WHITE-TAILED DEER AND CATTLE INTERACTIONS IN SOUTHEASTERN OKLAHOMA

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JANA SUE NELSON

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Thesis approved:

Scott Halaway
Thesis Adviser

Larry D. Talent

James H. Shaw

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

This thesis is comprised of 4 chapters written in formats suitable for submission to selected scientific journals. Chapter 1 serves as the introduction. The remaining 3 chapters are complete as written without need for additional supporting material. The manuscripts, written in Journal of Wildlife Management format, are: "Habitat use and preference of white-tailed deer and cattle in southeastern Oklahoma" (Chapter II), "Deer and cattle home range and activity patterns in southeastern Oklahoma" (Chapter III), and "Biomass production of preferred deer foods on southeastern Oklahoma pine plantations" (Chapter IV).

CHAPTER II

HABITAT USE AND PREFERENCE OF WHITE-TAILED DEER AND CATTLE IN SOUTHEASTERN OKLAHOMA

Jana S. Nelson and Scott Shalaway[1]

[1]Oklahoma Cooperative Wildlife Research Unit and Department of Zoology, Oklahoma State University, Stillwater, OK 74078

Abstract.-This study describes habitat use patterns for white-tailed deer and cattle in southeastern Oklahoma pine plantations. Habitat use for both deer and cattle depends on temperature, season, time of day, and food availability. Deer prefer mature timber during the day for the cover and protection it provides and young pine plantations or improved pastures at night for feeding. Cattle use mature timber for the protection it provides from summer sun and winter winds. Cattle habitat use is primarily dependent on management practices of the cattle owners.

Competition between white-tailed deer (Odocoileus virginianus) and cattle is dependent on the plant parts eaten, the amount of overlap in habitat use, the season of use, the amount of use, and the ability of the plant species to recover after use (Thill and Martin 1979). Because cattle are primarily grazers and white-tailed deer are primarily browsers, there should be little competition for forage between these two species. However, deer browse is usually sparse in young unthinned

loblolly pine (Pinus taeda) plantations and consists mainly of scattered hardwood reproduction and shade-tolerant shrubs and woody vines (Blair 1967). Cattle may compete with deer when there is a shortage of food, particularly in winter when they may both seek green vegetation. In summer there may be competiton for forbs. Thill and Martin (1979) found that the greatest overlap in cattle and deer diets occurred during winter on forested sites and during summer on clearcuts.

Comparison of habitat use is important for determining if deer and cattle use the same areas and thus might compete for forage. If the two species are not using the same areas then there is little chance that competition is occurring. Comparison of habitat use is also important for determining if there is potential for behavioral competition due to the presence of cattle. Hood and Inglis (1974) found that deer tend to avoid cattle, and Smith (1961) found that deer prefer to feed in areas inaccessible to cattle.

Funding for this project was provided by Weyerhaeuser Lumber Company; Oklahoma Department of Wildlife Conservation; Oklahoma Cooperative Wildlife Research Unit; and the Department of Zoology at Oklahoma State University. We truly appreciate technical support provided by staff at these agencies. We are also grateful for assistance in data collection provided by S. W. Conrady, M. E. Stewart, and M. L. Yaskanin. We thank J. H. Shaw and L. G. Talent for their review of this manuscript. Statistical assistance provided by W. D. Warde is especially appreciated.

STUDY AREA

This study was conducted on the Mountain Fork Wildlife Management

Area, McCurtain County in southeastern Oklahoma. The area is bordered on the west and north by U.S Highway 259 and by Broken Bow Lake on the east and south. It consists of approximately 19,000 ha of which Weyerhaeuser Lumber Company owns 15,708 ha. The remainder is owned by private individuals, the U.S. Corps of Engineers, and the Oklahoma Department of Wildlife Conservation. The region is characterized by rugged, low mountains at elevations from 93 m to 823 m. Much of the area is now in young growth of loblolly pine plantations ranging in age from new clearcuts to those planted in 1972.

METHODS

Deer were captured using tranquilizer guns, Stephenson box traps, and drop nets from January 1983 through March 1984. The deer were classified by sex and aged as either adults or yearlings (Table 1). Captured deer were instrumented with radio-transmitters and released. Cattle were captured in portable corrals in March 1983 and July 1983 and were also fitted with radio collars.

Radio-collared animals were located using hand-held Yagi antennas and standard triangulation procedures. Locations were made at least ten times each week for each animal. For a 24-hour period each week, locations were made hourly or bihourly as conditions permitted. Locations were first plotted on 1:24,000 aerial photographs and later transformed into grid coordinates. Habitat type, time, temperature interval, precipitation level, and percent cloud cover were recorded for each radio-location.

Cover maps were developed using aerial photographs, information on land use practices, and ground truthing. The habitat types identified

were:

1)Ph -- areas with over 50% mature pine;

2)Hp -- areas with over 50% mature hardwoods;

3)pp -- Weyerhaeuser pine plantations classified by year planted;

4)CC -- areas recently clearcut and not yet planted;

5)R -- residential areas; and

6)Ip -- Improved pastures.

Because not all animals had access to each habitat type, data analysis involved lumping of certain age classes. Mature timber was defined as any timber stand (pine or hardwood) over 20 years old. This determination was based on a predicted timber harvest rotation schedule of 20-25 years. Mature stands typically had high canopy closure and little understory vegetation. Pine plantations planted between 1972 and 1979 were defined as "older" plantations. They were characterized by partial canopy closure with an understory of woody shrubs and vines. Plantations planted in the 1980's were defined as "young" plantations and typically had no canopy closure and an understory consisting primarily of annuals and small woody vines.

Habitat use by month, season, time, and temperature, was calculated for each animal by determining the percentages of radio-locations occurring within each habitat type for each independent factor. Statistical analyses were performed using the Statistical Analysis System (Helwig and Council 1979). Habitat preference was determined by calculating the availability of each habitat type within each animals home range and for the overall study area and using a Chi-square test (Steel and Torrie 1980) to compare these values with the percent use each habitat type actually received. When the Chi-square test indicated

differential use of habitat types, we used the Bonferroni Z-test (Neu et. al. 1974) to determine which specific habitat types were preferred or avoided.

RESULTS AND DISCUSSION

Nine deer (5 females and 4 males) were captured between January 1984 and March 1984. Two deer were collared prior to this, but lost their collars before sufficient data were collected for analysis. Four additional bucks were captured in early 1983 but were not collared because originally this study was primarily interested in the effect competition with cattle might have on doe reproduction. Eight cattle were collared in March 1983. In July 1983, 4 additional cows were collared to replace those that had lost their collars. Habitat use was based on 4,630 locations for cattle taken between March 1983 and March 1984 and 1,197 locations for deer taken from March 1984 through July 1984.

Habitat preference.--Johnson (1980) emphasized the importance of analyzing both use and availability to determine habitat preference. A comparison of use versus availability within an animal's home range can provide information on which habitat types are most preferred by that animal. However, Johnson also noted that comparison of use versus availability solely within the animal's home range may introduce bias because the animal has already exhibited bias in its selection of that area. Our study found differences in habitat preference between habitat use within the home range and habitat use within the study area.

Initially, we compared use versus availability within each animal's

home range for both deer and cattle (Tables 2 and 3). Availability was calculated by overlaying the convex hull home range polygon (Mohr 1947) on the cover maps and using dot grids to determine the percentage of each habitat type. Within their home ranges, 4 deer showed a significant preference ($p<.01$) for mature pine stands. This preference may indicate that deer prefer mature timber for bedding areas because of the protective cover provided. Only 1 deer showed significant avoidance of mature pine timber. This avoidance occurred because she preferred a plantation planted in 1976. This plantation was capable of providing the benefits of mature pine timber including cover and a bedding area.

Improved pasture occurred within the home range of 4 deer. Based on the total number of radio-fixes for each animal, 1 of these deer showed strong preference and another showed strong avoidance of the pasture. The other 2 deer did not preferentially select for improved pastures based on yearly totals. However, improved pastures were significantly ($p<.001$) preferred based on diel patterns. This signifies the importance of improved pastures for feeding areas at night. Although the pasture were used for only a few hours each day, they provided an important feeding resource.

The 1 deer that had access to a plantation planted in 1983 showed significant avoidance ($p<.01$) of that habitat type. This avoidance probably reflected recuperation from mouth injuries suffered during capture in a box trap and not actual dislike of young plantations. For several months, this deer remained in a small area in mature pine timber.

Although 1 deer showed strong preference ($p<.01$) for a plantation planted in 1976, the other deer seemed to use pine plantations in direct relation to their availability.

The habitat preferences of cattle within their home ranges (Table 3) were significantly different than that of deer. Six of 8 cattle analyzed showed a highly significant ($p<.01$) avoidance of mature pine stands. The other 2 cattle showed slight preference ($p<.05$) for mature pines. This preference occurred because the cattle owner provided winter feeding areas for these 2 cows in mature pine stands. Half of the cows showed strong preference ($p<.01$) for older pine plantations. The preference for younger plantations was variable.

Providing a direct measure of cattle habitat preference or avoidance was difficult. Cattle habitat use was primarily regulated by the cattle owner. The preference analysis did not indicate that cattle prefer plantations planted in 1983. However, the herd that had access to a 1983 plantation would walk up to 2 miles within an hour to reach that habitat type. Even after being returned to the original setting, they would immediately attempt to return to the young plantation. Only by the use of fencing and cattle guards could cattle be kept off this area of young pines. Therefore, even though this area was within their home range, cattle had access to it for only a short period which is not considered in the Chi-square and Bonferroni Z-test analysis of habitat preference. Determination of cattle habitat preference or avoidance in this study was therefore based on a combination of statistical and observational data. To fully determine cattle preference, a study would have to be conducted in which cattle movements were unrestricted.

The second method for determining habitat preference was comparison of habitat use with the availability of each habitat type throughout the study area. Deer preferred improved pasture and pine plantations planted in 1977 (Table 4). They avoided plantations planted in 1980 and

those planted between 1972 and 1976. Cattle, however, preferred plantations planted in 1980 and avoided mature timber and plantations planted between 1972 and 1976 (Table 5). Cattle tend to avoid mature timber and older stands because these areas provide less forage production (Nelson 1984).

The comparison of habitat use to habitat availability provides only partial understanding of habitat use by deer and cattle. Season, temperature, and diel patterns also influence habitatuse.

Seasonal effects.--Phenological patterns of white-tailed deer (Halls 1978, Severinghaus and Cheatum 1956) were used to biologically define seasons for habitat use. The seasons used included winter (1 January-29 February), spring (1 March-14 May), fawning (15 May-14 June), summer (15 June-31 August), pre-rut (1 September-30 September), and rut (1 October-31 December). Deer preferred mature pine stands in the spring but avoided them in the summer (Table 6). There was no differential use of mature hardwood stands. Deer showed little difference in seasonal use of pine plantations, although there was some avoidance of older plantations during fawning and younger plantations in the spring. Deer appeared to avoid improved pastures in the spring. However, this avoidance may have occurred because the 5 deer that had access to improved pastures were captured there in March. These 5 deer showed significant preference ($p<.01$) for improved pasture during fawning season and summer.

Cattle also showed seasonal differences in habitat use (Table 7), but these selective use patterns were regulated by management practices. The habitat types that contained supplemental feeding areas were

preferred and the habitat types which lacked feeding areas were avoided. Cattle did indicate a preference for young plantations during the summer.

Temperature effects.--Ambient temperature had a significant effect on habitat use patterns (Table 8). During colder weather, deer indicated a strong preference for mature pine timber. During warmer temperatures, they avoided mature pine stands. Similarly deer avoided improved pasture during cold weather and preferred it at warmer temperatures. These differences are probably based on the ability of mature timber to provide protective warmth and cover during cold weather. Verme (1965) noted that deer in Michigan also use lowland conifer yards in winter because of the thermal cover they provide. Deer preference or avoidance of pine plantations did not follow a clear trend.

Temperature level also affected cattle habitat use (Table 9). Cattle preferred mature timber at high temperatures. The mature timber was able to provide shade and was thus cooler than surrounding areas. Cattle also preferred older plantations at colder temperatures and younger plantations in warmer weather. The older plantations were able to provide protection from the wind during cold months.

Diel effects.--Diel patterns significantly influence habitat use of deer (Table 10). Inglis et. al. (1975) noted that deer tend to use covered areas during the day and venture into more visible areas at night. Our data supported this trend. Deer showed a strong preference for young pine plantations and improved pasture between 5:00 pm and 6:00 am. These areas provided young vegetation growth for feeding. During

daylight hours deer were found primarily in mature timber or old plantations which provided protective cover.

Cattle responses to diel patterns were less consistent (Table 11). However, cattle did show a significant preference for mature timber between noon and midnight. Rather than indicating diel related preference, however, this trend may reflect that cattle used hardwood draws during afternoon hours to avoid the summer heat.

SUMMARY

Habitat use was dependent on many factors including food availability, temperature, season, time of day, and management practices. Because many of these factors are interrelated, it is difficult to determine exactly which factors are responsible for the differential use of habitat types. However, general habitat use trends were observed between deer and cattle. Deer used mature timber and older pine plantations (planted before 1976) 51% of the time. Cattle used mature timber and older stands only 18% of the time. Deer were frequently found in improved pastures. Although some cattle were also grazed on these pastures, the deer tended to use areas away from the cattle. Deer preferred and required young plantations or pastures for feeding areas, but these areas were used primarily at night. Although activity patterns were not significantly different for cattle at night (Nelson 1984), we noted that most cattle would bed down and were not active from 10:00 pm. until early morning.

Any differences in habitat use between two species helps minimize competition. The differences in habitat use between deer and cattle on southeastern Oklahoma pine plantations allowed both species to occupy an

area without directly being together. Because of these differences competition was minimized through avoidance. Forage production was also sufficient to allow production of both deer and cattle on the pine plantations. However, this does not indicate that competiton would not occur under a different set of conditions.

Currently, deer populations in southeastern Oklahoma are low. If deer populations increased, there would be greater intraspecific competition which could stress the resources and create additional competition with cattle. Likewise, increases in cattle numbers would probably stress forage production and cause competition between deer and cattle. The cattle herds analyzed in this study were managed by the use of cattle guards, fencing, supplemental feeding areas, and by being moved periodically from one plantation to another so that forage had time to regenerate. Without fencing, the cattle preferred to graze in a plantation planted in 1983. Deer also depend on these young plantations for feeding areas. If the cattle are allowed to graze in these young plantations without management, competition is likely to occur. Supplemental winter feeding areas are also critical for minimizing competition between these species. Competition in clearcuts is particularly likely during winter months when both species compete for evergreen browse. By providing feeding areas this major source of competition is reduced or eliminated.

Forage production may depend on climatic changes. Although forage production was adequate during the year studied, we do not suggest that vegetation production will always be adequate. Changes in weather or grazing practices will influence production. Because deer are dependent on young plantations for forage, they may compete with cattle if cattle

are allowed to deplete the forage supply during their daily grazing.

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Table 1.--Capture techniques and dates of capture for white-tailed deer in southeastern Oklahoma pine plantations from January 1983 through July 1984.

Animal ID	Sex	Age Class	Date of Capture	Technique
U1[a]	M	Yearling	11 February 83	Tranquilizer gun
U2[a]	M	Adult	12 February 83	Tranquilizer gun
U3[a]	M	Adult	5 March 83	Tranquilizer gun
U4[a]	M	Yearling	17 March 83	Tranquilizer gun
D1[b]	M	Yearling	31 March 83	Tranquilizer gun
D2[c]	M	Yearling	12 November 83	Box trap
D3	F	Adult	25 January 84	Tranquilizer gun
D5	M	Yearling	2 February 84	Box trap
D6	M	Yearling	4 February 84	Tranquilizer gun
D7	M	Yearling	6 March 84	Tranquilizer gun
D8	F	Adult	25 March 84	Drop net
D9	M	Yearling	25 March 84	Drop net
D10	F	Yearling	25 March 84	Drop net
D11	F	Adult	25 March 84	Drop net
D12	F	Adult	25 March 84	Drop net
D13[d]	F	Yearling	7 July 84	Transmitter dart

[a]Originally only does were wanted and bucks were not collared.

[b]Collar was lost 11 April 83 after 73 relocations

[c]Collar was lost by 20 November 83

[d]Insufficient sample size for inclusion

Table2.--Percent use of cover types compared to availability within their home ranges for 8 white-tailed deer in southeastern OKlahoma.

Animal ID	Mature Pine		Mature Hardwood		Improved Pasture		Pine Plantation 1976		Pine Plantation 1977		Pine Plantation 1981		Pine Plantation 1983		N	Chi-Sq
	Use	Avail	Use	Avail	Use	Avail	Use	Avail	Use	Avail	Use	Avail	Use	Avail		
D3	42 **	82					45 **	9			12	10			302	495.0
D5	97 **	73											3 **	27	284	82.9
D6	89	90									11	10			294	0.3
D7	54	63					1	8	39	28	6 **	1			203	74.5
D8	36 **	6	16	19	10 **	37	4	4	8	10	23	16			100	173.7
D9	12 **	3	2 **	23	50	37	10	10	17	12	8	9			139	73.7
D11	22	31	9	7	59 **	16	1	1	8	28	1	9			128	179.4
D12	29 **	9	31	30	21	24	4	2	2	5	11	12			139	67.7

** symbolizes strong preference or avoidance ($p<.01$)

Table 3.--Percent use of cover types compared to availability within their home ranges for 8 cattle in southeastern OKlahoma.

Animal ID	Mature Timber		Pine Plantation 1977-1979		Pine Plantation 1980		Pine Plantation 1981		Pine Plantation 1983		Other		N	Chi-Square
	Use	Avail	Use	Avail	Use	Avail	Use	Avail	Use	Avail	Use	Avail		
B2	38 **	78	17	9	26 **	6	19 **	7					592	679.9
F6	28 **	72	31 **	13	26 **	7	15	8					605	662.5
G7	7 **	30			18	16	65 **	20	9	18	1 **	16	593	1057.0
H8	9 **	71	23 **	10	56 **	12	12	7					163	384.6
I9	29	17	5	14	40	26	1 **	27			25 **	7	345	321.2
J10	30 *	17	4	14	45	30	2 **	31			18 *	8	416	267.1
K11	41 **	73	35 **	11	11	7	12	8					413	291.9
L12	24 **	79	54 **	10	15 *	6	7	5					342	842.0

* symbolizes preference or avoidance ($p<.05$)

** symbolizes strong preference or avoidance ($p<.01$)

-- symbolizes significant avoidance ($p<.01$)

Table 4.--Deer habitat use versus availability within the entire Mountain Fork Wildlife Management study area.

Habitat Type	% Use Observed		% Available
Mature Timber	49		40
Residential	1		3
Improved pasture	26	***	3
Pine plantations			
1972-1976	2	***	14
1977	13	***	5
1978	0		1
1979	0		6
1980	0	***	11
1981	8		11
1983	1		6

X^2=2681.4, n=1197, d.f.=9

***symbolizes strong preference or avoidance of a habitat type ($p<.01$)

Table 5.--Cattle habitat use versus availability within the entire Mountain Fork Wildlife Management study area.

Habitat Type	% Us Observed		% Available
Mature Timber	18	***	40
Pine plantations			
1972-1976	0	***	14
1977	8		5
1978	6		1
1979	5		6
1980	29	***	11
1981	18		11
1983	11		6
Other	4		6

X^2=4250.8, n=4630, d.f=8

*** symbolizes strong preference or avoidance of a habitat type ($p<.001$).

Table 6.--Seasonal habitat use patterns of white-tailed deer in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type during each season.

Cover types	Seasons		
	Spring 1 Mar-14 May	Fawning 15 May-14 Jun	Summer 15 Jun-31 Aug
Hp(over 50% mature hardwoods)	8.4	10.7	10.1
Ph(over 50% mature pine)	53.2[b]	40.1	25.6[a]
Pine plantation			
1974	0.1	0.0	0.0
1976	4.1	1.6	0.0
1977	15.0	10.2[a]	14.9
1981	9.8	11.8	1.8[a]
1983	0.6	0.0	0.0
Improved pasture	7.9[a]	25.6[b]	45.8[b]
Residential	0.8	0.0	1.8
Number of Locations	665	364	168

[a]symbolizes strong avoidance ($p<.001$)

[b]symbolizes strong preference ($p<.001$)

Table 7.--Seasonal habitat use patterns of cattle in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type during each season.

	Seasons					
Cover types	Winter 1 Jan-29 Feb	Spring 1 Mar-14 May	Fawning 15 May-14 Jun	Summer 15Jun-31 Aug	Pre-rut 1Sep-30 Sep	Rut 1 Oct-31 Dec
Hp(over 50% mature hardwoods)	26.9[b]	13.6[a]	3.4[a]	19.3	22.9[b]	23.2[b]
Ph(over 50% mature pine)	0.0[a]	1.8	0.4[a]	6.9[b]	0.3[a]	0.0[a]
Pine plantation						
1976	0.0	0.0	0.0	0.3	0.0	0.0
1977	18.1[b]	2.8[a]	1.7[a]	4.1[a]	12.4[b]	15.1[b]
1978	0.0[a]	9.3[b]	8.0[b]	3.5[a]	3.0[a]	7.4[b]
1979	20.8[b]	3.5	0.0[a]	0.4[a]	5.9	9.0[b]
1980	14.7[a]	38.4[b]	69.0[b]	24.2	19.0[a]	19.3[a]
1981	0.0[a]	18.1	12.8	22.1[b]	14.9	17.4
1983	1.8[a]	10.3	4.2[a]	16.6[b]	13.1	8.3
New clearcut	0.0	0.0	0.6	0.5	2.5	0.0
Other(barns, ponds)	17.7	2.0	0.0	1.9	5.9	0.2
Number of Locations	442	398	478	1215	763	1334

P<.001 [a]symbolizes avoidance [b]symbolizes preference

Table 8.--Temperature related use patterns of white-tailed deer in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type for each temperature interval.

Cover types	Temperature Interval (C) above 35	27-35	18-27	10-18	2-10	below 2
Hp(over 50% mature hardwoods)	18.7	9.8	12.2[b]	9.2	0.0[a]	0.0
Ph(over 50% mature pine)	31.2[a]	37.8[a]	39.3[a]	50.4	73.5[b]	52.2
Pine plantation						
1974	0.0	0.0	0.0	0.4	0.0	0.0
1976	0.0	0.3[a]	4.5[b]	5.0[b]	0.0[a]	0.0
1977	12.5	13.7	11.3	14.1	16.9	30.4[b]
1981	6.2	6.2[a]	12.2[b]	9.2	7.3	13.0[b]
1983	0.0	0.0	0.2	0.4	1.5	0.0
Improved pasture	31.2[b]	31.8[b]	19.1	11.4[a]	0.0[a]	0.0[a]
Residential	0.0	0.3	1.2	0.0	0.7	4.3
Number of Locations	16	336	425	262	136	23

$p<.001$ [a]symbolizes avoidance [b]symbolizes preference

Table 9.--Temperature related habitat use patterns of cattle in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type for each temperature interval.

	Temperature Interval (C)					
Cover types	above 35	27-35	18-27	10-18	2-10	below 2
Hp(over 50% mature hardwoods)	34.7[b]	23.1[b]	12.5[a]	17.5	26.8[b]	19.0
Ph(over 50% mature pine)	15.6[b]	3.2	0.7[a]	0.0[a]	0.2[a]	0.0
Pine plantation						
1974	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.3	0.0	0.0	0.0	0.0
1977	4.9[a]	5.9[a]	6.3[a]	7.3[a]	25.3[b]	31.0[b]
1978	4.5	2.6	9.2[b]	4.6	1.7[a]	6.0
1979	0.0[a]	1.5[a]	2.1[a]	9.1[b]	18.7[b]	25.0[b]
1980	9.0[a]	28.4	32.4[b]	30.4	17.0[a]	11.0[a]
1981	13.9	17.6	22.3[b]	15.3	2.5[b]	3.0[b]
1983	13.2	14.0[b]	11.8	9.2	3.1[a]	0.0[a]
New clearcut	2.1	0.8	0.2	0.8	0.5	0.0
Other(barns,ponds)	2.1	2.5	2.6	5.6	4.3	5.0
Number of Locations	288	1170	1527	869	645	100

P<.001 [a]symbolizes avoidance [b]symbolizes preference

Table 10.--Diel habitat use patterns of white-tailed deer in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type for each time period.

	Time periods					
Cover types	0000 0559	0600 0759	0800 1159	1200 1659	1700 1959	2000 2359
Hp(over 50% mature hardwoods)	5.1[a]	19.2[b]	10.6	8.6	11.3	5.1[a]
Ph(over 50% mature pine)	48.9	46.1	42.6	47.4	39.3	51.6
Pine plantation						
1974	0.0	0.0	0.3	0.0	0.0	0.0
1976	1.5	1.9	4.2	2.9	2.0	0.0
1977	11.7	11.5	16.4[b]	14.6	12.7	4.1[a]
1981	6.6	3.8	6.1	8.6	14.0[b]	23.7[b]
1983	0.0	1.9	0.3	0.0	1.3	0.0
Improved pasture	24.8	15.4	18.3	17.7	19.3	15.5
Residential	1.5	0.0	1.3	0.3	0.0	0.0
Number of Locations	137	52	378	384	150	97

$p<.001$ [a]symbolizes avoidance [b]symbolizes preference

Table 11.--Diel habitat use patterns of cattle in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Percent use was calculated by the number of locations within each habitat type for each time period.

	Time periods					
Cover types	0000 0559	0600 0759	0800 1159	1200 1659	1700 1959	2000 2359
Hp(over 50% mature hardwoods)	10.1[a]	12.7[a]	19.9	25.6[b]	15.1[b]	12.1[b]
Ph(over 50% mature pine)	0.0	2.1	2.0	2.8	2.0	1.0
Pine plantation						
1972	0.0	0.0	0.0	0.1	0.0	0.0
1976	0.0	0.0	0.1	0.2	0.0	0.0
1977	6.1[a]	6.4[a]	10.6	10.7[b]	9.7	6.8
1978	9.7[b]	4.8	5.4	3.4[a]	5.6	7.7[b]
1979	5.4	5.3	7.1	6.7	3.4	4.7
1980	33.5[b]	32.8	26.3	23.4[a]	28.7	31.8[b]
1981	20.1[b]	21.2[b]	15.2	13.4[a]	19.4[b]	19.4
1983	11.8	11.1	9.8	8.8[b]	13.3[b]	13.2[b]
New clearcut	0.5	0.5	0.3	0.8	0.8	0.6
Other(barn,pond)	2.8	3.1	3.0	4.3	2.1	2.9
Number of Locations	424	189	1158	1804	715	340

$P<.001$ [a]symbolizes avoidance [b]symbolizes preference

CHAPTER III

DEER AND CATTLE HOME RANGE AND ACTIVITY PATTERNS IN SOUTHEASTERN OKLAHOMA

Jana S. Nelson and Scott D. Shalaway[1]

[1]Oklahoma Cooperative Wildlife Research Unit and Department of Zoology, Oklahoma State University, Stillwater, OK 74078

Abstract.--Home range size and activity patterns were analyzed for white-tailed deer and cattle on southeastern Oklahoma pine plantations. Deer home ranges averaged 0.40 km^2 and cattle home ranges averaged 2.66km^2. Cattle home range size and activity patterns were primarily influenced by management practices. However, both deer and cattle responded to changes in food supply by increasing ranges when food was scattered and concentrating ranges when food was concentrated. Season, temperature, and diel patterns influenced home range size and activity patterns.

Home range size and activity patterns for deer and cattle are dependent on the availability of resources within an area. An animal's home range must include access to food and water, bedding locations, adequate cover to provide protection and concealment, and proper locations for mating and parturition. Generally, home range size increases as the availability and quality of resources decreases

(Sanderson 1966). However to provide maximum benefits, home ranges must also be small enough to allow the animal to gain a selective advantage through familiarity with the area (Burt 1943).

Deer home range size and activity patterns are particularly influenced by the distribution of resources within an area. Temperature, season of the year, and time of day also affect movement patterns. Cattle home range size and movement patterns, however, are more dependent on management practices of the cattle owners than on extrinsic factors or the ability of the habitat to provide their needs.

Competition between deer and cattle is in part dependent on the overlap between home ranges and activity patterns for these species. This paper presents an overview of home range size and activity patterns for white-tailed deer (Odocoileus virginianus) and cattle on southeastern Oklahoma pine plantations.

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STUDY AREA

This study was conducted on the Mountain Fork Wildlife Management Area, McCurtain County in southeastern Oklahoma. The area is bordered on the west and north by U.S Highway 259 and by Broken Bow Lake on the

east and south. It consists of approximately 19,000 ha of which Weyerhaeuser Lumber Company owns 15,708 ha. The remainder is owned by private individuals, the U.S. Corps of Engineers, and the Oklahoma Department of Wildlife Conservation. The region is characterized by rugged low mountains at elevations from 93 m to 823 m. Current management practices involve using the area for the production of loblolly pines. Pine plantations range in age from those recently clearcut to those planted before 1972.

METHODS

Deer were captured using tranquilizer guns, Stephenson box traps, and drop nets from January 1983 through March 1984. Captured deer were instrumented with radio collars and classified by sex and aged as either adults or yearlings. Cattle were captured in portable corrals in March 1983 and July 1983 and were also fitted with radio collars.

Radio-collared animals were located using hand-held Yagi antennas and standard triangulation procedures. Locations were made at least ten times each week for each animal. For a 24-hour period each week, locations were made hourly or bi-hourly as conditions permitted. Locations were first plotted on 1:24,000 aerial photographs and later transformed into grid coordinates.

A computer program developed by Hatfield (1978) was used to calculate home ranges by both the convex hull (Mohr 1947) and a computer generated minimum polygon method. Home range size was calculated on a seasonal and yearly basis for each animal. Seasons were based on phenological changes for white-tailed deer as described in the literature (Severinghaus and Cheatum 1956, Halls 1978, Ockenfels 1980).

The seasons used included winter (1 January-29 February), spring (1 March-14 May), fawning (15 May-14 June), summer (15 June-31 August), pre-rut (1 September-30 September), and rut (1 October-31 December).

Activity patterns were calculated by determining the mean distance traveled between successive locations. The maximum time interval between locations analyzed was 4 hours. Differences in mean distance traveled in different habitat types and at varying temperatures were tested by Analysis of Variance (ANOVA) and Least Significant Difference (LSD) (Steel and Torrie 1980). Statistical analyses were performed using the Statistical Analysis System (SAS) (Helwig and Council 1979).

RESULTS AND DISCUSSION

Eleven deer and twelve cattle were instrumented with radio transmitters. Of these, nine deer and nine cattle were relocated often enough to allow calculation of home range size. Due to the small sample size, differences due to sex and age were not evaluated.

The two methods of home range determination provided different average yearly home range sizes for white-tailed deer (Table 1). The minimum polygon method provides a more consistent measure because it does not include unused areas in the calculation of home range size. This method is particularly beneficial in reducing bias created by including areas surrounding the travel corridors that animals use when changing their center of activity. The convex hull calculations also exclude habitat types not used by the animals, but may include unused areas around travel corridors. Although we believe the minimum polygon method more accurately reflects deer home range patterns in the study area, the convex hull data are included for comparison. The convex hull

method was also used to generate the home range polygons that were used for calculation of habitat preference (Nelson 1984).

Because cattle movements are dependent on the management practices of the cattle owners, the home range values for cattle indicate areas of activity rather than actual home ranges (Table 2).

Deer.--Deer were located 1,728 times between February 1984 and July 1984. The average yearly home range size of 0.40 $\pm$.06 km^2 was smaller than values previously reported for deer in the southeast (Table 3). The small home range area presumably reflects the diversity of the habitat. Deer were found only in areas that contained a stand of mature timber in close proximity to water and young pine plantations or improved pastures. This high degree of interspersion allows access to both food and cover in a relatively small area. Verme and Ullrey (1972) noted that movements and home ranges of deer increased during the spring as a result of searching for forbs, buds, and new growth. Our deer also showed a significantly larger ($p<.05$) home range in spring than during any other season (Table 4). A decrease in the home ranges of does during fawning has been noted in the literature (Halls 1978). Does typically remain in a small area near protective cover when their fawns are young. Both bucks and does in this study showed a decrease in home ranges during fawning season. There was no significant difference ($p<.01$) between home range size during fawning and summer.

Part of the difference in home ranges between seasons may have been influenced by temperature levels (Table 5). Deer were most active during moderate (18-27 C) temperatures such as occurred during the spring. Deer movements averaged 0.287 km between locations during moderate

temperatures and only 0.127 km during extremely cool (below-2 C) weather. Moen (1976) found that northern deer conserve energy in winter by remaining under protective cover and by moving very little.

Extremely warm temperatures (above-35 C) may also have a negative influence on deer movement. Church (1971) noted that temperatures above 30 C can cause heat stress in cattle and may affect deer. Deer movements were shorter during extremely warm weather (0.232 km) than they were at moderate temperatures (0.277 km), but this difference was not significant ($p>.05$).

Although diel patterns influenced habitat use by deer (Nelson 1984), they had little effect on deer movement patterns (Table 6). The type of habitat a deer was in also showed no correlation with the distance moved between successive locations (Table 7).

Cattle.--The home ranges for cattle are based on 4,530 locations taken between March 1983 and March 1984. The average yearly area of activity was 2.66 $\pm$.82 km^2 which is significantly ($p<.01$) larger than the average home range of deer. The larger cattle home ranges reflected the management practices of cattle owners. The cattle are moved to different settings of pine plantations throughout the year to allow the cattle access to new plant growth. Cattle home ranges are large because the calculations considered the total area used and did not account for the shifts in use area. Home range size and the types of habitat used by cattle can be regulated by controlling fencing, cattle guards, and access to water.

Cattle seasonal ranges varied from 0.29 km^2 in winter to 2.13 km^2 during deer rutting season (Table 8). Individual seasonal home ranges

were significantly smaller than the yearly ranges indicating that cattle changed their centers of activity. The extremely small winter ranges occurred because the cattle owners provided supplemental feeding areas for the cattle during the winter months. Between 25 November 1983 and 25 March 1984, cattle were fed on a regular basis and did not move far from the feeding areas (Table 9).

The largest cattle home ranges occurred during deer rutting season. Herbaceous vegetation was becoming scarce and cattle moved around in an attempt to find food. Home ranges were also fairly large in summer as cattle searched for food after the new spring growth was no longer available. Although it seems like home range size during spring should be larger as the animals follow the new growth of forbs and grasses, actual home ranges were fairly small (1.04 km^2). However, distances moved between successive locations during spring were large (Table 10). This indicates that cattle moved around frequently to find new growth, but remained within relatively small areas. Home ranges during other seasons were not significantly different and reflected movements typical of cattle when adequate resources were available. Management practices and food availability seem to be the primary factors that influenced cattle activity patterns. Although cattle moved less during extremely cold weather (Table 11), this was partially a result of cattle gathering around their winter feeding areas. The longer distance moved during warm weather (27-35 C) was probably related to food availability in summer. As with deer, diel patterns had little influence on cattle movements (Table 12).

Comparisons between deer and cattle.--Deer home ranges were

considerably smaller than cattle home ranges. The difference in size presumably reflected the ability of the habitat to meet each animal's requirements. Deer were found in areas of high interspersion that contained mature timber for cover, young plantations or improved pasture for food, and access to water. There was no evidence that deer populations were large enough to have a negative effect on the production of food or cover. Cattle, on the other hand, were grazed at high enough intensity to deplete their food sources if not properly managed. Management practices involved moving the cattle to different areas so that there was an adequate food supply available and so that plants were given a chance to regenerate. These movements increased the home ranges of cattle.

Temperature, time of day, and season influenced activity patterns and home range size. For cattle, these movement patterns were highly influenced by management practices and food availability. However, the trends were similar for both deer and cattle. Both species moved less during extremely cold weather and were most active at moderate temperatures. Diel influences did not significantly affect movement patterns of either deer or cattle. Byford (1969) found that deer movements were concentrated when food was concentrated, but dispersed when food was dispersed. Both deer and cattle showed this trend in their response to the new growth of vegetation in the spring and the sparcity of vegetation in the fall. Both deer and cattle restricted their activity levels during winter.

MANAGEMENT IMPLICATIONS

The actual location of home ranges for deer and cattle was important

for determining if the potential for competition existed. The home ranges of the collared deer did not overlap with the ranges of the collared cattle. However, deer home ranges were near areas that were heavily used by non-collared cattle. Overlap in areas used by both deer and cattle was determined through spotlight counts which were conducted at least once a week. While cattle were gathered at winter feeding areas, deer were more active and visible. When the cattle became more active in early spring, deer sightings decreased noticeably. Deer were seldom seen together with cattle, although they both used the same settings. Hood and Inglis (1974) noted that some deer will shift their use area in response to the presence of cattle. Similarly, Smith (1961) found that when adequate food was available, deer frequented areas inaccessible to cattle. We were unable to determine if the deer on our study area avoided cattle for behavioral reasons or if the decrease in deer sightings was related to changes in seasonal or temporal patterns.

If the areas are properly managed, both deer and cattle can be produced on pine plantations. Julander (1955) concluded that ranges were more efficiently used by grazing both deer and cattle than by grazing either alone. The benefits of multiple range use include use of more plant species, stimulation of new growth by cropping off old parts, and increased animal production per land unit (Lewis 1957).

Proper management must involve providing areas of high interspersion for deer. Based on the home ranges of deer in this study, management areas need to provide mature timber, young plantations, and a water supply within a 0.5 km^2 area. Deer will use the central portions of pine plantations and cattle tend to avoid the central areas (Nelson 1984). However, if the plantations are too large, the deer will not

have close access to mature timber and will not use the area. Deer typically remain within their small home range and will not increase it even to reach an available food supply (Severinghaus and Cheatum 1956).

To manage pine plantations for both deer and cattle, cattle owners should be encouraged to provide supplemental feeding areas for their cattle. This practice is particularly important in winters when the supply of evergreen browse is low. Cattle owners should also move their cattle frequently to allow plant parts to regenerate. Because cattle tend to congregate together in groups, they are capable of depleting available resources within that particular area in a short time. Cattle management based solely on animal units per acre is inadequate in the pine plantation environment.

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Table 1.--Home ranges of white-tailed deer in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Home ranges were calculated using the minimum polygon method and the convex hull method.

Animal ID	Number of Locations	Minimum polygon Home range size (km^2)	Convex Hull Home range size (km^2)
D3	302	0.537	1.708
D5	284	0.188	0.513
D6	294	0.381	1.110
D7	203	0.392	1.818
D8	100	0.405	1.002
D9	139	0.394	1.012
D10	139	0.344	0.996
D11	128	0.609	2.174
D12	139	0.328	1.049
MEAN(±SE)		0.404(±.06)	1.265(±.25)

Table 2.--Home ranges of cattle in southeastern Oklahoma pine plantations, as determined by radio-telemetry. Home ranges were calculated using the minimum polygon method and the convex hull method.

Animal ID	Number of locations	Minimum polygon Home range size (km^2)	Convex hull Home range size (km^2)
A1	865	1.60	36.61
B2	592	3.14	9.88
C3	571	1.79	32.85
F6	605	2.28	7.91
G7	593	6.69	14.97
H8	163	3.20	5.60
I9	345	1.24	3.68
J0	416	0.91	3.48
K1	413	3.10	9.04
Mean (±SE)		2.66(±.82)	13.78(±5.85)

Table 3.--Comparisons of white-tailed deer home ranges in different southern areas calculated using the convex hull (minimum area) method.

Study	State	Average home range size(km^2) Does	Bucks
Nelson 1984	OK	1.26	
Ockenfel 1980	OK	9.80	
Progulske & Baskett 1958	MO	1.62	3.8
Michael 1965	TX	1.37	3.6
Marchinton 1968	AL	0.93	

Table 4.--Seasonal home range sizes (km^2) for white-tailed deer in southeastern Oklahoma pine plantations calculated using the minimum polygon method. Distances moved during seasons commonly underlined were not significantly different ($p>.05$).

Animal ID	Spring 1 Mar-14 May	Fawning 15 May-14 Jun	Summer 15Jun-31 Aug
D3	0.52	0.34	0.06
D5	0.18	0.05	0.04
D6	0.28	0.13	0.16
D7	0.34	0.25	0.31
D8	0.39	0.17	0.35
D9	0.29	0.08	0.04
D10	0.33	0.20	0.11
D11	0.60	0.10	0.05
D12	0.32	0.14	0.09
Mean (±SE)	0.36(±.06)	0.16(±.04)	0.13(±.05)

Spring Fawning Summer

Table 5.--Effects of temperature on mean distance moved by white-tailed deer on southeastern Oklahoma pine plantations. Distances moved during temperature intervals commonly underlined were not significantly different (p>.05).

Temperature range (C)	Mean distance (km)	Sample size (n)
above 35	0.232	13
27-35	0.196	144
18-27	0.277	271
10-18	0.297	207
2-10	0.259	116
below 2	0.127	14

ANOVA and LSD testing (=0.05)

10-18 18-27 2-10 above 35 27-35 below 2

Table 6.--Diel movement patterns of white-tailed deer on southeastern Oklahoma pine plantations. Mean distance is the average distance traveled between successive locations within each time period. Distances moved within time intervals commonly underlined were not significantly different (p>.05).

Time interval (hrs)	Mean distance (km)	Sample size (n)
0000-0559	0.286	69
0600-0759	0.268	46
0800-1159	0.291	167
1200-1659	0.227	174
1700-1959	0.211	75
2000-2359	0.260	72

ANOVA and LSD testing (=0.05)

0800-1159	0000-0559	0600-0759	2000-2359	1200-1659	1700-1959

Table 7.--Mean distance moved by white-tailed deer in various habitat types in southeastern OKlahoma. Distances moved in habitat types commonly underlined were not significantly different (p>.05).

Habitat type	Mean distance (km)	Sample size (n)
Mature timber	0.297	190
Pine plantations	0.265	432
Improved pasture	0.210	140

ANOVA and LSD testing (=0.05)

Mature timber Pine plantations Improved pastures

Table 8.--Seasonal home ranges (km^2) for cattle in southeastern Oklahoma calculated using the minimum polygon method.

Animal ID	Winter 1 Jan-29 Feb	Spring 1 Mar-14 May	Fawning 15 May-14 Jun	Summer 15 Jun-31 Aug	Pre-rut 1 Sep-30 Sep	Rut 1 Oct-31 Dec
A1	0.19	1.58	0.57	1.58	0.56	1.18
B2	0.89	1.87	0.79	2.17	2.83	3.19
C3	0.07	1.68	0.91	1.75	0.30	1.56
F6	0.60	0.46	1.69	1.67	1.40	2.20
G7	0.17	2.31	1.24	0.35	0.91	3.14
I9	0.03	0.15		1.17	0.91	1.23
J0	0.04	0.09		0.64	0.74	0.84
K1	0.60	0.19		3.08	1.90	1.98
L2	0.01			3.29	0.33	3.89
Mean(±SE)	0.29(±.15)	1.04(±.42)	1.04(±.19)	1.74(±.47)	1.10(±.39)	2.13(±.50)

Table 9.--Mean distance moved by cattle in various habitat types in southeastern Oklahoma. Distances moved in habitat types commonly underlined were not significantly different (p>.05).

Habitat type	Mean distance (km)	Sample size (n)
Mature timber	0.264	617
Pine plantations	0.249	2520
Roads	0.278	334
Feeding areas	0.143	577

ANOVA and LSD testing (=0.05)

Roads	Mature Timber	Pine Plantations	Feeding Areas

Table 10.--Effects of season on distance moved by cattle on southeastern Oklahoma pine plantations. Distances moved during seasons commonly underlined were not significantly different ($p>.05$).

Season	Dates	Mean distance (km)	Sample size (n)
Winter	1 Jan-29 Feb	0.136	315
Spring	1 Mar-14 May	0.307	319
Fawning	15 May-14 Jun	0.240	421
Summer	15 Jun-31 Aug	0.263	1114
Pre-rut	1 Sep-30 Sep	0.267	721
Rut	1 Oct-31 Dec	0.209	1162

ANOVA and LSD testing (=0.05)

Spring Pre-rut Summer Fawning Rut Winter

Table 11.--Effects of temperature on movement patterns of cattle in southeastern Oklahoma. Mean distance is the average distance traveled between successive locations for each temperature interval. Distances moved during temperature intervals commonly underlined were not significantly different ($p>.05$).

Temperature range (C)	Mean distance (km)	Sample size (n)
above 35	0.260	265
27-35	0.286	1090
18-27	0.270	1370
10-18	0.194	708
2-10	0.137	527
below 2	0.098	69

ANOVA and LSD testing (=0.05)

27-35	18-27	above 35	10-18	2-10	below 2
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Table12.--Diel movement patterns of cattle on southeastern Oklahoma pine plantations. Mean distance is the average distance traveled between successive locations within each time period. Distances moved during time intervals commonly underlined were not significantly different (p>.05).

Time interval (hrs)	Mean distance (km)	Sample size (n)
0000-0559	0.172	303
0600-0759	0.215	133
0800-1159	0.335	753
1200-1659	0.230	1332
1700-1959	0.281	506
2000-2359	0.228	268

ANOVA and LSD testing (=0.05)

0800-1159	1700-1959	1200-1659	2000-2359	0600-0759	0000-0559

CHAPTER IV

BIOMASS PRODUCTION OF PREFERRED DEER FOODS ON SOUTHEASTERN OKLAHOMA PINE PLANTATIONS

Jana S. Nelson and Scott D. Shalaway[1]

[1]Oklahoma Cooperative Wildlife Research Unit and Department of Zoology, Oklahoma State University, Stillwater, OK 74078

Abstract.--Vegetative production of preferred deer food species on southeastern Oklahoma pine plantations was quantified to evaluate the potential impact of herbivory on forage production. Biomass produced by grasses, woody new growth, and herbaceous vegetation was calculated for 16 sites ranging from new clearcuts to mature timber. The mean biomass produced ranged from 2,902 kg/ha on young pine plantations to 192 kg/ha in mature timber.

In many deer populations, forage quality and quantity may serve as limiting factors (Halls 1978). The importance of forage is particularly evident in the production of offspring. In optimal habitats which have an adequate quantity of high quality food, does generally produce two or three offspring. However when the quality or quantity is low, deer produce only one offspring or perhaps none.

Several factors influence forage production. Extrinsic factors such as weather, plant disease, soil erosion, or poor agricultural practices

may cause declines in productivity. Productivity is also affected by timber management practices. Forage production is typically increased by clearcutting . Clearcutting also tends to increase sprout growth and improves browse. Interspecific resource competition may also significantly affect the quantity and quality of forage available to deer.

The grazing of cattle and leasing of grazing rights on the forest range of southeastern Oklahoma has been a tradition for over 150 years. In 1970, shortly after Weyerhaeuser Company's aquisition of forest lands in southeastern Oklahoma, cattle numbers were estimated to be between 8,000 and 10,000. By 1974, there were approximately 25,000 privately owned cattle on Weyerhaeuser land in southeastern Oklahoma; virtually all were concentrated on the new pine plantations (Goodwin 1980).

Although cattle are primarily grazers and deer are primarily browsers, competition may occur when there is a shortage of food. Competition is particularly likely in winter when both species are seek green vegetation. Some competition for grasses in early spring may also occur. Segelquist and Pennington (1968) noted that deer populations in southeastern Oklahoma were small. They believed that the scarcity of browse, particularly evergreen browse for late winter, was a limiting factor.

The purpose of this study was to obtain baseline information on plant productivity for different ages of pine plantations.

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STUDY AREA

This study was conducted in McCurtain County in southeastern Oklahoma. The general topography of the area is low, rolling hills at elevations from 93 to 820 m. The soils are shallow, well to excessively drained, and slaty on gently sloping to steep slopes in the piedmont uplands. Some areas also have sandy loam or gravelly loam topsoils. The area is bounded on the north and west by U.S. Highway 259 and on the east and south by Broken Bow Lake. The overstory consists primarily of mature loblolly (Pinus taeda) and shortleaf pines (P. echinata), post oak (Quercus stellata), blackjack oak (Q. marilandica), southern red oak (Q. falcata), white oak (Q. alba), blackgum (Nyssa sylvatica), sweetgum (Liquidamber styraciflua), and black hickory (Carya texana). Most of the area is used for timber production of loblolly pines and for cattle grazing. The most frequent method of site preparation involves clearing the timber, roller-chopping the slash, and burning the site before replanting.

METHODS

Sixteen settings of pine plantations, ranging in age from newly planted to those planted prior to 1972, were selected for vegetative sampling. Selection was based on age, soil type, and timber management practices. Three exclosures were randomly located on each of the 16 settings. Each exclosure was constructed using three metal T-posts enclosed by hogwire. Exclosures were 1.3 m tall with an inner area of 1 m^2 and were designed to exclude both cattle and deer. Vegetation was sampled using the clip-and-weigh method described by Dalke (1941). In

August 1983, at the end of the growing season, a 0.5 m^2 section was clipped at ground level within each exclosure. Because only growth within 1.5 m of the ground is available to deer, we collected only new growth of woody shrubs and vines below this level. Fifteen plots outside the exclosures were also selected at random and clipped for each setting. As the vegetation was clipped, it was sorted into 21 categories of preferred deer food species: coralberry, Symphoricarpos spp.; elms, Ulmus spp.; oaks, Quercus spp.; hawthorns, Crataegus spp.; greenbrier, Smilax spp.; sumacs, Rhus spp.; French mulberry, Callicarpa spp.; blueberry, Vaccinium spp.; blackberry, Rubus spp.; sunflower, Helianthus spp.; asters, Aster spp.; grapes, Vitis spp.; clovers, Trifolium spp.; wild lettuce, Lactucca spp.; sticktights, Bidens spp.; false dandelions, Pyrrhopappus spp.; fleabanes, Erigeron spp.; horseweed, Conyza spp.; grasses; sedges; unclassified forbs; and other. These food groups were selected based on food preference studies of deer in the southeast (Korschgen 1954; Segelquist and Green 1968; Segelquist and Pennington 1968; Reeb and Silker 1978; Korschgen, Porath, and Torgerson 1980; and Warren and Hurst 1981). Total number of species per plot, number of stems per species, percent grazed of each species, and percent cover were recorded in the field as each plot was clipped. The plants were dried to a constant weight at 60 C in a forced air drying oven and weighed to the nearest 0.1 g.

Duncan's multiple range test was used to determine significant differences in biomass production among settings. Statistical analyses were performed using the Statistical Analysis System (Helwig and Council 1978).

RESULTS AND DISCUSSION

Vegetation was clipped on 274 plots including 43 exclosures and 231 plots outside the exclosures. Five exclosures and 9 sites outside the exclosures were not clipped due to vandalism or inaccessibility. The amount of biomass produced per site varied from 192 kg/ha for mature timber to 2,902 kg/ha for a newly planted plantation (Table 1). Although there was a high degree of variablity both within and among sites, several trends were detected.

In general, younger plantations (planted after 1975) produced more biomass than older plantations (planted 1972-1975). An exception was that sites planted in 1980 produced significantly lower biomass. This low production may have been caused by drought conditions during the year they were planted. The growing season (March-August) of 1980 recorded 29.05 cm (11.44 inches) below the normal rainfall of 66.44 cm (26.16 inches). Annual rainfall totaled only 106.2 cm, 23.0 cm below normal (Table 2).

Biomass production was significantly lower for hand planted mature pine stands than for all other sites. Three mature sites were sampled with a mean total forage yield of 370 kg/ha and varied from 192 kg/ha to 603 kg/ha. Fenwood (1984) found similar results in shortleaf pine stands in Arkansas. Mean total forage yields on his sites varied from 183 kg/ha in mature stands to 1,917 kg/ha in young plantations. Segelquist and Pennington (1968) determined yields of 113 kg/ha in undisturbed mature stands and 168 kg/ha in thinned stands in the Ouachita National Forest area.

The small amount of biomass produced in mature stands seems to be a direct result of canopy closure. One of the mature sites we sampled

produced 2,441 kg/ha. This site was ungrazed and was reseeded through natural regeneration. Therefore, there were large openings which allowed understory production of grasses and smaller browse species.

In addition to determining annual forage production for different ages of pine plantations, it is important to determine the types of plants that occurred on each setting. Deer typically prefer forbs and browse and cattle prefer grasses.

The relative proportion of forbs, browse, and grass production varied among settings (Table 3). Browse included new growth, leaves, and buds which might be palatable to deer. Old, dense woody twig growth was not measured. Variability among the sites was extremely high. No clear trends were evident. The type of plants produced on each site seemed to be dependent on soil quality, slope, and other factors inherent to that particular site. Variability within each setting was also very high. Although part of the variability was due to the small sample size, these values are also indicative of the degree of interspersion within each of these settings.

Productivity of herbaceous species (Table 4) and woody species (Table 5) are highly variable even among settings that were planted in the same year. Because sites were chosen that had the same soil types, similar cattle grazing regimes, and the same site preparation techniques, differences between settings must be a result of intrinsic factors which are specific for each setting. Although the biomass production values are highly variable, the vegetation composition of each setting sampled is accurate.

By looking at the frequency of occurrence and the percent weight of preferred deer food species, it is possible to evaluate trends in

species composition for different ages of pine plantations (Tables 6 and 7). The dominant plants, based on frequency, in young plantations (1980 or younger) were grasses, miscellaneous forbs, horseweed, sunflowers, sumac, and oaks. These species occurred in at least 20% of the plots. The same plants, except for oaks, were also dominant in older plantations (1972-1979). However, even though these species occurred in at least 20% of the older plots, all except grasses, miscellaneous forbs, and sumac occurred less often. Grasses, miscellaneous forbs, sumac, and oaks were the only species found more than 20% of the time in mature timber.

Based on percent weight, both young and old pine plantations produced an equal amount of browse (33%), forbs (33%), and grasses (33%). Mature stands produced more woody vegetation (50% by weight) and fewer grasses (23%) and forbs (21%). Thill (1984) found that mature stands in Louisiana produced 71% woody growth, 23% grasses, and 6% forbs.

An analysis of the most commonly grazed species helped determine if the potential for competition between deer and cattle existed. Grasses, horseweed, sunflowers, false dandelions, and hawthorns were the species most commonly grazed (Tables 6 and 7). However, grazing was noted only in close proximity to major roads. Cattle tended to remain with 20 yards of roads in most of their foraging. Therefore, cattle grazing should have little effect in the center of the pine plantations which allows for spatial separation between deer and cattle. Deer were seen during spotlight counts using the center of the plantations if there was access to protective cover. If a plantation is too large, neither deer nor cattle will use the forage in the central sections.

Biomass production of herbaceous vegetation and new browse growth does not seem to be a limiting factor for deer populations in southeastern Oklahoma. However, deer populations are extremely low at this time. If deer populations increased, competition might become more evident. In addition, further studies need to be done to test whether winter mast production is a limiting factor for deer in this area.

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Table 1.--Total biomass production for different ages of pine plantations. Settings with the same vertical line did not produce significantly different amounts of biomass ($p<.05$).

Age of Pine Plantation (year planted)	Total Biomass (kg/ha)
1983	2,902
1979	2,700
before 1971[a]	2,441
1976	2,340
1977	2,322
1981	2,186
1981	2,161
1975	2,003
1972	1,854
1973	1,798
1972	1,425
1980	1,340
1980	1,097
before 1971	613
before 1971	306
before 1971	192

[a]ungrazed

Table 2: Rainfall data from Carter Mountain Tower within study area.

Year	Total Rainfall (cm)	Deviation from Normal[a] (cm)
1972	123.3	- 5.9
1973	189.1	60.0
1974	156.5	27.4
1975	108.8	-20.3
1976	119.6	- 9.5
1977	111.6	-17.5
1978	115.6	-13.5
1979	152.8	23.6
1980	106.2	-23.0[b]
1981	123.0	- 6.1
1982	150.0	20.9
1983	124.2	- 4.9

[a] Normal derived from 30 years of data from 1940-1970 calculated as 129.1 cm.

[b] Drought year which effected plantation growth

Table 3.--Biomass production in kg/ha of browse, forbs, and grasses for different ages of pine plantations.

Setting ID	Age	Browse	Forbs	Grasses	Total
32420	1983	769	2,005	128	2,902
32476	1981	832	598	810	2,240
32406	1981	643	312	1,209	2,164
32436	1980	339	647	354	1,340
42443	1980	772	128	196	1,096
32418	1979	1,247	598	793	2,638
32438	1977	92	1,988	222	2,302
32445	1976	974	554	812	2,340
22459	1975	782	346	876	2,004
22476	1973	712	302	784	1,798
22480	1972	904	598	352	1,854
32434	1972	492	223	710	1,425
42494	pre1971	1,117	515	800	2,432
32436N	pre1971	294	146	173	613
32406N	pre1971	209	44	53	306
22459S	pre1971	118	38	36	192

Table 4.--Biomass production in kg/ha of herbaceous plant species for different ages of pine plantations.

Age	Sun-flower	Grape	Clover	Wild Lett-uce	Stick-Tights	False Dande-lion	Horse Weed	Lespe-deza	Other
1983	28.2	0.0	11.4	0.6	0.0	0.0	1,722.8	0.0	260.2
1981	327.8	0.0	0.0	0.0	25.8	0.0	0.8	68.8	170.2
1981	21.0	0.0	8.2	0.0	0.0	1.2	31.2	19.6	219.2
1980	346.8	0.0	0.0	18.6	0.0	0.0	4.2	36.6	251.6
1980	6.4	0.0	18.4	0.0	0.0	0.0	20.04	4.2	79.4
1979	61.6	6.4	0.2	8.6	0.0	0.0	2.0	93.8	509.0
1977	14.0	0.0	2.0	0.0	0.0	0.0	1,605.6	0.0	366.2
1976	47.0	47.2	3.0	21.00	0.0	48.6	27.6	70.4	260.0
1975	89.8	0.0	0.0	0.0	0.0	0.0	0.0	7.2	248.8
1973	0.0	24.4	87.0	0.0	0.0	0.0	0.4	13.2	175.6
1972	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	576.6
1972	119.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.8
pre-1971	247.8	0.0	0.4	0.0	0.0	0.0	40.4	0.0	226.0
pre-1971	84.6	0.0	0.0	6.6	0.0	0.0	0.0	0.8	52.6
pre-1971	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	41.8
pre-1971	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.6

Table 5.--Biomass production in kg/ha by woody plant species for different ages of pine plantations.

Age	Pine	Oak	Elm	Hickory	Haw-thorn	Green-brier	Sumac	Blue-berry	Black-berry
1983	0.0	48.2	0.0	175.0	11.6	0.4	506.2	0.0	7.8
1981	88.6	282.8	19.4	0.0	200.0	12.8	92.6	0.0	137.0
1981	0.0	148.8	6.2	128.6	41.6	144.6	55.2	0.0	75.6
1980	65.6	103.2	4.8	27.8	0.0	0.0	37.6	4.4	67.8
1980	0.0	98.4	6.6	198.4	20.8	51.8	53.4	42.6	186.8
1979	41.6	190.0	25.0	290.4	5.8	165.6	117.0	0.0	88.2
1977	9.8	31.8	0.0	0.0	0.0	6.6	26.2	0.0	18.0
1976	51.6	0.0	0.0	0.0	0.0	53.0	237.0	30.2	445.8
1975	88.8	81.8	17.6	213.2	86.6	46.2	36.6	3.4	93.0
1973	0.0	49.2	1.6	0.0	20.4	16.2	276.8	2.8	327.2
1972	139.8	0.0	61.6	151.6	0.0	309.2	74.0	0.0	34.4
1972	137.6	19.2	6.8	87.2	20.8	87.8	66.6	0.0	5.6
pre-1971	5.6	159.0	33.6	0.0	0.0	20.8	23.4	0.4	52.8
pre-1971	0.0	246.6	2.2	33.2	1.6	0.0	11.8	188.4	460.6
pre-1971	0.0	18.2	29.6	85.6	0.0	13.2	20.8	6.8	0.8
pre-1971	0.0	9.0	2.6	5.0	0.0	5.2	12.2	31.8	0.0

Table 6.--Frequency and percent weight of woody plant species for different ages of pine plantations. Percent weight is based on the percent of biomass contributed by that plant species to overall biomass produced by each age group. Percent grazed is based on the total number of times each plant species showed evidence of grazing.

Plant Species	1980 or younger		1972-1979		1971 or older		% Grazed
	% Occ	% Weight	% Occ	% Weight	% Occ	% Weight	
Pine	2	2	13	3	1	1	0
Oak	20	7	17	3	23	17	2
Elm	8	0	10	1	6	6	4
Hickory	15	5	18	5	7	8	7
Hawthorn	6	3	6	1	0	0	14
Greenbrier	15	2	18	5	14	4	9
Sumac	29	8	47	6	28	5	4
Blueberry	4	0	3	0	11	4	4
Blackberry	36	5	25	7	17	5	0

Table 7.--Frequency and percent weight of herbaceous plant species for different ages of pine plantations. Percent weight is based on the percent of biomass contributed by that plant species to overall biomass produced by each age group. Percent grazed is based on the total number of times each plant species showed evidence of grazing.

Plant Species	1980 or younger		1972-1979		1971 or older		% Grazed
	% Occ	% Weight	% Occ	% Weight	% Occ	% Weight	
Sunflower	31	7	24	2	13	8	23
Clover	18	0	18	1	1	0	13
Wild Lettuce	2	0	4	0	1	1	13
Sticktights	1	0	0	0	0	0	0
F. Dandelion	1	0	5	0	0	0	18
Horseweed	40	18	24	11	4	0	31
Lespedeza	19	1	13	1	3	0	6
Misc. Forbs	91	10	77	16	83	12	14
Grasses	94	28	97	32	79	23	36

VITA

Jana Sue Nelson

Candidate for Degree of

Master of Science

Thesis: WHITE-TAILED DEER AND CATTLE INTERACTIONS IN SOUTHEASTERN OKLAHOMA

Major Field: Wildlife Ecology

Biographical:

Personal Data: Born in Wichita, Kansas, November 27, 1959.

Education: Graduate of Southeast High School, Wichita, Kansas, June 1977; received Bachelor of Science degree in Biology from Southwestern College, Winfield, Kansas, May 1981; completed the requirements for Master of Science degree in Wildlife Ecology at Oklahoma State University, December 1984.

Professional Experience: Teaching assistant, Southwestern College, Winfield, Kansas, 1978-1981; Museum curator, Southwestern College, 1978-1981; Evaluated National Science Foundation grant, 1980-1981; Graduate teaching assistant for Department of Zoology, Oklahoma State University, Spring 1982; Student Aide, Oklahoma Deer Check Station, November 1982; Graduate research assistant, Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University, 1982-1984; Student trainee (Wildlife Biologist), U.S. Fish and Wildlife Service, Ecological Services, Fort Worth, Texas, May 1984 to October 1984.

Professional Organizations: The Wildlife Society, Tri-Beta Biological Society, Toastmaster's International.