GRAZING AND BURNING IMPACTS ON DEER DIETS ON LOUISIANA PINE-BLUESTEM RANGE

RONALD E. THILL, U.S. Forest Service, Southern Forest Experiment Station, Box 7600 SFA Station, Nacogdoches, TX 75962
ALTON MARTIN, JR., U.S. Forest Service, Southern Forest Experiment Station, 2500 Shreveport Highway, Pineville, LA 71360
HERSHEL F. MORRIS, JR., Feed and Fertilizer Laboratory, Louisiana State University, Baton Rouge, LA 70803
E. DONICE McCUNE, Departments of Mathematics and Statistics, Stephen F. Austin State University, Nacogdaches, TX 75962

Abstract: Diets of 3–5 tame white-tailed deer (*Odocoileus virginianus*) on adjacent ungrazed and continuously grazed (35% herbage removal by late Oct) forested pastures were compared for forage-class use, botanical similarities, foraging selectivity and efficiency, and diet quality. Both pastures were divided into 3 burning subunits and burned in late February on a 3-year rotation. Botanical composition of diets differed between and within pastures, but forage-class use was similar except during winter, when deer selected more browse on ungrazed subunits. Grazing had no effect on dietary protein, phosphorus (P), or calcium (Ca) levels, but diets from ungrazed subunits were higher in digestibility (except during summer) and contained more uncommon plant taxa. Deer foraged more efficiently on grazed than on ungrazed subunits but were less efficient on recent than on older burns. Diets from 1st-year burns were higher in protein during spring and summer and higher in P during spring.

J. WILDL. MANAGE. 51(4):873–880

Forested rangelands dominated by longleaf (*Pinus palustris*) or slash (*P. elliottii*) pine and bluestem grasses (*Schizachyrium* spp. and *Andropogon* spp.) occupy about 2 million ha of the southern Coastal Plain. Cattle have grazed southern forests since the 16th Century, but public land managers increasingly are under pressure from wildlife and environmental groups to curtail grazing due to its perceived detrimental effects on wildlife, especially white-tailed deer. Research to resolve this controversy began only recently (Thill and Martin 1986).

Prescribed burning is an integral part of forest, wildlife, and cattle management in the South,

but its effect[s] and cattle interactions have only r[ecently] been investigated (Thill 1984*a*, Thill and Martin 1986). Burning usually increases forage availability and nutrient content, and deer and cattle prefer to graze recent burns (Duvall and Whitaker 1964, Lay 1967). Late winter burning on a 3-year rotation is a common management practice for cattle.

The abundant rainfall, high temperatures, and heavily leached, acid soils of the southern Coastal Plain produce an abundance of native forage of limited nutritional value. Many native forages are deficient in P all year (Blair et al. 1977) and adequate in protein only during spring for optimum deer growth (Short 1969, Thill and Morris 1985).

The objective of this study was to determine effects of burning and grazing on deer diets. Specifically, we compared deer diet composition and nutritional [d]ata over a 3-year period from 3 rotationally burned subunits of a pasture receiving moderate yearlong grazing to those obtained on 3 subunits of an adjacent, rotationally burned, ungrazed pasture. Comparisons included forage-class use, botanical similarities, foraging efficiency, diet selectivity, and diet quality.

STUDY AREAS

The study was conducted October 1980 through August 1983 on 2 adjacent pastures on the Longleaf Tract on the Palustris Experimental Forest in central Louisiana. Both pastures were divided by firelines into 3 burning subunits, each about 18 ha. Both pastures were prescribed-burned at 2–5-year intervals during late winter since 1959. For this study, 1 subunit was burned in each pasture each year in late February (Thill and Martin 1986).

Cattle numbers in the grazed pasture had been reduced in recent years. Yearlong stocking from April 1971 through March 1974 at 1 cow/6–8 ha resulted in 66% herbage use and 10% browse use (Pearson 1976). Cattle were removed for 4 years and then restocked in fall 1977 and continued through 1980 at about 1 cow/19 ha. During this study, yearlong stocking was reduced to 1 cow/29 ha to achieve 35% average herbage use across subunits by late October. Because cattle prefer recent burns, use there averaged 46%, compared to 29% and 26% on the 2- and 3-year-old burns, respectively. The ungrazed pasture had not been stocked with livestock since 1956.

The overstory on both pastures is dominated by natural stands of 2nd growth longleaf pine averaging 13.4 m²/ha basal area (Thill 1[9]84). Current-year growth of hardwoods, shrubs, and vines ≤1.5 m height averaged 401 and 468 kg/ha on grazed and ungrazed subunits, respectively. The fall herbaceous standing crop averaged 949 kg/ha on grazed subunits and 1,039 kg/ha on ungrazed subunits. Graminoids comprised 72% of the herbage on grazed subunits and 83% on ungrazed subunits and consisted mostly of bluestems, panicum grasses (*Panicum* spp. and *Dicanthelium* spp.) and paspalums (*Paspalum* spp.).

Summers are hot and humid, but winters generally are mild. The frost-free period extends from mid-March to mid-November. Average annual precipitation of 147 cm generally is well distributed yearlong. Some green forage is available throughout winter from evergreen and tardily deciduous woody species, graminoids, and rosette-producing forbs.

Topography varies from nearly level to gently rolling hills with slopes of up to 12%. Soils predominantly are fine sandy loams with moderate to good drainage and low natural fertility.

METHODS

Food-habits data were obtained by direct observation of 3–5 tame deer as they foraged on each subunit. Data were collected during 4 seasons: fall (27 Sep–25 Nov), winter (5 Jan–23 Feb), spring (21 Mar–10 Jun), and summer (23 Jun–16 Aug).

All deer were familiarized with both pastures during many practice trials prior to their use in the study. Deer were harnessed and leashed, but were allowed to graze at will. Trials were begun at random starting points and were conducted between 0730 and 1500 hours. Each subunit was sampled on 4–5 dates at approximately equal intervals throughout each season. Distances walked by each animal during the 30–45-minute trials were estimated to the nearest 0.10 km on a pedometer worn by an observer.

Data were collected for 3–5 deer each time a subunit was sampled. Two 3.5-year-old deer (a doe and a castrate) and a 2.5-year-old doe were used initially; 2 does (8 months old) were added during 1981 winter trials. Deer were maintained between trials on commercial horse and mule feed (13% crude protein, 0.44% P, and 0.48% Ca) and a wide variety of native plants.

As each deer was observed, a sample was hand-plucked that duplicated, insofar as possible, the animal's diet with respect to species, plant parts,

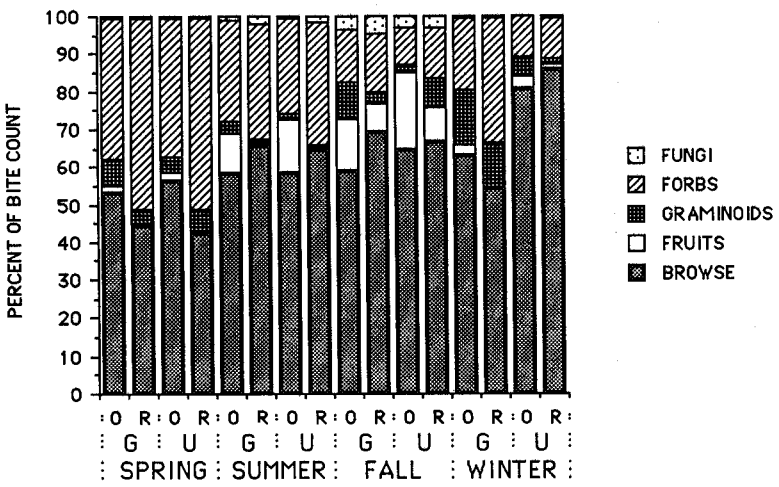

Fig. 1. Seasonal forage-class use by tame white-tailed deer on grazed (G) and ungrazed (U) pine-bluestem range in central Louisiana, 1980–83. Values are 3-year averages for recent (R) and older (O) (2–3-year-old) burns of a 3-year rotational burning system (from Thill and Martin 1986:fig. 1).

phenology, and forage weight. These simulated diet samples were dried to constant weight at 50 C, weighed, and ground through a 1-mm screen. These dry weights were used as estimates of forage intake for the entire foraging trial. An equal amount of this material from all deer for each date was composited, yielding 1 sample/subunit/date. Composite samples were analyzed for crude protein, Ca, and P (Assoc. Off. Anal. Chem. 1984). Cell wall constituents, acid detergent fiber, and acid detergent lignin were determined (Goering and Van Soest 1970) and used to predict dry-matter digestibility (Van Soest 1965, equation I). Although these estimates may not reflect actual, they provide a useful measure of relative digestibility (Short 1969). Nutritional analyses were conducted by the Louisiana State University Feed and Fertilizer Laboratory. All values are expressed on a dry-matter basis.

Diets were quantified using bite-count procedures (Thill 1984*b*). Similarities in botanical composition within and between pastures were calculated using Kulcyznski's coefficient of similarity (Oosting 1956:77). Bite-count data from all animals were composited across dates for each subunit to derive diet composition values for each season. Effects of burning and grazing on diet selectivity were evaluated using the following formula (Hobbs et al. 1983):

$$\text{Selectivity} = 100 - \Sigma(\%\text{ of common species in diet}).$$

Common species were defined as those having fall frequencies averaging >1% on 162 permanent 0.89-m² quadrats/subunit. As a measure of the contribution of ephemeral or uncommon foods to the diet, high values suggest greater selectivity.

Data were analyzed in a 3-factor (4 seasons, 2 grazing treatments, and 3 burn ages) complete block analysis of variance with blocking over years using BMDP statistical software (Dixon et al. 1985). Only 2-way interactions were considered. Differences among means were tested with Duncan's multiple range test. All tests were at the 0.05 level.

Data are based on 706 hours of observation and a total of 303,773 bite-counts. Observation time was distributed equally among subunits within each season. Average bite-count totals varied from 3,390/subunit during fall to 5,521 during spring and averaged 4,219 over all seasons.

RESULTS AND DISCUSSION

Forage-Class Use

Deer diets on both pastures were composed primarily of browse and forbs (Fig. 1). Graminoid use varied among areas but consisted mostly of low panicum grasses (*Dicanthelium* spp.). Fungi were used most during fall but usually comprised <5% of the diet. Fruit use was lowest on recent (1st-year) burns due to reduced fruit availability.

Differences in forage-class use between recent and older (2nd and 3rd year) burns were often substantial (Fig. 1), but spring and summer for-

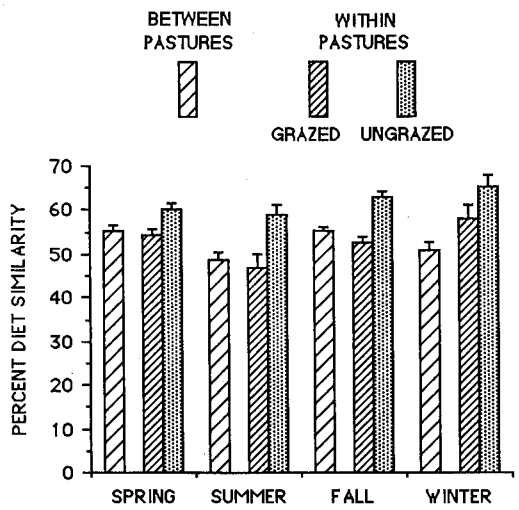

Fig. 2. Percentage similarities ($\bar{x} \oplus$ SE) in botanical composition of tame white-tailed deer diets between and within grazed and ungrazed pastures in central Louisiana, 1980–83. Values are averages across years with $N = 9$ (3 years × 3 subunits) for within-pasture comparisons and $N = 27$ for between-pasture comparisons.

age-class use was very similar for grazed and ungrazed treatments within both burn categories. Thus, differences during these seasons were attributed to burning rather than whether or not subunits had been grazed. Similar patterns of use were observed for browse and forbs during fall. However, winter diets seemed related to both grazing and burning, with diets from ungrazed units containing more browse but less graminoids and forbs than on grazed units. Graminoid use during winter was less on recent burns in both pastures, but forb use was higher on grazed, recent burns (Fig. 1).

Botanical Composition Similarities

On an annual basis, diet similarities between pastures averaged 52.6%, compared to within-pasture averages of 52.9% for grazed subunits and 61.8% for ungrazed subunits (Fig. 2). Thus, although differences in diet composition between grazed and ungrazed pastures were substantial, they were comparable to within-pasture differences.

Grazing Effect

Grazing decreased diet selectivity ($P < 0.0001$) but increased foraging efficiency ($P < 0.05$), expressed as the ratio of forage intake : distance travelled (Table 1). Diet digestibility was lower on grazed than on ungrazed subunits during spring, fall, and winter; summer digestibility was similar (Table 1). Greater foraging efficiency on grazed than on ungrazed subunits resulted from more efficient use of forbs and low-growing grasses, especially low panicums, which became more available as grazing removed the taller grasses.

Burning Effects

Burning in late February significantly affected all parameters evaluated ($P < 0.001$) except Ca:P ratio ($P > 0.27$). The effect of burning was independent of season for 5 parameters (Table 2) and season-dependent for 4 (Table 3). Deer consumed substantially more uncommon and ephemeral plant taxa on 1st-year burns than on older burns (Table 2). Foraging efficiency was sacrificed in achieving this higher diet selectivity, as deer travelled further and consumed less on 1st-year burns. However, diets on 1st-year burns were significantly higher in protein during spring and summer, higher in P during spring, and had better (lower) Ca:P ratios during spring (Table 3).

Foraging efficiency was consistently higher for older than for 1st-year burns for both grazed and ungrazed conditions. Greater availability and use of fruits on the older burns may be a partial explanation, especially during summer and fall. Greater travelling distances on 1st-year burns (Table 2) is also a cause, and may have been a behavioral response to reduced cover.

Crude protein (CP) requirements have been estimated at 13–25% for fawns (Smith et al. 1975) and 6–9% for adult maintenance (Robbins 1983). Simulated diet samples exceeded 8% CP throughout the year, but contained sufficient protein for growth (≥13%) only during spring (Table 3). The lowest value for an individual composite sample was 7.0% (summer) and the highest was 25.5% (spring).

Although minimum P requirements for white-tailed deer have not been adequately researched (Davis and Johnson 1986), P may be a major limiting factor for deer in the Southeast (Blair et al. 1977). P levels for individual composite samples varied from 0.05 (winter) to 0.42% (spring), but weekly averages exceeded 0.13% only during spring (Table 3). Diet samples from 1st-year burns contained more P than older burns during spring, but values were not different during fall and winter.

Ullrey et al. (1973) concluded that 0.40% Ca, together with 0.25–0.27% P, was adequate for

Table 1. Grazing effects on white-tailed deer diet selectivity, foraging efficiency, and predicted digestibility, central Louisiana, 1980–83.

Parameter	Season[a]	Grazed			Ungrazed		
		$\bar{x}$[b]	SE	N[c]	$\bar{x}$	SE	N
Selectivity (%)		24.3	1.1	163	34.7	1.5	165
Foraging efficiency		2.77	0.13	163	2.46	0.10	165
Digestibility (%)	Spring[d]	58.8	0.6	45	60.8	0.5	45
	Summer	58.4	0.4	42	58.3	0.4	42
	Fall	54.2	0.6	40	56.6	0.5	42
	Winter	54.7	0.5	36	59.2	0.6	36

[a] The grazing × season interaction was significant only for digestibility.
[b] $\bar{x}$'s within rows are all significantly different ($P < 0.05$) except summer digestibility.
[c] Sample sizes across years, burn ages, and seasons (except for digestibility).
[d] Spring = 21 Mar–10 Jun, summer = 23 Jun–16 Aug, fall = 27 Sep–25 Nov, and winter = 5 Jan–23 Feb.

growth of weaned fawns. With these accompanying levels of P, they indicated that 0.62% Ca was probably in excess of needs, but not harmful. Average seasonal Ca levels in this study exceeded 0.80% yearlong (Table 4) with levels for individual composited samples ranging from 0.47% during spring to 1.90% during winter. February burning reduced dietary Ca during spring, but Ca levels for 1st-year burns exceeded those of older burns during fall and winter.

An optimum Ca:P ratio has not been established for deer, but ratios of 2:1 to 1:2 are often suggested for domestic ruminants. Diet Ca:P ratios in this study were lowest during spring (3.6:1–6.2:1) and usually highest during winter (8.7:1–17.9:1). Burning reduced Ca:P ratios during spring, but Ca:P levels for 1st-year burns exceeded those from older burns during fall and winter (Table 3).

Burning during late February reduced crude fiber, cell wall constituents, and acid detergent fiber and lignin throughout the 1st year after burning and, consequently, increased predicted dry-matter digestibility in both pastures during all seasons (Table 2).

Seasonal differences in predicted digestibility were relatively small (Table 1), especially in comparison to declines in CP and P from spring to summer (Table 3). Thus, although digestibility of individual forage species may vary widely throughout the year (Short et al. 1975), these data suggest that selective foraging by deer may yield diets of fairly constant yearlong digestibility.

Diet Selectivity and Forage Quality

Crude protein and cell solubles in diets of Colorado ungulates on winter range were positively correlated with diet selectivity (Hobbs et al. 1983). Although correlations were low, we also found diet selectivity positively correlated with CP during spring ($r = 0.26$, $P = 0.013$) and fall ($r = 0.27$, $P = 0.013$) and with P during spring ($r = 0.27$, $P = 0.001$). As selectivity increased, crude fiber, cell wall constituents, acid detergent fiber, and lignin all tended to decrease; consequently, predicted digestibility was positively correlated with selectivity during spring ($r = 0.41$, $P < 0.001$), fall ($r = 0.24$, $P = 0.027$), and winter ($r = 0.43$, $P < 0.001$).

Table 2. Burning effects ($\bar{x} \pm$ SE) on white-tailed deer intake, distance travelled, foraging efficiency, diet selectivity, and digestibility, central Louisiana, 1980–83.

Parameter	Burn age		
	1st year ($N = 125$)[a]	2nd year ($N = 120$)	3rd year ($N = 83$)
Forage intake (g/min)	1.38 ± 0.04 A[b]	1.68 ± 0.05 B	1.58 ± 0.06 B
Distance travelled (km/30 min)	0.81 ± 0.03 A	0.65 ± 0.02 B	0.64 ± 0.03 B
Foraging efficiency	2.02 ± 0.10 A	3.03 ± 0.15 B	2.88 ± 0.16 C
Selectivity (%)	36.4 ± 1.9 A	27.2 ± 1.4 B	22.7 ± 1.2 C
Digestibility (%)	59.6 ± 0.3 A	56.6 ± 0.4 B	56.4 ± 0.4 B

[a] Sample sizes across seasons, years, and grazing treatments.
[b] $\bar{x}$'s within rows followed by unlike letters are significantly different ($P < 0.05$).

Table 3. Season and burning effects ($\bar{x} \pm$ SE) on white-tailed deer diet protein and minerals, central Louisiana, 1980–83.

Parameter	Burn age	Spring[a]	Summer	Fall	Winter
Crude protein (%)	1	17.1 ± 0.6 A[b] (30)[c]	11.5 ± 0.2 A (28)	9.9 ± 0.2 A (35)	8.8 ± 0.2 A (32)
	2	14.8 ± 0.5 B (35)	9.8 ± 0.2 B (33)	8.9 ± 0.2 A (28)	9.5 ± 0.3 A (24)
	3	14.8 ± 0.6 B (25)	9.7 ± 0.2 B (23)	9.5 ± 0.2 A (19)	9.4 ± 0.3 A (16)
Calcium (Ca) (%)	1	0.88 ± 0.03 A	1.34 ± 0.05 A	1.18 ± 0.04 A	1.33 ± 0.05 A
	2	1.03 ± 0.02 B	1.24 ± 0.05 A	1.00 ± 0.04 B	1.00 ± 0.06 B
	3	0.94 ± 0.04 AB	1.24 ± 0.04 A	0.95 ± 0.04 B	1.00 ± 0.08 B
Phosphorus (P) (%)	1	0.26 ± 0.01 A	0.13 ± 0.004 A	0.11 ± 0.005 A	0.09 ± 0.004 A
	2	0.20 ± 0.01 B	0.12 ± 0.003 AB	0.11 ± 0.005 A	0.11 ± 0.006 A
	3	0.19 ± 0.01 B	0.10 ± 0.002 B	0.11 ± 0.006 A	0.11 ± 0.007 A
Ca:P ratio	1	3.9 ± 0.3 A	10.7 ± 0.5 A	11.9 ± 0.7 A	16.2 ± 1.2 A
	2	5.9 ± 0.4 B	11.1 ± 0.5 A	9.4 ± 0.5 B	10.6 ± 1.5 B
	3	5.6 ± 0.5 B	11.9 ± 0.5 A	9.4 ± 0.8 B	10.5 ± 1.6 B

[a] Spring = 21 Mar–10 Jun, summer = 23 Jun–16 Aug, fall = 27 Sep–25 Nov, and winter = 5 Jan–23 Feb.
[b] $\bar{x}$'s within seasons and parameters followed by unlike letters are significantly different ($P < 0.05$).
[c] Values within parentheses are numbers of forage samples analyzed; values are identical for all subsequent parameters.

Season and Year Effects

Forage intake was significantly lower during winter than spring and summer, and distances walked were higher during fall than other seasons (Table 4). Deer were more selective during spring and fall than summer and winter, presumably because many ephemeral species are abundant during spring and often reappear with moderating fall weather.

Deer travelled farther and consumed less forage that was lower in CP and P (and higher in Ca) during the 1st year than during the last 2 years (Table 5). This may suggest a need for more extensive familiarization of deer with study areas. Predicted digestibility and selectivity were comparable among years (Table 5).

Implications

Available information suggests that forage preferences are similar for wild and tame deer (Wallmo and Neff 1970). Supplemental feeding has little effect on forage preferences of tame deer (Regelin et al. 1976), but its effects on diet quality are unknown. Tame deer studies should be useful in assessing relative differences among habitat treatments. In this regard, our findings suggest that deer inhabiting similar pine-bluestem range, with or without grazing or rotational burning, must contend with suboptimum CP and P levels and high Ca:P ratios from summer through winter.

Our findings support previous research showing that burning temporarily improves nutritional quality of deer forage. However, burning also reduces foraging efficiency and availability and use of fruits of woody plants within the 1st year after burning. Nevertheless, forage quality is more limiting to southern deer than forage availability (Lay 1957), and without periodic burning, carrying capacity would rapidly decline as browse grew beyond reach and pine needle accumulations reduced availability and production of herbage.

Table 4. Seasonal effects ($\bar{x} \pm$ SE) on white-tailed deer forage intake (g/min), distance travelled (km/30 min), and diet selectivity (%), central Louisiana, 1980–83.

Parameter	Spring[a] (N = 90)[b]	Summer (N = 84)	Fall (N = 82)	Winter (N = 72)
Intake	1.64 ± 0.06 A[c]	1.60 ± 0.04 AB	1.48 ± 0.05 BC	1.42 ± 0.05 C
Distance	0.69 ± 0.02 A	0.65 ± 0.02 A	0.81 ± 0.04 B	0.68 ± 0.03 A
Selectivity	32.4 ± 1.6 A	25.4 ± 1.5 B	33.4 ± 2.1 A	26.5 ± 2.4 B

[a] Spring = 21 Mar–10 Jun, summer = 23 Jun–16 Aug, fall = 27 Sep–25 Nov, and winter = 5 Jan–23 Feb.
[b] Sample sizes across years, burn ages, and grazing treatments.
[c] $\bar{x}$'s within rows followed by different letters are significantly different ($P < 0.05$).

Table 5. Yearly variation in diet quality ($\bar{x} \pm$ SE) and white-tailed deer activities, central Louisiana, 1980–83.

Parameter	Year 1 ($N = 125$)[a]	Year 2 ($N = 120$)	Year 3 ($N = 83$)
Crude protein (%)	10.9 ± 0.3 A[b]	11.4 ± 0.3 B	11.6 ± 0.3 B
Calcium (Ca) (%)	1.30 ± 0.03 A	0.99 ± 0.02 B	1.04 ± 0.02 B
Phosphorus (P) (%)	0.13 ± 0.01 A	0.15 ± 0.01 B	0.14 ± 0.01 B
Ca:P ratio	13.2 ± 0.7 A	7.8 ± 0.3 B	8.5 ± 0.3 B
Digestibility (%)	58.1 ± 0.3 A	57.6 ± 0.3 A	57.4 ± 0.4 A
Selectivity (%)	29.1 ± 1.7 A	31.4 ± 1.9 A	28.1 ± 1.5 A
Forage intake (g/min)	1.40 ± 0.04 A	1.60 ± 0.05 B	1.62 ± 0.05 B
Distance travelled (km/30 min)	0.97 ± 0.03 A	0.61 ± 0.02 B	0.56 ± 0.02 B
Foraging efficiency	1.63 ± 0.08 A	2.93 ± 0.13 B	3.24 ± 0.15 B

[a] Sample sizes across seasons, burn ages, and grazing treatments.
[b] $\bar{x}$'s within rows followed by unlike letters are significantly different ($P < 0.05$).

Although patterns of forage-class use were similar during much of the year, grazing influenced availability of certain preferred deer foods. Winter rosettes of many forbs and grasses were more available (and often more abundant) where grazing had removed the taller bunch grasses, but browse was generally less abundant on the grazed subunits. Consequently, winter deer diets from grazed units contained less browse and more forbs and grasses.

Although differences in botanical composition were substantial between (and within) pastures, these differences presumably become biologically significant only as they affect deer nutrition. However, deer in this study selected diets of comparable nutritional quality on both pastures. Nutritional parameters were affected more by burning than by grazing. With the exception of foraging selectivity and digestibility, we concluded that vegetative changes resulting from moderate yearlong grazing were not sufficient to adversely affect foraging efficiency or nutritional quality of diets selected by deer on similar sites. However, additional research may be needed comparing tame and wild deer diets and determining behavioral responses of wild deer to grazing and rotational burning.

LITERATURE CITED

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. 1984. Official methods of analysis. 14th ed. Washington, D.C. 1141pp.

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. 41:667–676.

DAVIS, L. G., AND M. K. JOHNSON. 1986. Dietary phosphorus requirements of deer. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 38:285–290.

DIXON, W. J., M. B. BROWN, L. ENGLEMAN, J. W. FRANE, M. A. HILL, R. I. JENNRICH, AND J. D. TOPOREK, editors. 1985. BMDP statistical software. Univ. California Press, Berkeley. 734pp.

DUVALL, V. L., AND L. B. WHITAKER. 1964. Rotation burning: a forage management system for longleaf pine-bluestem ranges. J. Range Manage. 17:322–326.

GOERING, H. K., AND P. J. VAN SOEST. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). U.S. Dep. Agric., Agric. Handb. 379. 20pp.

HOBBS, N. T., D. L. BAKER, AND R. B. GILL. 1983. Comparative nutritional ecology of montane ungulates during winter. J. Wildl. Manage. 47:1–16.

LAY, D. W. 1957. Some nutritional problems of deer in the southern pine type. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 10:53–58.

———. 1967. Browse palatability and the effects of prescribed burning in southern pine forests. J. For. 65:826–828.

OOSTING, H. J. 1956. The study of plant communities. 2nd ed. W. H. Freeman and Co., San Francisco, Calif. 440pp.

PEARSON, H. A. 1976. Botanical composition of cattle diets on a southern pine-bluestem range. U.S. For. Serv. Res. Note SO-216. 3pp.

REGELIN, W. L., R. M. BARTMANN, D. W. REICHERT, AND P. H. NEIL. 1976. The influence of supplemental feed on food habits of tamed deer. U.S. For. Serv. Res. Note RM-316. 4pp.

ROBBINS, C. T. 1983. Wildlife feeding and nutrition. Acad. Press. New York, N.Y. 343pp.

SHORT, H. L. 1969. Physiology and nutrition of deer in southern upland forests. Pages 14–18 *in* L. K. Halls, ed. Proc. of a symposium on white-tailed deer in the southern forest habitat. U.S. For. Serv., Southern For. Exp. Stn., Nacogdoches, Tex.

———, R. M. BLAIR, AND E. A. EPPS, JR. 1975. Composition and digestibility of deer browse in southern forests. U.S. For. Serv. Res. Pap. SO-111. 10pp.

SMITH, S. H., J. B. HOLTER, H. H. HAYES, AND H. SILVER. 1975. Protein requirement of white-tailed deer fawns. J. Wildl. Manage. 39:582–589.

THILL, R. E. 1984*a*. Deer and cattle diets on longleaf pine-bluestem range. Proc. Annu. Conf.

Southeast. Assoc. Fish and Wildl. Agencies 36: 410–419.

———. 1984*b*. Deer and cattle diets on Louisiana pine-hardwood sites. J. Wildl. Manage. 48:788–798.

———, AND H. F. MORRIS, JR. 1985. Quality of spring deer diets on Louisiana pine-hardwood sites. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 37:127–137.

———, AND A. MARTIN, JR. 1986. Deer and cattle diet overlap on Louisiana pine-bluestem range. J. Wildl. Manage. 50:707–713.

ULLREY, D. E., W. G. YOUATT, H. E. JOHNSON, L. D. FAY, B. L. SCHOEPKE, W. T. MAGEE, AND K. K. KEAHEY. 1973. Calcium requirements of weaned white-tailed deer fawns. J. Wildl. Manage. 37:187–194.

VAN SOEST, P. J. 1965. Comparison of two different equations for prediction of digestibility from cell contents, cell-wall constituents, and the lignin content of acid detergent fiber. J. Dairy Sci. 48: 815.

WALLMO, O. C., AND D. J. NEFF. 1970. Direct observations of tame deer to measure their consumption of natural forage. Pages 105–110 *in* Range and wildlife habitat evaluation—a research symposium. U.S. For. Serv. Misc. Publ. 1147.

Received 21 July 1986.
Accepted 1 April 1987.