EFFECT OF CATTLE STOCKING RATE ON THE NUTRITIONAL ECOLOGY OF WHITE-TAILED DEER IN MANAGED FORESTS OF SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS

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INTRODUCTION

White-tailed deer (Odocoileus virginianus) are an important resource in the southern Piedmont region of the United States (Halls 1973) Historical accounts list the white-tailed deer as the only wild cervid in this region of the United States (Seton 1927, Taber 1966) Deer were considered an important food and clothing source not only for early European colonists but also for Indians inhabiting the region (Newsom 1969)

During the 1890's, deer populations in southeastern Oklahoma and southwestern Arkansas were reduced due to market hunting that occurred in the Ouachita Mountains and surrounding area (Stobaugh 1981) Deer populations reached their low about 1914 despite enactment of regulations limiting hunting activity Restoration of deer populations in the region began with the establishment and stocking of wildlife refuges (e g , Howard County Wildlife Refuge, Arkansas) with deer Although populations have increased, their genetic variability may be low due to the limited number of individuals released into this area (Karlin et al 1989) Furthermore, deer found in upland regions of the South tend to be small because of nutrient limitations and climatic stresses that affect deer in this region (Short et al 1969)

Dietary interactions involving white-tailed deer and cattle interest wildlife managers because of possible effects of cattle on nutritional condition of deer and habitat carrying capacity (Teer 1984)

Evidence suggests that under high cattle stocking regimes, livestock may be better competitors for available forage and cause deer to forage in areas containing vegetation of lower nutritional value (Crawford 1984) McMahan and Ramsey (1965) observed that deer use of low quality, ashe juniper (Juniperus ashei) habitat increased with cattle density Additionally, deer use of meadows in California decreased with the presence of cattle (Bowyer and Bleich 1984) A significant shift from forb to browse dominated diets has been observed for deer using areas grazed by cattle (Waid et al 1984, Austin and Urness 1986) However, Austin and Urness (1986) found that crude protein in deer diets was elevated in areas with cattle, which suggested that increased browse consumption by deer may enhance nitrogen availability When grass matures, cattle can increase use of forest habitat concentrating competition on browse (Fitzgerald et al 1986)

The loblolly pine (Pinus taeda)/shortleaf pine (Pinus echinata)/ hardwood forest type that occurs in southeastern Oklahoma and southwestern Arkansas accounts for from 20 to 31 million ha of rangeland in the southern forested region and is the predominant forest type in the South (Stransky 1969, Byrd et al 1984) Cattle grazing has been used historically in southern pine forests in conjunction with forest harvests (Byrd et al 1984) to utilize grasses (e g , Andropogon spp) that occur in openings post harvest Substantial amounts of browse also are produced in forest openings during the first few years post clearing (Stransky 1969) Forest products companies generally approve of cattle stocking operations in this and other forest types because cattle can reduce fuel loading and thus, risk of wildfire (Byrd et al 1984)

Significant diet overlap between cattle and deer may occur on these rangelands because of heavy cattle stocking found in some oak-pine forests and regenerating pine plantations in southeastern Oklahoma Because deer forage extensively on mast in winter (Segelquist et al 1969, Short et al 1969, Harlow et al 1975), low mast production could promote competition between deer and cattle for available browse species, which are low in nutrients in winter (Fuller 1976)

The purpose of this study was to determine the effects of cattle stocking rate on the nutritional ecology of white-tailed deer and cattle by comparing seasonal differences in dietary characteristics, fecal nutrient levels, and physical condition of deer collected in the loblolly/shortleaf pine/hardwood forests of southeastern Oklahoma and southwestern Arkansas Although, Nelson (1984) studied habitat use by deer and cattle in southeastern Oklahoma, she provided limited information on effects of cattle on the local deer population I hypothesized that cattle stocking would negatively effect deer dietary composition and physical condition A multivariate statistical approach, using a variety of nutritional characteristics was used to test hypotheses concerning the effects of cattle stocking on white-tailed deer populations

STUDY AREAS

Southeastern Oklahoma and southwestern Arkansas together comprise the Athens Piedmont Plateau, which lies to the south of the Ouachita Mountains of Oklahoma and Arkansas (Crow 1974) The area is diverse vegetationally and is surrounded by 3 distinct vegetation types eastern forested region of Arkansas, midwestern prairie region of Oklahoma, and coastal region of eastern Texas Elevation of the plateau ranges from about 87 to 280 m above sea level (Goodwin 1980) Climate is subtropical with hot, humid summers and mild winters, rainfall averages 137 2 cm/year (Fuller 1976)

Soils of the region are composed of 3 associations, Redland, Kiamichi, and Chula (Jenkins and Steinbrenner 1981, James 1982) Redland soils are the most common soils on the Athens Piedmont Plateau These soils are moderately deep, well drained with medium to fine texture that developed from quartz sandstone and are characterized by slopes of 5-20% (Jenkins and Steinbrenner 1981) Kiamichi soils are shallow, lithic, well drained, clayey soils that have developed from sandstone and shale of the Stanley Shale Formation (James 1982) Chula soils are deep, well drained soils that have weathered from the novaculite uplift and are usually found on steep slopes (James 1982) Kiamichi and Chula soils are characterized by slopes of 20-65%

Climax plant species of the plateau are white oak (*Quercus alba*) and shortleaf pine (*Pinus echinata*) However, large tracts ($\leq$ 300 ha) have been commercially harvested and replanted with loblolly pine seedlings Natural oak/pine forests are punctuated with a variety of other tree species including sweetgum (*Liquidambar styraciflua*), other oaks (*Q marilandica*, *Q phellos*, *Q falcata*), hickories (*Carya tomentosa*), and elms (*Ulmus americana*, *U alata* and *U rubra*) Common browse species include greenbriars (*Smilax* spp), sumac (*Rhus copallina*), various honeysuckles (*Lonicera japonica*, *L sempervirens*), dogwoods (*Cornus florida*, *C drummondi*), American beautiberry (*Callicarpa americana*), hollies (*Ilex* spp), raspberry (*Rubus* spp), and blueberry (*Vaccinium* spp) Numerous herbaceous species including legumes (Lespedeza spp , Desmodium spp), composites (Helianthus spp , Rudbeckia spp , Solidago spp) and spurges (Euphorbia spp) occur in forest openings

Weyerhaeuser Company has owned about 1 1 million ha of land (about 360,000 ha in Oklahoma and 800,000 ha in Arkansas) on and surrounding the Athens Piedmont Plateau since 1969 (Goodwin 1980) and currently harvests natural vegetation (i e , shortleaf pine) and commercially planted tracts of loblolly pine In 1974, due to a sizable increase (from 10,000 to 25,000 head) in cattle grazing that was associated with even-aged management of forests, Weyerhaeuser Co attempted to close their lands to cattle grazing However, local pressure from environmental and political groups led to the development of a range management plan for the continuation of grazing on these forested lands As of 1980, about 300 permittees grazed 25,000-30,000 head of cattle per year on Weyerhaeuser Co lands in Oklahoma alone (Goodwin 1980)

In order to assess effects of cattle stocking on deer populations, 3 study areas were selected in areas that differed in cattle stocking regimes, but were similar in geographical and vegetational characteristics Study areas were located in McCurtain County, Oklahoma (34^{o} 15′ to 34^{o} 25′N, 94^{o} 45′ to 94^{o} 50′W) (1 head/3 ha, heavy cattle stocking), Howard County, Arkansas (34^{o} 10′ to 34^{o} 20′N, 94^{o} 5′ to 94^{o} 15′W) (1 head/18 ha, moderate to light cattle stocking), and Pike County, Arkansas (34^{o} 15′ to 34^{o} 20′N, 93^{o} 40′ to 93^{o} 50′W) (no cattle stocking) (Fig 1) Twelve disjunct habitat blocks (4/study area) were delineated for fecal collections Blocks contained similar amounts of natural oak/pine habitat, loblolly pine plantations that were planted $\geq$5 years prior to the study, and loblolly pine plantations that were planted <5 years prior to the study or would be planted within the first year of the study (Table 1) Block size (F = 1 10, 2,9 df, P = 0 38), percent natural vegetation (F = 0 62, 2,9 df, P = 0 56), percent loblolly pine plantations ≥5 years of age (F = 2 63, 2,9 df, P = 0 13), and percent loblolly pine plantations <5 years of age (F = 1 24, 2,9 df, P = 0 34) did not differ among habitat blocks across study areas prior to the start of the study

MATERIALS AND METHODS

PLANT REFERENCE MATERIAL

Plant material (leaves, stems, fruit) was collected for use as comparative reference material for the identification of plant fragments in deer and cattle feces Plant material was dried in a plant press, identified to species, and a subsample was soaked in 95% alcohol for 1 week to remove plant pigments, rinsed, bleached, and soaked in lactophenol blue for a second week to stain and preserve plant fragments (Davitt and Nelson 1980) Subsamples were then blended in 200 ml of distilled water and fragments of leaf, twig, and fruit epidermis transferred to microscope slides, dried by placing slides on a hot plate, and permanently mounted in glycerin gel

ASSESSING DIET COMPOSITION

Fresh fecal samples (Jenks et al 1990) of deer and cattle were collected seasonally (i e , fall [Oct], winter [Feb], spring [May], summer [Aug]) from all habitat blocks from October 1986 to October 1988 Fresh fecal material was located in each study area by searching roads in habitat blocks for deer sign (e g , tracks) Random transects were walked in pine plantations and natural vegetation surrounding locations containing deer sign

Fecal samples were individually dried in a forced air oven (50 C) and mixed in a Waring blender Feces were then composited by habitat block and season by hand mixing 1 +/-0 01g of each individual fecal sample collected in the block (Jenks et al 1989) Subsamples of composited feces were prepared for determination of dietary composition using the procedures described for reference material to ensure that fragments in fecal material would resemble reference material (Davitt and Nelson 1980) A 1-g aliquot of blended feces was soaked in 95% alcohol for 1 week to remove plant pigments, rinsed, bleached, and soaked in lactophenol blue for a second week to stain and preserve plant fragments Subsamples were then blended in 200 ml of distilled water and transferred to microscope slides (4 slides/composite)

Botanical composition of composited fecal samples was determined by randomly (Whysong and Miller 1987) locating 100 microscope fields (25 fields per slide) (Sparks and Malechek 1968), identifying plant fragments within the field at 100-400X by comparing fecal plant fragments with specimens in the reference collection (Holechek and Valdez 1985b), and counting the number of square microns (at 100X) of each plant fragment (i e , fragment area [Stewart 1967]) Percent composition of each plant species was then calculated by summing the total number of square microns per plant species and dividing by the total number of square microns counted per composited sample Percent composition of individual plant species consumed by cattle and deer were summed by forage class (i e , browse, conifer, fern, forb, grass, mast, and other) (Weckerly and Nelson 1990) to facilitate comparisons of deer and cattle populations Dietary overlap was calculated using the procedure outlined by Anthony and Smith (1977)

INDEXING DIET QUALITY

Fecal nitrogen (N) of collected samples was determined using the Kjeldahl method (Williams 1984) Percent N was determined using a sulfuric acid digestion on duplicate 0 25g samples of composited feces that had been ground to pass through a 1-mm mesh screen (Jenks et al 1989) If duplicates differed by more than 5%, data were discarded and percent nitrogen was determined on 2 new subsamples Ribonucleic acid (RNA) concentrations were determined on triplicate 0 4g aliquots of ground (i e , 1-mm mesh screen), composited feces using a perchlorate digest with $AgNO_3$ precipitation (Zinn and Owens 1982, 1986), if >5% error occurred among triplicates, data were discarded and samples reanalyzed

ASSESSING DEER CONDITION

Adult female deer were collected from each of the 3 study areas in February and August 1987-1988 Deer were located at night by spotlighting clearcuts and associated natural vegetation Deer were neck-shot using a high powered rifle Blood samples were obtained via heart puncture using Vacutainers (Becton Dickinson, Rutherford, NJ) that contained EDTA(K_3) (i e , whole blood) and gel-clot activator (i e , serum samples) immediately after harvest and placed on ice

Gastrointestinal tracts were removed from collected deer in the field, and carcasses transported to a field station (1/study area) for necropsy During necropsies, heart, lungs, and reproductive tracts were excised, and eviscerated carcasses weighed (to the nearest lb and converted to kg) Number of fetuses/doe was determined from reproductive tracts of deer collected in February (Adams 1960, Wilson and Sealander 1971, Hesselton and Sauer 1973, Kie and White 1985) Femurs were removed for analysis of marrow fat using the dry weight procedure (Neiland 1970) Kidneys and perirenal fat were removed for determination of the kidney fat index (Riney 1955) Adrenal glands (Hoffman and Robinson 1966) were removed and paired weights determined to the nearest 0 1g (Kie et al 1983) Deer age-class was determined using standard tooth replacement and wear criteria (Severinghaus 1949, Severinghaus and Cheatum 1956)

Whole blood samples were used to determine packed cell volume (PCV) using the microcapillary method (Ravel 1989 10) Clotted blood samples were centrifuged for 15 minutes at 2000 rpm, serum removed, frozen at a nearby facility, and transported to the laboratory for analyses Blood serum was analyzed for several constituents that assess protein, energy, and mineral status total protein (biuret reaction [Falkner and Meites 1982 318]), albumin (dye-binding with bromcresol green [Falkner and Meites 1982 323]), blood urea nitrogen (urease-berthelot method [Falkner and Meites 1982 357]), creatinine (Jaffe reaction [Tietz 1976 996]), gamma globulin (salt precipitation [Johnstone and Thorpe 1987]), glucose (o-toluidine method [Falkner and Meites 1982 253]), cholesterol (Franey and Amedor 1967), calcium (o-cresolphthalein procedure [Tietz 1976 908]), and phosphorus (molybdate procedure [Faulkner and Meites 1982 915]) Concentration of total globulins was determined by subtracting albumin from total protein Blood urea nitrogen/creatinine and albumin/globulin ratios were calculated from concentrations of applicable constituents

STATISTICAL METHODS

Dietary information, fecal nutritive analyses and characteristics of collected deer were compared by season, area, and species where appropriate All data were combined by season for the 2 years of the study to reduce the chance of a Type I error (Sokal and Rohlf 1981 159) (i e , combined data increased seasonal variation, which decreased the chance that differences in nutritional characteristics would be found when no difference among area, season, or species occurred [W D Warde, Department of Statistics, Oklahoma State University, pers comm]) A Priori hypothesis testing was used on all data (i e , dietary percentages, fecal nutritive characters, carcass and blood serum attributes) to test the hypothesis that deer under no cattle stocking differed from deer under cattle stocking and its orthogonal contrast, deer under moderate stocking differed from deer under heavy stocking

To correct for heteroscedasticity, dietary percentages were arcsine transformed after taking the square root (Sokal and Rohlf 1981 427) Bartlett's Tests (Sokal and Rohlf 1981 403) were used to test for heteroscedasticity in fecal percentages of nitrogen and ribonucleic acid, and carcass and blood characteristics of collected deer, if variances were heterogeneous, data were rank transformed (Conover and Iman 1981) prior to comparison of deer and/or cattle populations

A principal component analysis with varimax rotation of factors (Johnson and Wichern 1988 403) was conducted on dietary percentages of browse, grass, fern, forb, mast, and conifer for cattle and deer combined MANOVA was used on principal components by season and species to test the above stated hypotheses Fecal nutritive characteristics were compared using ANOVA Carcass and blood serum variables were compared with ANCOVA using age and/or carcass weight as covariates (Kie et al 1983) A canonical discriminant function analysis (Wilkinson 1988) was conducted on carcass and blood serum variables that were significant in univariate comparisons to 1) reduce the number of dimensions on which populations could be compared and 2) aid in the assessment of nutritional condition

RESULTS

CLIMATE

Total rainfall for months that deer and feces were collected ranged from 0 84 cm to 8 71 cm over the 2 years of the study and was variable intraseasonally (Fig 2) May precipitation decreased from 8 55 cm in 1987 to 0 84 cm in 1988 Variation in precipitation occurred in other seasons but to a lessor degree Average daily temperature ranged from 6 C to 27 C over the 2 years of the study with low intraseasonal variation (Fig 2)

FOOD HABITS

A total of 1745 deer and 1140 cattle fecal samples was collected from October 1986 to October 1988 A minimum of 15 deer fecal pellet groups was collected from most habitat blocks in McCurtain, Howard, and Pike counties during each of the 9 collections Only 6 deer fecal groups were located in each of Blocks A and C of Pike County in October 1986, and 12 groups were located in Block C of Pike County in February 1987 Adequate fecal samples ($\geq$15 [Anthony and Smith 1974]) of cattle were collected during the 9 collections in McCurtain County However, only 5 cattle samples were collected in October 1986, and no samples were collected in February 1987 and October 1988 in Howard County (reflecting the absence of cattle on the area)

Fecal samples were composited (168 total,108 deer and 60 cattle), and subsamples mounted on microscope slides for diet analysis However, dietary composition was determined for only 152 composites (i e , October 1986 to August 1988, 96 deer and 56 cattle) A total of 250 plant species was collected and characterized (e g , cell type, presence or absence of trichomes) for use in identification of fragments in composited fecal samples

Deer Diets

Diversity of deer diets was high during all seasons studied (Figs 3-7, Appendix I) Browse (e g , *Lonicera* spp /*Symphoricarpos orbiculatus*, *Cornus* spp , *Quercus* spp), including conifers (e g , *Pinus* spp and *Juniperus virginiana*), was the major constituent in deer diets in McCurtain and Howard counties in all seasons except May (Fig 3,4, Table 2) Furthermore, browse and conifers (e g , *Lonicera* spp / *Symphoricarpos orbiculatus*, *Quercus* spp , *Rhus* spp , *Pinus* spp , and *Cornus* spp) were the major constituents of deer diets in Pike County throughout the year and accounted for a minimum of 42% of diets (Fig 5, Table 2) Conifers were highest in February diets in all 3 study areas and increased from 11% and 6% to 49% and 27% from February 1987 to 1988 in McCurtain and Howard counties, respectively (Fig 3,4, Table 2) Conifers tended to be higher in deer diets in all seasons in McCurtain County than in Pike County (Table 2)

Major forbs in deer diets included *Antennaria plantaginifolia*, *Abutilon threophrasti*, *Lespedeza* spp , *Solidago* spp , and *Croton capitatus* Forbs (e g , composites) constituted 48% and 46% of deer diets in Howard County in May 1987 and McCurtain County in May 1988, respectively (Figs 3,4, Appendix I) Pike County diets were consistently lowest in forbs in both winters (5% and 3% for February 1987-88) Mast (e g , acorns, *Rhus* spp seed heads, *Prunus* spp drupes) composition of deer diets varied from a high of 31% of diets of Pike County deer in August 1988 to a low of 1% for McCurtain County in May 1987 Ferns (e g , *Polystichum acrosticoides*) accounted for 14% and 17% of deer diets in February 1987 in McCurtain County and February 1988 in Howard County, respectively (Table 2) Grass (e g , *Panicum* spp) composition of deer diets was highest in February and May diets and ranged from 17% to a low of 0 3% in Howard County in February 1988 and August 1987, respectively

Winter deer diets tended to be the least diverse (Appendix I) and depending on the study area were dominated by either conifers or Caprifoliaceae (i e , *Lonicera japonica*/*Symphoricarpos orbiculatus*) Dietary conifer was negatively related to dietary Caprifoliaceae in winter in deer (F = 12 526, 1,22 df, P = 0 002) (Fig 8) Diets of Pike County deer were generally high in Caprifoliaceae and low in conifer in winter, whereas diets of McCurtain County deer were generally high in conifer and low in Caprifoliaceae Diets of Howard County deer were intermediate with respect to both dietary categories

Cattle Diets

Diets of cattle in McCurtain and Howard counties were dominated by grasses (e g , *Andropogon* spp and *Panicum* spp) (Figs 6,7, Table 2), but the grass component of cattle diets in McCurtain County was more diverse than Howard County (Appendix I) Percentages of grasses in cattle diets ranged from a low of 59% in McCurtain County in October

1987 to a high of 96% in Howard County in August 1987 (Figs 6,7, Appendix I) Browse (e g , *Rhus* spp , *Cornus* spp) and conifer (e g , *Pinus* spp) forage classes were lower throughout the study in Howard County than in McCurtain County cattle diets Use of browse and conifer forage classes by cattle peaked in February 1987 and 1988 (Figs 6,7) and corresponded to peak use of conifers by deer in McCurtain and Howard counties (Figs 3,4)

Although mast and fern forage classes accounted for a significant proportion of deer diets (Figs, 3-5), these categories were not abundant in cattle diets in either McCurtain or Howard counties (Figs 6,7) Forb use by cattle varied seasonally and ranged from a high of 26% in October 1987 in McCurtain County to a low of 3% in Howard County in February 1988 Forb (e g , *Lespedeza* spp , *Croton capitatus*, *Solidago* spp) use by cattle, as with browse and conifer, tended to be lower in Howard County (except during May 1987) than McCurtain County (Figs , 6,7, Appendix I)

Diet Similarity Indices

Similarity indices calculated from dietary proportions of plant species ranged from 2 5 to 66 8% across all possible within and between species comparisons (Table 3) Generally, deer diets were more similar to deer diets from other study areas than to cattle diets Dietary overlap between populations of deer from McCurtain and Pike counties tended to be lower than either McCurtain-Howard or Howard-Pike comparisons despite the high dietary overlap that occurred in October 1986 (Table 3) Lower dietary overlap indicated that deer diets from the heavily stocked area were most dissimilar from deer from the no cattle study area Dietary overlap between sympatric deer and cattle populations was relatively low (<35%), but tended to be higher in McCurtain than Howard County (Table 3)

Comparisons of Diet Composition

Browse (*F* = 613 59, 1,150 df, *P* < 0 001), conifer (*F* = 11 69, 1,150 df, *P* = 0 001), fern (*F* = 16 14, 1,150 df, *P* < 0 001), forb (*F* = 10 05, 1,150 df, *P* = 0 002), grass (*F* = 1159 79, 1,150 df, *P* < 0 001), and mast (*F* = 110 76, 1,150 df, *P* < 0 001) forage classes differed significantly between deer and cattle   Percentages of browse, conifer, fern, forb and mast were higher in deer diets, whereas percent grass was higher in cattle diets   Within deer populations, percent dietary browse differed (*F* = 22 61, 1,84 df, *P* < 0 001) among populations with higher levels in Pike County than in McCurtain and Howard counties

Dietary conifer also differed among deer populations, deer diets were lower (*F* = 11 40, 1,84 df, *P* = 0 001) in conifer in Pike County than McCurtain and Howard counties Furthermore, conifer levels were higher (*F* = 15 66, 1,84 df, *P* < 0 001) in McCurtain than Howard County deer diets   No significant differences (*F* = 0 28, 2,84 df, *P* = 0 76) in dietary grass were found among deer populations   However, a significant (*F* = 2 36, 6,84 df, *P* = 0 04) area by season interaction was found for percent dietary mast   Percent mast in deer diets was significantly higher (*F* = 9 21, 1,21 df, *P* = 0 006) in Howard County than McCurtain County in May, whereas percent mast in deer diets was significantly higher (*F* = 9 07, 1,21 df, *P* =0 007) in Pike County than McCurtain and Howard counties in August, no differences in dietary mast occurred among deer populations in October (*F* = 2 02, 2,21 df, *P* = 0 16) or February (F = 0 67, 2,21 df, *P* = 0 52)   Dietary forb percentages in deer diets also differed among populations with levels in Pike County significantly lower (F = 17 12, 1,84 df, P < 0 001) than McCurtain and Howard counties Dietary fern content of deer diets did not differ (F = 1 74, 2,84 df, P = 0 18) among populations

Composition of cattle diets also differed among study areas Browse (F = 30 63, 1,48 df, P < 0 001), conifer (F = 47 88, 1,48 df, P < 0 001), and mast (F = 5 27, 1,48 df, P = 0 03) percentages in cattle diets were lower in Howard County than McCurtain County Significant area by season interactions were found in both grass (F =5 94, 3,48 df, P = 0 002) and forb (F =4 97, 3,48 df, P = 0 004) forage classes Percent dietary grass was higher in cattle diets in Howard County in October (F = 23 47, 1,10 df, P = 0 001), February (F = 9 96, 1,10 df, P = 0 01), and August (F = 27 11, 1,14 df, P < 0 001), but not in May (F = 0 57, 1,14 df, P = 0 46) Conversely, percent dietary forb comprised a greater percentage of cattle diets in McCurtain County than Howard County in February (F = 9 19, 1,10 df, P = 0 01) and August (F = 15 92, 1,14 df, P = 0 001), but not in October (F = 1 24, 1,10 df, P = 0 29) or May (F = 0 52, 1,14 df, P = 0 48) No difference (F = 0 05, 1,48 df, P = 0 829) in percentage of dietary fern was found for cattle diets from McCurtain and Howard counties Because fern was rarely found in cattle diets, no further analyses were conducted on this forage category

A total of 91 54% of the variation in conifer, browse, forb, grass and mast forage categories was explained by the first 3 principal components The first principal component was a linear combination of forage categories with dietary browse, mast, and grass contributing largely to component scores (i e , Y_1 = 0 91[browse] - 0 89[grass] + 0 87[mast] + 0 06[conifer] + 0 11[forb]) Principal component 2 (i e , Y_2 = -0 13[browse] + 0 22[grass] + 0 16[mast] - 0 98[conifer] +

0 14[forb]) and 3 (i e , Y_3 = -0 09[browse] + 0 35[grass] + 0 05[mast] + 0 13[conifer] - 0 98[forb]) were linear combinations of forage categories with dietary conifer and forb contributing the greatest to component scores, respectively Thus, synthetic components (i e , principal component scores) formed axes of browse and mast vs grass, conifer, and forb (Fig 9-13)

Principal component scores were compared across populations and ungulate species using MANOVA Separate MANOVAs were calculated by season because of an area x season interaction (deer, F = 1 76, 18,232 df, P = 0 031, cattle, F = 2 83, 9,112 df, P = 0 005) (Fig 9)

In October, deer and cattle diets differed significantly (F = 183 34, 3,32 df, P < 0 001) with predominant separation occurring on principal component 1 (i e , browse and mast vs grass component) (Fig 10) Separation between deer and cattle also occurred on both forb (PC-3) and conifer (PC-2) axes No differences occurred in synthetic dietary factors among deer populations (F = 0 36, 3,19 df, P = 0 784) (Fig 10) However, component scores for cattle populations differed significantly (F = 56 24, 3,8 df, P < 0 001) with predominant separation occurring on the first and second (i e , browse and mast vs grass and conifer) principal components

Deer and cattle differed significantly across dietary principal components in February (F = 53 13, 3,32 df, P < 0 001) (Fig 11) As in October, predominant separation occurred on principal component 1 (i e , browse and mast vs grass) Significant separation (F = 7 66, 3,19 df, P = 0 001) also occurred among deer populations, deer in Pike County differed from those in McCurtain and Howard counties Separation occurred on all 3 axes with deer from study areas exposed to cattle stocking consuming more forbs and conifers and less browse and mast compared to the area without cattle (Fig 11) Significant differences ($\underline{F}$ = 4 73, 3,8 df, $\underline{P}$ = 0 035) also occurred between the 2 cattle populations with predominant separation occurring on the second and third (i e , conifer and forb, respectively) principal components

Significant separation between deer and cattle dietary factors occurred on all 3 principal components in May ($\underline{F}$ = 340 31, 3,36 df, $\underline{P}$ < 0 001) (Fig 12) Although no differences were found among the 3 deer populations ($\underline{F}$ = 2 17, 3,19 df, $\underline{P}$ = 0 125) (Fig 12), dietary factors of cattle populations differed ($\underline{F}$ = 5 07, 3,12 df, $\underline{P}$ = 0 017) with predominant separation occurring on first and second principal components

Deer and cattle differed across synthetic dietary factors in August with primary separation occurring on principal component 1 ($\underline{F}$ = 262 57, 3,36 df, $\underline{P}$ < 0 001) (Fig 13) Deer populations differed significantly ($\underline{F}$ = 13 95, 3,19 df, $\underline{P}$ < 0 001), component scores for deer in Pike County differed from McCurtain and Howard Predominant separation occurred on first and third principal components with deer from areas with cattle consuming more forbs and less browse and mast than deer from the Pike County study area Cattle populations also differed ($\underline{F}$ = 17 04, 3,12 df, $\underline{P}$ < 0 001) in August with primary separation occurring on all 3 principal components

INDICES OF DIET QUALITY

<u>Fecal Nitrogen</u>

Levels of fecal N were determined in composited deer and cattle feces collected from October 1986 to October 1988 (Table 4) Mean concentration of fecal N ranged from a low of 1 17% for cattle from

Howard County ın February 1988 to a high of 3 29% for deer from Howard County in May 1987 (Table 4) Analysis of fecal N levels of deer was conducted on data collected from February 1987 to October 1988 because only 8 seasons could be used in the ANOVA Furthermore, comparisons of cattle populations relative to fecal N could only be conducted for 2 seasons (i e , May and August) with ANOVA because cattle fecal samples from Howard County were not available Cattle feces were collected ın McCurtain and Howard counties in February and October 1988, t-tests were conducted on data from these 2 seasons separately

Levels of fecal N differed (t = 9 70, 166 df, P < 0 001) between deer and cattle, deer feces had higher percentages of fecal N in all seasons (Fıg 14) A strong seasonal effect was apparent in concentration of fecal N with lowest levels occurring in February and peak levels occurring in May (Fıg 15, Table 4), however an area by season interaction (F = 4 36, 6,84 df, P = 0 001) was observed Thus, fecal N of deer was analyzed seasonally when assessing differences among areas Fecal N in deer feces from Pike County was significantly lower than McCurtain and Howard counties in August (F = 12 09, 1,21 df, P = 0 002) and October (F = 7 71, 1,21 df, P = 0 01), but higher in February (F = 12 54, 1,21 df, P = 0 002) No differences (F = 0 79, 2,21 df, P = 0 47) in fecal N of deer from study areas occurred in May

Concentration of fecal N for cattle varied seasonally from a low in February to a peak in May (Fig 15, Table 5), however an area by season interaction (F = 15 24, 1,28 df, P = 0 001) also was indicated Levels of fecal N were lower in cattle from Howard County than McCurtain County in August (F = 18 97, 1,14 df, P = 0 001), October 1987 (t = 8 71, 6 df, P < 0 001), and February 1988 (t = 7 96, 6 df, P < 0 001), however, no difference (F = 0 65, 1,14 df, P = 0 43) in fecal N was found in May

Fecal Ribonucleic Acid (RNA)

Mean RNA concentrations ranged from 0 033% for cattle feces from Howard County collected in February 1988 to 0 188% for deer feces collected in Pike County in May 1988 (Table 5) As with fecal N, data collected from February 1987 to October 1988 were used in the ANOVA Furthermore, levels of fecal RNA in cattle feces were analyzed using the same statistical analyses that were employed for fecal N

Fecal RNA concentration differed (F = 71 60, 1,166 df, P < 0 001) between deer and cattle over the 2 years of the study (Fig 16, Table 5) Within deer populations, an area by season interaction occurred (F = 2 47, 6,84 df, P = 0 03) (Fig 17) and thus, differences among populations were analyzed seasonally No differences in fecal RNA occurred among deer populations in February (F = 0 13, 2,21 df, P = 0 88) or May (F = 1 86, 2,21 df, P = 0 18) However, RNA concentration in deer feces from Pike County were significantly lower in August (F = 21 59, 1,21 df, P < 0 001) and October (F = 4 22, 1,21 df, P = 0 05) than concentrations in feces from McCurtain and Howard counties, fecal RNA for deer populations in McCurtain and Howard counties did not differ from one another in either August (F = 0 10, 1,21 df, P = 0 76) or October (F = 2 63, 1,21 df, P = 0 12)

Fecal RNA concentrations in cattle feces also varied seasonally from May to August (F = 29 26, 1,28 df, P < 0 001) Furthermore, mean levels of fecal RNA for May and August were lower for cattle from Howard County than those from McCurtain County, although variation across years was high (Fig 17) Fecal RNA concentration also was lower in October

1987 (t = 2 46, 6 df, P = 0 70) in cattle feces from Howard County than in feces collected in McCurtain County, no difference in fecal RNA occurred among cattle populations in February 1988 (t = 1 54, 6 df, P = 0 18)

DEER COLLECTIONS

Carcass Characteristics

A total of 62 female (52 adults, 10 fawns) white-tailed deer was collected from February 1987 to August 1988 A significant area by season interaction (F = 5 75, 2,55 df, P j= 0 005) was evident in carcass weight of collected deer Average adjusted carcass weights ranged from 29 3 to 22 6 kg in February and 31 8 to 28 8 kg in August (Table 6) Adjusted carcass weight of deer (i e , using age as the covariate) was significantly higher (F = 8 99, 1,28 df, P = 0 006) for Pike County in February than McCurtain and Howard counties, which were similar in carcass weight (F = 3 43, 1,28 df, P = 0 09) (Table 6) However, adjusted carcass weights of deer collected in August were significantly higher in Howard County than McCurtain County (F = 4 46, 1,26 df, P = 0 04) Adjusted carcass weight of deer collected from Pike County did not differ from those collected in McCurtain and Howard counties in August (F = 2 68, 1,26 df, P = 0 11) (i e , Ho Pike = McCurtain + Howard, a priori hypothesis), however adjusted carcass weight for Pike County deer was lower (F = 6 14, 1,26 df, P = 0 02) (i e , Ho Pike = Howard) than Howard County deer (Table 6)

To assess the use of carcass weight and age as covariates for comparison of organ, fat, and reproductive characteristics, ANCOVAs were calculated using the covariates carcass weight and age separately and simultaneously in the model Neither age (F = 1 42, 1,54 df, P = 0 24) nor carcass weight (F = 0 02, 1,54 df, P = 0 88) was a significant covariate for the kidney fat index Age was the most consistent covariate in that it was significant when used alone and remained significant when combined with carcass weight as a second covariate However, age was not a significant (F = 2 48, 1,42 df, P = 0 12) covariate for spleen weight when used alone or with carcass weight (F = 0 001, 1,41 df, P = 0 99)

Average paired adrenal weights (adjusted) ranged from 3 0g to 3 5g for collected deer (Table 6) A significant (F = 5 07, 1,53 df, P = 0 03) seasonal effect occurred in paired adrenal weights with weights of deer collected in August higher than in February No significant differences (F = 0 08, 2,53 df, P = 0 92) in paired adrenal weight occurred among deer collected from study areas Average spleen weight ranged from 200 4g to 250 9g for collected deer (Table 6) As with paired adrenal weights, no significant differences (F = 0 49, 2,43 df, P = 0 62) in spleen weight occurred in deer collected from the 3 study areas

Energy status of collected deer was assessed, in part, using femur marrow fat and the kidney fat index Average percent femur marrow fat ranged from 36 5% to 68 3% for collected deer A significant seasonal effect (F = 23 36 1,57 df, P < 0 001) was noted with February values higher than those of deer collected in August (Table 6) Deer collected from Pike County had the highest percentage of femur marrow fat (F = 16 81, 1,57 df, P < 0 001) in February and August compared to deer from other study areas Deer collected from Howard County had higher levels (F = 4 67, 1,57 df, P = 0 04) of femur marrow fat than deer collected from McCurtain County

Average KFI ranged from 20 6% to 49 2% for collected deer (Table 6) Seasonal variation was evident with higher levels of kidney fat occurring in February However, a significant (F = 3 55, 2,55 df, P = 0 04) area by season interaction was observed In winter, deer collected from Pike County had significantly higher (F = 4 67, 1,28 df, P = 0 04) KFI, deer collected from McCurtain and Howard counties had similar KFI (F = 3 89, 1,28 df, P = 0 06) In summer, KFI did not differ (F = 1 85, 2,27 df, P = 0 18) among the 3 deer populations (Table 6)

Reproductive Traits

Reproductive rate (i e , fetuses/doe [Hesselton and Sauer 1973]) was determined for deer collected in February 1987-88 (Table 6) Of 10 female fawns collected from study areas in February, 2 fawns that were collected from Pike County were pregnant Therefore, reproductive rates were compared without fawns to assess adult fecundity and with fawns included in the analysis to assess the effect of pregnant fawns on overall fecundity rates of deer populations Reproductive rate ranged from 0 to 2 fetuses per adult doe (i e , >0 7 years) Adult female deer from Pike County had significantly (F = 14 95, 1,18 df, P = 0 001) more fetuses than adult females from McCurtain and Howard counties, reproductive rates of adult deer from McCurtain and Howard counties were similar (F = 2 02, 1,18 df, P = 0 17) (Table 6) When fawns were included in the analysis, deer collected from Pike County continued to have significantly (F = 25 37, 1,28 df, P < 0 001) more fetuses than deer from McCurtain and Howard counties Furthermore, as with the adult sample, reproductive rates of deer from McCurtain and Howard counties were not different (F = 2 77, 1,28 df, P = 0 11)

Serum Chemistry and Hematology

Degree of hemolysis of collected sera (Blankenship and Varner 1978) was assessed as slight to non-hemolyzed in all samples Average concentration of serum albumin ranged from 3 44 to 4 05 g/dl and did not vary seasonally (F = 0 12, 1,55 df, P = 0 73) Concentrations of albumin were lower (F = 6 30, 1,55 df, P = 0 02) for deer from McCurtain County during February and August than deer from Howard County, serum albumin for Pike County deer was intermediate and did not differ (F = 0 20, 1,55 df, P = 0 65) from the other 2 study areas (Table 7)

Average albumin/globulin ratios ranged from 0 90 to 2 08 and were significantly lower (F = 46 62, 1,55 df, P < 0 001) for deer collected in August than those collected in February (Table 7) Deer collected from Howard County had significantly (F = 13 07, 1,55 df, P < 0 001) higher average albumin/globulin ratios than deer collected from McCurtain County in February and August, ratios for deer collected from Pike County were intermediate and did not differ (F = 0 02, 1,55 df, P = 0 90) from the other 2 study areas

Concentrations of serum glucose for collected deer were variable and averages for study areas ranged from 92 27 to 229 38 mg/dl (Table 7) A significant (F = 3 50, 2,55 df, P = 0 04) area by season interaction occurred in glucose concentration Glucose concentration was similar (F = 0 86, 2,28 df, P = 0 44) for deer in all 3 study areas in February but was lower (F = 8 82, 1,27 df, P = 0 006) in McCurtain County than Howard County in summer Concentrations of glucose were intermediate for deer from Pike County in summer and did not differ (F = 0 93, 1,27 df, P = 0 34) from the other 2 study areas

Average blood urea nitrogen ranged from 6 77 to 25 25 mg/dl A significant (F = 3 02, 2,54 df, P = 0 05) area by season interaction was evident in serum blood urea nitrogen of collected deer In February, blood urea nitrogen of deer did not differ (F = 0 47, 2,28 df, P = 0 63) among study areas However, mean concentration of blood urea nitrogen was lower (F = 14 23, 1,27 df, P = 0 001) in deer from Pike County than those from McCurtain and Howard counties in August (Table 7) Concentrations of blood urea nitrogen were similar for deer collected in McCurtain and Howard counties (F = 3 06, 1,27 df, P = 0 10) in August

Average ratios of blood urea nitrogen/creatinine ranged from 5 31 to 16 69 over the 2 seasons and varied seasonally (F = 34 61, 1,55 df, P < 0 001), ratios for deer were lower in August than February (Table 7) Ratios also varied among deer populations with deer collected from Pike County significantly lower (F = 5 17, 1,55 df, P = 0 027) than deer collected from McCurtain and Howard counties However, blood urea nitrogen/creatinine ratios for deer collected from McCurtain and Howard counties were similar (F = 0 001, 1,55 df, P = 0 99)

Average concentration of phosphorus in serum ranged from 8 55 to 12 57 mg/dl and varied seasonally (F = 10 74, 1,55 df, P = 0 002) with concentrations in August lower than in February (Table 7) Although no statistical area by season interaction occurred (F = 1 347, 2,55 df, P = 0 27), relationships among serum phosphorus means were inconsistent for deer collected from Pike County (Table 7) Thus, data were analyzed separately by season No difference in serum phosphorus (F = 0 215, 2,28 df, P = 0 808) was found among deer populations in February However, serum phosphorus was lower (F = 6 54, 1,27 df, P = 0 008) in August for deer from Pike County than deer from other study areas

Furthermore, serum phosphorus for deer from McCurtain County was lower (F = 4 92, 1,27 df, P = 0 035) than deer from Howard County   Ratios of calcium/phosphorus ranged from 0 91 to 1 23 and did not vary seasonally (F = 3 36, 1,55 df, P = 0 072)   However, deer collected from Pike County had higher (F = 6 34, 1,55 df, P = 0 015) calcium/phosphorus ratios than deer collected from McCurtain and Howard counties, which did not differ (F = 0 07, 1,55 df, P = 0 79) from one another

Average concentration of total protein (range = 6 04 - 8 12 g/dl), globulin (range = 2 15 - 4 10 g/dl), gamma globulin (range = 0 77 - 1 07 m/dl), creatinine (range = 1 31 - 1 79 mg/dl), and cholesterol (range = 45 50 - 60 25 mg/dl) in serum varied seasonally over the 2 years of the study (Table 7)   Significantly higher concentrations of total protein (F = 19 71, 1,55 df, P < 0 001), globulin (F = 45 73, 1,55 df, P < 0 001), and cholesterol (F = 8 09, 1,55 df, P = 0 006) occurred in deer in August than in February   Conversely, concentrations of gamma globulin (F = 66 16, 1,55 df, P < 0 001), and creatinine (F = 16 88, 1,55 df, P < 0 001) were higher in deer in February than in August   No differences in total protein (F = 0 46, 2,55 df, P = 0 63), globulin (F = 0 77, 2,55 df, P = 0 47), cholesterol (F = 0 88, 2,55 df, P = 0 42), gamma globulin (F = 0 18, 2,55 df, P = 0 84), or creatinine (F = 0 02, 2,55 df, P = 0 92) concentrations were found among deer from the 3 study areas   Average calcium concentration ranged from 10 00 to 12 15 mg/dl for deer, no significant seasonal (F = 2 48, 1,55 df, P = 0 12) or study area (F = 1 48, 2,55 df, P = 0 236) differences were observed (Table 7)

Average packed cell volume ranged from 41 33 to 50 80% and varied seasonally (F = 6 18, 1,46 df, P = 0 017) with lower percentages occurring for deer in August than in February (Table 7)   However, no significant differences ($\underline{F}$ = 1 88, 2,46 df, $\underline{P}$ = 0 164) occurred among deer populations

Multivariate Condition Assessment

To assess differences among populations relative to carcass and blood characteristics, a MANCOVA was calculated using characteristics of collected deer that differed significantly among 1 or more deer populations In addition, a 1 5 year-old male deer that was collected from Pike County in February 1988 was included in the analysis because this individual displayed characteristics that suggested an extremely poor physical condition (i e , femur marrow fat = 14 64%, KFI = 9 42%, packed cell volume = 35 3%, serum total protein = 3 94 g/dl, serum albumin = 2 02 g/dl, serum glucose = 74 9 mg/dl), which included an injury to the left front foreleg Thus, the poor nutritional condition of this individual was used as an aid in categorizing individuals and populations relative to their nutritional condition

Carcass weight, femur marrow fat, kidney fat index, albumin/globulin and calcium/phosphorus ratios were included in the MANCOVA Blood urea nitrogen and blood urea nitrogen/creatinine ratio were not included in the model because their inclusion contributed to a significant area by season interaction ($\underline{F}$ = 3 49, 10,104 df, $\underline{P}$ = 0 024) Furthermore, high blood urea nitrogen values can occur when deer are experiencing both high and low nutritional regimes (Ullrey et al 1967, deCalesta et al 1975, 1977) and can be diminished when deer are consuming high energy diets (Kirkpatrick et al 1975, Rowlands 1980) Therefore, blood urea nitrogen information did not aid in separation of deer populations

Because variables included in the MANCOVA were significant *a priori* (i e , in univariate comparisons), a significant MANCOVA (F = 3 49, 10,104 df, P = 0 001) was expected Canonical factors that were generated from the multivariate analysis were derived from linear combinations of the variables used in the MANCOVA The first canonical factor was a weighted average of all variables used in the analysis (i e , Y_1 = 0 722[femur marrow fat] + 0 569[carcass weight] + 0 361[kidney fat index] + 0 477[albumin/globulin ratio] + 0 360[calcium/ phosphorus ratio]) Thus, collected deer that were characterized by heavy carcass weight, high fat characteristics, and elevated albumin/globulin and calcium/phosphorus ratios would score high on this factor The second canonical factor was a contrast between albumin/ globulin and KFI verses calcium/phosphorus ratio (i e , Y_2 = 0 073[femur marrow fat] - 0 230[carcass weight] - 0 365[kidney fat index] - 0 699[albumin/globulin ratio] + 0 473[calcium/phosphorus ratio]) Therefore, deer with elevated albumin/globulin ratios and KFIs would score negatively and deer with elevated calcium/phosphorus ratios would score positively

Considerable variation occurred among the canonical scores generated from the analysis (Fig 18) However, bivariate centroids of study areas differed significantly (F = 4 18, 5,52 df, P = 0 003) for all 3 study areas based on results of MANCOVA and 95% bivariate confidence ellipses (Fig 18) Scores for deer collected from Howard County were variable relative to canonical factor 1 and individual canonical scores tended to overlap scores associated with deer from McCurtain and Pike counties However, Howard County deer tended to score low on the second canonical factor because of elevated albumin/globulin ratios and low calcium/phosphorus ratios associated with these deer (Fig 18)

The lone male deer that was included in the analysis scored moderately on both canonical factors, however the high carcass weight of this individual (i e , 30 84 kg) relative to carcass weight of females most likely enhanced its canonical score on factor 1 (Fig 18) Nevertheless, comparison of female scores with those of the lone male would suggest that individual deer in poor nutritional condition would score moderate to low on canonical factor 1 (i e , due to low carcass characteristics) and moderately on canonical factor 2 (i e , due to low to moderate albumin/ globulin and high calcium/phosphorus ratios)

Because canonical scores of deer collected from Howard County tended to overlap scores of deer collected from the other study areas, they were removed from the analysis to assess the position of scores of deer from McCurtain County relative to those of Pike County deer Deer collected from Pike County scored moderate to high on both canonical factors, whereas, deer collected from McCurtain County scored moderate to low on both factors (Fig 19)

DISCUSSION

FOOD HABITS AND DIET OVERLAP

Various methodologies exist to determine plant species composition of herbivore diets from fecal samples (Holechek 1982) Effects of sample preparation (Vavra and Holechek 1980, Holechek et al 1982), in vitro digestion (Vavra and Holechek 1980, Holechek and Valdez 1985a), fragmentation (Johnson and Wofford 1983), slide and frequency observation numbers (Holechek and Vavra 1981), and correction factors (Dearden et al 1975, Leslie et al 1983) have been assessed

Stewart (1967) found that plant species percentages in diets could be obtained by measurement of fragment area, which reduces effects of variation in fragment size on dietary determinations Although time consuming, this method was considered best for assessing differences in dietary composition among populations of deer and cattle because fragment size can vary significantly despite efforts (e g , grinding) to increase fragment uniformity Percentages of plant species determined from fecal analysis were not corrected for differential digestibility (Dearden et al 1975, Leslie et al 1983) because biases associated with uncorrected percentages were not considered important when making deer to deer or cattle to cattle comparisons, correction factors would affect intraspecific dietary determinations similarly Correction of deer and cattle diets may have enhanced comparisons, but sufficient information on digestibilities was unavailable and unless digestibility estimates can be obtained from deer and cattle consuming the plant species of interest (Campa et al 1984, Jenks and Leslie 1988), corrected estimates could be inaccurate

Diets of deer exposed to a continuum of cattle stocking pressure were diverse relative to individual species contributions (Appendix I) However, high dietary variation can occur in southern forested ecosystems because of the high vegetative richness of this region Korschgen et al (1980) identified 458 plant foods in deer rumina collected in spring and summer in Missouri Moreover, tame deer were found to consume 107 plant taxa (i e , forbs) on clear-cuts in central Louisiana, only 3 of which accounted for $\geq$ 1% of the diet (Thill 1984)

Variation in deer diets was affected by the presence of cattle on study areas Diets of deer from Pike County (no cattle) had higher percentages of browse and mast in October and lower conifer and forb throughout the year than diets of deer exposed to cattle stocking (i e , McCurtain and Howard counties) Furthermore, diets of deer from Pike County had similar levels of browse (54 9%) and grass (7 8%) as deer exposed to cattle stocking in central Texas (Waid et al 1984) However, the amounts of forbs in diets of deer from McCurtain (25 5%) and Howard (26 2%) counties were more similar to deer from central Texas (35%) than diets of deer in Pike County, which indicates a tendency for forb preference by deer (Waid et al 1984) Austin and Urness (1986) found that deer diets on grazed range in Utah contained higher levels of browse and grass, which may have resulted from a lowered availability of forbs as a result of cattle grazing study plots Warren and Krysl (1983) found lower forb consumption by deer exposed to a low level of stocking of domestic and exotic ruminants than at a higher level of stocking

Lower amounts of forbs in diets of deer that were not exposed to cattle grazing may have resulted from successional patterns that occur in southern forests In loblolly pine plantations, ground stratum evenness (i e , plant species individuals distributed as evenly as possible [Pielou 1966]) of plant species decreases over the first 3 years post-clearing due to the increased dominance of Andropogon virginicus (Felix et al 1983), a grass species not preferred by deer Forb availability in areas dominated by Andropogon virginicus declines temporally post-clearing (Keever 1950, Pinder 1975), which could account for low forb consumption by deer in Pike County The forb component of diets of deer exposed to cattle grazing was primarily composed of legumes and composites and may have occurred due to the removal of the dominant Andropogon virginicus by cattle grazing, which can increase forb growth (Pinder 1975) Thill et al (1987) found that winter rosettes of forbs and grasses were both more abundant and available where bunch grasses had been removed by grazing Cattle diets, especially in Howard County, contained a high proportion of Andropogon spp

Consumption of evergreen browse in northern ecosystems occurs in winter when preferred forage is covered by snow and therefore is unavailable to deer (Coblentz 1970, Jenkins and Wright 1988) In southern forests, twigs of deciduous trees and shrubs receive limited use (i e , $\leq$ 16% of diets) by deer in winter (Lay 1964, Cushwa et al 1970, Harlow and Hooper 1971, Weckerly and Nelson 1990), possibly due to their high handling time relative to low energy and high fiber content Increased conifer consumption by deer exposed to cattle grazing in winter could represent nonselective foraging relative to availability (Lagory et al 1985) of loblolly pine In February, conifer consumption was pronounced and tended to increase with cattle stocking rate (especially in February 1988) Conifers are low in digestibility (e g , Pinus spp digestibility in winter = 44 1% [Blair et al 1977]) in all seasons, and the high level of conifer consumption in McCurtain County during winter suggested that availability of higher quality forage may have been limited Conversely, diets of deer from Pike County were lowest in conifer but highest in Caprifoliaceae (i e , Lonicera spp / Symphoricarpos orbiculatus), which averaged 35 2% of the diet in

February 1987-88 and was negatively correlated with consumption of conifers (Fig 8)

Low Caprifoliaceae and high conifer composition of diets of deer exposed to cattle grazing in winter could negatively affect the nutritional condition of deer during this season Blair et al (1980) found that Lonicera japonica had a digestibility of 64 7% in January Furthermore, Segelquist et al (1971) found Japanese honeysuckle leaves to be more digestible in winter than any native forage in Arkansas In the Hill counties of Ohio, deer diets contained 29 9% (frequency of occurrence) Japanese honeysuckle, which ranked second as a principal deer food during this season (Nixon et al 1970) Whittington (1984) also noted that honeysuckle was an important food of deer throughout the year on the Piedmont Plateau of the southern Atlantic states

Dietary overlap was low (<67%) among deer from the 3 study areas and deer-cattle comparisons (<35%) Low dietary overlap among deer populations might have resulted from a shift in plant species composition due to the presence of cattle on study areas in McCurtain and Howard counties, which is consistent with the higher dietary overlap between McCurtain-Howard and Howard-Pike deer populations Thill et al (1987) found that average dietary similarities of tame deer ranged from 52 6% to 61 8% across comparisons of grazed and ungrazed pastures in Louisiana, which were within the range of diet overlap estimates for this study

Although dietary overlap between sympatric deer and cattle populations was low, it was considerably higher than overlap between cattle and mule deer (Odocoileus hemionus) in the Piceance Basin and Douglas Mountain Area, Colorado (≤4% [Hubbard and Hansen 1976, Hansen et al 1977]) Currie et al (1977) also found low competition between cattle and mule deer for the spring-fall grazing period in managed ponderosa pine (Pinus ponderosa) rangelands in Colorado Overlap of mule deer and cattle diets in southern Colorado ranged from 12% to 38% (Hansen and Reid 1975) Seasonal estimates of dietary overlap in this study (i e , spring = 21 1, summer = 17 2, autumn =17 9, winter = 32 9) were lower than those determined for deer and cattle in central Louisiana in spring and autumn (spring = 25 8, autumn = 26 0), higher in summer (11 8), and similar for winter (30 7) (Thill and Martin 1989)

Dietary overlap between deer and cattle was highest in February in McCurtain County and approached the highest level in Howard County, which further suggested that the season of highest competition between deer and cattle is winter Thill (1984) calculated a dietary overlap of 45 6% for tame deer and cattle on forested sites in Louisiana in winter, however, dietary overlap was 10 5% for deer and cattle on clear-cut pine-hardwood sites, which had a higher frequency of use by cattle than forested sites McMahan (1964) considered competition to be heavy between deer and cattle, goats, and sheep during winter on the Edwards Plateau, Texas

Multivariate methodologies have been employed to a limited extent to ascertain the importance of nutrient content and consumption of plant species on the nutrition of white-tailed deer (Vangilder et al 1982, Weckerly and Nelson 1990) Significant variation in dietary characteristics can often be explained through the reduction of factors that can influence deer nutrition For example, Vangilder et al (1982) was able to reduce nutritional information on 34 forages consumed by deer in Missouri to 4 factors that explained 73 5% of the variation in the data Furthermore, Weckerly and Nelson (1990) were able to assess the use of forage categories and their nutrient composition on dietary variation of male and female deer Although multivariate analyses may not be robust because of restrictive assumptions and multiple interpretations (Rextad et al 1990), principal components analysis in this study was employed after detection of significant univariate differences in dietary percentages of forage categories Thus, multivariate analyses were used as an extension of univariate analyses, not as a substitute

In this study, 3 factors relating consumption of forage categories to deer and cattle populations that differed with respect to stocking regimes explained 91 54% of the variation in the data Principal component 1 separated deer and cattle, cattle scored low on this axis due to high dietary intake of grasses Conversely, deer scored high on this axis due to high dietary browse and mast Vangilder et al (1982) found that multivariate separation occurred between forages that are high in rapidly fermented cell solubles and calcium (i e , leaves and fruits of woody species) and those that have a high cellulose fraction (i e , forbs, grasses and grains) Thus, major separation between deer and cattle that occurred on principal component 1 is likely a result of physiological differences that occur between the 2 species (i e , browser vs grazer [Hofmann and Stewart 1972, Hofmann 1988]) Cattle select diets high in cellulose that is retained in the rumen for a relatively long time (Hofmann 1988), deer select diets high in rapidly fermentable cell solubles that have a relatively short ruminal retention time (Short et al 1974) During February, sympatric deer and cattle populations were more similar with respect to this axis than during other seasons, which may have represented a significant shift toward forages that were unacceptable relative to cell soluble and cellulose content for both ungulate species (i e , low grass for cattle and low browse/mast for deer)

Significant separation occurred among deer and cattle populations in February on principal component 2 Because differences in diets among deer populations that occurred relative to this factor were a result of conifer intake, principal component 2 might be interpreted as a forage availability factor Diets of deer that were sympatric with cattle tended to be more similar to diets of cattle under heavy stocking (i e , McCurtain County) (Fig 11) during this season, which indicated a reduced forage availability This information paralleled diet overlap indices for February (Table 3) and further suggested that the greatest level of dietary competition between deer and cattle occurred in this season

Separation among deer populations also occurred on principal component 3 in February and August Deer from Pike County scored high on this factor due to low dietary forbs Thus, this separation could represent facilitation (Bell 1971, Gordon 1988) of deer consumption of forbs by cattle Other researchers (Warren and Krysl 1983) have observed an increase in forb consumption by deer on rangelands grazed by cattle

INFLUENCE OF GRAZING ON DIET QUALITY

Fecal Nitrogen

Fecal N is composed of undigestible dietary nitrogen (including some secondary compounds and structural material), water soluble N, bacterial N, and endogenous nitrogen (Arman et al 1975) Despite component variability, fecal N has been used to assess quality of forage ingested by wild herbivores (Arman et al 1975, Erasmus et al 1978, Leslie and Starkey 1985, Wofford et al 1985) and to rank quality of deer wintering areas in Maine (Hodgman and Bowyer 1986) Coe (1983) found fecal N to be a good predictor of dietary N down to a level of 5% crude protein (CP) Hobbs (1987) elaborated on problems with fecal N as a predictor of dietary N, however, Leslie and Starkey (1987) suggested that fecal N could be used under a variety of circumstances, which included seasonal, intraspecies comparisons within similar habitats

Although interspecies comparisons of fecal N between deer and cattle may be questionable because of differing digestive adaptations that can affect the mechanics of digestion (Short 1963, 1964), fecal N was significantly higher for deer than cattle in all seasons studied (Fig 14) Higher concentrations of fecal N in deer may occur due to high loss of fermentable material from the rumen to the intestines (Orskov et al 1972, cited by Van Soest 1982 47) Clemens and Maloiy (1983) found that percent dry matter in the small intestine decreased with increased consumption of grass when comparing 16 wild ruminant species Cattle consumed a high proportion of poacids (Table 2, Appendix I), which tend to be low in N content (Blair et al 1977) Leslie and Starkey (1985) found that fecal N of elk was lower than deer in some seasons in old-growth forests Because elk select poacids, their diets can be similar to cattle and sheep (Skovlin et al 1968, Constan 1972)

Coefficients of determination (r^2) for the relationship between dietary and fecal nitrogen for deer have ranged from 0 57 (Robbins et al 1975) to 0 95 (Leslie and Starkey 1985) Low r^2 values determined in some studies may result from high concentrations of tannins (Mould and Robbins 1981), which bind proteins and reduce their digestibility (McLeod 1974, Reed 1986, Robbins et al 1987a, 1987b) Yet, forages that contain high concentrations of condensed tannins (>5%) may not be preferred by wild ruminants (Cooper and Owen-Smith 1985) and concentrations of tannins in plants may peak during seasons when competition for forage is low (spring) (Happe et al 1990) If secondary compounds had affected fecal N levels of deer, higher levels of fecal N would have been expected in deer feces from McCurtain and Howard counties because of significantly elevated intake of conifers (Table 2) However, deer from Pike County had the highest level of fecal N in winter, diets of deer from Pike County were composed primarily of Caprifoliaceae Fecal N of cattle from McCurtain County declined from October to February despite increased consumption of browse and conifer

Levels of fecal N were lowest in winter and indicated that dietary quality also was lowest during this season Because fecal N of deer from Pike County was higher than for deer populations exposed to cattle grazing, competition between deer and cattle for available forage may have occurred Increased dietary competition between deer and cattle in February is supported by overlap indices (Table 3), proximity of principal component scores for sympatric deer and cattle populations that were determined from dietary analyses (Fig 11), and canonical scores of collected deer that were determined from condition indices (Fig 19) Feces from Pike County were significantly lower in N concentration than those collected in McCurtain and Howard counties in

August and October, which may suggest a facilitative effect from cattle during these seasons resulting in an increased consumption of forbs

Fecal N concentration of cattle was lower in Howard County in August, October, and February than in McCurtain County Higher levels of fecal N for cattle from McCurtain County may have resulted from the higher intake of browse, which is generally higher in nitrogen content than grasses (Blair et al 1977) This also might be expected because of the higher dietary overlap of deer and cattle in McCurtain County compared to Howard County As with deer, fecal N of cattle decreased in February despite higher consumption of conifers than in other seasons

Fecal Ribonucleic Acid

Because of positive effects of tannins on excretion of N (Mould and Robbins 1981), nitrogenous subfractions of feces have been used to better predict diet quality of ruminants (Van Soest 1982, Wofford et al 1985, Leslie et al 1989, Leite and Stuth 1990) Wofford et al (1985) used nucleic acids, and nonfiber bound N subfractions to evaluate the use of fecal indices for predicting dietary quality Leslie et al (1989) noted that concentrations of fecal N and fecal diaminopimelic acid (i e , an index of microbial N [Van Soest 1982, McAllan and Smith 1983]) were correlated in deer and moose (*Alces alces*) However, limited success has been achieved in enhancing predictive measures using nitrogenous subfractions (Leite and Stuth 1990)

Nucleic acids have been used as a measure of microbial N (Smith 1975, Smith and McAllan 1970, McAllan and Smith 1983) As with diaminopimelic acid, nucleic acids indirectly index microbial protein synthesis and presumably are not directly affected by increased consumption of secondary compounds Nucleic acid content of feces has been correlated with fecal N (Wofford et al 1985) and daily flows of microbial N from the rumen of steers were similar when calculated using RNA and diaminopimelic acid (McAllen and Smith 1983)

In this study, the relationship of fecal RNA of deer to cattle showed a similar trend to fecal N (Fig 16) with concentrations in cattle lower than deer However, intraspecies comparisons of RNA were more variable than fecal N and failed to clarify differences that occurred in fecal N relative to deer and cattle populations Therefore, determination of fecal RNA did not enhance understanding of relationships involving dietary and fecal characters

INFLUENCE OF GRAZING ON DEER CONDITION

Carcass Characteristics

Morphometric traits (e g , body weight) of deer have been used to compare populations under differing densities (Kie et al 1980, Kie et al 1983) and nutritional constraints (Hesselton and Sauer 1973, Seal et al 1972, 1978), and to assess the effect of grazing and deer-harvest management on condition (Warren and Krysl 1983) Body weights have been suggested as one of the best chronic indicators of physical condition (Hesselton and Sauer 1973, Kie et al 1983) During February, carcass weights were heavier for deer collected in Pike County than in McCurtain and Howard counties, which suggested that cattle stocking was negatively affecting condition Carcass weight of deer collected in McCurtain County was significantly lighter than those collected in Howard County in August, which also suggested a negative influence of cattle on deer condition in this season Warren and Krysl (1983) found that carcass weights were similar on 2 areas with different stocking rates, despite the collection of older deer from an area with high domestic and wild ruminant densities These similar weights were interpreted as a negative effect of stocking as older deer were expected to weight more than younger deer

Analysis of covariance (ANCOVA) is necessary for the comparison of body characteristics of collected animals because under the circumstances of collection, weight and/or age of collected specimens cannot be predetermined (Steel and Torrie 1980 401) Organ weights and fat characteristics of deer have been found to vary with age and body weight (Anderson et al 1974, Kie et al 1983) and thus this variation can conceal differences that are attributable to treatments Kie et al (1983) used age as a covariate to assess differences in carcass and fat characteristics of deer collected from 2 herds of differing density Allometric relationships between age and weight, and organ and gland weights have been determined for mule deer (Anderson et al 1974) Age was found to be a highly significant covariate for all carcass characteristics, except spleen weight and percent KFI Neither age nor carcass weight was a significant covariate for spleen weight when both were used simultaneously in ANCOVA Anderson et al (1974) found a low (r = 0 10), but significant, correlation coefficient for spleen weight and age of female mule deer and suggested that the high variability may have been due to affects of exercise and hemorrhage during collection Thus, inherent variation that occurs during collection could have affected spleen weights and would decrease the usefulness of this organ in assessing differences due to effects of cattle on deer nutritional condition

Adrenal weights have been suggested as useful indicators of stress when comparing deer populations (Christian et al 1960, cited by Verme and Ullrey 1984)   Kie et al (1983) found a difference ($\underline{P}$ < 0 10) in paired adrenal weights of 2 deer herds of differing densities   However, Seal et al (1983) found no evidence of increased adrenal corticosteroid activity with increased density in an enclosed deer herd   No differences in paired adrenal weights were found for deer exposed to various levels of cattle stocking in this study, despite differences in carcass and dietary characteristics

Because of the obligatory lipogenesis that occurs in deer despite the consumption of poor quality forage (Verme and Ozoga 1980) and extreme variation in fat levels of deer (Anderson et al 1972), use of fat reserves can be unreliable in assessing condition unless accompanied by other measures of nutritional condition   Furthermore, different methodologies exist for determining the kidney fat index (Monson et al 1974, Torbit et al 1988) and femur marrow fat (Verme and Holland 1973, Hunt 1979, Torbit et al 1988), and use of either index alone may be unreliable as an indicator of condition (Ransom 1965)

Amount of kidney fat in deer varies seasonally (Harris 1945, Finger et al 1981, Waid and Warren 1984) with higher reserves in females occurring in winter than in other seasons in the South (Johns et al 1984, Deliberto et al 1989)   Young animals possess lower levels of fat when compared to adults (Bjarghou et al 1977, Johns et al 1984, Ballard and Whitman 1987, Cederlund et al 1989)   In this study, age was a significant covariate in the analysis of femur marrow fat but not KFI   Despite problems that may limit the usefulness of fat characteristics in population comparisons, deer collected from McCurtain County had low levels of kidney fat in February and femur marrow fat in February and August   While some researchers have been unable to link reduction of fat deposits with lower carcass weights (Warren and Krysl 1983, Kie et al 1984), Kie et al (1983) reported reduced carcass weight and fat deposits in a deer herd maintained at a high density Fat characteristics of deer in this study supported the aforementioned differences in carcass weight in February and further suggested that deer in McCurtain County were in poorer nutritional condition relative to deer from other study areas

Reproductive Traits

Reproductive rate of deer is affected by dietary quality (Cheatum and Severinghaus 1950) Fetuses per doe have been determined from collected animals to assess reproductive performance of deer populations (Hesselton and Sauer 1973, McCullough 1979, Teer 1984) Reproductive rate varies with age, fawns and yearlings have lower reproductive rates than adults (Hesselton and Sauer 1973, Teer 1984) Hesselton and Sauer (1973) considered reproductive rate one of the best indicators of nutritional condition Because fawns will only breed under ideal nutritional conditions (McCullough 1979, Teer 1984), reproductive rate of females collected in February were analyzed with and without the inclusion of fawns Age was a significant covariate in analyses involving reproductive rate, which supports lower rates for yearlings than adults In all analyses, reproductive rate of Pike County deer collected in winter was higher than deer populations exposed to cattle grazing Furthermore, adjusted reproductive rates for adults and fawns (Table 6) collected from Pike and McCurtain counties were similar to deer consuming diets representative of high and low levels of nutrition, respectively (high = 1 74, low = 0 95 [Verme 1965])

Serum Chemistry and Hematology

Blood serum characteristics have been used to assess condition in deer (Blankenship and Varner 1978, Seal et al 1978, Kie et al 1983), pronghorns (Antilocapra americana) (Seal and Hoskinson 1978), bighorn sheep (Ovis canadensis) (Franzmann 1971), elk (Cervus elaphus) (Wolfe et al 1982), moose (Franzmann and LeResche 1978), bison (Bison bison) (Hawley and Peden 1982), and collared peccary (Tayassu tajacu) (Lochmiller and Grant 1984) Many hematological characteristics and serum constituents (e g , total protein, globulin, glucose, cholesterol) have been reported to respond directly to adverse dietary and habitat conditions However, few blood characteristics are singularly definitive in the diagnosis of nutritional status, and therefore, blood profiles are generally required when assessing nutritional condition (Rowlands 1980, Lochmiller et al 1986)

Blood serum albumin has been determined regularly when characterizing and comparing blood profiles (Bandy et al 1957, Seal and Erickson 1969, Franzmann 1971, Blankenship and Varner 1978) Serum albumin is important in maintaining plasma oncotic pressure (Guyton 1986 208) and lowered levels have been associated with reduced production due to liver cell damage, deficient protein intake, and/or stress induced catabolism of body protein (Ravel 1989 432) Albumin levels have been found to vary seasonally (Waid and Warren 1984), however, similar levels have been found for wild ungulates that reportedly differed in nutritional condition (Franzmann 1971, Blankenship and Varner 1978, Seal et al 1978) Alternatively, increased albumin concentrations have been associated with improved condition in moose (Franzmann and LeResche 1978), elk (Weber et al

1984), and cattle (Rowlands 1980) Kie et al (1983) found lower serum albumin levels for adult deer that were held at a high density within an enclosure than deer outside the enclosure Deer collected in McCurtain County had lower serum albumin levels than deer collected in Howard County possibly due to a lower protein intake

Albumin/globulin ratios have been used to compare populations of wild ruminants in order to assess albumin production relative to amount of transport and antibody protein in blood (Seal and Erickson 1969, Blankenship and Varner 1978, Wolfe et al 1982) Low ratios can occur because of limited production of albumin (Ravel 1989 432), Waid and Warren (1984) suggested that depressed albumin levels could be partially explained by the effect of globulin levels on albumin synthesis Lower albumin/globulin ratios have been noted in wild elk when compared to captive elk that were considered in good health (Wolfe et al 1982) Although serum globulin levels did not differ among populations of deer (Table 7), albumin/globulin ratios were lower in deer collected in McCurtain County than in Howard County Low ratios for deer from McCurtain County might be expected because of lower carcass weight and reproductive rate, which might further suggest that protein synthesis is limited in this population compared to other deer populations

Blood urea nitrogen is frequently used to assess protein intake in white-tailed deer (Blankenship and Varner 1978, Seal et al 1978, Kie et al 1983), blood urea nitrogen fluctuates directly with protein intake (Kirkpatrick et al 1975, Bahnak et al 1979) However, energy intake can affect serum concentrations (Kirkpatrick et al 1975, Rowlands 1980), and deer under fasting conditions can have high levels of this serum constituent, possibly due to increased catabolism of muscle (deCalesta et al 1975, 1977, Delgiudice et al 1987) Moreover, Waid and Warren (1984) found a relatively weak correlation (r = 0 24) between blood urea nitrogen and rumen crude protein, which further indicated that use of this serum constituent may be of limited use for comparing populations Concentrations of blood urea nitrogen in summer and ratios of blood urea nitrogen/creatinine during summer and winter were lower in deer from Pike County than McCurtain and Howard counties Bahnak et al (1979) found that female deer on a low protein and energy diet had reduced concentrations of blood urea nitrogen, total serum protein, and amino acid nitrogen, low levels of serum constituents were considered a reflection of lactational stress Thus, reduced levels of blood urea nitrogen and its associated ratio with serum creatinine may have occurred in this study because of reduced protein availability or negative effects from the high demands of gestation and lactation on these deer

Serum glucose levels can vary significantly due to method of animal capture and postprandial relationships (Franzmann 1972, Blankenship and Varner 1978, Wesson et al 1979) Bandy et al (1957) noted large standard deviations about mean glucose levels of black-tailed deer (O h columbianus) Because of inherent variation, serum glucose has not been a reliable character for assessing animal condition (Blankenship and Varner 1978, Seal et al 1978, Kie et al 1983) Yet, differences in serum glucose have been observed in comparisons of wild and captive animals (Franzmann 1971, Wolfe et al 1982) and fasted deer (Hershberger and Cushwa 1984) and was considered one of the more useful serum constituents for evaluating condition of moose (Franzmann and LeResche 1978) Lower concentrations of glucose in deer from McCurtain

County compared to Howard County in August might suggest that caloric intake was adversely influenced by heavy cattle stocking

Serum electrolytes have been used to assess mineral status of wild populations, levels represent the dynamic flux of absorption, extraction and deposition in bone, and excretion (Franzmann and LeResche 1978) Serum calcium and phosphorus were considered 2 of the most useful blood characters for assessing condition of moose (Franzmann and LeResche 1978) Soils in the southern Piedmont region are generally low in phosphorus (Whittington 1984) and efforts have been made to link soil characteristics with measures of condition (i e , body weights) (Jacobson 1984) Franzmann (1971) suggested that reduced serum phosphorus levels in wild bighorn sheep represented a reduced ability to maintain blood levels of this serum constituent

Levels of serum phosphorus were lowest in deer collected in Pike County in August and together with slightly higher levels of serum calcium in February, resulted in the highest levels of the calcium/phosphorus ratio Delgiudice et al (1987) noted that serum phosphorus increased with time in captive, fasted deer while serum calcium remained normal and suggested that fasted deer experienced secondary hyperparathyroidism Diets of deer from Pike County contained a higher proportion of browse than deer exposed to varied levels of cattle stocking Vangilder et al (1982) found that leaves of woody species contained a high level of calcium Thus, higher serum calcium/phosphorus ratios of deer collected from Pike County could have resulted from consumption of diets high in browse Kie et al (1980) found a higher level of ruminal calcium and calcium/phosphorus ratio in deer held at high density within an enclosure These deer consumed less forbs and more grasses than deer outside the enclosure, however, dietary browse was similar for both deer populations

Seasonal variation occurred in total serum protein, serum globulin, albumin/globulin ratio, gamma globulin, creatinine, cholesterol, phosphorus, and packed cell volume Higher serum creatinine, gamma globulin, phosphorus, albumin/globulin ratio, and packed cell volume occurred in February than in August, and suggested a hemoconcentration effect (Delgiudice et al 1987, 1990) Higher levels of serum total protein, globulin, and cholesterol occurred in August than in February, and although these increased levels are contrary to a postulated hemoconcentration effect in February, they may have resulted from increased protein (i e , total serum protein and globulin) and energy (i e , cholesterol) in forage in August No differences in total serum protein, globulin, gamma globulin, creatinine, cholesterol, or packed cell volume occurred among deer populations Card et al (1985) also was unable to detect differences in cholesterol in blood of captive deer on diets that varied in energy intake Similarity in levels of total serum protein and blood urea nitrogen in winter suggested that protein intake was similar for the 3 deer populations Yet, low blood urea nitrogen (12 1 mg/dl) and total serum protein (3 94 g/dl) of the lone male that was included in analyses suggested that this individual was protein malnourished Similar concentrations of serum globulin and gamma globulin among deer populations suggested that deer in this study were not responding immunologically to infectious disease (Rowlands 1980)

Multivariate analysis was conducted on characteristics that were significantly different among the 3 populations and have been demonstrated to be useful in assessing animal condition (i e , body weight and fat [Kie et al 1983], albumin, calcium, and phosphorus [Franzmann and LeResche 1978]) Addition of the lone male as a "poor condition" control animal aided in the assessment of nutritional condition of female deer because all characteristics of the male, except carcass weight, suggested poor condition A similar multivariate approach (i e , discriminant analysis) was used to assess differences in rations consumed by bison and cattle from blood constituents, blood urea nitrogen, cholesterol, and total serum protein were found to aid in the discrimination of ration groups

Franzmann (1985) discussed the need for increased use of multivariate analyses (i e , discriminant analysis) in studies of wild animal physiology Considerable overlap of deer populations from the 3 study areas occurred on synthetic factor axes and as such, it was not possible to classify deer by area of collection Nevertheless, centroids for study areas differed significantly (Fig 18 and 19) Because high body weights and fat attributes were considered positive nutritional characteristics, deer that scored high on factor 1 were considered in good nutritional condition Although low albumin/globulin ratios can occur due to a number of factors, high ratios would suggest a high nutritional condition Thus, deer scoring low on factor 2 may have been in good nutritional condition Furthermore, high calcium/phosphorus ratios could suggest inadequate phosphorus availability (Franzmann 1971) to deer, calcium/phosphorus ratio for the lone male was high (1 83), which suggested deer scoring high on factor 2 were in poor condition relative to this nutrient Thus, deer in good condition would be expected to score low to moderate on factor 2 and high on factor 1 Deer collected in McCurtain County scored low on factor 1 and moderate on factor 2, which suggested that these deer were in poorer nutritional condition relative to other deer populations

DENSITY-DEPENDENT EFFECTS

Although some white-tailed deer populations continue to exhibit characteristics that suggest a high nutritional condition concurrently with high population density (Dusek et al 1989), density-dependent (e g , lowered body weights and reproductive rates with increasing density) effects have been well documented in other deer populations (Teer et al 1965, McCullough 1979) When forage availability and quality are low, the number of female deer pregnant with twins and triplets relative to those pregnant with single fetuses decreases (McCullough 1979) Reproductive rate dropped from 1 9 fawns per female under favorable forage conditions to 0 43 fawns per female when forage abundance declined in New York (Cheatum and Severinghaus 1950) Additionally, Teer et al (1965) found an inverse relationship between incidence of ovulation and deer density in Texas, ovulation rates decreased as deer density increased Reduced body weights, fat attributes, and other measures of condition of deer can result from intraspecific competition (Kie et al 1983)

Despite presumed equal carrying capacities for the 3 study areas (i e , study areas had similar soils, topography, vegetation, and habitat manipulation) prior to the stocking of cattle, deer density differed and seemed to be related to density of cattle on study areas (Fig 20) (unpubl rep , Weyerhaeuser Co , Hot Springs, Ark) Although densities (determined from helicopter surveys [Melchiors et al 1985]) of deer in McCurtain and Pike counties were similar, deer density in

Pike County could have been biased by increased vegetative density, which would reduce deer visibility As such, these data were not included in regression analysis Because study areas in Howard and McCurtain counties were similar in vegetative physiognamy, I assumed that visibility biases were equal

Higher deer density in Howard County may have resulted from facilitation effects by cattle on deer (i e , increased forb availability [Table 2]) Deer collected from Howard County scored moderately on canonical factor 1 (Fig 18), which suggested a somewhat negative effect on carcass characteristics However, blood constituents for this deer population suggested that deer were in good condition relative to other study areas (Table 7) Likewise, these deer consumed low levels of conifers in all seasons except February and consumption of forbs was higher in Howard County than Pike County in all seasons (Table 2) Yet, reproductive rate in Howard County was lower than in Pike County, which could have resulted from intra- or interspecific competition

Assuming that the 3 study areas could support similar deer densities without cattle, density for McCurtain County could have been below carrying capacity or carrying capacity was reduced due to heavy cattle stocking (Fig 20) A relatively high nutritional condition and reproductive rate of deer in McCurtain County would be expected in response to reduced intraspecific competition for food resources if deer density was below carrying capacity and interspecific competition with cattle was minimal However, deer in McCurtain County consumed the highest percentages of conifer, had the lowest reproductive rate, and canonical scores of condition indices indicated that deer were in poor nutritional condition relative to deer collected from other study areas Thus, multivariate assessments of condition and presumably lowered deer density in McCurtain County support a conclusion that heavy cattle stocking had a negative effect on deer condition

CONCLUSIONS

White-tailed deer in the loblolly pine/shortleaf pine/hardwood habitat type tend to be small relative to northern deer (Seton 1927), possibly due to the effects of deficient net energy, protein, and phosphorus, and high carbon and fiber in forages of the region (Short 1969) Because of low soil fertilities, southern deer consume varied diets, which can be supplemented with high amounts of mast (Lay 1965) However, acorn production is variable in this habitat type and without agricultural crops, which can account for a significant proportion of the diet when available (Korschgen 1962, Dusek et al 1989, Weckerly and Nelson 1990), deer must forage opportunistically and maximize dietary richness to meet nutrient needs (Lay 1964)

In the South, summer can be a stressful season for female deer because of high temperatures and demands of lactation (Short 1969) Hot temperatures can reduce forage intake of deer when energy costs of heat dissipation are high (Short 1964) Additionally, forage quality declines during this season (Lay 1969) Because of these affects, deer die-offs, which normally occur in winter in the north, are more common in late summer in the South (McMahan 1964, Lay 1969)

Nutrient concentrations are reduced in winter forages (Blair et al 1977) Because of limited ephemeral snow cover in the South, a variety of mature forbs, grasses, and woody twigs may be available to deer, however, their low quality can negatively affect the nutritional condition of deer (Short 1975) Moreover, continuous, year-round grazing may increase competition for available forage between deer and cattle populations (McMahan 1964), further reducing nutritional condition of deer

This study assessed the effect of 3 levels of cattle stocking on deer populations in southern pine forest using a combination of dietary, morphometrical, reproductive, physiological, and fecal indices Although past studies that have assessed competitive interactions among sympatric herbivores relied on a combination of measures that included habitat use and forage availability, as well as, indices of dietary habits and animal condition (Anthony and Smith 1977, Leslie et al 1984, Jenkins and Wright 1988), study areas were selected to minimize variation in habitat characteristics Therefore, differences in deer nutritional condition could be directly attributed to effects of cattle stocking

In summer, significant variation in food habits and indices of nutritional condition occurred among deer populations but some indices were contradictory relative to assessment of nutritional status of deer populations In winter, multivariate assessment indicated consistently that cattle negatively affected deer populations Higher consumption of conifers, lower fecal N, lower carcass weights, and lower reproductive rates were characteristic of deer collected in McCurtain County and thus, likely resulted from the effects of heavy cattle stocking Improved nutritional condition of deer would be expected with a reduction in stocking rate in McCurtain County during winter Because negative effects of cattle grazing were observed in winter at a moderate level of cattle stocking, a seasonal (e g , spring through fall) grazing system may be necessary to ameliorate these negative effects on deer populations

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Table 1 Vegetation composition of study area blocks delineated for collection of plant and fecal material

County	Percent Natural Vegetation	Percent 0-4 yr Plantations	Percent >=5 yr Plantations	Hectares
McCurtain				
Block A	34	28	38	1536
Block B	41	24	35	946
Block C	33	33	34	1541
Block D	26	36	37	1144
Mean	34	30	36	1292
SE	3	3	1	148
Howard				
Block A	28	39	32	1240
Block B	31	39	30	1244
Block C	40	27	33	1329
Block D	29	37	34	1569
Mean	27	36	32	1346
SE	6	3	1	77
Pike				
Block A	38	33	29	1236
Block B	29	27	44	1205
Block C	17	35	48	1273
Block D	29	31	40	634
Mean	28	32	40	1087
SE	4	2	4	152

Table 2 Seasonal dietary composition by forage class of white-tailed deer and cattle determined by microhistological analysis of fecal samples collected October 1986 to August 1988 from study areas in McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

Season	Forage Class	Deer			Cattle	
		McCurtain	Howard	Pike	McCurtain	Howard
October 1986	Browse	0 44 (0 04)[a]	0 42 (0 05)	0 48 (0 08)	0 08 (0 01)	---- ----
	Conifer	0 09 (0 02)	0 03 (0 01)	0 04 (0 01)	0 03 (0 01)	---- ----
	Fern	----	0 01 (0 01)	0 01 *	0 01 * [b]	---- ----
	Forb	0 23 (0 05)	0 22 (0 07)	0 21 (0 06)	0 18 (0 03)	---- ----
	Grass	0 04 (0 02)	0 05 (0 01)	0 04 (0 02)	0 65 (0 02)	---- ----
	Mast	0 20 (0 05)	0 26 (0 07)	0 21 (0 05)	0 02 (0 01)	---- ----
	Total	0 98 *	0 99 *	0 98 (0 01)	0 96 (0 01)	---- ----
February 1987 ?	Browse	0 35 (0 07)	0 55 (0 04)	0 57 (0 06)	0 07 (0 03)	---- ----
	Conifer	0 11 (0 03)	0 06 (0 03)	0 06 (0 01)	0 08 (0 02)	---- ----
	Fern	0 14 (0 07)	0 02 (0 01)	0 02 (0 01)	t [c]	---- ----
	Forb	0 18 (0 07)	0 15 (0 04)	0 05 (0 01)	0 08 (0 01)	---- ----
	Grass	0 16 (0 04)	0 09 (0 02)	0 13 (0 04)	0 75 (0 05)	---- ----
	Mast	0 05 (0 03)	0 14 (0 04)	0 17 (0 07)	0 01 *	---- ----
	Total	1 00 *	1 00 *	1 00 *	0 98 *	---- ----
May 1987	Browse	0 38 (0 02)	0 38 (0 06)	0 42 (0 06)	0 05 (0 01)	0 01 *
	Conifer	0 09 (0 05)	0 02 (0 01)	0 03 (0 02)	0 02 (0 01)	t
	Fern	0 05 (0 03)	0 01 (0 01)	0 01 (0 01)	---- ----	---- ----
	Forb	0 35 (0 05)	0 48 (0 06)	0 39 (0 05)	0 17 (0 03)	0 24 (0 02)
	Grass	0 03 (0 01)	0 05 (0 03)	0 07 (0 01)	0 71 (0 04)	0 71 (0 02)
	Mast	0 01 (0 01)	0 04 (0 02)	0 06 (0 01)	0 01 *	---- ----
	Total	0 92 (0 05)	0 97 (0 01)	0 98 (0 02)	0 96 (0 01)	0 96 (0 01)

Table 2 , Continued

Season	Forage Class	Deer			Cattle	
		McCurtain	Howard	Pike	McCurtain	Howard
August 1987	Browse	0 41 (0 05)	0 53 (0 02)	0 62 (0 04)	0 02 (0 01)	t
	Conifer	0 03 (0 02)	0 01 (0 01)	0 02 (0 01)	0 03 (0 01)	t
	Fern	t	t	t	---- ----	---- ----
	Forb	0 38 (0 04)	0 33 (0 03)	0 12 (0 03)	0 25 (0 02)	0 03 (0 02)
	Grass	0 02 (0 01)	t	0 06 (0 04)	0 65 (0 01)	0 96 (0 02)
	Mast	0 14 (0 01)	0 10 (0 01)	0 15 (0 05)	0 01 *	t
	Total	0 97 (0 01)	0 97 (0 01)	0 96 (0 01)	0 95 (0 02)	0 99 (0 01)
October 1987	Browse	0 47 (0 04)	0 54 (0 07)	0 67 (0 04)	0 08 (0 03)	0 01 *
	Conifer	0 02 (0 01)	0 01 (0 01)	0 01 *	0 04 (0 03)	t
	Fern	t	t	0 01 (0 01)	---- ----	---- ----
	Forb	0 18 (0 06)	0 23 (0 03)	0 16 (0 06)	0 26 (0 07)	0 16 (0 01)
	Grass	0 03 (0 01)	0 09 (0 04)	0 05 (0 03)	0 59 (0 05)	0 80 (0 02)
	Mast	0 27 (0 02)	0 09 (0 02)	0 06 (0 01)	0 01 (0 01)	t
	Total	0 97 (0 01)	0 96 (0 02)	0 96 (0 01)	0 97 (0 01)	0 97 (0 01)
February 1988	Browse	0 22 (0 04)	0 30 (0 09)	0 69 (0 09)	0 07 (0 03)	0 04 (0 01)
	Conifer	0 49 (0 02)	0 27 (0 04)	0 06 (0 04)	0 14 (0 04)	0 01 *
	Fern	0 07 (0 03)	0 17 (0 11)	0 03 (0 01)	t	0 01 *
	Forb	0 07 (0 04)	0 03 (0 02)	0 03 (0 01)	0 09 (0 02)	0 03 (0 01)
	Grass	0 12 (0 03)	0 17 (0 08)	0 11 (0 05)	0 64 (0 05)	0 87 (0 02)
	Mast	0 02 (0 01)	0 03 (0 03)	0 02 (0 01)	t	0 01 *
	Total	0 98 (0 01)	0 96 (0 04)	0 94 (0 04)	0 95 (0 01)	0 97 *

Table 2 , Continued

Season	Forage Class	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
May 1988	Browse	0 34 (0 05)	0 36 (0 07)	0 50 (0 09)	0 02 *	0 02 (0 01)
	Conifer	0 08 (0 02)	0 05 (0 02)	0 03 (0 01)	0 03 (0 01)	t
	Fern	0 01 (0 01)	0 02 (0 01)	---- ----	0 01 (0 01)	t
	Forb	0 46 (0 05)	0 37 (0 05)	0 31 (0 09)	0 21 (0 02)	0 18 (0 02)
	Grass	0 08 (0 03)	0 15 (0 04)	0 10 (0 04)	0 65 (0 02)	0 70 (0 02)
	Mast	0 03 (0 01)	0 06 (0 02)	0 05 (0 01)	0 01 (0 01)	t
	Total	1 00 *	1 00 *	0 99 (0 01)	0 92 (0 02)	0 90 (0 01)
August 1988	Browse	0 50 (0 05)	0 51 (0 07)	0 44 (0 03)	0 02 (0 01)	0 01 *
	Conifer	0 12 (0 05)	0 01 *	0 03 (0 02)	0 03 (0 01)	t
	Fern	t	---- ----	t	---- ----	---- ----
	Forb	0 19 (0 03)	0 31 (0 08)	0 12 (0 01)	0 13 (0 03)	0 09 (0 01)
	Grass	0 07 (0 03)	0 02 (0 01)	0 06 (0 02)	0 73 (0 02)	0 83 (0 02)
	Mast	0 10 (0 03)	0 13 (0 03)	0 31 (0 03)	t	t
	Total	0 98 *	0 97 (0 01)	0 97 (0 02)	0 91 *	0 93 (0 01)

[a]Standard error in parentheses
[b]* = < 0 01
[c]t = trace

Table 3 Percent dietary overlap[a] by season of collection for white-tailed deer and cattle in McCurtain County, Oklahoma, and Howard and Pike counties, Arkansas

Season	McCurtain-Howard (deer)	McCurtain-Pike (deer)	Howard-Pike (deer)	McCurtain (deer-cattle)	Howard (deer-cattle)
October 1986	61 6	64 3	64 4	21 8	----
February 1987	54 8	38 9	47 9	31 2	----
May 1987	57 4	59 0	62 7	20 7	14 8
August 1987	66 8	40 2	52 7	16 7	2 5
October 1987	57 0	43 9	60 4	14 0	16 4
February 1988	61 7	34 2	43 2	34 6	20 1
May 1988	62 0	59 0	66 0	21 5	22 1
August 1988	62 2	43 5	41 7	17 6	8 4

[a]As described by Anthony and Smith (1977)

Table 4 Concentration of fecal nitrogen (%) of white-tailed deer and cattle feces collected from McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

	Deer			Cattle	
Season	McCurtain	Howard	Pike	McCurtain	Howard
October 1986	2 47 (0 14)[a]	2 12 (0 11)	2 40 (0 12)	1 94 (0 06)	----
February 1987	1 99 (0 09)	1 95 (0 11)	2 15 (0 09)	1 64 (0 18)	----
May 1987	2 91 (0 23)	3 29 (0 20)	2 91 (0 16)	2 22 (0 06)	2 28 (0 03)
August 1987	2 52 (0 12)	2 27 (0 16)	2 15 (0 12)	1 85 (0 04)	1 56 (0 05)
October 1987	2 52 (0 05)	2 65 (0 02)	2 24 (0 10)	1 68 (0 03)	1 37 (0 02)
February 1988	1 96 (0 04)	1 95 (0 07)	2 18 (0 07)	1 42 (0 03)	1 17 (0 01)
May 1988	3 22 (0 14)	3 22 (0 22)	3 05 (0 19)	2 32 (0 06)	2 35 (0 05)
August 1988	2 77 (0 07)	2 83 (0 11)	2 17 (0 10)	2 00 (0 06)	1 74 (0 05)
October 1988	2 61 (0 19)	2 62 (0 30)	2 26 (0 08)	1 80 (0 07)	----

[a]Standard error in parentheses

Table 5 Concentration of fecal RNA (%) of white-tailed deer and cattle feces collected from McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

	Deer			Cattle	
Season	McCurtain	Howard	Pike	McCurtain	Howard
October 1986	0 1589 (0 0109)	0 1438 (0 0056)	0 1524 (0 0059)	0 0854 (0 0070)[a]	----
February 1987	0 1084 (0 0080)	0 0933 (0 0095)	0 1335 (0 0164)	0 0558 (0 0137)	----
May 1987	0 1189 (0 0071)	0 1619 (0 0091)	0 1140 (0 0051)	0 0982 (0 0045)	0 0548 (0 0024)
August 1987	0 0828 (0 0122)	0 0786 (0 0040)	0 0566 (0 0077)	0 0496 (0 0059)	0 0580 (0 0058)
October 1987	0 1044 (0 0055)	0 0825 (0 0105)	0 0616 (0 0087)	0 0675 (0 0043)	0 0504 (0 0055)
February 1988	0 0863 (0 0035)	0 1148 (0 0116)	0 0750 (0 0033)	0 0428 (0 0052)	0 0331 (0 0037)
May 1988	0 1663 (0 0127)	0 1689 (0 0125)	0 1877 (0 0270)	0 0798 (0 0058)	0 0785 (0 0020)
August 1988	0 0918 (0 0059)	0 1035 (0 0139)	0 0471 (0 0029)	0 0642 (0 0038)	0 0415 (0 0019)
October 1988	0 0749 (0 0128)	0 0641 (0 0065)	0 0587 (0 0123)	0 0497 (0 0032)	----

[a]Standard error in parentheses

Table 6 Unadjusted and adjusted[a] carcass characteristics and reproductive rates of white-tailed deer collected in February and August 1987-88 from McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

Character	Study Areas[b]			Seasonal Average
	McCurtain	Howard	Pike	
Carcass Weight (kg)		February		
Unadjusted	24 6 (1 8)	25 3 (2 3)	27 7 (1 9)	25 7 (1 2)[c]
Adjusted	22 6 (1 3)	25 9 (1 2)	29 3 (1 4)	25 1 (0 7)
		August		
Unadjusted	28 2 (1 0)	31 3 (1 3)	30 3 (1 6)	25 7 (0 8)
Adjusted	29 3 (0 9)	31 8 (0 8)	28 8 (0 8)	29 9 (0 8)
Paired Adrenal Weight (g)		February		
Unadjusted	3 3 (0 4)	3 0 (0 4)	3 3 (0 5)	3 2 (0 2)
Adjusted	3 0 (0 3)	3 1 (0 3)	3 5 (0 3)	3 0 (0 1)
		August		
Unadjusted	3 1 (0 2)	3 3 (0 4)	3 4 (0 4)	3 3 (0 2)
Adjusted	3 5 (0 2)	3 4 (0 2)	3 0 (0 2)	3 5 (0 1)

Table 6 Continued

Character	Study Areas McCurtain	Howard	Pike	Seasonal Average
Spleen Weight[d] (g)		February		
	200 4	212 2	250 9	218 0
	(18 9)	(20 4)	(15 8)	(11 5)
		August		
	225 1	236 3	212 4	224 6
	(22 5)	(15 9)	(12 7)	(9 9)
Femur Marrow Fat (%)		February		
Unadjusted	51 4	59 0	68 3	59 0
	(5 5)	(4 4)	(3 6)	(2 9)
Adjusted	47 6	60 2	71 3	57 9
	(3 6)	(3 3)	(4 0)	(2 5)
		August		
Unadjusted	36 5	40 5	52 4	43 1
	(2 6)	(4 9)	(4 1)	(2 6)
Adjusted	38 6	41 3	49 4	44 3
	(3 6)	(3 5)	(3 8)	(2 6)
KFI[d] (%)		February		
	27 1	41 1	49 2	38 2
	(4 0)	(5 7)	(6 0)	(3 4)
		August		
	20 6	28 3	17 5	22 1
	(4 9)	(4 6)	(2 2)	(2 4)

Table 6 Continued

Character	Study Areas McCurtain	Howard	Pike	Seasonal Average
Reproductive Rate (fetus/doe)				
		February		
Adults				
Unadjusted	1 2	1 4	2 0	1 5
	(0 2)	(0 2)	(0 0)	(0 1)
Adjusted	1 1	1 4	2 2	1 5
	(0 1)	(0 1)	(0 2)	(0 1)
Adults and Fawns				
Unadjusted	0 9	0 9	1 6	1 1
	(0 2)	(0 3)	(0 2)	(0 1)
Adjusted	0 7	1 0	1 8	1 1
	(0 1)	(0 1)	(0 2)	(0 1)

[a]Means adjusted using ANCOVA with age as the covariate

[b]Sample size for carcass weight and femur marrow fat and was 11, 12, 9, and 10, 10, 10 for February and August in McCurtain, Howard, and Pike counties, respectively Sample size for KFI was 11, 12, 8, and 10, 10, 10 in February and August in McCurtain, Howard, and Pike counties, respectively Sample size for paired adrenal weight was 11, 9, 8 and 10, 10 ,10 in February and August in McCurtain, Howard, and Pike counties, respectively Sample size for spleen weight was 7, 7, 5 and 10, 10, 10 in February and August in McCurtain, Howard, and Pike counties, respectively Sample size for reproductive rate was 11, 12, 9 for McCurtain, Howard, and Pike counties, respectively

[c]Standard error in parentheses

[d]Covariate (age) for spleen weight (_P_ = 0 12) and KFI (_P_ = 0 88) was not significant

Table 7 Serum chemical and hematological characteristics of white-tailed deer collected in February and August 1987-88 from McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

		Study Areas[a]			
Character	Season	McCurtain	Howard	Pike	Seasonal Average
Total Protein	February	6 39	6 04	6 21	6 22
		(0 54)	(0 52)	(0 41)	(0 28)[b]
(g/dl)	August	7 33	8 12	7 41	7 62
		(0 28)	(0 20)	(0 27)	(0 15)
Albumin	February	3 45	3 90	3 77	3 70
		(0 33)	(0 13)	(0 25)	(0 17)
(g/dl)	August	3 44	4 05	3 50	3 66
		(0 10)	(0 13)	(0 17)	(0 09)
Globulin	February	2 94	2 15	2 44	2 51
		(0 35)	(0 26)	(0 30)	(0 18)
(g/dl)	August	3 90	4 10	3 94	3 96
		(0 21)	(0 21)	(0 20)	(0 11)
Albumin/ Globulin Ratio	February	1 44	2 08	1 84	1 78
		(0 29)	(0 30)	(0 42)	(0 19)
	August	0 90	1 03	0 90	0 94
		(0 04)	(0 08)	(0 06)	(0 04)
Glucose	February	165 83	140 50	229 38	175 29
		(29 50)	(16 33)	(75 64)	(24 92)
(mg/dl)	August	92 27	131 83	99 63	107 91
		(8 88)	(11 02)	(6 73)	(5 96)
Cholesterol	February	45 50	46 27	47 89	46 47
		(3 65)	(4 47)	(4 92)	(2 42)
(mg/dl)	August	53 25	53 20	60 25	55 57
		(3 83)	(1 88)	(3 85)	(1 95)

Table 7 Continued

Character	Season	Study Areas			Seasonal Average
		McCurtain	Howard	Pike	
Blood Urea Nitrogen (mg/dl)	February	22 94	25 25	22 31	23 57
		(3 12)	(2 60)	(3 02)	(1 65)
	August	12 22	9 37	6 77	9 46
		(1 88)	(0 89)	(0 46)	(0 80)
Creatinine (mg/dl)	February	1 56	1 57	1 79	1 63
		(0 06)	(0 07)	(0 15)	(0 06)
	August	1 40	1 40	1 31	1 36
		(0 05)	(0 05)	(0 09)	(0 04)
Blood Urea Nitrogen/ Creatinine Ratio	February	15 35	16 69	12 35	14 96
		(2 41)	(1 93)	(1 39)	(1 18)
	August	9 02	6 87	5 31	7 07
		(1 53)	(0 63)	(0 38)	(0 62)
Calcium	February	10 75	11 51	12 15	11 43
		(0 73)	(0 68)	(1 04)	(0 46)
	August	10 00	10 44	10 17	10 20
		(0 23)	(0 22)	(0 56)	(0 21)
Phosphorus (mg/dl)	February	12 15	12 37	12 57	12 35
		(0 94)	(0 82)	(1 56)	(0 61)
	August	9 75	11 00	8 55	9 77
		(0 45)	(0 48)	(0 66)	(0 35)
Calcium/ Phosphorus Ratio	February	0 91	0 95	1 05	0 96
		(0 06)	(0 06)	(0 13)	(0 05)
	August	1 05	0 97	1 23	1 08
		(0 07)	(0 06)	(0 07)	(0 04)

Table 7 Continued

Character	Season	Study Areas: McCurtain	Howard	Pike	Seasonal Average
Gamma Globulin	Feb	1 07 (0 07)	0 97 (0 05)	0 98 (0 07)	1 01 (0 04)
(mg/dl)	Aug	0 77 (0 02)	0 78 (0 02)	0 78 (0 02)	0 78 (0 01)
Packed Cell Volume	Feb	48 29 (2 56)	49 92 (1 54)	50 80 (2 98)	49 78 (1 39)
(%)	Aug	41 33 (2 24)	45 71 (2 05)	47 76 (2 20)	45 03 (1 31)

[a]Sample size for serum characteristics by study area are 11, 11, 9, in February for McCurtain, Howard, and Pike counties, respectively, and 10 for each of the 3 study areas in August Sample size for packed cell volume in February and August was was 7, 8, 9, and 9, 9, 10, for McCurtain, Howard, and Pike counties, respectively

[b]Standard error in parentheses

LIST OF FIGURES

18 Canonical factor scores derived from carcass and physiological characteristics of white-tailed deer collected from McCurtain County, Oklahoma, and Howard and Pike counties, Arkansas, February and August 1987-88 (dots = McCurtain County, circles = Howard County, triangles = Pike County, star = male deer collected in Pike County, Arkansas, February 1988) Ellipses denote 95% confidence regions about centroides

19 Canonical factor scores derived from carcass and physiological characteristics of white-tailed deer collected from McCurtain County, Oklahoma, and Pike County, Arkansas, February and August 1987-88 (dots = McCurtain County, triangles = Pike County, star = male deer collected in Pike County, Arkansas, February 1988) Ellipses denote 95% confidence regions about centroides

20 Relationship between white-tailed deer and cattle density for study areas in McCurtain County, Oklahoma, and Howard and Pike counties, Arkansas (dots = McCurtain County, circles = Howard County, triangles = Pike County) Densities were determined from helicopter surveys conducted by Weyerhaeuser Company Density estimates for Pike County were not included in regression analysis

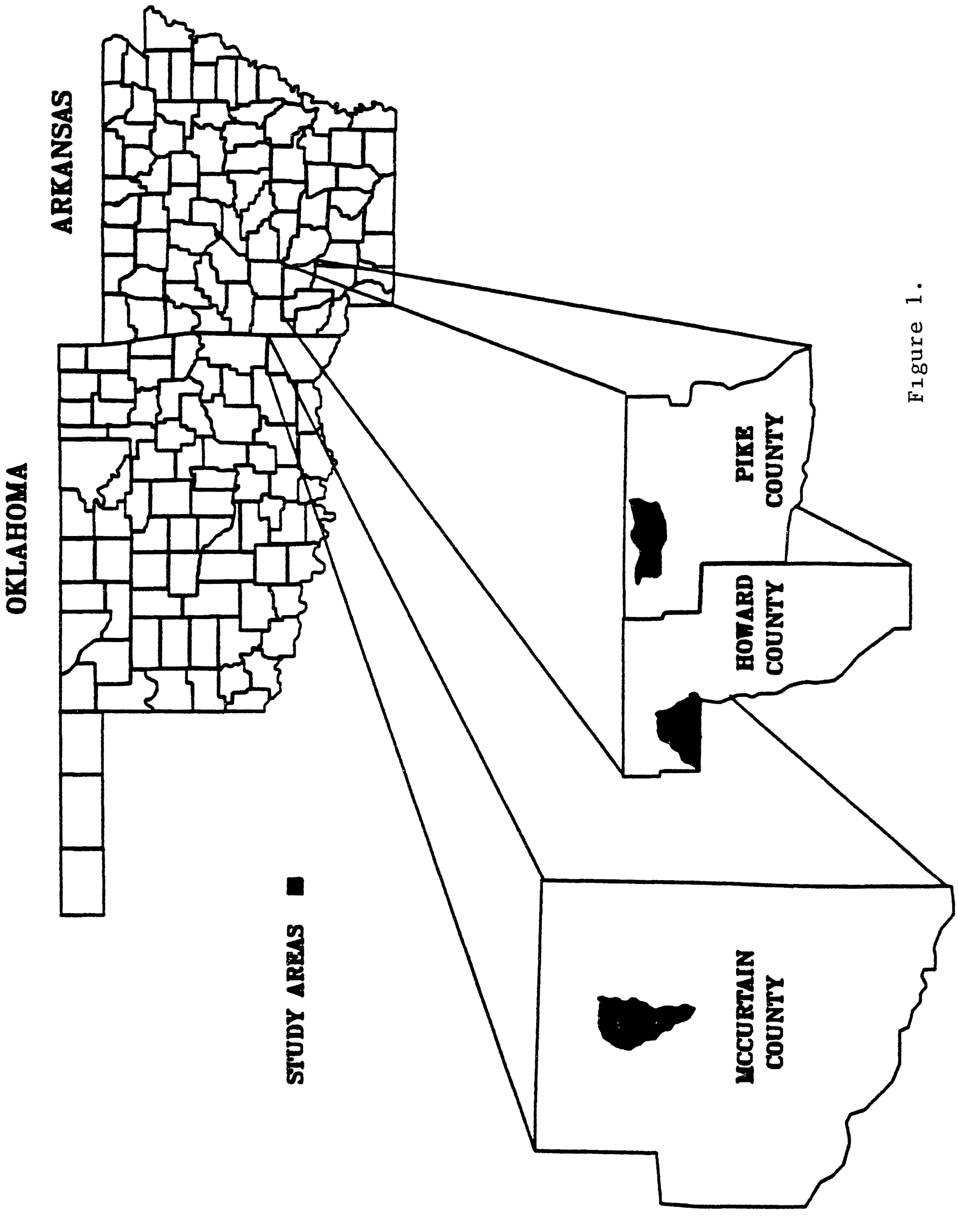

OKLAHOMA
ARKANSAS
PIKE
COUNTY
HOWARD
COUNTY
MCCURTAIN
COUNTY
STUDY AREAS

Figure 1.

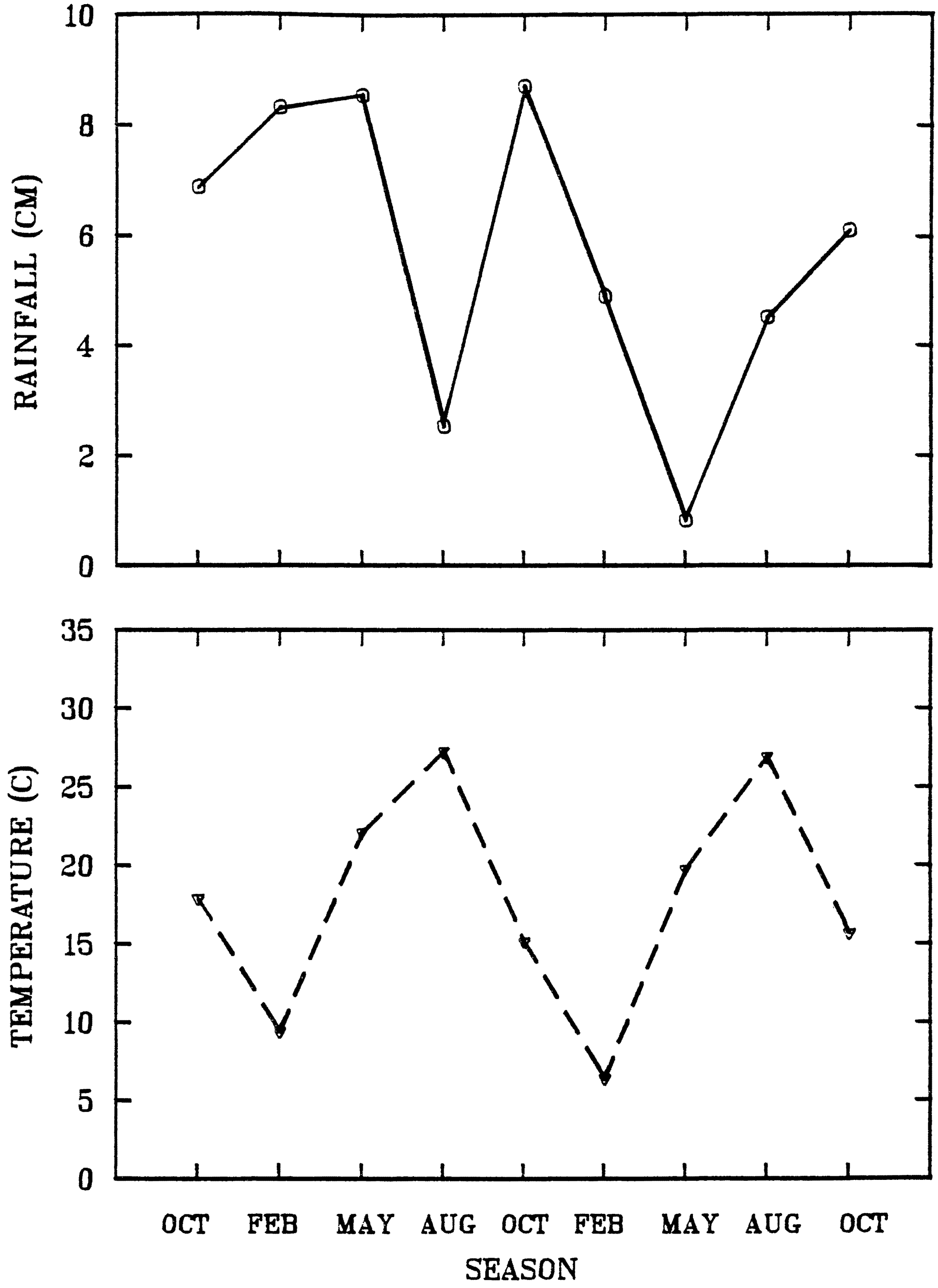

RAINFALL (CM)
10
8
6
4
2
0
TEMPERATURE (C)
35
30
25
20
15
10
5
0
OCT FEB MAY AUG OCT FEB MAY AUG OCT
SEASON

Figure 2

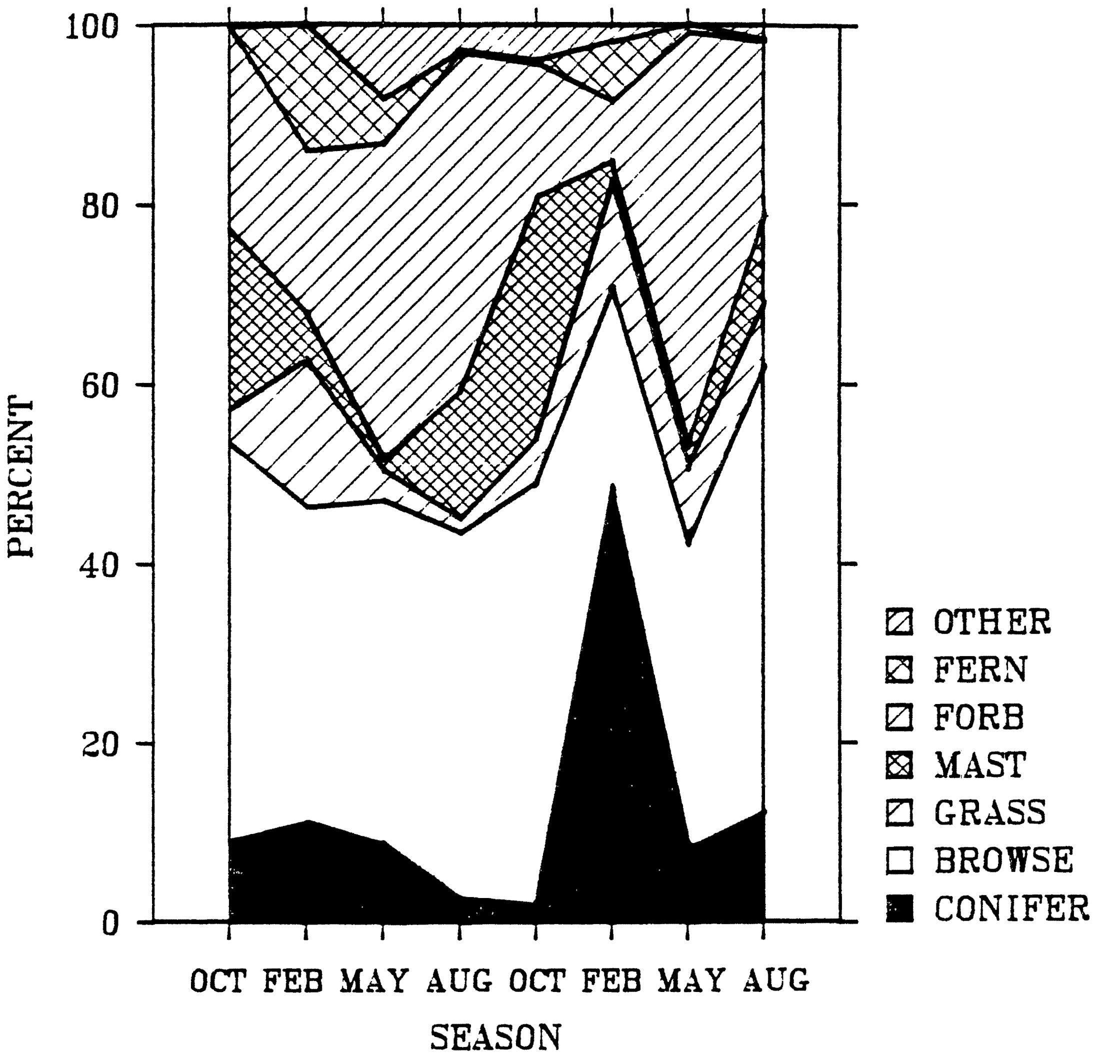

100
80
60
40
20
0
PERCENT
OCT FEB MAY AUG OCT FEB MAY AUG
SEASON
OTHER
FERN
FORB
MAST
GRASS
BROWSE
CONIFER

Figure 3

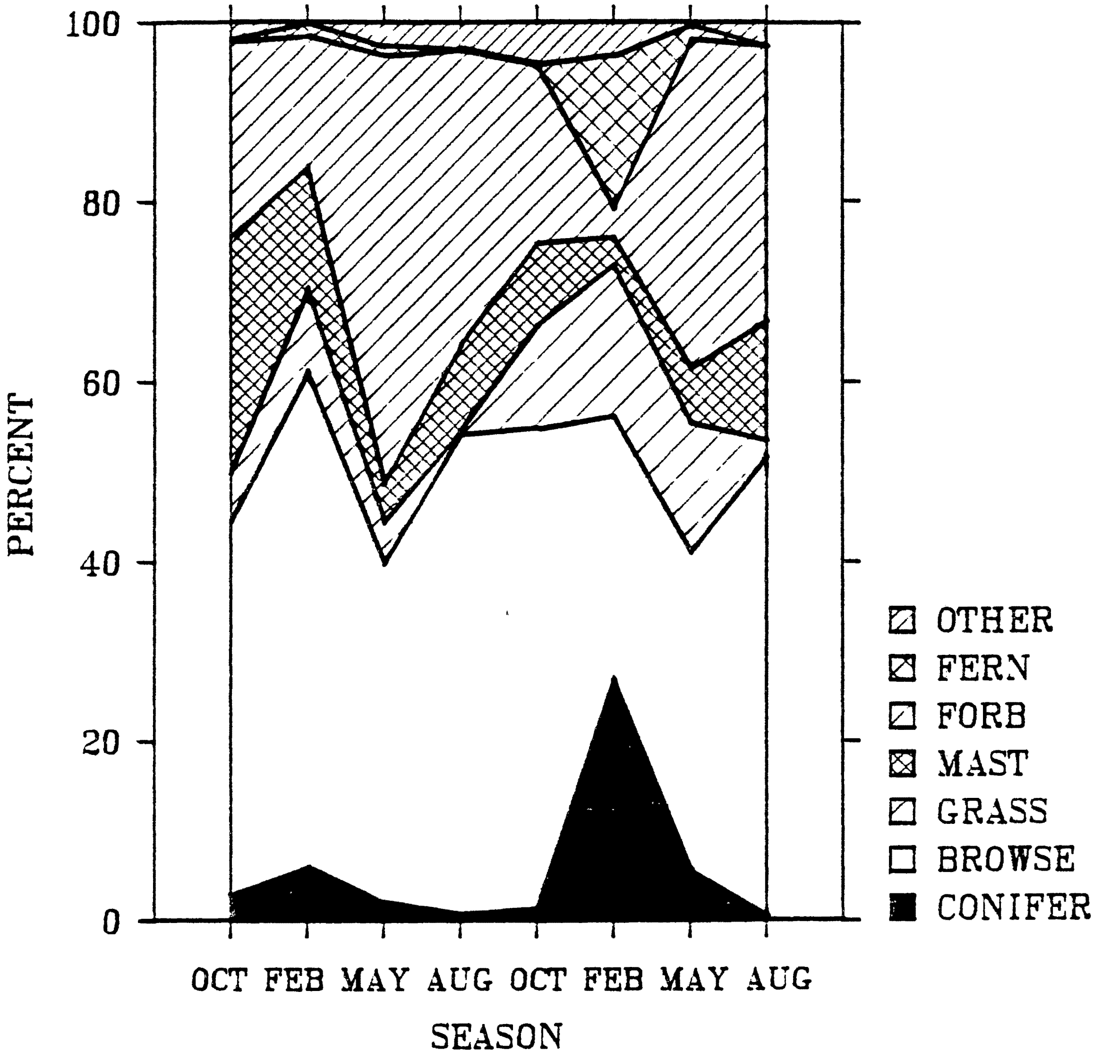

100
80
60
40
20
0
PERCENT
OTHER
FERN
FORB
MAST
GRASS
BROWSE
CONIFER
OCT FEB MAY AUG OCT FEB MAY AUG
SEASON

Figure 4

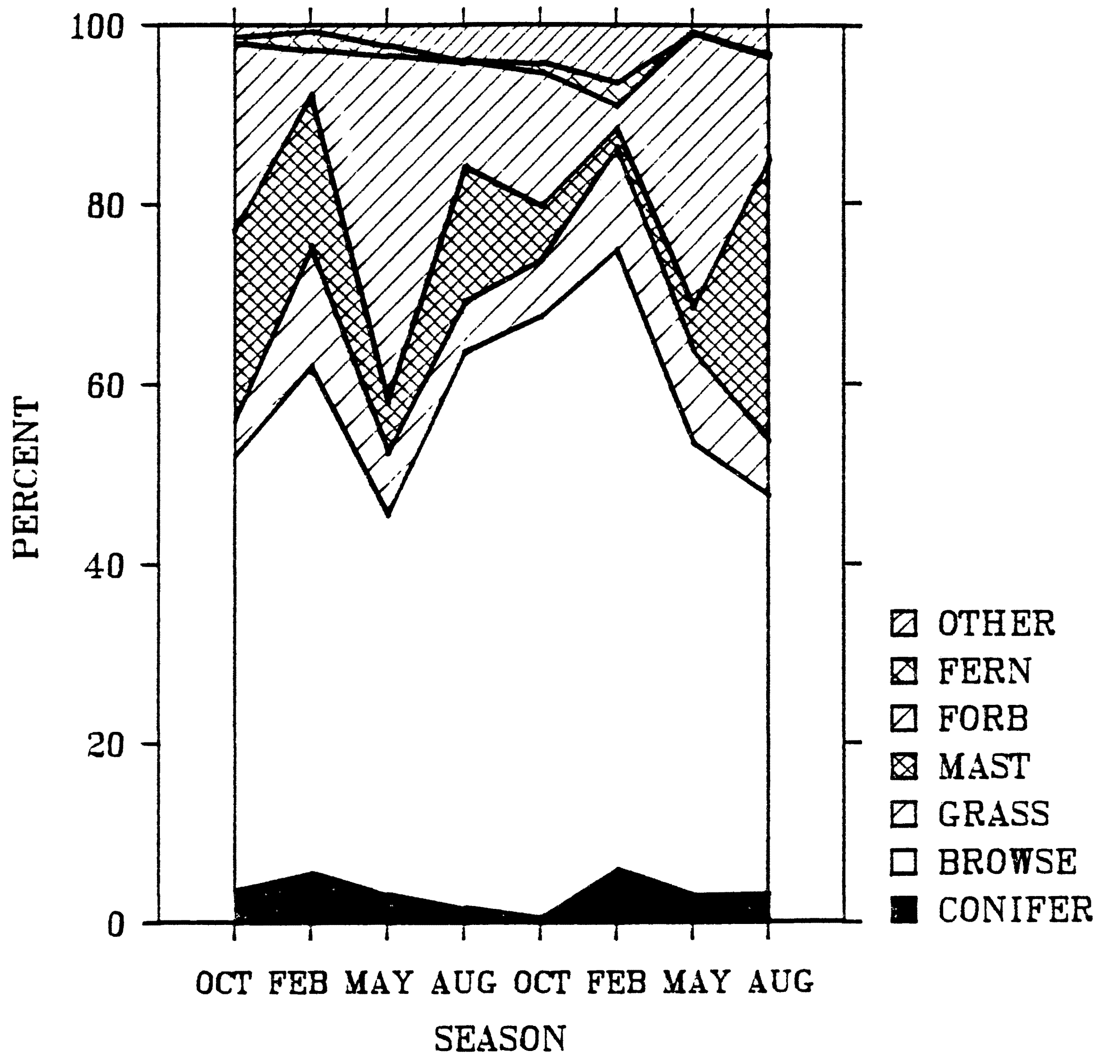

100
80
60
40
20
0
PERCENT
OCT FEB MAY AUG OCT FEB MAY AUG
SEASON
OTHER
FERN
FORB
MAST
GRASS
BROWSE
CONIFER

Figure 5

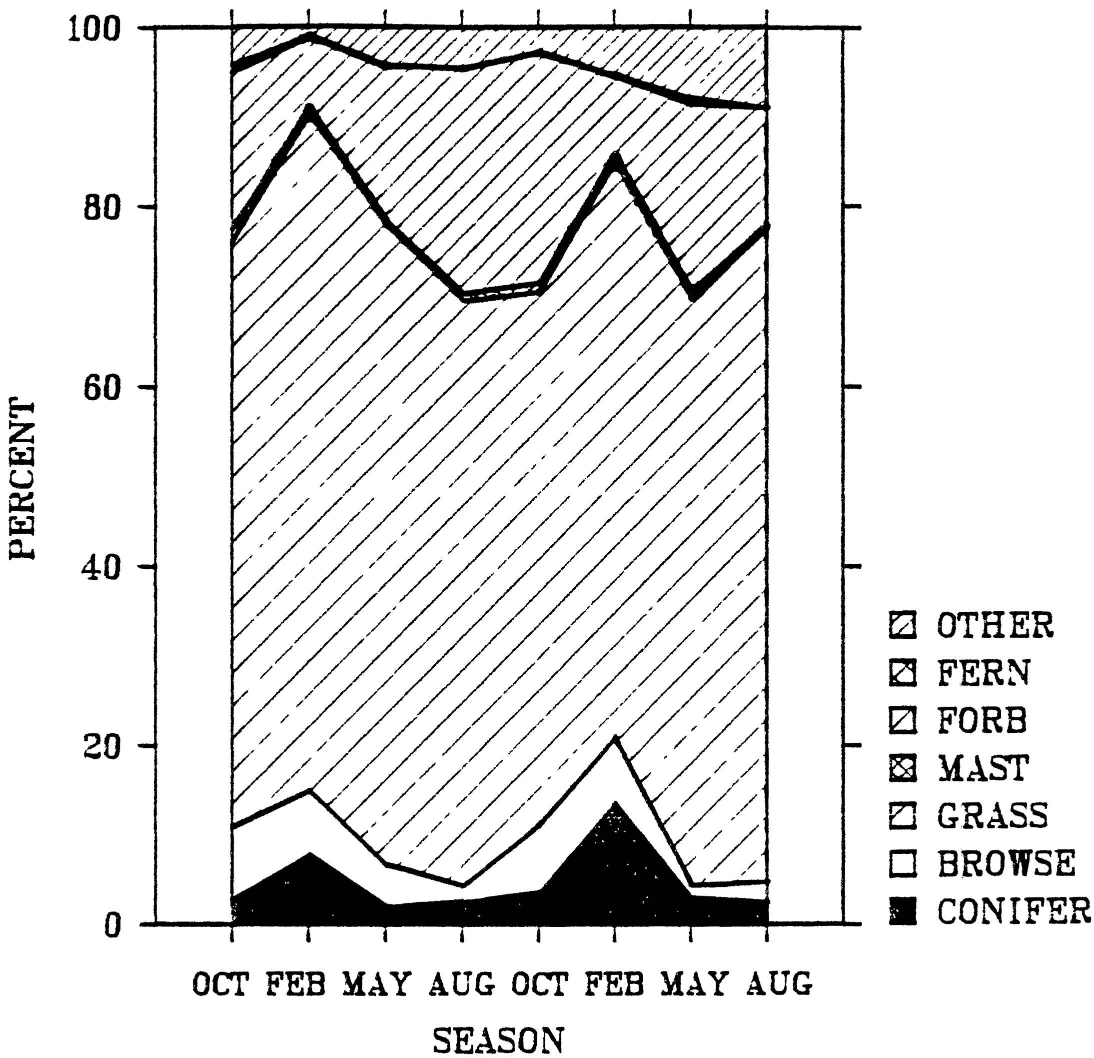
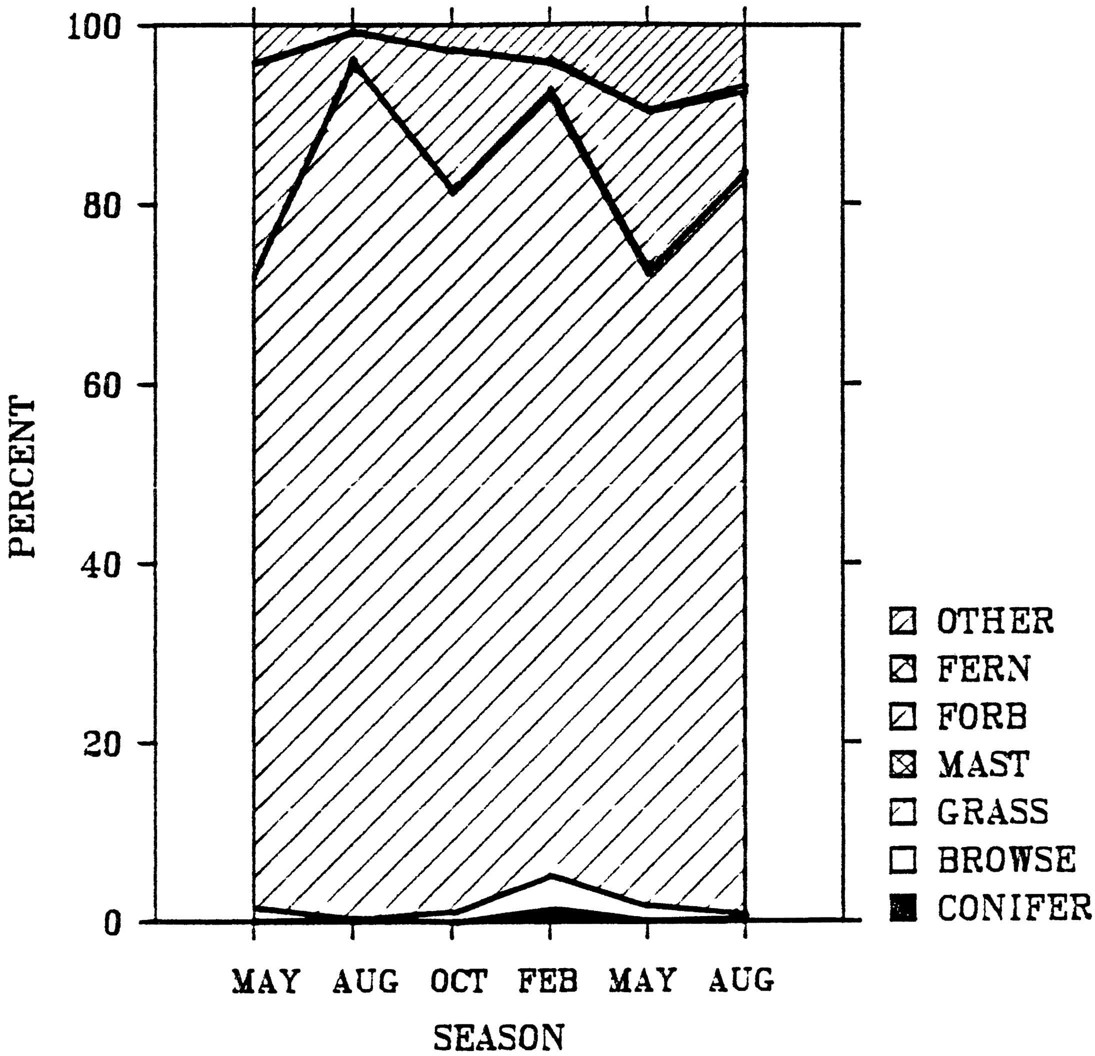
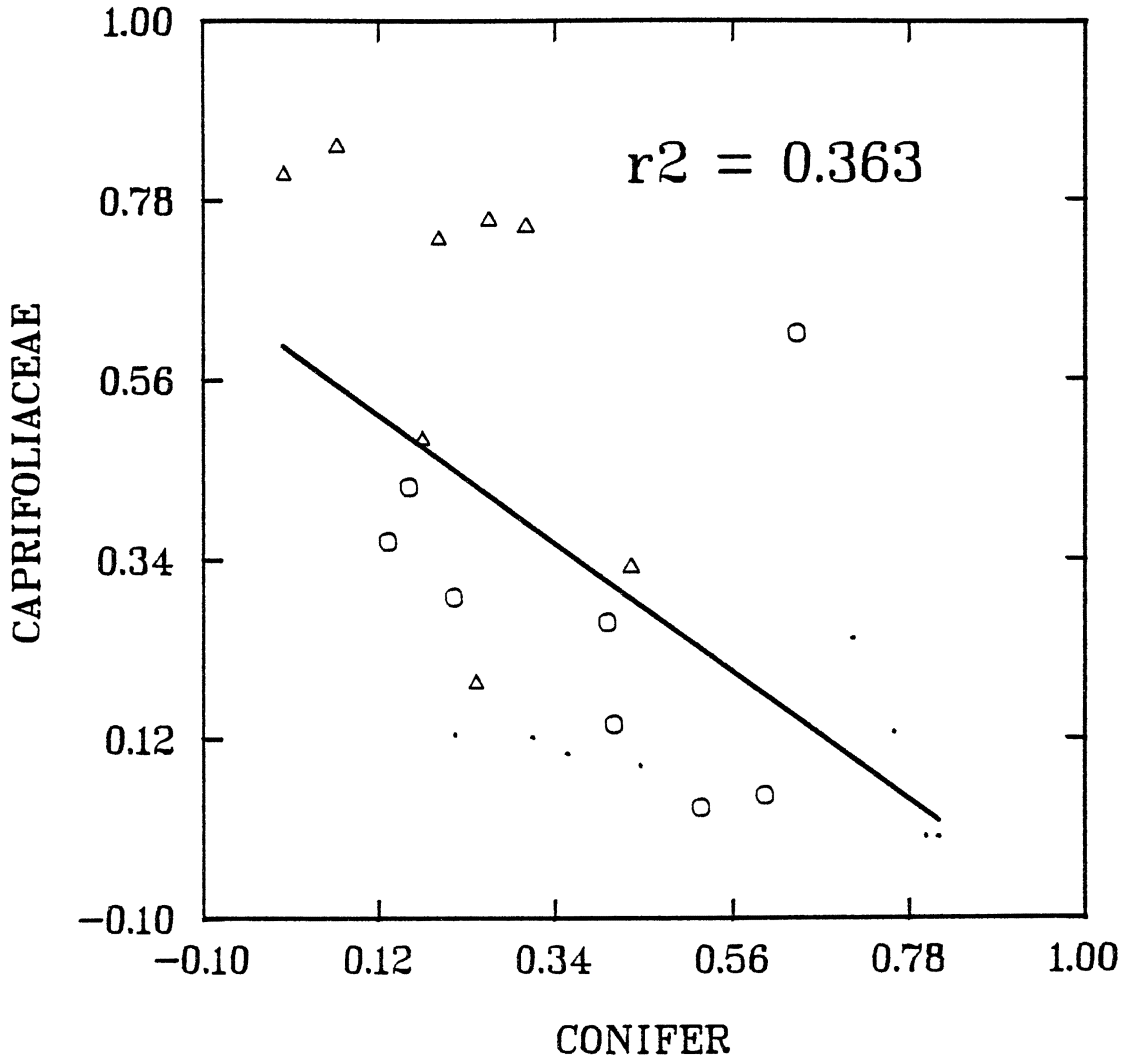

100
80
60
40
20
0
PERCENT
OCT FEB MAY AUG OCT FEB MAY AUG
SEASON
OTHER
FERN
FORB
MAST
GRASS
BROWSE
CONIFER

Figure 6



100
80
60
40
20
0
PERCENT
MAY AUG OCT FEB MAY AUG
SEASON
OTHER
FERN
FORB
MAST
GRASS
BROWSE
CONIFER

Figure 7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CAPRIFOLIACEAE
CONIFER
1.00
0.78
0.56
0.34
0.12
−0.10
−0.10
0.12
0.34
0.56
0.78
1.00

Figure 8

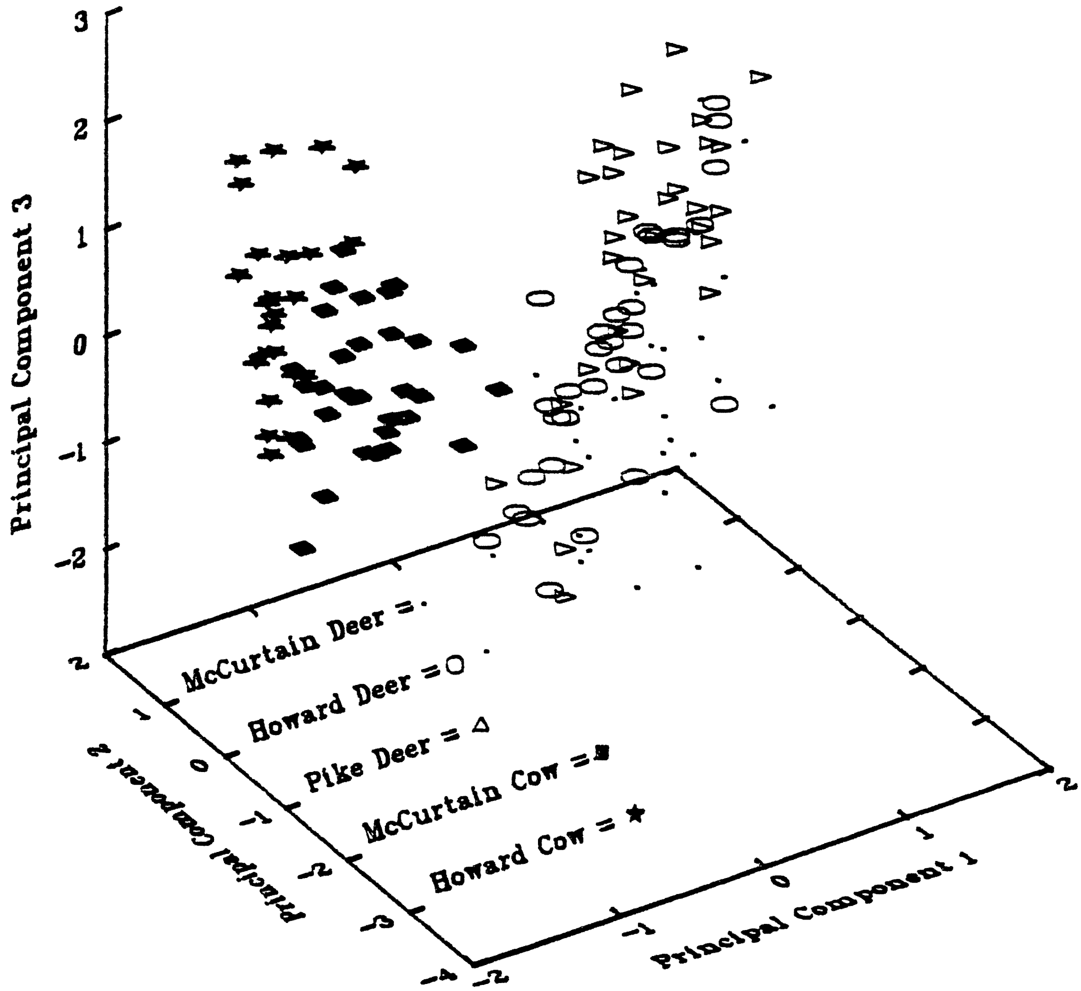

Principal Component 3
3
2
1
0
-1
-2
2
1
0
-1
-2
-3
-4
Principal Component 2
-2
-1
0
1
2
Principal Component 1
McCurtain Deer = .
Howard Deer = O
Pike Deer = △
McCurtain Cow = ■
Howard Cow = ★

Figure 9

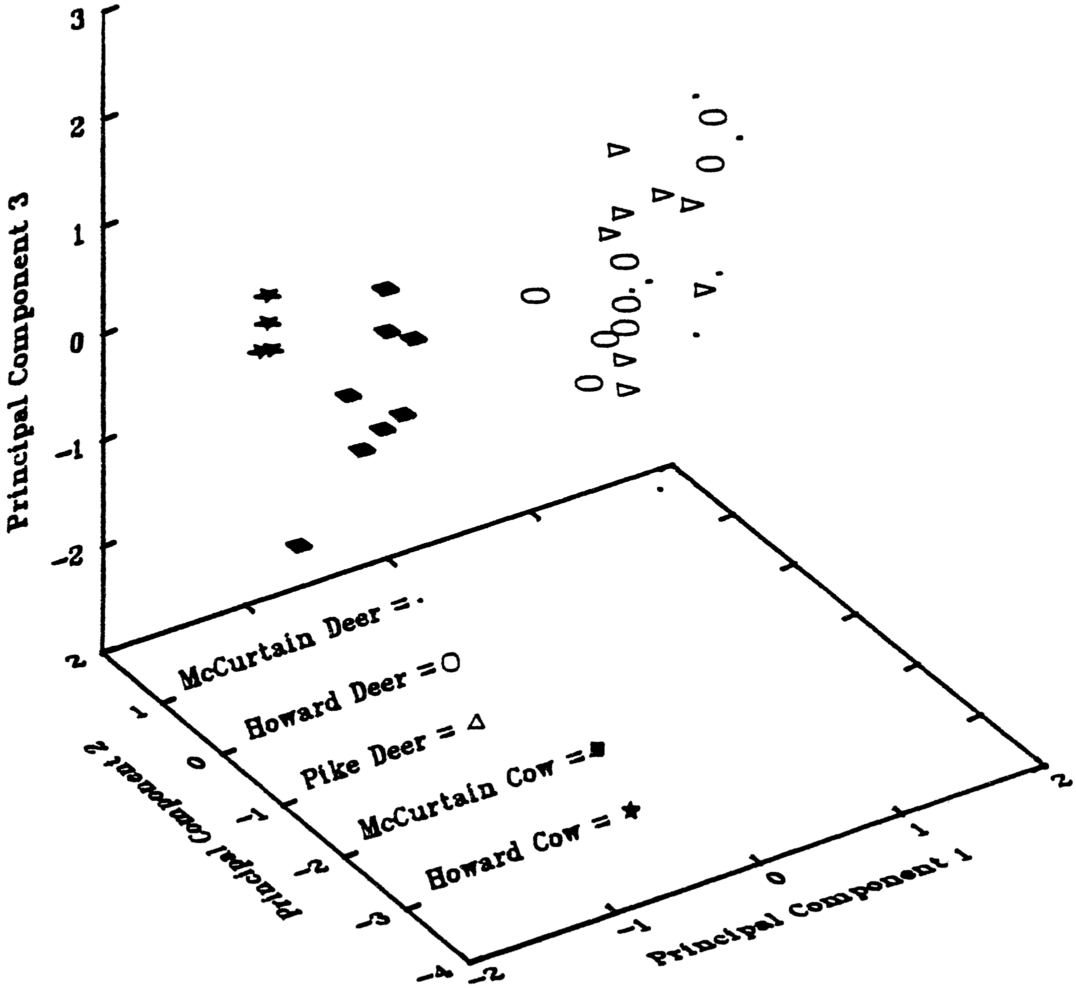

Principal Component 3
3
2
1
0
-1
-2
2
1
0
-1
-2
-3
-4
Principal Component 2
-2
-1
0
1
2
Principal Component 1
McCurtain Deer = ·
Howard Deer = O
Pike Deer = Δ
McCurtain Cow = ■
Howard Cow = ★

Figure 10

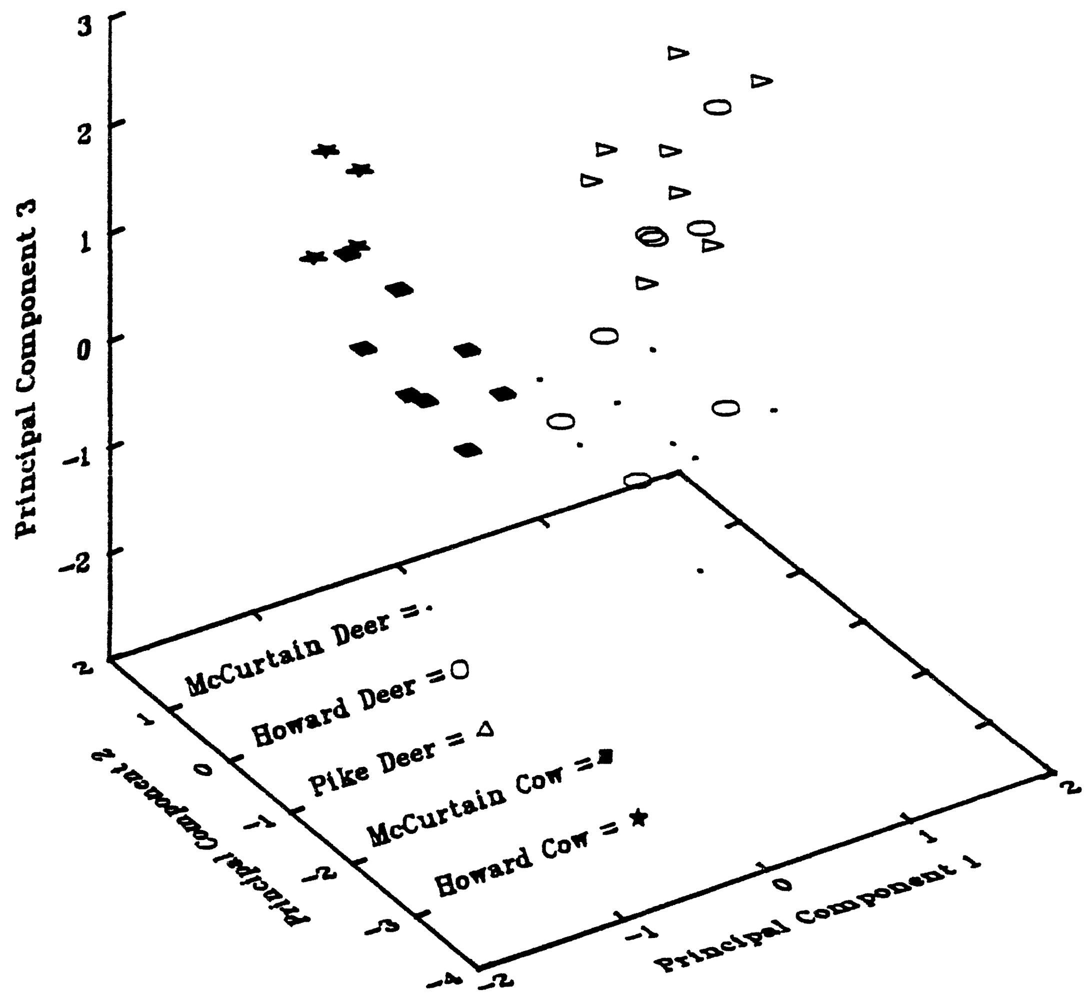

Principal Component 3
Principal Component 2
Principal Component 1
McCurtain Deer = .
Howard Deer = O
Pike Deer = Δ
McCurtain Cow = ■
Howard Cow = ★

Figure 11

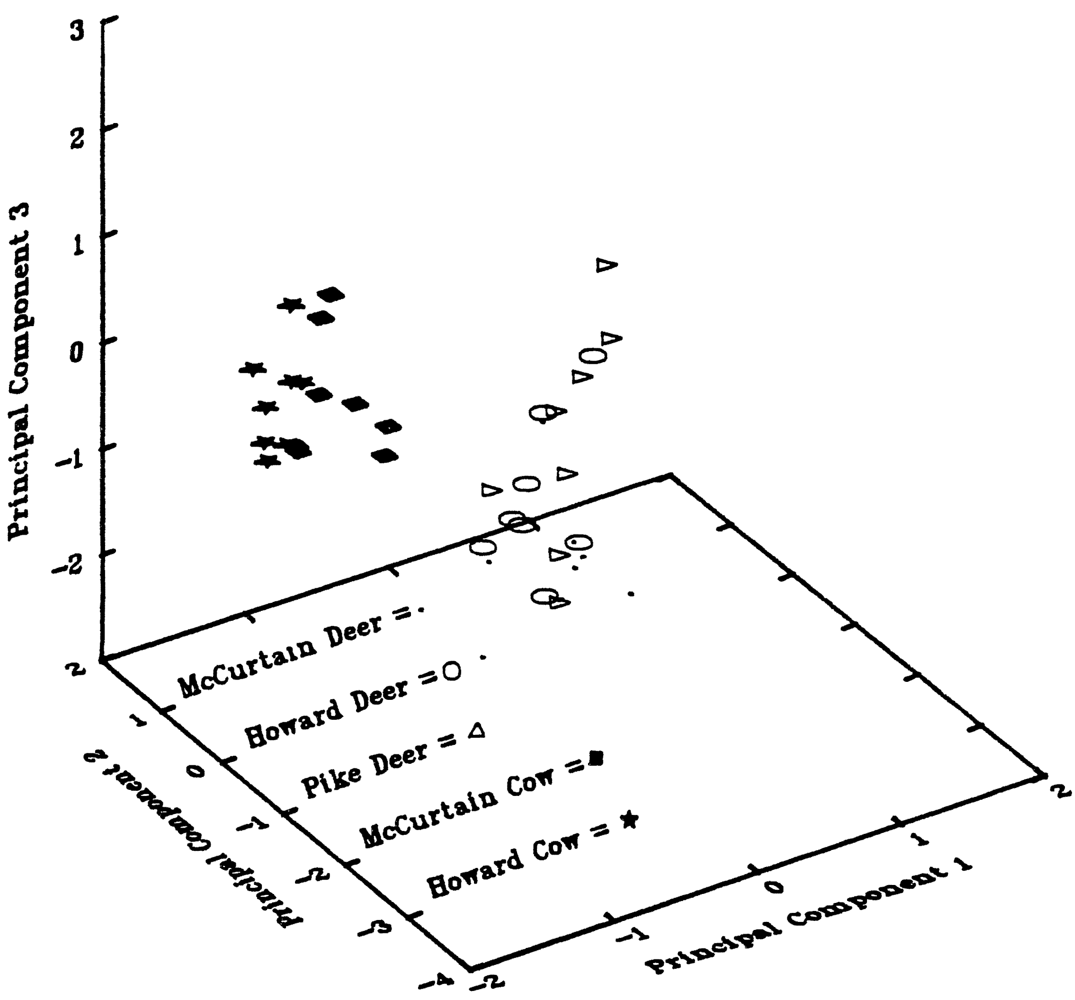

Principal Component 3
3
2
1
0
-1
-2
McCurtain Deer = ·
Howard Deer = O
Pike Deer = Δ
McCurtain Cow = ■
Howard Cow = ★
Principal Component 2
2
1
0
-1
-2
-3
-4
Principal Component 1
-2
-1
0
1
2

Figure 12

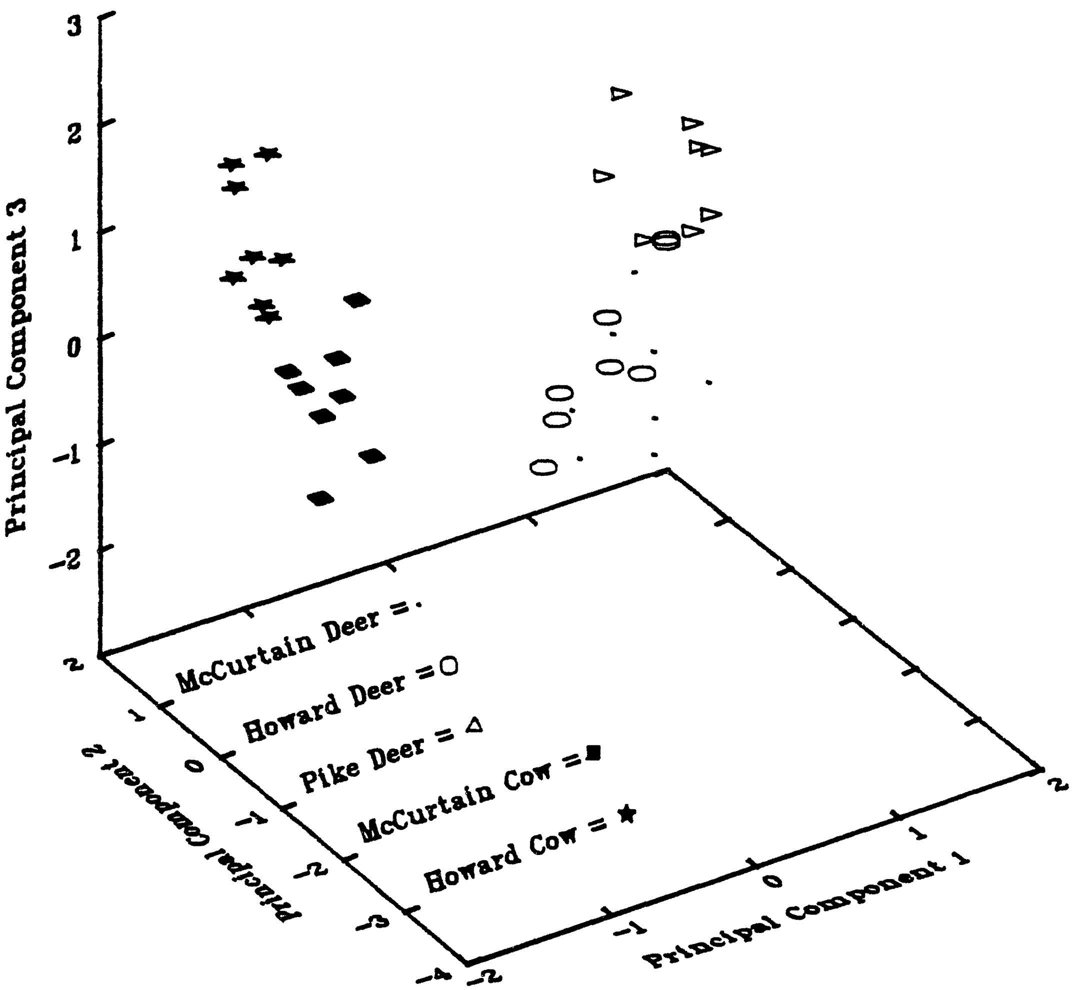

Principal Component 3
Principal Component 2
Principal Component 1
McCurtain Deer = .
Howard Deer = O
Pike Deer = Δ
McCurtain Cow = ■
Howard Cow = ★

Figure 13

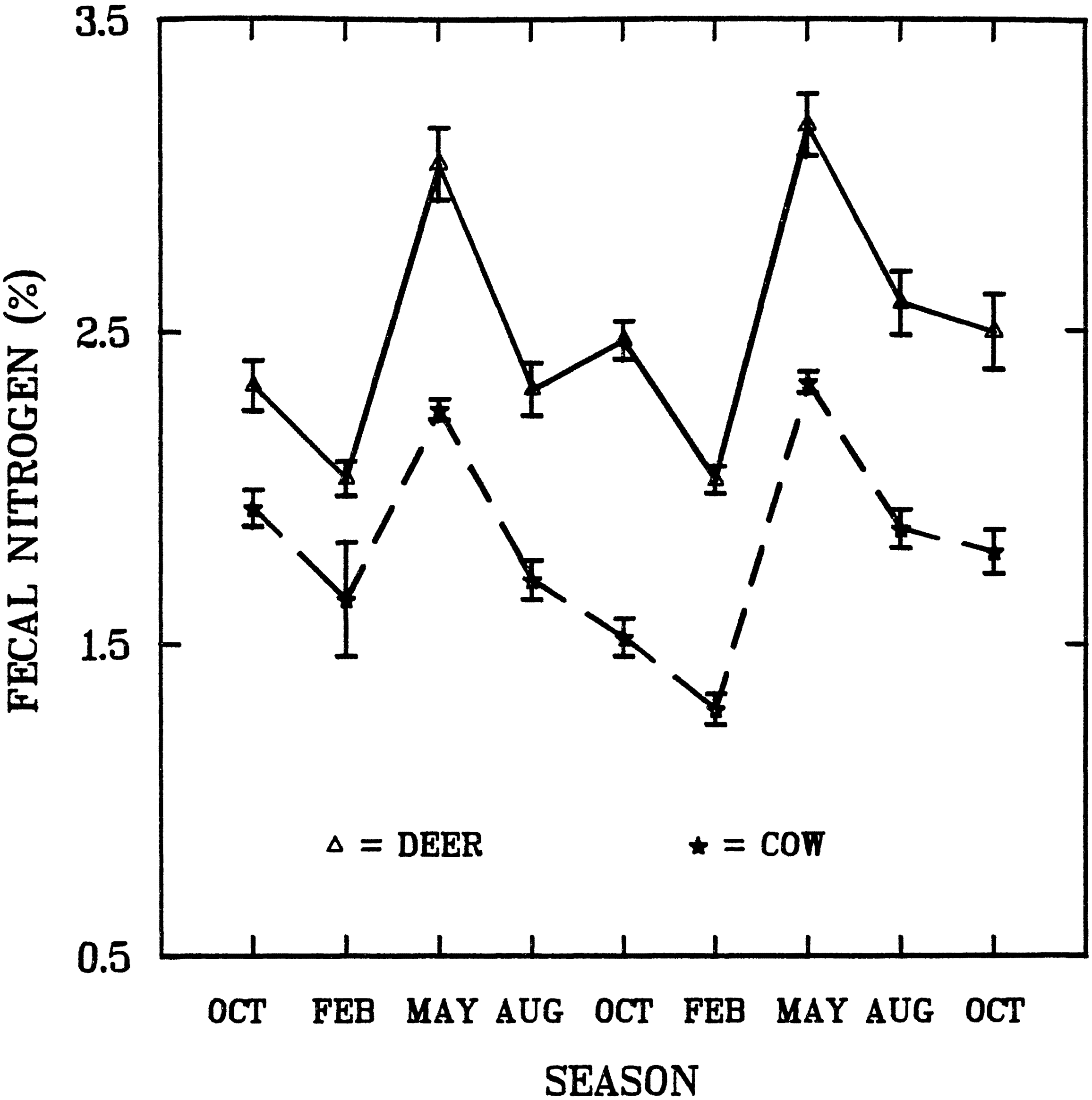
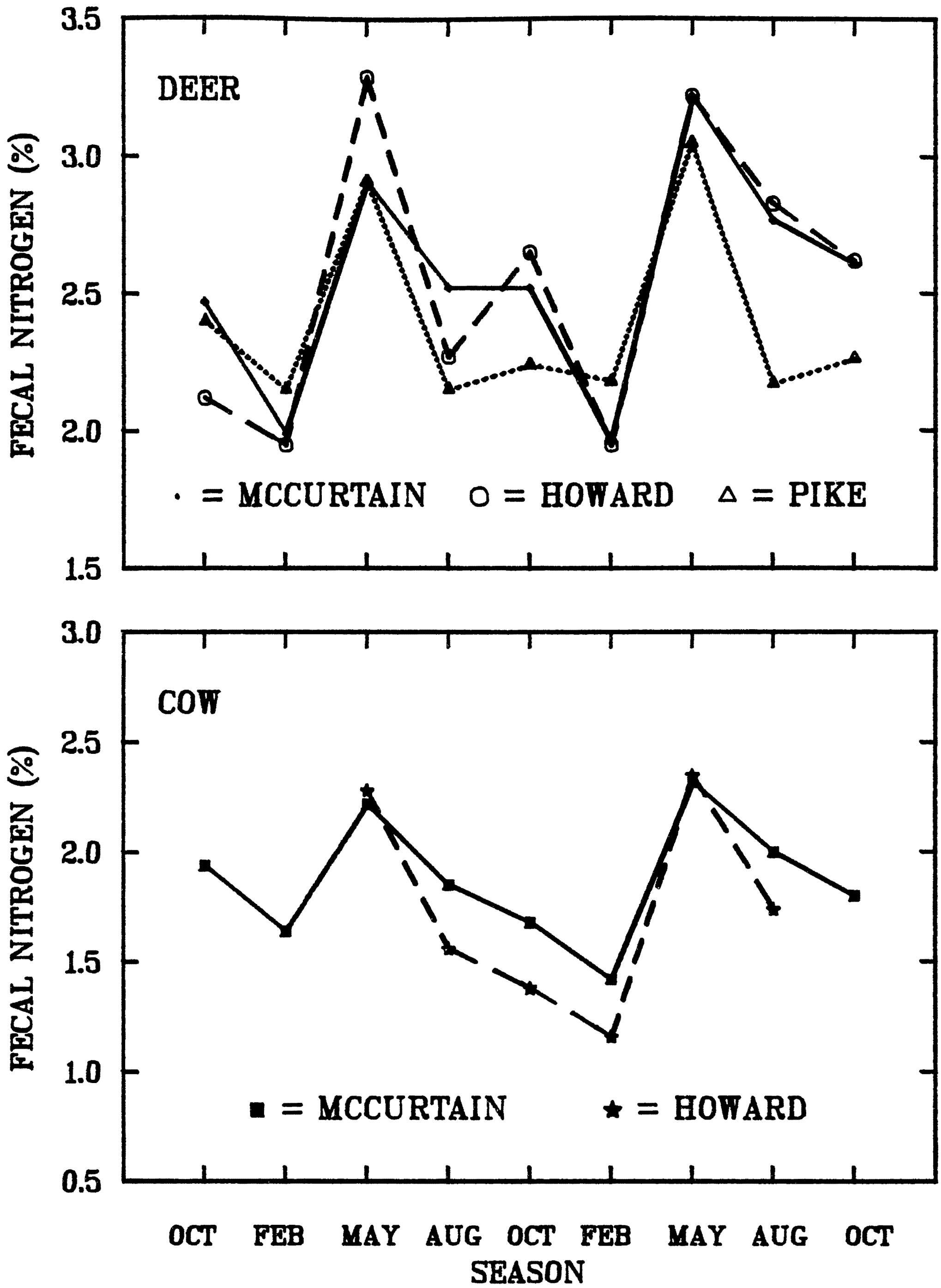

3.5
2.5
1.5
0.5
FECAL NITROGEN (%)
△ = DEER
★ = COW
OCT
FEB
MAY
AUG
OCT
FEB
MAY
AUG
OCT
SEASON

Figure 14



3.5
3.0
2.5
2.0
1.5
FECAL NITROGEN (%)
DEER
· = MCCURTAIN
○ = HOWARD
△ = PIKE
3.0
2.5
2.0
1.5
1.0
0.5
FECAL NITROGEN (%)
COW
■ = MCCURTAIN
★ = HOWARD
OCT
FEB
MAY
AUG
OCT
FEB
MAY
AUG
OCT
SEASON

Figure 15

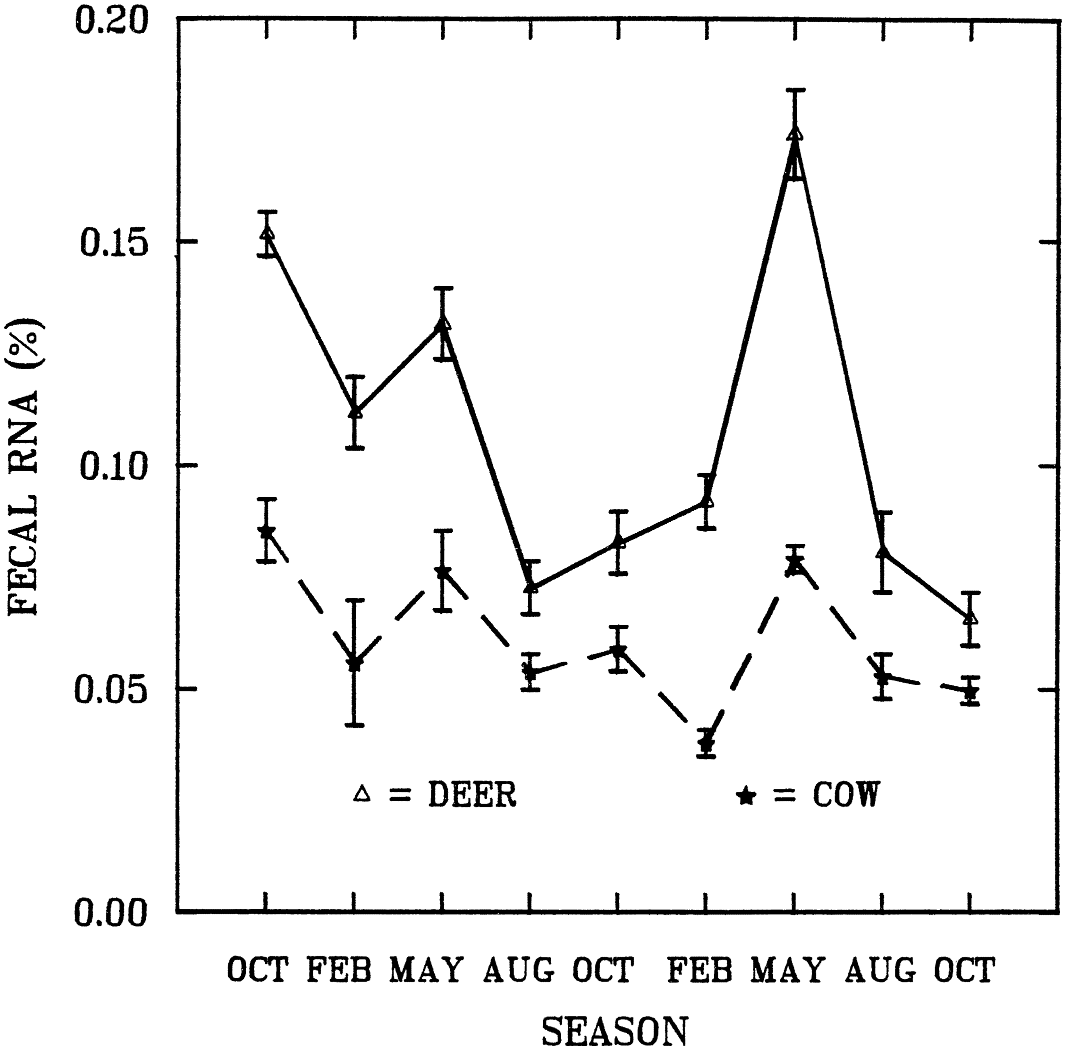

0.20
0.15
0.10
0.05
0.00
FECAL RNA (%)
△ = DEER
★ = COW
OCT FEB MAY AUG OCT FEB MAY AUG OCT
SEASON

Figure 16

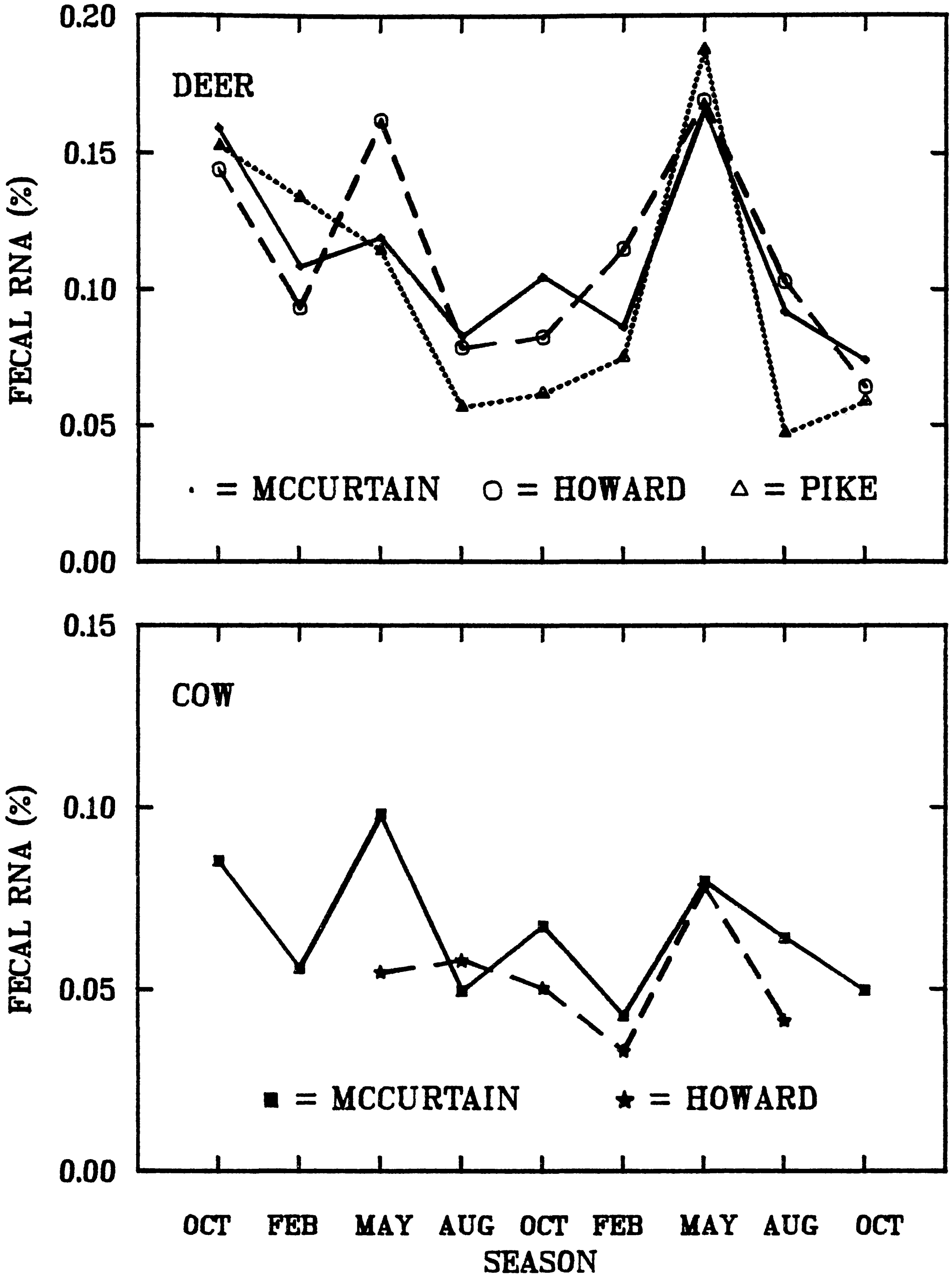
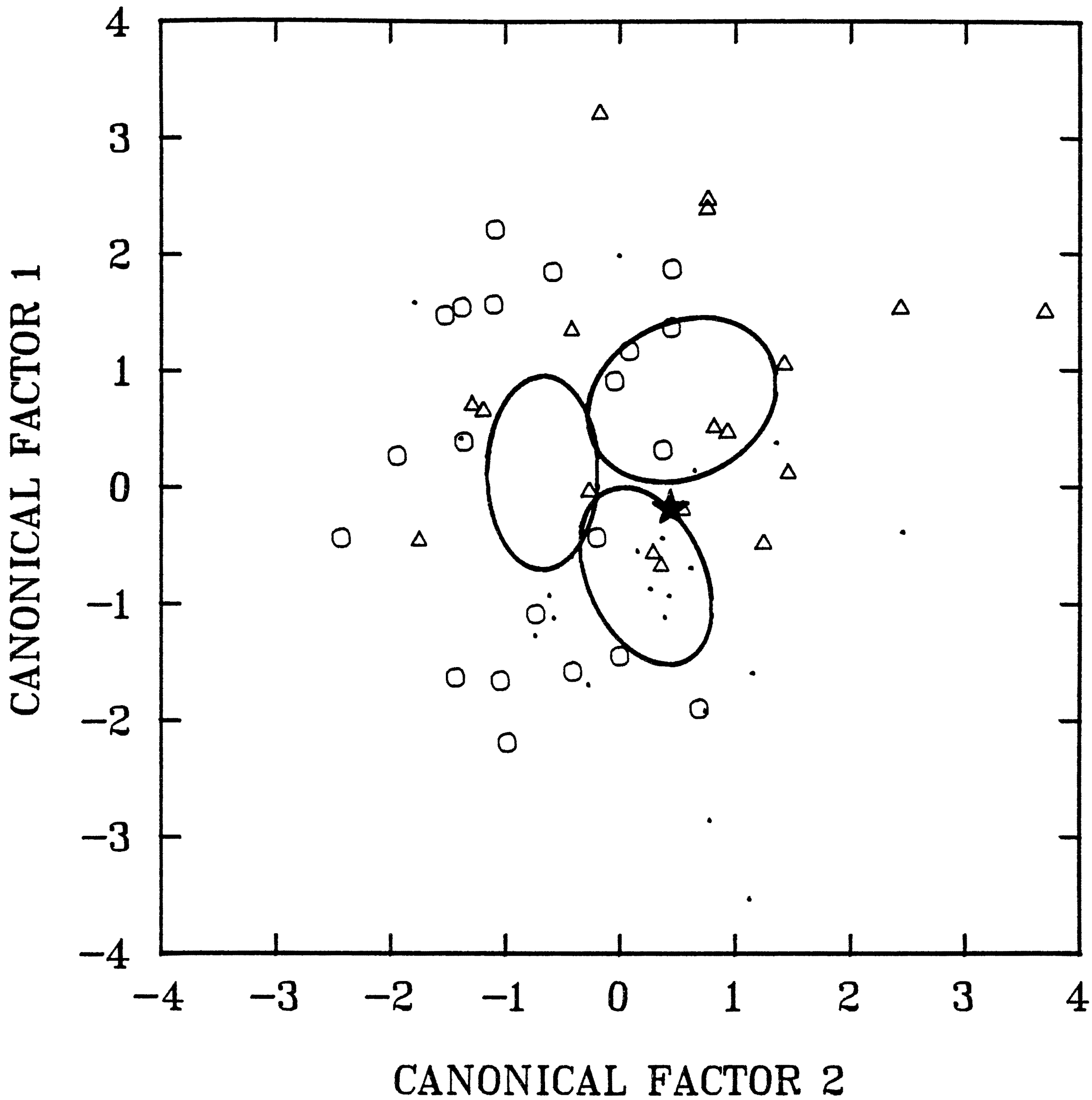
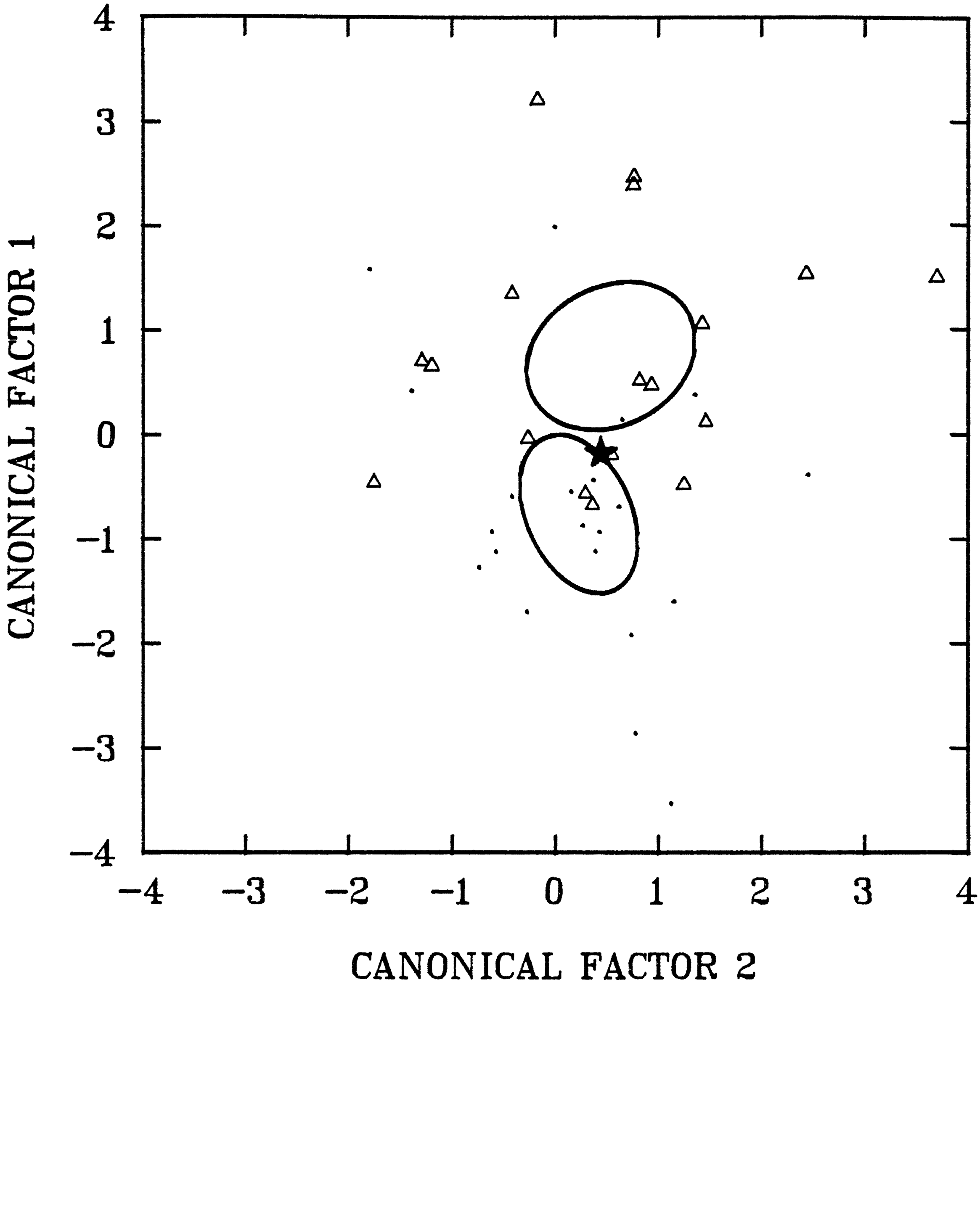

0.20
DEER
0.15
0.10
0.05
0.00
FECAL RNA (%)
• = MCCURTAIN ○ = HOWARD △ = PIKE
0.15
COW
0.10
0.05
0.00
FECAL RNA (%)
■ = MCCURTAIN ★ = HOWARD
OCT FEB MAY AUG OCT FEB MAY AUG OCT
SEASON

Figure 17



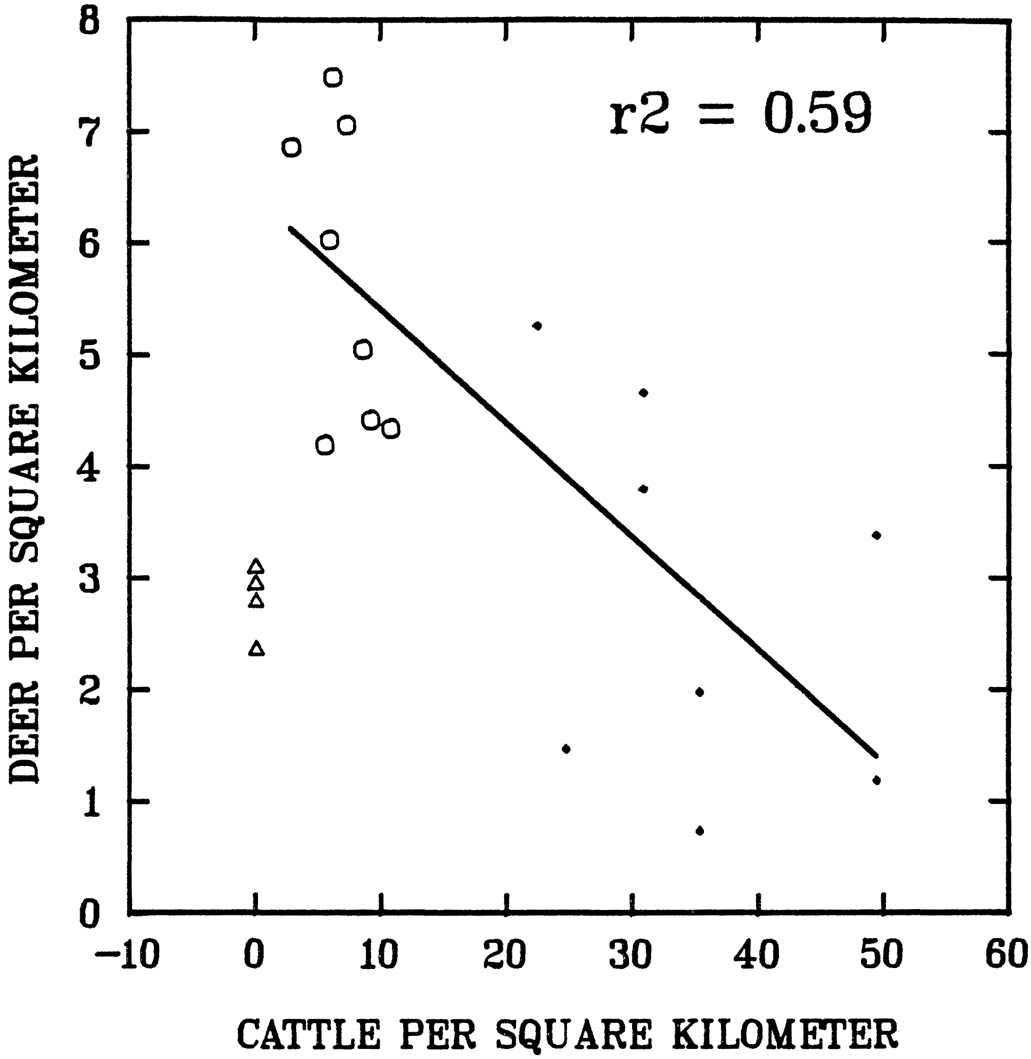
4
3
2
1
0
−1
−2
−3
−4
CANONICAL FACTOR 1
−4
−3
−2
−1
0
1
2
3
4
CANONICAL FACTOR 2

Figure 18



4
3
2
1
0
−1
−2
−3
−4
CANONICAL FACTOR 1
−4
−3
−2
−1
0
1
2
3
4
CANONICAL FACTOR 2

Figure 19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DEER PER SQUARE KILOMETER
0
1
2
3
4
5
6
7
8
-10
0
10
20
30
40
50
60
CATTLE PER SQUARE KILOMETER

Figure 20

APPENDIX I

Appendix I   Seasonal plant species composition of white-tailed deer and cattle determined by microhistological analysis of fecal samples collected October 1986 to August 1988 from study areas in McCurtain County, Oklahoma and Howard and Pike counties, Arkansas

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
			OCTOBER 1986		
BROWSE					
Callicarpa americana	t[a]	0 03 (0 01)	0 01 (0 01)	---- ----	---- ----
Ceanothus americanus	0 04 (0 02)	t	0 02 (0 01)	---- ----	---- ----
Cornus spp	0 04 (0 01)	0 06 (0 02)	0 04 (0 02)	0 01 (0 01)	---- ----
Fraxinus spp	0 07 (0 01)	0 01 (0 01)	0 05 (0 02)	---- ----	---- ----
Lonicera spp / _Symphoricarpos orbiculatus_	0 02 (0 01)	0 09 (0 01)	0 13 (0 07)	t	---- ----
Prunus spp	t	0 01 (0 01)	t	---- ----	---- ----
Quercus spp	0 02 *[b]	0 03 (0 01)	0 02 (0 01)	t	---- ----
Rhus spp	0 17 (0 03)	0 06 (0 03)	0 10 (0 01)	0 03 (0 01)	---- ----
Smilax spp	0 01 (0 01)	0 02 (0 01)	0 03 (0 02)	t	---- ----
Vitus spp	t	---- ----	0 02 (0 02)	---- ----	---- ----
Other	0 06 *	0 10 *	0 06 *	0 03 *	---- ----
Total	0 44 (0 04)	0 42 (0 05)	0 48 (0 08)	0 08 (0 01)	---- ----
CONIFER					
Pinus spp	0 09 (0 01)	0 03 (0 01)	0 04 (0 01)	0 03 (0 01)	---- ----
Other	t	---- ----	---- ----	---- ----	---- ----
Total	0 09 (0 02)	0 03 (0 01)	0 04 (0 01)	0 03 (0 01)	---- ----
FERN Total	---- ----	0 01 (0 01)	0 01 *	0 01 *	---- ----

Appendix I Continued

Plant Species	Deer						Cattle			
	McCurtain		Howard		Pike		McCurtain		Howard	
FORB										
Acalypha gracilens	0 02	(0 01)	0 04	*	0 03	(0 02)	----	----	----	----
Antennaria plantaginifolia	0 09	(0 03)	0 02	*	t		t		----	----
Clitoria mariana	0 01	*	t		t		0 01	*	----	----
Croton capitatus	t		t		t		0 02	(0 01)	----	----
Desmodium spp	0 01	(0 01)	0 03	(0 02)	0 01	(0 01)	----	----	----	----
Helianthus spp	t		0 01	(0 01)	t		----	----	----	----
Lespedeza spp	0 01	(0 01)	0 02	(0 01)	0 01	(0 01)	0 02	*	----	----
Phlox spp	t		----	----	0 03	(0 02)	----	----	----	----
Plantago spp	t		0 01	*	t		0 03	(0 01)	----	----
Solidago spp	t		t		0 04	(0 03)	0.02	(0 01)	----	----
Other	0 07	*	0 07	*	0 06	*	0.08	*	----	----
Total	0 23	(0 05)	0 22	(0 07)	0 21	(0 06)	0 18	(0 03)	----	----
GRASS										
Andropogon spp	----	----	----	----	----	----	0 08	(0 01)	----	----
Andropogon virginicus	----	----	----	----	t		0 02	(0 01)	----	----
Arundinaria gigantea	----	----	----	----	----	----	0 02	(0 01)	----	----
Carex spp	t		t		----	----	0 02	(0 01)	----	----
Eragrostis spp	----	----	t		----	----	0 02	(0 01)	----	----
Panicum spp	t		0 01	(0 01)	0 02	(0 01)	0 21	(0 02)	----	----
Uniola spp	----	----	----	----	----	----	0 02	(0 01)	----	----
Other	0 03	*	0 03	*	0 02	*	0 26	*	----	----
Total	0 04	(0 02)	0 05	(0 01)	0 04	(0 02)	0 65	(0 02)	----	----

Appendix I Continued

Season	Forage Class	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
MAST						
Quercus spp		0 16 (0 05)	0 19 (0 02)	0 14 (0 02)	t	---- ----
	Other	0 04 *	0 07 *	0 07 *	0.01 *	---- ----
	Total	0 20 (0 05)	0 26 (0 07)	0 21 (0 05)	0 02 (0 01)	---- ----
				FEBRUARY 1987		
BROWSE						
Cornus spp		0 14 (0 07)	0 03 (0 01)	0.03 (0 01)	0.03 (0 01)	---- ----
Fraxinus spp		0 07 (0 01)	0 14 (0 02)	0 01 (0 01)	---- ----	---- ----
Ilex spp		0 01 *	0 04 (0 01)	0 02 (0 01)	---- ----	---- ----
Lonicera spp / Symphoricarpos orbiculatus		0 01 *	0 11 (0 02)	0 40 (0 06)	t	---- ----
Quercus spp		0 01 (0 01)	0 05 (0 03)	0 02 (0 01)	0 02 (0 01)	---- ----
Rhus spp		0 06 (0 02)	0 12 (0 02)	0 02 (0 01)	0 03 (0 01)	---- ----
Smilax spp		0 01 *	0 03 (0 03)	0 04 (0 01)	t	---- ----
	Other	0 04 *	0 03 *	0 02 *	0 01 *	---- ----
	Total	0 35 (0 07)	0 55 (0 04)	0 56 (0 06)	0.07 (0 03)	---- ----
CONIFER						
Juniperus virginiana		0 01 *	0 01 (0 01)	t	---- ----	---- ----
Pinus spp		0 10 (0 03)	0 05 (0 02)	0 05 (0 01)	0 08 (0 02)	---- ----
	Total	0 11 (0 03)	0 06 (0 03)	0 06 (0 01)	0 08 (0 02)	---- ----

Appendix I Continued

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
FERN					
Polystichum acrostichoides	0 14 (0 07)	0 01 (0 01)	0 02 (0 01)	---- ----	---- ----
Total	0 14 (0 07)	0 01 (0 01)	0 02 (0 01)	t	---- ----
FORB					
Antennaria plantaginifolia	0 10 (0 07)	0 06 (0.04)	0 02 (0 01)	t	---- ----
Erigeron spp	0 02 (0 01)	0 01 *	t	---- ----	---- ----
Hypericum spp	0 01 *	0 01 *	---- ----	---- ----	---- ----
Lespedeza spp	t	0 01 (0 01)	---- ----	t	---- ----
Plantago spp	t	0 01 (0 01)	---- ----	0.03 (0 01)	---- ----
Other	0.05 *	0 05 *	0 03 *	0.05 *	---- ----
Total	0 18 (0 07)	0 15 (0 04)	0 05 (0 01)	0 08 (0 01)	---- ----
GRASS					
Andropogon spp	---- ----	---- ----	---- ----	0.11 (0 03)	---- ----
Andropogon virginicus	0 01 (0 01)	0 01 *	0 01 *	0 01 *	---- ----
Arundinaria gigantea	0 01 (0 01)	---- ----	---- ----	0 02 (0 01)	---- ----
Axonopus spp	---- ----	---- ----	---- ----	0 02 (0 02)	---- ----
Bouteloua spp	t	t	---- ----	0.01 *	---- ----
Carex spp	0 02 (0 02)	t	t	0 07 (0 03)	---- ----
Danthonia spicatum	0 02 (0 01)	t	0 01 *	0 03 (0 03)	---- ----
Elymus canadensis	t	t	t	0 03 (0 01)	---- ----
Eragrostis spp	t	t	---- ----	0 04 (0 02)	---- ----
Lepidium oblongum	---- ----	---- ----	0 02 (0 01)	---- ----	---- ----

Appendix I Continued

Plant Species	Deer						Cattle			
	McCurtain		Howard		Pike		McCurtain		Howard	
GRASS										
Panicum spp	0 05	(0 02)	0 03	(0 01)	0 04	(0 01)	0.10	(0 03)	----	----
Poa pratensis	----	----	----	----	----	----	0 04	(0 03)	----	----
Sporobolus spp	----	----	----	----	----	----	0 02	(0 02)	----	----
Uniola spp	----	----	----	----	----	----	0.05	(0 01)	----	----
Other	0 04	*	0 05	*	0 04	*	0.20	*	----	----
Total	0 16	(0 04)	0 09	(0 02)	0.13	(0 04)	0 75	(0 05)	----	----
MAST										
Quercus spp	t		t		0 13	(0 07)	t		----	----
Rhus spp	0 05	(0 03)	0 11	(0 04)	0 02	(0 02)	----	----	----	----
Other	----	----	0 03	*	0 02	*	t		----	----
Total	0 05	(0 03)	0 14	(0 04)	0 17	(0 07)	0 01	*	----	----
MAY 1987										
BROWSE										
Callicarpa americana	0 01	(0 01)	0 01	*	0 01	(0 01)	----	----	----	----
Ceanothus americanus	0 02	(0 01)	t		----	----	----	----	----	----
Cornus spp	0 09	(0 03)	0 05	(0 03)	0 08	(0 01)	t		t	
Fraxinus spp	0 01	*	0 02	(0 01)	0 03	(0 01)	----	----	----	----
Hammamelis vernalis	0 01	(0 01)	t		t		----	----	----	----
Ilex spp	t		0 01	(0 01)	----	----	----	----	----	----
Lonicera spp / Symphoricarpos orbiculatus	0 04	(0 02)	0 06	(0 02)	0 10	(0 04)	t		t	

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
BROWSE					
Myrica spp	0 01 (0 01)	0 04 (0 04)	0 01 (0 01)	---- ----	---- ----
Ostrya virginiana	t	---- ----	0 03 (0 03)	---- ----	---- ----
Prunus spp	t	0 04 (0 02)	t	t	t
Quercus spp	t	0 02 *	0 02 (0 02)	---- ----	---- ----
Rhus spp	0 03 (0 02)	0 01 (0 01)	0 04 (0 01)	0 03 (0 01)	t
Toxicodendron radicans	0.05 (0 02)	0 04 (0.01)	0.03 (0 01)	---- ----	---- ----
Rubus spp	0 03 (0 02)	0 01 *	0.03 (0 01)	---- ----	---- ----
Smilax spp	---- ----	0 02 *	0 01 *	t	t
Vitus spp	t	0 02 (0 01)	---- ----	---- ----	---- ----
Other	0 06 *	0.02 *	0 02 *	t	---- ----
Total	0 38 (0 02)	0 38 (0 06)	0 42 (0 06)	0 05 (0 01)	0 01 *
CONIFER					
Juniperus virginiana	0 03 (0 03)	t	---- ----	---- ----	---- ----
Pinus spp	0 05 (0 03)	0 02 (0 01)	t	0.02 (0 01)	t
Total	0 09 (0 05)	0 02 (0 01)	0 03 (0 01)	0 02 (0 01)	t
FERN					
Polystichum acrosticoides	0 01 (0 01)	t	---- ----	---- ----	---- ----
Other	0 04 (0 03)	t	0 01 (0 01)	---- ----	---- ----
Total	0 05 (0 03)	0 01 (0 01)	0 01 (0 01)	---- ----	---- ----
FORB					
Acalypha gracilens	0 02 (0 01)	0 02 *	0 02 (0 02)	---- ----	---- ----

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
FORB					
Antennaria plantaginifolia	0 04 (0 03)	0 01 *	t	t	t
Callirhoe digitata	0 09 (0 03)	0 12 (0 04)	0 07 (0 02)	t	t
Clitoria mariana	t	---- ----	t	t	0 01 (0 01)
Cynoglossum amabile	t	t	---- ----	0 02 (0 01)	t
Desmodium spp	t	0 03 (0 01)	0 01 (0 01)	---- ----	---- ----
Gelsemia spp	---- ----	---- ----	---- ----	t	0 01 *
Helianthus spp	0 03 (0 01)	0 02 (0 02)	0 02 *	---- ----	---- ----
Hypericum spp	0 02 (0 01)	0 02 (0 01)	t	---- ----	---- ----
Lespedeza spp	t	0 02 (0 01)	0 02 (0 02)	0.01 *	0 06 (0 01)
Monarda spp	---- ----	0 01 *	0 01 (0 01)	---- ----	---- ----
Oxalis spp	t	t	0 01 *	t	t
Penstemmon spp	t	---- ----	0 02 (0 01)	---- ----	---- ----
Plantago spp	0 02 *	0 04 (0 02)	0 01 *	0 02 (0 01)	0 01 *
Potentilla spp	---- ----	0 02 (0 02)	---- ----	---- ----	---- ----
Solidago spp	t	t	0 02 *	t	---- ----
Trifolium reflexum	0 01 *	0 03 (0 02)	0 02 (0 01)	---- ----	---- ----
Other	0 09 *	0 12 *	0 15 *	0 10 *	0 14 *
Total	0 35 (0 05)	0 48 (0 06)	0 39 (0 05)	0 17 (0 03)	0 24 (0 02)
GRASS					
Andropogon spp	t	---- ----	0 02 (0 01)	0 18 (0 01)	0 16 (0 05)
Andropogon virginicus	---- ----	---- ----	---- ----	0 02 *	0 24 (0 08)
Bouteloua spp	---- ----	t	---- ----	t	0 03 (0 01)
Carex spp	t	---- ----	t	0 05 (0 02)	0 01 *
Eragrostis spp	t	---- ----	---- ----	0 03 *	t
Festuca spp	---- ----	---- ----	---- ----	0 02 *	---- ----

Appendix I Continued

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
GRASS					
<u>*Juncus*</u> spp	t	0 02 (0 02)	0 02 (0 01)	---- ----	---- ----
<u>*Panicum*</u> spp	---- ----	t	t	0 19 (0 02)	0 10 (0 02)
<u>*Sporobolus*</u> spp	---- ----	---- ----	---- ----	0 03 (0 01)	0 02 (0.01)
<u>*Uniola*</u> spp	---- ----	---- ----	---- ----	0 01 *	0 01 *
Other	0 02 *	0 02 *	0 02 *	0.17 *	0 13 *
Total	0 03 (0 01)	0 05 (0 03)	0 07 (0 01)	0.71 (0 04)	0 71 (0.02)
MAST					
<u>*Quercus*</u> spp	0 01 *	0 02 *	0 05 (0 01)	t	---- ----
<u>*Rhus*</u> spp	t	0 02 (0 02)	t	---- ----	---- ----
Total	0 01 (0 01)	0 04 (0 02)	0.06 (0 01)	0.01 *	---- ----
			AUGUST 1987		
BROWSE					
<u>*Acer rubrum*</u>	0.01 (0 01)	---- ----	---- ----	---- ----	---- ----
<u>*Alnus*</u> spp	0 01 (0 01)	---- ----	t	---- ----	---- ----
<u>*Cornus*</u> spp	0 02 (0 01)	0 02 *	0 02 (0 01)	---- ----	---- ----
<u>*Fraxinus*</u> spp	0 03 (0 01)	t	0 02 (0 01)	---- ----	---- ----
<u>*Ilex*</u> spp	0 01 (0 01)	t	0 01 (0 01)	---- ----	---- ----
<u>*Lonicera*</u> spp / <u>*Symphoricarpos orbiculatus*</u>	0 02 *	0 08 (0 02)	0 10 (0 03)	t	t
<u>*Prunus*</u> spp	0 02 *	0 08 (0 06)	t	---- ----	---- ----
<u>*Quercus*</u> spp	t	t	0 01 *	t	---- ----
<u>*Rhus*</u> spp	0 14 (0 03)	0 14 (0 04)	0 05 (0 03)	t	---- ----

Appendix I Continued

Plant Species	Deer McCurtain		Deer Howard		Deer Pike		Cattle McCurtain		Cattle Howard	
BROWSE										
Toxicodendron radicans	0 02	*	t		t		----	----	----	----
Rubus spp	0 06	(0 03)	0 10	(0 04)	0.22	(0 05)	----	----	----	----
Smilax spp	0.01	*	0 03	(0 01)	0 03	(0 01)	----	----	----	----
Vitus spp	0 01	*	0 02	(0 01)	t		----	----	----	----
Other	0 05	*	0 04	*	0 15	*	0 01	*	----	----
Total	0 41	(0 05)	0 53	(0 02)	0 62	(0 04)	0 02	(0 01)	t	
CONIFER										
Pinus spp	0 03	(0 02)	0 01	(0 01)	0.02	(0 01)	0.03	(0 01)	t	
FERN										
Unknown	t		t		t		----	----	----	----
FORB										
Callirhoe digitata	0 09	(0 03)	0 10	(0 03)	0 03	(0 01)	0 01	*	----	----
Clitoria mariana	0 01	*	0 01	*	t		0 01	*	----	----
Croton capitatus	0 02	*	0 01	(0 01)	t		----	----	----	----
Erigeron spp	0 04	(0 03)	t		----	----	----	----	----	----
Lespedeza spp	0 02	*	0 02	*	t		0 07	(0 01)	t	
Monarda spp	t		0 01	*	t		----	----	----	----
Oxalis spp	----	----	t		t		t		0 02	(0 02)
Plantago spp	t		t		t		0 09	(0 04)	----	----
Solidago spp	t		0 01	*	0 01	*	----	----	----	----
Trifolium reflexum	0 01	*	0 02	(0 01)	t		----	----	----	----
Other	0 18	*	0 14	*	0 06	*	0 07	*	0 01	*
Total	0 38	(0 04)	0 33	(0 03)	0 12	(0 03)	0 25	(0 02)	0 03	(0 02)

Appendix I Continued

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
GRASS					
Andropogon spp	---- ----	---- ----	---- ----	0 10 (0 01)	0 18 (0 04)
Andropogon virginicus	---- ----	---- ----	---- ----	t	0 39 (0 06)
Bouteloua spp	---- ----	---- ----	t	t	0 02 *
Carex spp	---- ----	---- ----	---- ----	0 03 (0 01)	0 01 *
Danthonia spicatum	---- ----	---- ----	---- ----	0 01 *	0 02 *
Eragrostis spp	---- ----	---- ----	---- ----	0.01 *	0.06 (0 02)
Festuca spp	---- ----	---- ----	---- ----	0.02 (0.01)	0 01 *
Panicum spp	t	---- ----	0 03 (0 03)	0 11 (0 01)	0 02 *
Sorghum bicolor	---- ----	---- ----	---- ----	t	0 09 (0.04)
Sporobolus spp	---- ----	---- ----	---- ----	t	0 01 (0 01)
Uniola spp	---- ----	---- ----	---- ----	0 01 (0 01)	0 01 (0 01)
Other	0 02 *	t	0 02 *	0 34 *	0 14 *
Total	0 02 (0 01)	t	0 06 (0 04)	0.65 (0 01)	0 96 (0 02)
MAST					
Quercus spp	0 01 *	0 02 (0 01)	t	t	t
Rhus spp	0.09 (0 01)	0 01 (0 01)	0 01 (0 01)	---- ----	---- ----
Other	0 04 *	0 07 *	0 14 *	t	---- ----
Total	0 14 (0 01)	0 10 (0 01)	0 15 (0 05)	0.01 *	t
			OCTOBER 1987		
BROWSE					
Acer rubrum	0 02 *	0 04 (0 02)	t	---- ----	---- ----
Cornus spp	0 02 (0 02)	0 02 (0 01)	0 01 *	0 02 *	t
Fraxinus spp	0 13 (0 01)	0 01 *	t	---- ----	---- ----
Ilex spp	0 01 (0 01)	0 03 (0 02)	0 03 (0 02)	---- ----	---- ----

Appendix I Continued

Plant Species	Deer						Cattle			
	McCurtain		Howard		Pike		McCurtain		Howard	
BROWSE										
<u>Lonicera</u> spp / <u>Symphoricarpos</u> <u>orbiculatus</u>	0 01	*	0 07	(0 03)	0 30	(0 07)	t		t	
<u>Morus</u> <u>rubra</u>	0 01	(0 01)	t		t		----	----	----	----
<u>Phytolacca</u> <u>americana</u>	0 01	(0 01)	0 01	(0 01)	0 04	(0 04)	----	----	----	----
<u>Prunus</u> spp	0 03	*	0 06	(0 03)	0 05	(0 01)	----	----	----	----
<u>Quercus</u> spp	0 03	(0 01)	0 06	(0 02)	0 02	(0 01)	----	----	----	----
<u>Rhus</u> spp	0 07	(0 02)	0 07	(0 03)	0 08	(0 02)	0 02	(0 01)	t	
<u>Rosa</u> spp	----	----	0 01	(0 01)	t		----	----	----	----
<u>Rubus</u> spp	0 04	(0 01)	0 06	(0 03)	0 02	*	t		t	
<u>Smilax</u> spp	0 03	(0 02)	0 03	(0 01)	0 04	(0 01)	----	----	----	----
Other	0 06	*	0 07	*	0 06	*	0 03	*	t	
Total	0 47	(0 04)	0 54	(0 07)	0 67	(0 04)	0 08	(0 03)	0 01	*
CONIFER										
<u>Pinus</u> spp	0 02	(0 01)	0 01	(0 01)	0 01	*	0 04	(0 03)	t	
FERN										
Unknown	t		t		0 01	(0 01)	----	----	----	----
FORB										
<u>Callirhoe</u> <u>digitata</u>	t		0 01	(0 01)	t		----	----	----	----
<u>Clitoria</u> <u>mariana</u>	----	----	t		t		0 01	*	----	----
<u>Croton</u> <u>capitatus</u>	0 01	*	0 01	*	0 01	(0 01)	t		t	
<u>Desmodium</u> spp	t		t		----	----	0 02	(0 01)	----	----
<u>Eupatorium</u> spp	t		0 02	(0 01)	----	----	t		t	

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
FORB					
Plantago spp	---- ----	t	t	0 11 (0 06)	t
Solidago spp	0 04 (0 03)	0 04 (0 01)	0 01 (0 01)	0 02 *	0 07 (0 01)
Other	0 12 *	0 14 *	0 13 *	0 10 *	0 07 *
Total	0 18 (0 06)	0 23 (0 03)	0 16 (0 06)	0 26 (0 07)	0 16 (0 01)
GRASS					
Andropogon spp	---- ----	---- ----	0 01 (0 01)	0 06 (0 01)	0 15 (0 04)
Arundinaria gigantea	---- ----	---- ----	---- ----	0 01 *	t
Bouteloua spp	---- ----	t	---- ----	0 06 (0 05)	0 05 (0 04)
Carex spp	t	---- ----	---- ----	0 02 *	0 10 (0 02)
Eragrostis spp	0 01 *	t	---- ----	0 03 (0 01)	0 02 *
Festuca spp	---- ----	---- ----	---- ----	t	0 02 (0 01)
Juncus spp	t	0 03 (0 03)	0 01 (0 01)	---- ----	---- ----
Lepidium obongatum	0 02 (0 02)	0 02 *	0 01 *	---- ----	---- ----
Panicum spp	---- ----	t	t	0 24 (0 04)	0 21 (0 04)
Uniola spp	---- ----	---- ----	---- ----	t	0 11 (0 06)
Other	---- ----	0 02 *	0 01 *	0 17 *	0 13 *
Total	0 03 (0 01)	0 09 (0 04)	0 05 (0 03)	0 59 (0 05)	0 80 (0 02)
MAST					
Quercus spp	0 02 (0 02)	0 02 (0 01)	0 01 *	t	---- ----
Rhus spp	0 17 *	0 03 (0 02)	t	t	---- ----
Other	0 08 *	0 04 *	0 04 *	t	t
Total	0 27 (0 02)	0 09 (0 02)	0 06 (0 01)	0 01 (0 01)	t

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
			FEBRUARY 1988		
BROWSE					
<u>Cornus</u> spp	0 05 (0 01)	0 08 (0 02)	0 04 (0 01)	0 03 (0 02)	t
<u>Fraxinus</u> spp	0 02 (0 01)	0 01 (0 01)	t	t	t
<u>Ilex</u> spp	0 01 (0 01)	0 02 (0 01)	0 10 (0 06)	---- ----	---- ----
<u>Lonicera</u> spp / <u>Symphoricarpos orbiculatus</u>	0 02 (0 01)	0 09 (0 08)	0 31 (0 14)	0 01 (0 01)	t
<u>Quercus</u> spp	0 03 (0 03)	0 05 (0 01)	0 04 (0 01)	t	0 02 *
<u>Rhus</u> spp	0 05 (0 02)	t	0 02 *	0 02 (0 01)	t
<u>Rubus</u> spp	t	t	0 03 (0 01)	---- ----	---- ----
<u>Smilax</u> spp	0 02 (0 01)	t	0 10 (0 04)	---- ----	---- ----
<u>Vaccinium</u> spp	---- ----	t	0 02 *	---- ----	---- ----
Other	0 02 *	0 03 *	0 03 *	t	0 01 *
Total	0 22 (0 04)	0 30 (0 09)	0 69 (0 09)	0 07 (0 03)	0 04 (0 01)
CONIFER					
<u>Juniperus virginiana</u>	0 20 (0 08)	0 15 (0 06)	0 02 (0 02)	t	---- ----
<u>Pinus</u> spp	0 29 (0 09)	0 12 (0 07)	0 04 (0 02)	0 13 (0 04)	0 01 *
Total	0 49 (0 02)	0 27 (0 04)	0 06 (0 04)	0 14 (0 04)	0 01 *
FERN					
<u>Polystichum acrosticoides</u>	0 07 (0 03)	0 17 (0 11)	0 02 (0 01)	---- ----	---- ----
Total	0 07 (0 03)	0 17 (0 11)	0 03 (0 01)	t	0 01 *

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
FORB					
Antennaria plantaginifolia	0 02 (0 02)	0 01 *	t	---- ----	---- ----
Cynoglossum amabile	---- ----	---- ----	---- ----	0 01 (0 01)	0 01 *
Other	0 05 *	0 02 *	0 03 *	0 08 *	0 02 *
Total	0 07 (0 04)	0 03 (0 02)	0 03 (0 01)	0 09 (0 02)	0 03 (0 01)
GRASS					
Andropogon virginicus	---- ----	---- ----	---- ----	0 06 (0 02)	0 24 (0 03)
Aristida spp	t	t	---- ----	0 02 *	t
Arundinaria gigantea	---- ----	---- ----	---- ----	0 02 (0 01)	---- ----
Bouteloua spp	t	---- ----	---- ----	0 03 (0 03)	0 02 *
Carex spp	0 01 *	0 01 (0 01)	---- ----	0 02 (0 01)	0 10 (0 02)
Elymus canadensis	t	t	t	0 10 (0 03)	t
Eragrostis spp	t	t	t	0 04 (0 01)	0 03 *
Lepidium obongatum	t	---- ----	0 02 (0 01)	---- ----	---- ----
Panicum spp	0 05 (0 02)	0 12 (0 06)	0 07 (0 04)	0 08 (0 02)	0 09 (0 01)
Sporobolus spp	---- ----	---- ----	---- ----	0 02 (0 02)	t
Uniola spp	---- ----	---- ----	---- ----	0 02 (0 01)	0 10 (0 03)
Other	0 05 *	0 03 *	0 01 *	0 23 *	0 27 *
Total	0 12 (0 03)	0 17 (0 08)	0 11 (0 05)	0 64 (0 05)	0 87 (0 02)
MAST					
Rhus spp	0 01 *	0 01 (0 01)	t	---- ----	---- ----
Other	0 01 *	0 02 *	0 02 *	t	0 01 *
Total	0 02 (0 01)	0 03 (0 03)	0 02 (0 01)	t	0 01 *

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
			MAY 1988		
BROWSE					
Callicarpa americana	0 02 (0 01)	0 01 *	0 02 *	---- ----	---- ----
Ceanothus americana	---- ----	t	0 01 (0 01)	---- ----	---- ----
Cornus spp	0 03 (0 02)	0 04 (0 01)	0 07 (0 01)	t	t
Hammamelis vernalis	t	0 02 (0 01)	---- ----	---- ----	---- ----
Lonicera spp / *Symphoricarpos orbiculatus*	0 02 *	0 03 (0 02)	0 08 (0 04)	t	t
Ostrya virginiana	0 02 (0 01)	0 01 (0 01)	0 01 (0 01)	---- ----	---- ----
Prunus spp	0 04 (0 03)	0 01 *	0 03 *	---- ----	---- ----
Rhus spp	0 03 (0 01)	0 10 (0 04)	0 07 (0 02)	t	t
Rubus spp	0 03 (0 02)	0 03 *	0 06 (0 03)	t	t
Toxicodendron radicans	0 02 *	0 02 (0 01)	0 03 (0 01)	---- ----	---- ----
Smilax spp	0 01 (0 01)	0 01 (0 01)	0 04 (0 02)	---- ----	t
Vitus spp	0 05 (0 02)	0 02 (0 01)	0 01 *	---- ----	---- ----
Other	0 07 *	0 05 *	0 07 *	0 01 *	t
Total	0 34 (0 05)	0 36 (0 07)	0 50 (0 09)	0 02 *	0 02 (0 01)
CONIFER					
Juniperus virginiana	0 03 (0 03)	0 02 (0 02)	---- ----	---- ----	---- ----
Pinus spp	0 05 (0 01)	0 03 (0 01)	0 03 (0 01)	0 03 (0 01)	t
Total	0 08 (0 02)	0 05 (0 02)	0 03 (0 01)	0 03 (0 01)	t

Plant Species	Deer McCurtain		Deer Howard		Deer Pike		Cattle McCurtain		Cattle Howard	
FERN (unknown)										
Total	0 01	(0 01)	0 02	(0 01)	----	----	0 01	(0 01)	t	
FORB										
Acalypha gracilens	0 04	(0 02)	0 01	*	0 03	(0 01)	----	----	----	----
Abutilon threophrasti	0 07	(0 03)	0 02	(0 01)	0 01	*	t		t	
Callirhoe digitata	0 06	(0 02)	0 03	*	0 04	(0 01)	t		t	
Clitoria mariana	0 01	*	0 01	*	----	----	0 02	*	t	
Desmodium spp	t		0 02	*	0 01	*	----	----	----	----
Erigeron spp	0 02	*	t		0 01	*	----	----	----	----
Euphorbia spp	t		0 03	(0 02)	0 02	(0 01)	----	----	----	----
Helianthus spp	0 02	(0 02)	0 02	(0 01)	t		----	----	----	----
Hypericum spp	t		0 01	*	t		----	----	----	----
Lespedeza spp	t		0 01	(0 01)	t		0 02	*	0 03	*
Monarda spp	0 03	*	t		0 01	(0 01)	----	----	----	----
Oenothera lauvandulifolia	0 01	(0 01)	t		t		----	----	----	----
Oxalis spp	t		t		0 02	(0 01)	t		t	
Plantago spp	t		0 01	(0 01)	0 01	*	0 05	*	0 05	(0 02)
Strophostiles spp	0 01	*	0 01	(0 01)	0 01	(0 01)	----	----	----	----
Trifolium reflexum	0 03	(0 01)	t		0 01	*	----	----	----	----
Verbascum thapsis	0 07	(0 03)	0 01	(0 01)	0 01	*	----	----	----	----
Other	0 06	*	0 15	*	0 11	*	0 11	*	0 09	*
Total	0 46	(0 05	0 37	(0 05)	0 31	(0 09)	0 21	(0 02)	0 18	(0 02)

Appendix I Continued

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
GRASS					
Andropogon spp	t	0 04 (0 02)	0 02 (0 01)	0 13 *	0 18 (0 02)
Andropogon virginicus	---- ----	---- ----	---- ----	t	0 07 (0 03)
Aristida spp	---- ----	---- ----	---- ----	0 01 *	t
Bouteloua spp	t	t	---- ----	t	0 03 (0 02)
Carex spp	t	---- ----	t	0 05 (0 02)	0 06 (0 02)
Eragrostis spp	t	t	t	0 02 *	0 05 (0 01)
Festuca spp	---- ----	---- ----	---- ----	0 02 (0 01)	t
Panicum spp	0 03 (0 01)	0 02 *	0 02 (0 02)	0 14 (0 04)	0 10 *
Sorghum bicolor	---- ----	---- ----	---- ----	t	0 01 *
Sporobolus spp	---- ----	---- ----	---- ----	0 08 (0 03)	0 03 *
Uniola spp	---- ----	---- ----	---- ----	t	0 04 (0 02)
Other	0 04 *	0 09 *	0 05 *	0 18 *	0 12 *
Total	0 08 (0 03)	0 15 (0 04)	0 10 (0 04)	0 65 (0 02)	0 70 (0 02)
MAST					
Quercus spp	0 02 (0 01)	0 02 *	0 02 *	t	t
Rhus spp	---- ----	0 01 (0 01)	---- ----	---- ----	---- ----
Other	0 01 *	0 03 *	0 03 *	t	---- ----
Total	0 03 (0 01)	0 06 (0 02)	0 05 (0 01)	0 01 (0 01)	t
AUGUST 1988					
BROWSE					
Alnus rugosa	0 03 (0 02)	t	---- ----	---- ----	---- ----
Cornus spp	0 05 (0 02)	0 04 (0 01)	0 03 (0 02)	t	t

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
BROWSE					
Lonicera spp / Symphoricarpos orbiculatus	0 03 (0 02)	0 07 (0 02)	0 03 *	t	t
Phytolacca americana	t	t	0 02 (0 02)	---- ----	---- ----
Platanus occidentalis	0 02 (0 01)	---- ----	t	---- ----	---- ----
Prunus spp	0 06 (0 01)	0 06 (0 02)	0 04 (0 02)	---- ----	---- ----
Rhus spp	0 13 (0 04)	0 15 (0 02)	0 01 *	0 01 *	t
Toxicodendron radicans	0 04 (0 01)	0 06 (0 03)	t	t	---- ----
Rosa spp	0 02 (0 01)	0 01 *	t	---- ----	---- ----
Rubus spp	0 03 *	0 03 *	0 12 (0 03)	---- ----	---- ----
Smilax spp	0 01 *	0 01 *	0 01 *	---- ----	---- ----
Vitus spp	0 01 *	t	t	---- ----	---- ----
Other	0 06 *	0 07 *	0 16 *	t	t
Total	0 50 (0 05)	0 51 (0 07)	0 44 (0 03)	0 02 (0 01)	0 01 *
CONIFER					
Juniperus virginiana	0 03 (0 03)	---- ----	---- ----	---- ----	---- ----
Pinus spp	0 09 (0 06)	0 01 *	0 03 (0 02)	0 03 (0 01)	t
Total	0 12 (0 05)	0 01 *	0 03 (0 02)	0 03 (0 01)	t
FERN (Unknown)	t	---- ----	t	---- ----	---- ----
FORB					
Acalypha gracilens	0 01 *	t	---- ----	---- ----	---- ----
Ambrosia spp	---- ----	0 01 (0 01)	---- ----	---- ----	---- ----

Appendix I Continued

Plant Species	Deer			Cattle	
	McCurtain	Howard	Pike	McCurtain	Howard
FORB					
Antennaria plantaginifolia	0 03 (0 01)	t	t	t	---- ----
Callirhoe digitata	0 02 *	0 02 *	0 01 (0 01)	---- ----	---- ----
Clitoria mariana	0 02 *	t	t	t	t
Croton capitatus	0 02 (0 02)	0 02 (0 01)	0 02 (0 01)	0 02 *	0 01 *
Euphorbia spp	t	0 01 *	0 03 (0 02)	---- ----	---- ----
Gelsemia spp	t	0 02 (0 02)	---- ----	---- ----	---- ----
Lespedeza spp	t	0 01 *	---- ----	0 03 *	0 02 *
Monarda spp	t	0 03 (0 03)	t	---- ----	---- ----
Oxalis spp	t	0 01 (0 01)	t	t	t
Plantago spp	t	t	---- ----	0 03 (0 02)	0 02 (0 01)
Other	0 08 *	0 16 *	0 06 *	0 04 *	0 04 *
Total	0 19 (0 03)	0 31 (0 08)	0 12 (0 01)	0 13 (0 03)	0 09 (0 01)
GRASS					
Andropogon spp	t	t	0 03 (0 03)	0 10 (0 02)	0 11 (0 02)
Andropogon virginicus	---- ----	---- ----	---- ----	0 02 (0 01)	0 26 (0 05)
Arundinaria gigantea	---- ----	---- ----	---- ----	0 03 (0 01)	t
Bouteloua spp	t	---- ----	---- ----	0 02 (0 02)	0 02 *
Carex spp	0 01 *	---- ----	t	0 02 *	t
Danthonia spicatum	t	---- ----	---- ----	t	0 01 *
Elymus canadensis	t	---- ----	---- ----	0 03 (0 01)	---- ----
Eragrostis spp	t	---- ----	t	0 03 *	0 02 *
Festuca spp	---- ----	---- ----	---- ----	0 02 *	0 08 (0 01)
Panicum spp	0 01 *	t	0 01 (0 01)	0 16 (0 02)	0 07 (0 02)
Sorghum bicolor	---- ----	---- ----	---- ----	t	0 02 (0 02)
Sporobolus spp	---- ----	---- ----	---- ----	t	0 05 *

Appendix I Continued

Plant Species	Deer McCurtain	Deer Howard	Deer Pike	Cattle McCurtain	Cattle Howard
GRASS					
<u>Uniola</u> spp	---- ----	---- ----	---- ----	0 01 *	t
Other	0 03 *	0 01 *	0 01 *	0 27 *	0 17 *
Total	0 07 (0 03)	0 02 (0 01)	0 06 (0 02)	0 73 (0 02)	0 83 (0 02)
MAST					
<u>Phytolacca americana</u>	0 04 (0 02)	0 03 (0 03)	0 03 *	t	t
<u>Prunus</u> spp	t	t	0 05 (0 02)	---- ----	---- ----
<u>Quercus</u> spp	t	0 04 (0 03)	t	t	t
Other	0 05 *	0 06 *	0 23 *	---- ----	---- ----
Total	0 10 (0 03)	0 13 (0 03)	0 31 (0 03)	t	t

[a]t = trace
[b]* = < 0 01

VITA

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Candidate for Degree of

Doctor of Philosophy

Thesis EFFECT OF CATTLE STOCKING RATE ON THE NUTRITIONAL ECOLOGY OF WHITE-TAILED DEER IN MANAGED FORESTS IN SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS

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