaldson, David; Hunter, Carl; Holder, T.H. 1951. Arkansas deer herd. Little Rock, AR Arkansas Game and Fish Commission. 72 p.

Eve, J. Hammond; Kellogg, Forest E. 1977. Management implications of abomasal parasites in southeastern white-tailed deer. Journal of Wildlife Management. 41(2): 169-177.

Fowells, H.A., comp. 1965. Silvics of forest trees of the United States. Agric. Handb. 271. Washington, DC: U.S. Department of Agriculture. 762 p.

French, C.E.; McEwen, L.C.; Magruder, N.D.; Ingram, R.H.; Swift, R.W. 1955. Nutritional requirements of the white-tailed deer for growth and antler development. Bulletin 600P. University Park, PA: Pennsylvania Agricultural Experiment Station. 50 p.

Halls, Lowell K.; Crawford, Hewlette S., Jr. 1960. Deer-forest habitat relationship in north Arkansas. Journal of Wildlife Management. 24(4): 387-395.

Logan, Tom. 1973. Study of white-tailed deer fawn mortality on Cookson Hills Deer Refuge, eastern Oklahoma. In: Proceedings of the annual conference of the Southeastern Association of Game and Fish Commissioners; 1972 October 22-25; Knoxville, TN. Columbia, SC: Southeastern Association of Game and Fish Commissioners: 27-39.

Magruder, N.D.; French, C.E.; McEwen, L.C.; Swift, R.W. 1957. Nutritional requirements of white-tailed deer for growth and antler development. II. Experimental results of the third year. Bulletin 628. University Park, PA: Pennsylvania Agricultural Experiment Station. 21 p.

McCullough, Dale R. 1984. Lessons from the George Reserve, Michigan. In: Halls, L.K., ed. White-tailed deer: ecology and management. Harrisburg, PA: Stackpole Books; Washington, DC: Wildlife Management Institute. 211-260.

Price, Phyllis K.; Cartwright, Michael; Rogers, Mitchell J. 1979. Genetic variation in white-tailed deer from Arkansas. Arkansas Academy of Scientific Proceedings. 33: 64-66.

Segelquist, Charles A.; Rogers, Mitch; Ward, Fred. D. 1972. Quantity and quality of Japanese honeysuckle on Arkansas Ozark food plots. In: Proceedings of the annual conference of the Southeastern Association of Game and Fish Commissioners; 1971 October 17-20; Charleston, SC. Columbia, SC: Southeastern Association of Game and Fish Commissioners: 47-53.

Segelquist, Charles A.; Rogers, Mitch; Ward, Fred D.; Leonard, Robert G. 1973. Forest habitat and deer populations in an Arkansas Ozark enclosure. In: Proceedings of the annual conference of the Southeastern Association of Game and Fish Commissioners: 1972 October 22-25; Knoxville, TN. Columbia, SC: Southeastern Association of Game and Fish Commissioners: 15-21.

Segelquist, Charles A.; Ward, Fred. D.; Leonard, Robert G. 1969. Habitat-deer relations in two Ozark enclosures. Journal of Wildlife Management. 33(3): 511-520.

Short, Henry L.; Blair, Robert M.; Epps, E.A., Jr. 1975. Composition and digestibility of deer browse in southern forests. Res. Pap. SO-111. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 10 p.

Tilley, J.M.A.; Terry, R.A. 1963. A two-stage technique for the in *vitro* digestion of forage crops. Journal of British Grassland Society. 18: 104-111.

Torgerson, Oliver; Porath, Wayne R. 1984. Midwest oak-hickory forest. In: Halls, L.K., ed. White-tailed deer: ecology and management. Harrisburg, PA: Stackpole Books; Washington, DC: Wildlife Management Institute. 41 l-426.

Ulrey, D.E.; Youah, W.G.; Johnson, H.E.; Fay, L.O.; Schoepke, B.L.; McGee, W.T.; Keahey, K.K. 1973. Calcium requirements of weaned white-tailed deer fawns. Journal of Wildlife Management. 37(2): 187-194.

Van Soest, R.J. 1967. Development of a comprehensive system of feed analyses and its application to forages. Journal of Animal Science. 26: 119-128.

Verme, Louis J. 1977. Assessment of natal mortality in upper Michigan deer. Journal of Wildlife Management. 41(4): 700-708.

Wilm, H.G.; Costello, D.F.; Klipple, G.E. 1944. Estimating forage yield by the double-sampling method. Journal of American Society of Agronomy. 36(3): 194-203.

Rogers, M.J.; Halls, L.K.; Dickson, J.G. 1990. Deer Habitat in the Ozark forests of Arkansas. Res. Pap. SO-259, New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Two enclosures of 590 and 675 acres were constructed and stocked with white-tailed deer (*Odocoileus virginianus*) to determine the deer carrying capacity of an Ozark mountain forest and to evaluate the impact of winter food plots on deer survival and productivity.

Keywords: Carrying capacity, disease, forage, mast, parasites, predators, white-tailed deer.