MORTALITY OF WHITE-TAILED DEER FAWNS IN THE WICHITA MOUNTAINS, COMANCHE COUNTY, OKLAHOMA, PART II

By

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PREFACE

The purpose of this study is primarily to determine the direct and possible indirect factors causing mortality of white-tailed deer fawns in the Wichita Mountains of Oklahoma. Specific objectives include (1) documentation of doe-fawn behavior, movements, and productivity rates; (2) identification of specific causes of mortality; (3) determination of the influence of capture, marking, and subsequent monitoring techniques on fawn mortality; (4) description of intra- and interspecific competition between deer and other ungulates, and its impact on deer productivity; and (5) formulation of a management strategy for the Comanche County deer herd. This project is designed to supplement and clarify information compiled in a doctoral study completed by G. W. Garner in 1976.

Two techniques of marking and monitoring radio-collared fawns, (1) color-marking, radio-collaring, and daily observation versus (2) radio-collaring and daily triangulation only, were used to observe the effects of human disturbance on fawn mortality, movement, and home range use. Observations of marked does, marked fawns, unmarked deer, and other ungulates were recorded to provide information on inter- and intraspecific competitors of white-tailed deer for fawning habitat. Habitat characteristics of fawn bedsites were also evaluated.

Financial assistance was provided by the Oklahoma Department of Wildlife Conservation, Fort Sill Military Reservation, and the Oklahoma Cooperative Wildlife Research Unit. Housing and facilities utilized during field studies were provided through the Wichita Mountains National Wildlife Refuge by former manager, Roger Johnson.

I express sincere appreciation to my major adviser, James C. Lewis, Technical Editor, U.S. Fish and Wildlife Service, for his understanding and support throughout the project. I also express gratitude to committee member Jeff Powell, Associate Professor of Agronomy, for assistance in analysis of the fawn bedsite data. Appreciation is extended to Bryan P. Glass, Professor of Zoology, and Paul A. Vohs, Unit Leader, Oklahoma Cooperative Wildlife Research Unit, and Associate Professor of Wildlife Ecology, for serving as members of my graduate committee.

Research data was gathered with the cooperation of many individuals in Comanche County: Gene Stout, biologist, and his staff at Fort Sill Military Reservation; O. B. Hamblin, District Chief of Law Enforcement, Oklahoma Department of Wildlife Conservation, and Game Rangers Haskell Besherse, Carroll Dodd, and Mike Gabbard; Gene Bartnicki, Elmer Parker, and Nita Fuller, Wichita Mountains National Wildlife Refuge staff, and many other people who provided assistance.

Others who added their support during this study were: Gerald W. Garner, who assisted in the field in the initial months of the study and later as a consultant; Greg Butts, biologist, Kerr Wildlife Management Area, for supplying fawn carcasses through courtesy of the Texas Parks and Wildlife Department; Larry Claypool provided statistical expertise; Iris McPherson set up the computer programs; Alan Kocan provided clinical and veterinary assistance; Deborah Holle, John Litvaitis, and Gene Waldrip shared their time and experiences during simultaneous studies; and project technicians Kevin Ehlers, Craig Endicott, Steve Leisher, Don Martin, and Brian Pilcher assisted during many long hours of field "experience."

In conclusion I would like to thank my wife, Darlene, for her understanding during this project.

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CHAPTER I

INTRODUCTION

The format and style of Chapters II, III, and IV in this thesis each meet the manuscript specifications for a scientific journal with international circulation. Chapter II was written in this manner to expedite submission to the PROCEEDINGS OF THE SOUTHEASTERN ASSOCIATION OF GAME AND FISH COMMISSIONERS. Chapters III and IV were written using the guidelines of the Journal of Wildlife Management. Each paper is complete and needs no supportive information outside of its respective chapter.

Information collected during this study which was not used in Chapters II, III, or IV is included in the appendices. This data could be used to complement future research or for publications dealing with white-tailed deer in the Wichita Mountains of Oklahoma.

Approval for presenting the thesis in this manner is based upon the Graduate College's policy of accepting a thesis written in manuscript form and their approval of the major professor's request for a waiver of the standard format in a letter dated 23 March 1977.

CHAPTER II

PREPARTUM, BIRTH, AND POSTPARTUM RELATIONSHIPS OF WHITE-TAILED DOES AND FAWNS

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Abstract: Fourteen adult white-tailed deer (Odocoileus virginianus) does were captured (10 in 1976 and 4 in 1977) and fitted with radio transmitters. Eight of the 14 survived through at least 1 parturition period with properly functioning collars. Five does were relocated and observed regularly in the fawning seasons of 1976 and 1977 (2 does were monitored both years) in order to describe behavior and spatial relationships between does and fawns. Eleven fawns of the radio-collared does and 37 other fawns were captured soon after birth, radio-collared, released, and monitored regularly. Four other does marked with ear streamers supplemented data from radio-collared does and fawns. Some does shifted or reduced use of established home ranges just prior to parturition and separated themselves from conspecifics, usually by moving to the edge or outside of their established home range. Does remained near the birth site for approximately 24 hours and then moved away with their fawns. Distance between sibling fawns and distance between does and their fawns increased the first 8 days postpartum. Physical description and behavior of does that is characteristic during prepartum, birth, postpartum, and after loss of fawns, is described. High fawn mortality was considered responsible for the differences between social groupings observed in summer in the study area and groupings noted in other states.

An understanding of behavior is essential to any study of population ecology. Knowledge of mobility, territory, and social organization are required to understand changes in natality, mortality, density, and structure of a population (Dasmann and Taber 1956:143). Downing and McGinnes (1969:711) stated, "In spite of extensive deer research, there is still a need for basic life-equation and behavioral information." The fawning season is a significant yet poorly understood time in the life of white-tailed deer (Townsend and Bailey 1975:348). The approximately 3-month "parturition period" discussed in this paper is defined by Fraser (1968) as a sequence including prepartum, birth, and postpartum activities.

Social interactions within a particular group of animals are significantly influenced by the density of the population (Odum 1971). Much of the information about the social behavior of white-tailed deer has been documented through observation of relatively dense populations (23 to 76 deer per km^2) (Thomas et al. 1965, Hawkins and Klimstra 1970, Hirth 1977). In contrast, this paper describes behavior of deer in a population (6 to 10 per km^2; Stout 1977, unpublished report, Division of Fish and Wildlife, Fort Sill Military Reservation, Fort Sill, Oklahoma, Bartush 1978, Garner et al. 1978) with one-seventh to one-half the density of the studies cited in the previous sentence.

Radio telemetry equipment was regularly used to locate deer. The only use of radio telemetry for describing behavioral and spatial relationships of does and their neonatal fawns being monitored simultaneously, was among Key deer (O. v. clavium) (Hardin et al. 1976). A recent study of direct and indirect factors causing high fawn mortality in an Oklahoma deer population (Bartush 1978) made possible the documentation of behavior, movements, and home ranges of does and their fawns in southwestern Oklahoma during the parturition period.

Financial assistance was provided by the Oklahoma Department of Wildlife Conservation (ODWC), Fort Sill Military Reservation (FSMR), and the Oklahoma Cooperative Wildlife Research Unit (OCWRU) at Oklahoma State University (OSU). Project technicians Kevin Ehlers, Craig Endicott, Steve Leisher, Don Martin, and Brian Pilcher assisted in the field. Appreciation is also extended to the many individuals and agencies credited elsewhere (Bartush 1978).

STUDY AREA

The study area is in the Wichita Mountains of Comanche County, southwestern Oklahoma, an area separated from other occupied deer habitat and surrounded by agricultural land. Wichita Mountains National Wildlife Refuge (WMNWR) and FSMR contain most of the mountains; portions of the refuge and reservation were used as specific study sites. The topography of the Wichita Mountains ranges from nearly level prairies to rocky slopes exceeding 20 percent, with maximum elevations of 755 m, rising 427 m above the surrounding plains.

Mixed grass species compose the prairie which makes up the majority of the study area (Crockett 1964). Woody vegetation is found primarily near creek bottoms and along fracture lines on rocky slopes where soils are sandy or gravelly. Wooded uplands are predominantly post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) (Buck 1964). Trees common in bottomlands are elm (*Ulmus americana*), hackberry (*Celtis* spp.), and post oak. Transitions between the prairie and wooded habitats are abundant and form an intermediate or savanna woodland.

Two specific study sites--Pinchot (5,300 ha) and Wye (3,500 ha) areas--were used for capture of deer and behavioral observations. Located on FSMR and WMNWR, the Wye area has elevations of 427 m - 488 m and gentle sloping hills that rarely exceed 10 percent. The Pinchot area, entirely within WMNWR, contains the highest elevation of the mountain complex, and has mountain slopes of 10 - 20 percent.

Population densities of deer vary on FSMR and WMNWR, but the Pinchot and Wye study sites were selected because they appeared to contain higher densities than other areas of the Wichita Mountains. Fawn survival through the first 3 months postpartum is low (Bartush 1978, Garner et al. 1978). Fawn:doe ratios in late fall have ranged from 14 - 45:100 does (1975 - 1977). Garner et al. (1978) stated that over 90 percent of the fawn mortality was due to predation by coyotes (Canis latrans) and bobcats (Lynx rufus) in 1974 and 1975. High fawn mortality caused by these same predators continued through the 2 years of this study (Bartush 1978).

METHODS AND MATERIALS

Field work occurred from 1 February 1976 to 10 October 1977. Adult deer were captured during January and February of 1976 and 1977 using box traps with cottonseed bait. Fawns were captured by hand as soon as possible after birth. The age of each adult deer was determined based on tooth wear and replacement (Severinghaus 1949), their sex was recorded, and they were weighed, measured, radio collars were attached, and they were released at the capture site. Radio collars (Wildlife Materials, Incorporated, Carbondale, Illinois)[1] for adult deer consisted of nylon webbing with the

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[1]Mention of a product does not constitute endorsement by the author.

transmitter and battery case attached. The entire collar, batteries, and transmitter weighed approximately 400 gm. Transmitters for fawns were smaller (110 gm) than adult units and were affixed to expandable elastic collars. AVM model LA12 portable receivers and hand-held 4-element yagi antennas (AVM Instrument Company, Champaign, Illinois) were used to monitor transmitter signals. Transmitters and receivers operated at frequencies between 164.425 and 164.725 mHz.

Movements of radio-collared does were monitored at approximate 2-week intervals during fall, winter, and early spring months. Attempts were made to observe these animals during each relocation effort. Beginning on 15 May of 1976 and 1977, monitoring efforts were intensified; does were located 2 or more times per week to gather information on prepartum activities and to increase the chances of finding their fawns before they became too large to catch.

Does observed within 48 hours before fawning had enlarged udders and distended abdomens. Various observers of penned deer have noted an enlargement of the dam's udder from 2 weeks to 2 days before fawning (Golley 1957, Townsend and Bailey 1975). When evidence of these later stages of pregnancy were observed, several radio triangulations were made daily in order to find the fawning site. If the doe was not closely monitored during this period, the chance of capturing the fawn(s) at the birth site was greatly reduced. The triangulation was done carefully so that she would not be unduly disturbed.

Prior to capture, fawns were located using 2 principal methods. First, does were observed from high vantage points (mountains and observation towers) by use of binoculars and spotting scopes. Knowledge of postpartum doe behavior (Downing and McGinnes 1969, White et al. 1972) enabled researchers to identify pregnant does and does that had already fawned. After field workers saw a specific fawn for the first time, it was usually observed until it bedded down and then an attempt was made to capture it. The second capture method involved careful observation of the radio-collared doe with an attempt to estimate the approximate time she would give, or had given, birth. The birth site of the doe's fawn(s) could then be approximately determined, facilitating capture of the neonate(s). This method became quite successful after field researchers gained knowledge of behavior of parturient does and the physical appearance of the marked animals was closely observed.

All radio-tagged fawns and their radio-collared does were located daily by triangulation and observation of the animal, or by triangulation only. Precautions were used when locating all radio-tagged animals due to the severe deflection of high frequency signals in the rocky terrain; short distance triangulations from 50 to 250 m were used. Behavior of radio-tagged deer during prepartum, birth, and postpartum was described.

Descriptions of behavior and movements of deer, weather conditions, and habitat use were recorded on standard forms. Observations of deer social groups were recorded as primary (fawn-sibling or fawn-doe) and secondary associations (all other groupings; Hawkins and Klimstra 1970). These observations were further categorized as family groups (a doe and fawn(s) or adult does associated over several months) or adult buck groups. Aggressive behavior between does was recorded using posture designations of Thomas et al. (1965). Interactions between does and other animals were also recorded.

Locations of marked deer were plotted on standard forms and a sketch map made of the site. These locations were later marked on overlays of large-scale aerial photos to determine movement and home range. The modified-minimum-area technique was used to determine home ranges (Harvey and Barbour 1965), and areas were measured with a compensating polar planimeter.

RESULTS AND DISCUSSION

Fourteen adult does were captured (10 in 1976 and 4 in 1977) and fitted with radio transmitters. Eight of the 14 survived through at least 1 parturition period with properly functioning collars. These 8 deer supplied much of the information about behavior and spatial relationships between parent does, fawns, and other deer.

Four additional does, marked with ear streamers, also provided data on behavior. Additional information resulted from 461 man-hours spent observing deer during the 2 fawning seasons.

Forty-eight fawns were captured, radio-tagged, and released; 11 were from radio-tagged does and 6 from the does marked with ear streamers. Twelve of the 48 fawns consisted of 6 pairs of siblings from unmarked does; 4 pairs were captured at their birth sites.

Prepartum

Prepartum was characterized by changes in home range (Table 1) of some does. Six of the 8 radio-collared does utilized larger or different areas during the fall and winter months(Table 1). Does Y_1 and R were associated with 4 unmarked does during the winter of 1976, forming a stable family group. Doe Y_1 died in December 1976. In 1977 3 does were captured (Y_2, O, and Wh_2) which appeared to be 3 of the 4 does which had comprised the herd that doe R associated with in winter 1976. These 4 marked individuals remained in the same group with 2 unmarked does during the winter of 1977. After 1 April 1976, Does Y_1 and R moved to areas which contained none or very little of their previously established home ranges. In 1977, doe R again moved to the prepartum area utilized the previous year. Does Y_2, O, and Wh_2 appeared to move to areas outside of their established home ranges, but only 5 triangulations of each animal were made between the month of capture (February) and 1 April, and a shift in home range could not be confirmed. Doe Wh_1 reduced her

Table 1. Yearly and prepartum home range (ha), and home range changes of radio-collared does in the Wichita Mountains, Oklahoma, 1976 and 1977.

Doe identification and year	Home range in ha and (number of relocations)			% Prepartum home range within winter/fall home range
	Annual	Sept. - Mar.	1 April to parturition	
1976				
Y_1	54.7 (41)	18.1 (16)	21.7 (13)	12
R	40.9 (45)	17.3 (19)	29.5 (14)	2
LB_1	69.5 (36)	13.8 (13)	I[a]	
Wh_1	44.4 (49)	31.2 (18)	18.7 (16)	100
LB_2	61.4 (43)	21.7 (10)	I[a]	
1977				
Y_2	23.4 (23)	10.5 (8)	5.2 (10)	0
R	30.5 (47)	9.4 (12)	2.3 (11)	0
O	64.1 (46)	12.3 (8)	9.6 (9)	0
Wh_2	41.9 (80)	10.2 (7)	4.3 (8)	0
Wh_1	41.4 (28)	14.2 (12)	3.5 (10)	100

[a]Home range calculation incomplete through prepartum period.

home range in 1976 and 1977. Does LB_1 and LB_2 appeared to use the same home range between 1 April and birth of their fawns, but these data were incomplete (Table 1) because the precise time of fawning was not determined.

Decreased home range and/or movements by white-tailed does seem characteristic of prepartum (Hawkins and Klimstra 1970, Miller 1970, Sparrowe and Springer 1970). Dasmann and Taber (1956:153) documented seasonal shifts in areas utilized by nonmigratory Columbian black-tailed deer (O. hemionus columbianus). Shifts in areas utilized by does in the latter study may be a response to daily or seasonal changes in quantity or quality of elements essential to the animal (Dasmann and Taber 1956:158).

Size of doe groups (groups of does with fawns and yearlings) declined from an average of 3.9 individuals the second week of May to 1.5 by 11 June (Fig. 1). Doe herd size declined as parturition approached. Twenty-four to 48 hours before parturition each marked doe isolated herself from other deer. Another behavioral change noted in the days just prior to parturition was an increase in the frequency of aggressive actions of pregnant does toward conspecifics (Fig. 2).

Behavioral and social relationships observed in deer during prepartum in the Wichita Mountains were similar to those reported in other studies. Hawkins and Klimstra (1970) and Hirth (1977) mentioned a decrease in doe herd size as the fawning season approached.

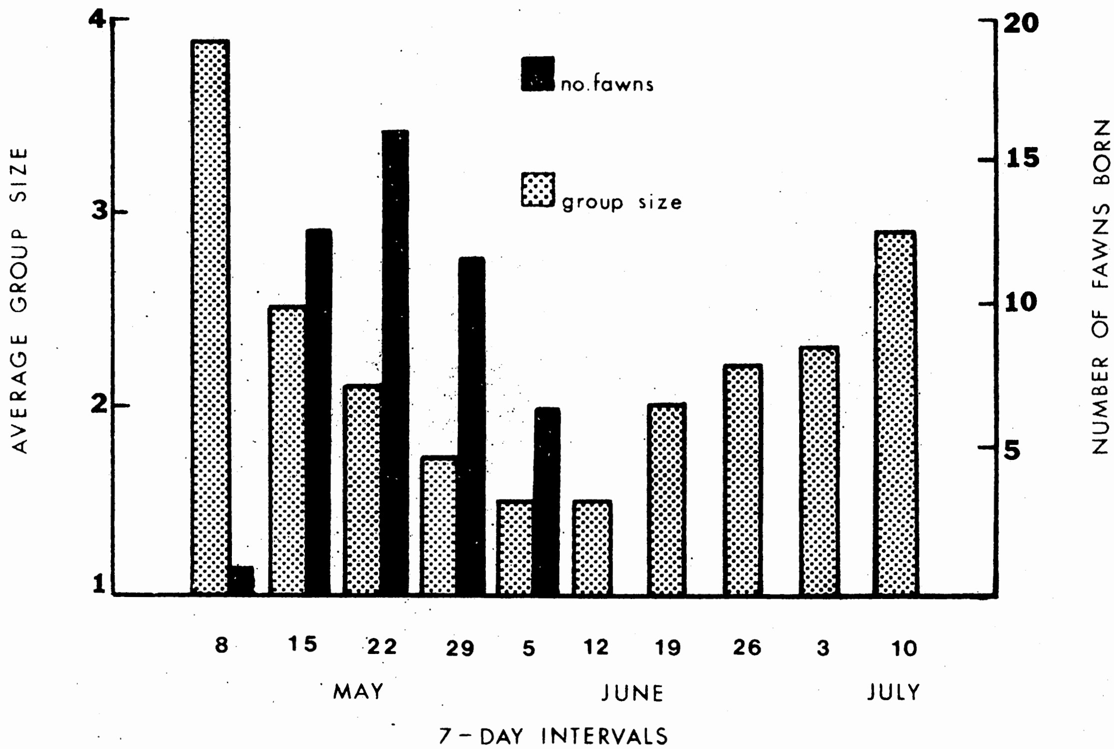

Fig. 1. Average size of doe groups and estimated birth date of 48 fawns, listed in 7-day intervals, Wichita Mountains, Oklahoma, 1976 and 1977. Numbers listed on the abscissa represent the first date of each interval.

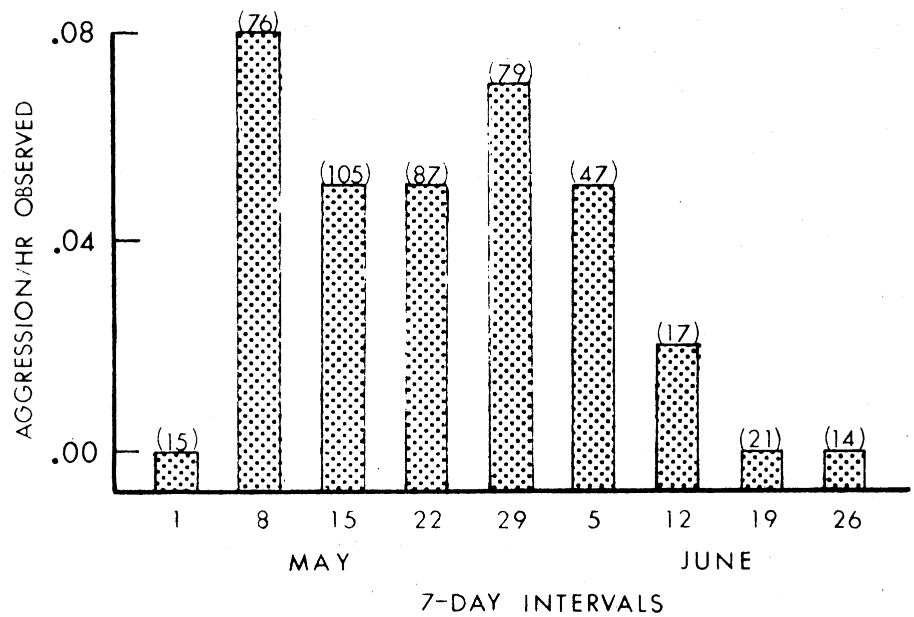

Fig. 2. Occurrence of aggressive behavior recorded (in 461 hours of observation) within doe groups at the Wichita Mountains, Oklahoma, 1976 and 1977. Numbers listed on the abscissa represent the first date of each interval.

Intraspecific aggression was also believed to be at least partially responsible for the decline in average number of individuals within doe groups (Dasmann and Taber 1956) as deer approached parturition. The interrelationship between increased aggression, smaller group size, and peak fawning dates is apparent.

Haugen and Speake (1957), Halford and Alldredge (1975), and Townsend and Bailey (1975) postulated that penned deer may be attempting to isolate themselves from other deer or disturbances prior to fawn drop. These same actions to isolate themselves seemed characteristic of parturient does observed during this project. Does with known home ranges and known fawning areas moved to an edge of or outside their home range just prior to giving birth. The isolation from conspecifics and the movements were characteristic behaviors that helped researchers find the does' fawning sites and enable capture of the fawn(s). This movement by the radio-collared does occurred 4 out of the 5 times their fawns were captured at or near the birth site. Fawns of 4 other marked does were captured or seen soon after birth, but the precise fawning site was not identified. Two of these probable fawning areas were at the edge of the respective doe's home range.

Birth

Judging from her behavior for 105 minutes, and the condition of her fawns at capture, doe 0 was observed giving birth. She was bedded 500 m from the observer in dense native prairie grasses 0.75

to 1 m in height, which prevented a clear view of the birth sequence. The doe's head and neck were visible except when she appeared to be licking herself or the fawns. Twice she arose, walked in a small circle, then laid down; these movements are similar to birth activities described in other studies (Haugen and Speake 1957, Miller 1965, Halford and Alldredge 1975, Townsend and Bailey 1975).

Doe O was approached at dusk and she ran when researchers were 15 m away. The bedsite was a flattened, circular area of matted grass, 1 m in diameter, containing spots of blood and small pieces of afterbirth. Two fawns were in the bedsite; 1 was dry, the other had a small portion of moist and matted hair on its hindquarters. The doe stayed within 200 m (as indicated by radio signals) but was not seen or heard by the researchers. The birth sites in this study resembled a birth site used by a black-tailed doe (Miller 1965).

Judging from their physical condition, 3 other pairs of twin fawns were captured within 24 hours postpartum at the birth site. Each fawning site was similar in size and appearance to the fawning bedsite of doe O. In all 3 cases the siblings, while not always in the birth site (but within 10 m), were less than 3 m apart and docile. The dams stayed nearby while fawns were marked.

White et al. (1972:898) stated, "Our observations and those of Micheal (1964) lead us to conclude that birth among these deer is somewhat casual, occurring largely within the regular activities of the dam and with few obvious changes in routine or special precautions except isolation from other deer." The latter conclusion, based on observations in Texas, could not be applied to the selection of fawning sites by does in the Wichita Mountains, where marked does exhibited some fidelity to fawning areas. In 1977, fawning areas of 5 does were less than 300 m from sites they used in 1976. Fawns (1 in 1976 and 2 in 1977) of a sixth doe were captured within the 4 ha area where she had been captured as a fawn in 1974. Dasmann and Taber (1956) mentioned that black-tailed deer might show fidelity to preferred or traditional fawning areas.

Fidelity of does to fawning areas and their movement to specific sites for fawning, sometimes outside of their winter home ranges, as opposed to casual selection of birth sites, may be partly due to the density of a given deer population. The areas in Texas where birth sites seemed to be selected casually (Micheal 1964, White et al. 1972:898) contained deer densities 25 percent higher than that of the area in California (Dasmann and Taber 1956), where does seemed to select specific habitat for fawning, and 4 times greater than the Wichita Mountains deer population. Pregnant does may unsuccessfully seek isolation prior to giving birth in high population densities in Texas.

In the years of this study, 5 known and 4 probable fawning sites were located in a specific habitat type; 3 other possible fawning areas were near an ecotone, where the specific site and habitat could not be precisely determined. Among the 9 known or probable fawning sites, 5 were in open prairie, 3 were in "savanna woodland," and 1 was in closed-canopy woodland with a dense understory. Dasmann and Taber (1956:145) mentioned that black-tailed does utilized dense brush in which to give birth to their fawns. Use of dense cover (cornfields and heavy vegetation) and the secretive nature of deer are suggested as reasons why does are seen less in the summer (Hawkins and Klimstra 1970:410, Sparrowe and Springer 1970:427) than at other seasons. Judging from the habitat used for parturition in the Wichita Mountains, does did not seek the heavy woody cover or brush available for fawning, even though such cover was to be found in home ranges of all marked does. Does primarily used prairie sites for fawning which may offer better concealment at the ground level for the neonatal fawn. The does' wariness and reduced home range appeared to be reasons that they were seen less frequently during and just after parturition.

Postpartum

Behavior and physical characteristics of the doe were helpful in recognizing the approximate time elapsed since birth, thereby facilitating capture of the fawn(s). In the 24 hours postpartum, does Wh_1, Wh_2, O, and R were located less than 100 m from their fawns. Florida Key deer also remained with their fawns almost 100 percent of the time within 24 hours postpartum (Hardin et al. 1976). Does were less likely to run when approached by a researcher in the first few days postpartum, ran only a short distance, or flattened against the ground in a manner resembling the prostrate position of young fawns (Micheal 1964, Miller 1965). The latter behavior occurred especially when a doe's fawn(s), less than 3 weeks old, were nearby. After 3 weeks postpartum this hiding behavior was not observed among the dams.

Physical appearance of the doe was also important in approximating the time elapsed since birth. Decreased distention of the abdomen, a well-developed udder with rather clean, pink-colored teats, and a swollen, red, and sometimes slightly bleeding vulva were characteristic of a doe that had recently given birth. Apparently blood and/or a watery fluid discharge from the vulva of does continues for some hours after the fawns are delivered. On 2 occasions does were frightened from a bedsite and small patches of blood and watery discharge were found. Intensive observations of the vicinity of 1 of these bedsites led to the capture, 6 hours later, of twin fawns approximately 24 hours old.

Does and their fawns left the parturition sites after 24 hours postpartum. All siblings bedded separately, from 15 to 260 m apart ($\bar{x}$ 112), after the first 24 hours (Fig. 3a). Downing and McGinnes (1969:712) and White et al. (1972) reported a similar separation of siblings. Distance between siblings generally increased through the first 8 days of age but began an erratic decline during the next 9 days (Fig. 3a). The distance between fawn(s) and their dam also

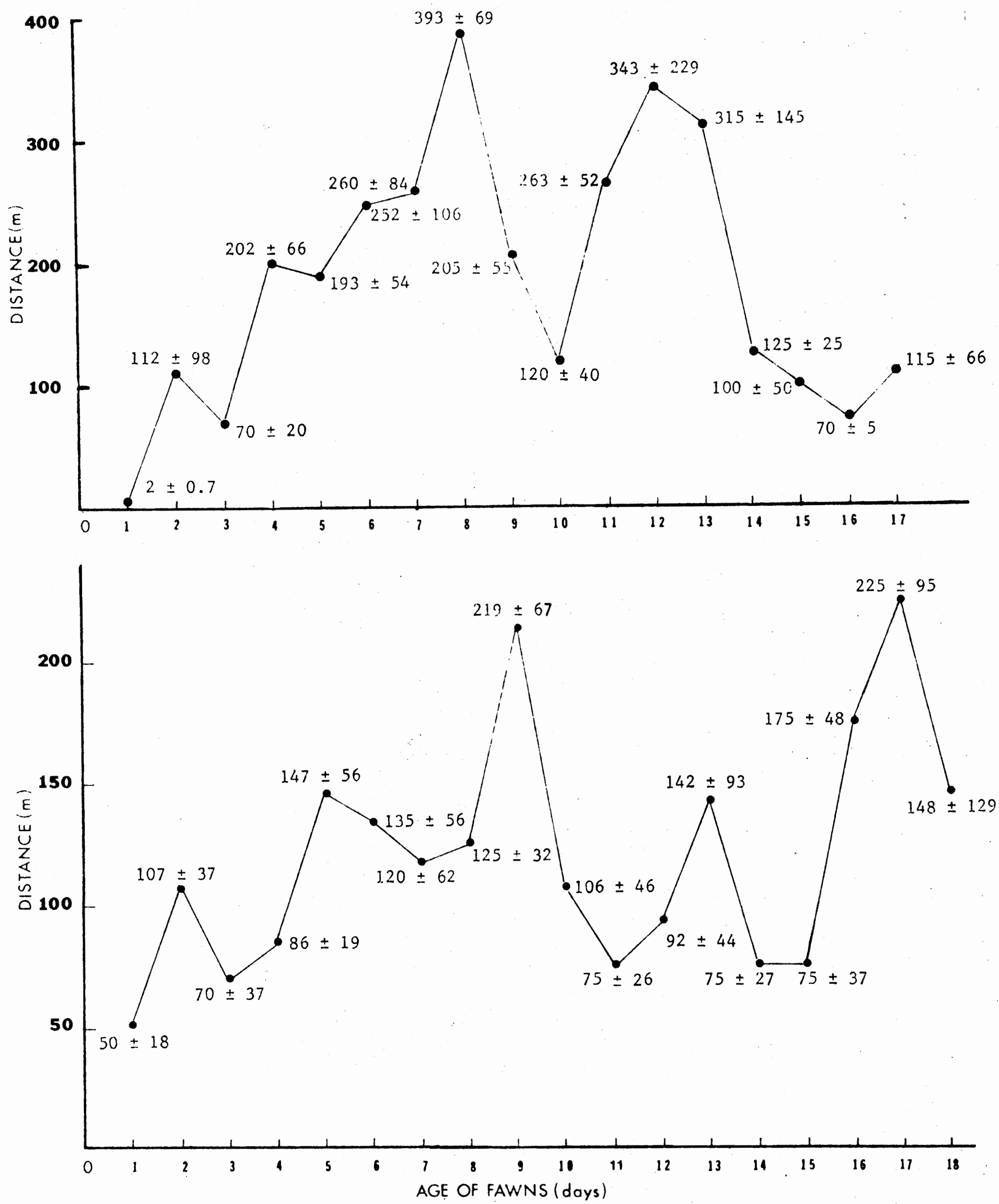

Fig. 3. Average distance (m) ± SE between sibling fawns from 1 to 17 days of age (a, upper illustration), and average distance (m) ± SE between radio-collared does and their fawns from 1 to 18 days postpartum (b, lower illustration), Wichita Mountains, Oklahoma, 1976 and 1977.

increased through the first 9 days, but was also erratic for the next 9 days (Fig. 3b). The spatial relationships between individual fawns and does were extremely variable. For example, 1 fawn was never located more than 300 m from the doe during the first month postpartum, while another fawn was located 500 and 700 m from its dam during the first 10 days postpartum. Generally, the distances between does and their fawns were less than 200 m.

Home ranges of does and fawns were also plotted. The areas utilized by the does were small the first 3 weeks following birth (Table 2), but then the home range began to increase. Home range size of neonatal fawns appeared similar to the area used by the dam in the first 2 to 3 weeks postpartum. Activity periods of fawns tended to increase as they grew older (Jackson et al. 1972). Garner and Morrison (1978) noted that home range of fawns in the Wichita Mountains increased as the age of the fawns increased. Increasing home range size of fawns was also documented during this project (Bartush 1978).

Daily movement of fawns appeared to be influenced by disturbance factors. The daily movements of all radio-collared fawns were greater in the first 3 days after capture than in the fourth to sixth days postcapture (t test, $P \leq 0.1$) (Table 3). Daily movements were also affected by predators. One member of each of 4 sets of radio-tagged twins was killed by a predator. Three of the surviving fawns moved to an area outside of their established home range

Table 2. Home range (ha) of 11 fawns and their 7 dams in the first 2 to 3 weeks postpartum, Wichita Mountains, Oklahoma, 1976 and 1977.

Doe	Fawn(s) age at capture (days)	Doe home range	Fawn(s) home range and (days survived)	
1976				
Y_1	2	1.8	1.1 (13)	
LB_1	7	1.3	0.6 (6)	
Wh_1	1	2.1	5.4 (14)	2.6 (13)
LB_2	6	4.0	0.5 (10)	
1977				
R	1	2.5	3.9 (21+)	3.1 (19)
O	1	5.7	5.1 (21+)	<1 (3)
Wh_2	1	3.1	2.3 (21+)	<1 (2)

Table 3. Average daily movement ± SE for male and female fawns at 1-3 and 4-6 days postcapture, Wichita Mountains, Oklahoma.

Sex	Sample size	Mean daily movement ± SE (m)
1-3 days postcapture	41	166.9 ± 20.6
M	22	198.4 ± 31.6
F	19	130.5 ± 23.5
4-6 days postcapture	41	130.6 ± 16.1
M	22	163.2 ± 27.4
F	19	92.8 ± 8.4

within 24 hours after death of their siblings; the fourth sibling was killed by predators less than 24 hours after its sibling was killed. Two of the 3 sibs that moved out of their home range were killed by predators the second day after the death of their sibling. The single surviving sibling which by then had returned to the previously established home range, was killed by a coyote 8 days after its twin died.

The movement of siblings, after the death of their respective twins, was presumably a response by the doe to the death of her other fawn. The association between a doe and her fawns is the strongest social bond of white-tailed deer (Hawkins and Klimstra 1970). A significant disturbance such as violent death of a fawn changes the normal behavior pattern in the primary association. Garner and Morrison (1978) described fawn home ranges in the Wichita Mountains as being significantly larger than those reported in other areas (Kjos and Montgomery 1969, Logan 1972), and suggested 1 reason might be the more open terrain. The high level of predation on fawns causes movement of surviving siblings, and thus was another factor causing larger home ranges. The increased activity of surviving siblings may have also increased the chance that they will be killed by predators.

Interspecific aggression between does and elk (Cervus canadensis) and between deer and coyotes was evident during the parturition period. Two instances of direct aggression were observed between does and elk, though deer seemed to avoid elk on WMNWR (Waldrip 1977:48) and in other areas (Kramer 1973). On 10 May 1976 a cow elk was observed pursuing a young doe, and on 30 May 1976 a doe, with a well-developed udder, was seen chasing a cow elk. Nine does were seen actively pursuing and striking coyotes between 25 May and 30 June in the 2 years of this project. Such interactions between coyotes and deer were not observed in other months. Speaking of deer at the Wichita Mountains, Garner (1976:40) stated, "Reactions of deer to nearby predators appeared to be dependent upon sex of the deer and its reproductive state." Does which had fawned exhibited the most aggressive response towards predators. Micheal (1967) described similar observations of interactions between deer and predators at the Welder Wildlife Refuge in Texas. Interspecific and intraspecific aggression by does increased simultaneously during the parturition period and this behavior seemed to reflect the strong maternal instinct of the does.

Changes in behavior of the does were observed after death of their fawns. Does were observed in the general area of their fawn's last bedsite prior to death, exhibiting what could be described as searching behavior (White et al. 1972). One radio-collared doe was observed searching in a distinct area 3 different times (ranging from about 20 minutes to just over 60 minutes) during an 8-hour period. Between searches this doe intermittently drank, ate, or bedded for short periods. As the researchers approached the doe ran a short distance, but remained nearby as the area was searched. At 1 spot where the doe had searched intensively, bone fragments, hair, blood, and hooves of a fawn were found. These remnants appeared fresh and were similar to descriptions by White (1973) and Garner et al. (1978) of fawn remains after consumption by a predator. Does observed "searching" appeared restless and exhibited various activities (grooming, feeding, etc.) for brief periods but repeatedly returned to the searching behavior.

The udder and teats of does that had recently lost their fawns were swollen. On 2 separate occasions individual does were observed that appeared to be in pain; they walked slowly, with hind legs stiffened, and often licked their swollen udders. Radio-collared does remained isolated from other deer for at least 3 days after their fawns died. Between 3 and 6 days after loss of their fawns, these does began to associate with other adult deer while feeding and resting. Such an association with other adult deer was never observed among does whose fawns were alive and less than 3 weeks old.

After losing her fawn to predators, doe LB_1 was observed for 3 days. On the third day her udder was swollen and she began feeding and resting with other does; thus, she presumably had no surviving twin fawn. Approximately 3 weeks later (after 4 additional observations of this doe) LB_1 was seen nursing a young fawn and they remained together through the duration of the summer. In the matriarchal social organization (Hawkins and Klimstra 1970) older does normally are the dominant individuals within a given family group. Hersher et al. (1963) described more subordinate goats as the most likely to adopt kids. Since doe LB_1 was 2 years old (probably subordinate in the adult doe group) and showed all signs of having lost fawns, it appears that she adopted the fawn. McGinnes and Downing (1970) documented the adoption of a fawn that had been abandoned by its mother.

Adult doe groups were increasingly common in WMNWR as summer progressed (Fig. 1), in contrast to populations with high fawn survival (Hawkins and Klimstra 1970, Hirth 1977), but similar to areas experiencing low survival of fawns (Hirth 1977). Beginning in late June group size began to increase. Relocation and observations of radio-collared or marked does revealed that stable groups of adult does (family groups) were common from midsummer through early spring. After death of their fawns, does joined with members of the herd associated with prior to parturition. Due to the low annual recruitment of fawns, the doe and fawn(s) social group described by Hawkins and Klimstra (1970) as commonly seen in summer was not the group most characteristic of WMNWR. Related adult doe groups were the more prevalent social groupings in this study area during postpartum. Only small numbers of does and fawns incorporated into these adult social units during mid- and late summer months.

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CHAPTER III

MORTALITY AND MOVEMENTS OF WHITE-TAILED FAWNS IN THE WICHITA MOUNTAINS, OKLAHOMA

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Abstract: Forty-eight white-tailed deer (*Odocoileus virginianus*) fawns were captured and released in the Wichita Mountains of Oklahoma in order to determine factors influencing mortality and movements. Two methods of marking and radio relocation were used to determine the comparative effects of these 2 treatment types. Fawn mortality was 89.6 percent through 90 days postcapture, with 90.7 percent occurring in the first 30 days. Predators were involved in 88.4 percent of the mortality, with evidence that these fawns were killed rather than fed on as carrion. Ten fawns were sacrificed and their carcasses placed in known fawn bedsites. Scavenging occurred 48 hours or more after placement. There was no evidence of scavenging on the 43 fawns released alive but later found dead. Home range increased from 0.1 ha at 7 days postpartum to 16.9 ha at 49 days postpartum. Daily movements increased from 104 m to 295 m in the same 7 weeks. Significant differences in

mortality, home range, and daily movement were not observed between the 2 marking and monitoring treatments. Male fawns had significantly larger home ranges and daily movements than females, regardless of treatment type.

Steele (1969) theorized that high mortality of fawns was regulating the white-tailed deer population of the Wichita Mountains. Garner et al. (1978) documented that fawn mortality was high, and was due to predation by coyotes (Canis latrans) and bobcats (Lynx rufus). Although the immediate cause of death of fawns was determined, Garner et al. (1978) listed disease organisms, nutritional status of does, and interspecific competition between deer and other ungulates as indirect factors which may be predisposing fawns to predators. Garner et al. (1978) also mentioned that marked fawns may have a higher mortality than unmarked fawns.

McGinnes and Downing (1970:190) described high survival (91.7 percent) of normal fawns despite handling, marking with ear tags with streamers (1.9 x 6.4 cm), and ear tattooing. White et al. (1972) indicated that capture and marking increased predator-related mortality of deer fawns by 6 to 18 percent. Ear streamer size (3.8 x 15 cm) was the factor they described as having the most influence on this increased mortality of fawns at the Welder Wildlife Refuge in southern Texas. Colored ear streamers on fawns may draw the attention of predators. In addition to the color, Queal and

Hlavachick (1968) noted that deer with ear streamers moved their ears with greater frequency than deer without ear streamers; this additional ear movement may attract the attention of predators. Other unknown factors may also have affected the mortality differences noted in southern Texas (White et al. 1972); the effects of the radio collar, tattooing, clinical samples, and later monitoring activities on mortality of instrumented animals were not determined.

This project was initiated in part to determine (1) if predation was solely responsible for regulation of the Wichita Mountains deer herd, or a function of more subtle factors (marking, disease, human interference, and interspecific or intraspecific competition), and (2) if the high mortality of fawns documented by Garner et al. (1978) would continue or was characteristic only of 1974 and 1975. This manuscript describes the factors influencing fawn mortality and movement, and the effect of 2 techniques of marking and subsequent monitoring on deer fawns in the Wichita Mountains of Oklahoma. Financial assistance for the study was provided by the Oklahoma Department of Wildlife Conservation (ODWC), Fort Sill Military Reservation (FSMR), and Oklahoma Cooperative Wildlife Research Unit (OCWRU)[1] at Oklahoma State University. The author acknowledges the

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[1]Oklahoma State University, Oklahoma Department of Wildlife Conservation, U.S. Fish and Wildlife Service, and Wildlife Management Institute cooperating.

assistance of the many individuals and agencies listed elsewhere (Bartush 1978).

STUDY AREA

The 2 intensive study sites are located on the contiguous FSMR and Wichita Mountains National Wildlife Refuge (WMNWR) in Comanche County of southwestern Oklahoma. The Wichita Mountains complex rises 427 m above the surrounding plains and is isolated from other deer ranges by agricultural land. FSMR and WMNWR comprise most of the deer range in this mountain region described by Buck (1964) and Crockett (1964). WMNWR areas utilized were generally undisturbed by human activity and protected from wildfire. FSMR contains artillery impact areas where uncontrolled range fires are common, multiple artillery firing points, observation posts, and areas where troops and tanks maneuver. WMNWR supports substantial populations of white-tailed deer, elk (Cervus canadensis), buffalo (Bison bison), and Texas longhorns (Bos taurus). White-tailed deer are the principal big game species on FSMR, though a small number of elk are also present.

Wye and Pinchot (Garner et al. 1978) were the intensive study sites. The 5,300 ha Pinchot area is entirely within WMNWR and is characterized by steep rocky ridges with tall grass prairie in level valleys; in contrast, the 3,500 ha Wye area has a more homogeneous topography with low hills and gently sloping drainages. Elevations in the Pinchot area are the highest in the mountain system, rising to 755 m, while the Wye area ranges between 427 - 488 m. Both study sites are predominantly open prairie with woods confined mainly to coarse soils located on rocky slopes and creek bottoms. Transitions between the prairie and closed-canopy woodlands are abundant, forming an abrupt edge (in data analysis, edge included a zone 15 m into each distinct habitat type) or a gradual intermediate habitat described as savanna woodland. The study sites have an estimated density of 8 to 10 deer per km^2. The Wye, encompassing portions of both FSMR and WMNWR, was treated as 2 units during data analysis--the refuge unit and Quanah unit of FSMR--due to the differences in land use practices, competitive species, and human disturbance.

MATERIALS AND METHODS

Does and fawns were observed from mountains and military towers in an effort to locate fawn bedding sites. The fawns were captured at the bedsite by a 3- or 4-man crew (Garner et al. 1978). A second successful method involved capturing and radio-collaring pregnant does. Through subsequent relocations and observation of the does, the time of parturition could be estimated and, later, the young fawns could be located and captured. Other capture methods used to a limited extent were observation of fawns from a helicopter, and subsequent capture by a ground crew in the manner described by Lund (1975), and spotlighting fawns bedded at night.

Radio transmitters were affixed to white, expandable elastic collars (110 gm) and contained temperature-sensitive units

(Wildlife Materials, Incorporated, Carbondale, Illinois)[1] installed between the transmitter package and the fawn's neck. AVM model LA12 portable receivers and hand-held 4-element yagi antennas (AVM Instrument Company, Champaign, Illinois) were used to monitor transmitter signals. The pulse rate of the transmitter changed whenever the host animal's body temperature dropped below 32^{o}C (90^{o}F). The temperature unit usually enabled researchers to determine that a fawn was alive without approaching closer than 50 m, and therefore it was unnecessary to flush it from a bedsite.

The fawns were separated into 2 groups which were marked and monitored separately. The 2 types of treatment were alternately used in each of the study sites as the fawns were captured. To fawns in group T_1 a radio collar, numbered metal ear tags, and colored ear streamers (4 x 7.5 cm) were affixed, a tattoo was placed on the left ear, the fawn was weighed, 13 body measurements were made, and blood and rectal samples were taken. This procedure generally took from 10 to 20 minutes. Fawns in group T_2 were handled less and marked less distinctively. A radio collar was affixed but no ear tags or ear streamers were attached, and the ear was not tattooed; only 4 measurements were made on these fawns, they were weighed, and a rectal swab was taken. T_2 animals were usually

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[1]Mention of the manufacturer of a product does not constitute endorsement by the author.

handled in less than 10 minutes. T_1 individuals were observed daily, with physical appearance and behavior used to ascertain the fawns' condition. T_1 fawns usually flushed from the bedsite after 14 days of age. T_2 fawns were triangulated at distances of 50 - 250 m from the researchers and status determined by pulse of the temperature device within the collar, eliminating human disturbances after capture and release. Long distance triangulations ($<$ 250 m) of instrumented animals were avoided due to the severe bounce or deflection of high frequency signals in the rocky terrain.

Locations of fawns were recorded on standardized field forms and accompanying sketch maps. Daily movements were calculated from measurements between successive 24-hour locations plotted on overlays of large-scale aerial photographs. Daily movements and home range were averaged by weeks of age; a fawn had to be monitored at least 4 days within each week of age before its home range or daily movement were included in a specific age category. Jackson et al. (1972:264) employed a similar age group technique in order to decrease the variation in activity data gathered from individual fawns. Home range estimations were calculated using the modified-minimum-area technique (Harvey and Barbour 1965). Areas were measured using a compensating polar planimeter.

All fawn mortalities were documented on field forms. Descriptions of Smith (1945), Dill (1947), Cook et al. (1972), Beale and Smith (1973), White (1973), and Garner et al. (1978) were used as criteria to distinguish causes of mortality. Disposition of the carcass, characteristics of wounds and the death site, predator or scavenger sign in the vicinity of the death site, carcass consumption, and collar condition were used to distinguish between predator-involved mortalities and mortalities not involving predators (Garner et al. 1978). When entire fawn carcasses were found, they were taken to the Oklahoma Animal Disease Diagnostic Center for necropsy. Partial remains or slightly decomposed carcasses were frozen for later necropsy at Oklahoma State University School of Veterinary Medicine. The School of Veterinary Medicine completed a hemogram, identified parasites from blood samples, and analyzed rectal swabs for *Salmonella* sp.

Ten fawn carcasses were obtained from the Kerr Wildlife Management Area, Texas, through the aid of biologist Greg Butts of the Texas Parks and Wildlife Department. These carcasses were used to differentiate between direct predation and scavenging on fawns. The fawns were asphyxiated and frozen immediately after capture. Each carcass was handled carefully to keep it as free as possible from unnatural odors. All carcasses were radio-collared, and 5 had ear tags and colored ear streamers attached in order to duplicate the T_1 and T_2 marking procedures. The 10 carcasses were then placed in bedsites which had been used recently by live fawns at randomly selected points within the study area. The carcasses were checked daily and the time interval between placement and disturbance by predators or carrion-eaters was recorded.

Home range and daily movement data were analyzed using the Statistical Analysis System computer programs (Service 1972). These data were categorized by weekly age groups. Analysis of variance procedures, with Student's t and standard F tests, were used during statistical treatment of data (Steel and Torrie 1960). The null hypotheses of no difference between groups of data were rejected whenever the test result was ≤ 0.05.

RESULTS

Mortality

Forty-eight fawns were captured--20 in 1976 and 28 in 1977; 24 fawns (10 in 1976 and 14 in 1977) received each treatment type in the 2 years of this project. Forty-three of the 48 fawns died (89.6 percent) within 3 months postcapture (Table 1). Most of the 43 fawns died within 30 days postcapture (38 of 43; 90.7 percent), with 4 remaining animals surviving from 36 to 63 days after release (Table 2). Garner et al. (1978) found that fawn mortality occurred over a longer period of time with only 55.2 percent occurring in the first 30 days.

Thirty-eight of the mortalities (88.4 percent) involved predators, 2 involved starvation and/or abandonment, causes of death of 2 were unknown, and 1 drowned (Table 1). Three of the 48 cultures from rectal swabs were positive for *Salmonella* sp. bacteria (all 3 positive in 1977), though none of the clinical symptoms (Robinson et al. 1970) of this disease were observed. Mortality of male

Table 1. Survival and causes of mortality among 48 radio-collared white-tailed deer fawns, grouped by T_1 and T_2 marking and monitoring treatments, Wichita Mountains, Oklahoma, 1976 and 1977.

Status of Fawns	No. of fawns			% Of fawns in treatment group			% Of deaths in treatment group		
	T_1	T_2	Total	T_1	T_2	Total	T_1	T_2	Total
Total marked	24	24	48	50	50	100.0			
Survived 6 months or longer	4	1	5	16.7	4.2	10.4			
Mortalities:	20	23	43	83.3	95.8	89.6			
Predation not involved:									
Starvation	1	1	2	4.2	4.2	4.2	5.0	4.3	4.6
Accidental (drowned)		1	1		4.2	2.1		4.3	2.3
Unknown factors	1	1	2	4.2	4.2	4.2	5.0	4.3	4.6
Subtotal	2	3	5	8.3	12.5	10.4	10.0	13.0	11.6
Predation-involved:									
Coyote	3	7	10	12.5	29.2	20.8	15.0	30.4	23.2
Bobcat	1		1	4.2		2.1	5.0		2.3

Table 1. (Continued)

Status of fawns	No. of fawns			% Of fawns in treatment group			% Of deaths in treatment group		
	T_1	T_2	Total	T_1	T_2	Total	T_1	T_2	Total
Coyote probable	7	6	13	29.2	25.0	27.1	35.0	26.1	30.2
Bobcat probable		1	1		4.2	2.1		4.3	2.3
Predator unknown	6	6	12	25.0	25.0	25.0	30.0	26.1	27.9
Predator unknown plus other factors	1		1	4.2		2.1	5.0		2.3
Subtotal	18	20	38	75.0	83.3	79.2	90.0	86.9	88.4

Table 2. Survival and mortality history of fawns radio-monitored in the Wichita Mountains, Oklahoma, 1976 and 1977.

		Days		
Fawn number	Sex-and study site	Age[a] at capture	Survived postcapture	Primary cause of death
C 1[b]	M-W[c]	6	11	Predator + other factors
C 2	F-W	8	2	Probable coyote
C 3	F-P	9	5	Starvation
C 4	M-W	9	6	Probable coyote
C 5	M-W	1	14	Coyote
C 6	M-P	10	Alive[d]	
C 7	M-P	9	27	Probable coyote
C 8	M-W	7	7	Coyote
C 9	M-P	10	Alive	
C 10	M-P	18	49	Unknown
Z 1	M-W[f]	10	6	Probable coyote
Z 2	F-W[f]	5	8	Coyote
Z 3	M-P	6	19	Coyote
Z 4	F-W	8	17	Probable coyote
Z 5	F-W	7	13	Predator unknown
Z 6	M-W	1	13	Predator unknown
Z 7	F-P	2	15	Coyote
Z 8	F-P	6	10	Coyote

Table 2. (Continued)

Fawn number	Sex and study site	Days: Age[a] at capture	Days: Survived postcapture	Primary cause of death
Z 9	F-P	10	54	Unknown
Z 10	M-P	10	15	Probable coyote
D 1	M-W	3	8	Coyote
D 2	F-W	7	11	Predator unknown
D 3	F-W	8	1	Predator unknown
D 4	M-W	7	6	Probable coyote
D 5	M-W_f	8	14	Bobcat
D 6	F-P	1	Alive	
D 7	M-P	7	26	Predator unknown
D 8	F-W	8	5	Probable coyote
D 9	M-P	14	16	Probable coyote
D 10	F-P	15	63	Predator unknown
D 11	F-W	16	13	Predator unknown
D 12	M-P	1	27	Predator unknown
D 13	M-P	1	36	Probable coyote
D 14	F-W_f	12	Alive	
T 1	F-W	3	11	Coyote
T 2	F-W_f	7	14	Coyote
T 3	M-W	2	1	Probable bobcat

Table 2. (Continued)

Fawn number	Sex-and study site	Days: Age[a] at capture	Days: Survived postcapture	Primary cause of death
T 4	F-W	5	8	Probable coyote
T 5	F-W	3	6	Coyote
T 6	F-P	6	7	Predator unknown
T 7	M-P	1	2	Drowned
T 8	M-W	7	11	Predator unknown
T 9	M-P	8	18	Probable coyote
T 10	M-W	14	17	Probable coyote
T 11	F-P	12	3	Probable coyote
T 12	F-P	3	Alive	
T 13	F-P	1	19	Predator unknown
T 14	M-P	1	4	Starvation

[a]Fawns aged using technique of Haugen and Speake (1958).

[b]C and D prefixes indicate fawns in T_1 treatment group in 1976 and 1977, respectively; Z and T prefixes indicate fawns in T_2 treatment group in 1976 and 1977, respectively.

[c]W designates Wye area; P designates Pinchot area; W_f indicates fawns captured on FSMR portion of the Wye area.

[d]Fawn survived through 1 November 1977.

fawns (23 of 25; 92 percent) was not significantly ($t \leq 0.05$) different than mortality of females (20 of 23; 87 percent). Statistical differences in mortality were not observed between study areas.

Cause of death for fawns C 3 and T 14 was listed as starvation (Table 2). Fawn C 3 was observed nursing a doe 2 days after capture and the presumed dam showed no sign of rejection. On the fourth day postcapture, C 3 was observed walking about and made 2 attempts to approach a pair of adult does; both times the fawn was rejected. On the fifth day the fawn was found dead. C 3 was obviously emaciated and necropsy confirmed death by starvation. Fawn T 14 was a sibling of fawn D 13 and both were captured at their birth site (Bartush 1978). The dam was 2 years of age and had been radio-collared the previous winter. T 14 was marked and monitored by T_2 procedures, while D 13 was a T_1 type. Fawn T 14 was apparently abandoned at or near the birth site, while D 13 remained in good physical condition through 36 days of age when it was killed by a coyote. The fawns were probably the first offspring of this doe, which may account for the acceptance of 1 sibling and rejection of the other. These cases of abandonment did not appear to be caused by marking and handling procedures. Marking and handling of fawns in Virginia (McGinnes and Downing 1970) also appeared to have no adverse effect on survival.

Fawn T 7 (Table 2) apparently drowned within 48 hours after it was born. This fawn was marked at its birth site within 24 hours postpartum and though it appeared in good condition, was somewhat uncoordinated at this age. T 7 was found in a depression containing 0.5 m of water lined with rocks and grass which possibly prevented its escape and caused it to drown.

All fawns captured in this study were checked daily by triangulation, thus mortalities were documented no less than 24 to 30 hours after death. The 10 fawn carcasses provided by the Texas Parks and Wildlife Department and placed in known bedsites provided evidence (from feathers, tracks, scats, broken bones, etc.) that scavenging occurred 48 hours or more after placement (Table 3) and 8 of 10 carcasses had been fed on by vultures (Cathartes aura). In contrast, there was no evidence of scavenging by vultures on carcasses of the 43 fawns released alive but later found dead during this project. The amount of carcass consumed was less and the extent of decomposition was greater on the placed fawn carcasses when compared to radio-collared fawns which died of natural causes after release. This and other evidence indicated that (1) daily monitoring of fawns provided accurate information on the status of radio-collared individuals, and (2) substantiated the fact that direct predation was the principal mortality agent of fawns in this study, rather than "unknown" factors which were followed by consumption of the carcass by scavengers and/or predators.

Measurements of habitat surrounding fawn bedsites (Bartush 1978) and elk calf bedsites (Waldrip 1977:48) indicated that the 2

Table 3. Time elapsed and types of factors disturbing 10 carcasses of fawns that were sacrificed and placed in bedsites previously used by fawns in the Wichita Mountains, Oklahoma, 1977.

	Total carcasses	
Category	Number	%
Carcasses undisturbed for:		
24 hours	10	100
48 hours	6	60
72 - 80 hours	2	20
Disturbed within 24 - 48 hours:		
Predators and vultures	3	30
Vultures only	1	10
Disturbed within 48 - 72 hours:		
Vultures only	4	40

species had different preferences for bedding habitat. Elk preferred steep wooded slopes with substantial boulder cover, while deer used prairie areas without boulders. Interactions between does and between does and cow elk were observed, but there was no evidence of intra- or interspecific competition for fawning or calving sites, that might have influenced susceptibility to predation.

General habitat types in the vicinity of fawn bedsites were tabulated in relation to total habitat available (Table 4). Prairie comprised the majority (60 to 80 percent) of the habitat, but in all study sites fawns preferred savanna edge and closed forest habitats for bedsites (x^2, $P < 0.05$). This preference was even more apparent in the bedsites used by fawns 24 hours prior to being killed by a predator. Twenty-two (57.9 percent) bedded in savanna 24 hours prior to death, indicating that fawns are more vulnerable to predators in savanna than in prairie or closed forest. Radio-collared coyotes used savanna habitat significantly more than its availability on WMNWR (Litvaitis 1978:19) which may be a factor involved in the high mortality of fawns located in this habitat prior to death.

Home Range and Daily Movement

Significant differences did not exist between 1976 and 1977 home range and daily movements, nor did they exist between study areas, so further analysis was completed with all data combined. Home range (Fig. 1) and daily movements (Fig. 2) generally increased through the first 7 weeks of age. Differences between fawns of 1

Table 4. General habitat types available and those selected as daytime bedsites by fawns, Wichita Mountains, Oklahoma, 1976 and 1977.

Habitat type	(Number of fawn bedsites) and % of habitat				
	Pinchot	WMNWR portion of Wye	FSMR portion of Wye	All study areas	Predator-associated mortalities
Prairie					
Available	73.1	62.1	80.8	70.1	70.1
Utilized	(378) 59.6	(93) 59.2	(12) 19.7	(483) 56.7	(14) 36.8
Closed forest					
Available	12.1	21.4	10.5	14.7	14.7
Utilized	(91) 14.4	(20) 12.7	(24) 39.3	(135) 15.8	(2) 5.3
Savanna and edge					
Available	14.8	16.5	8.7	15.2	15.2
Utilized	(165) 26.0	(44) 28.1	(25) 41.0	(234) 27.5	(22) 57.9

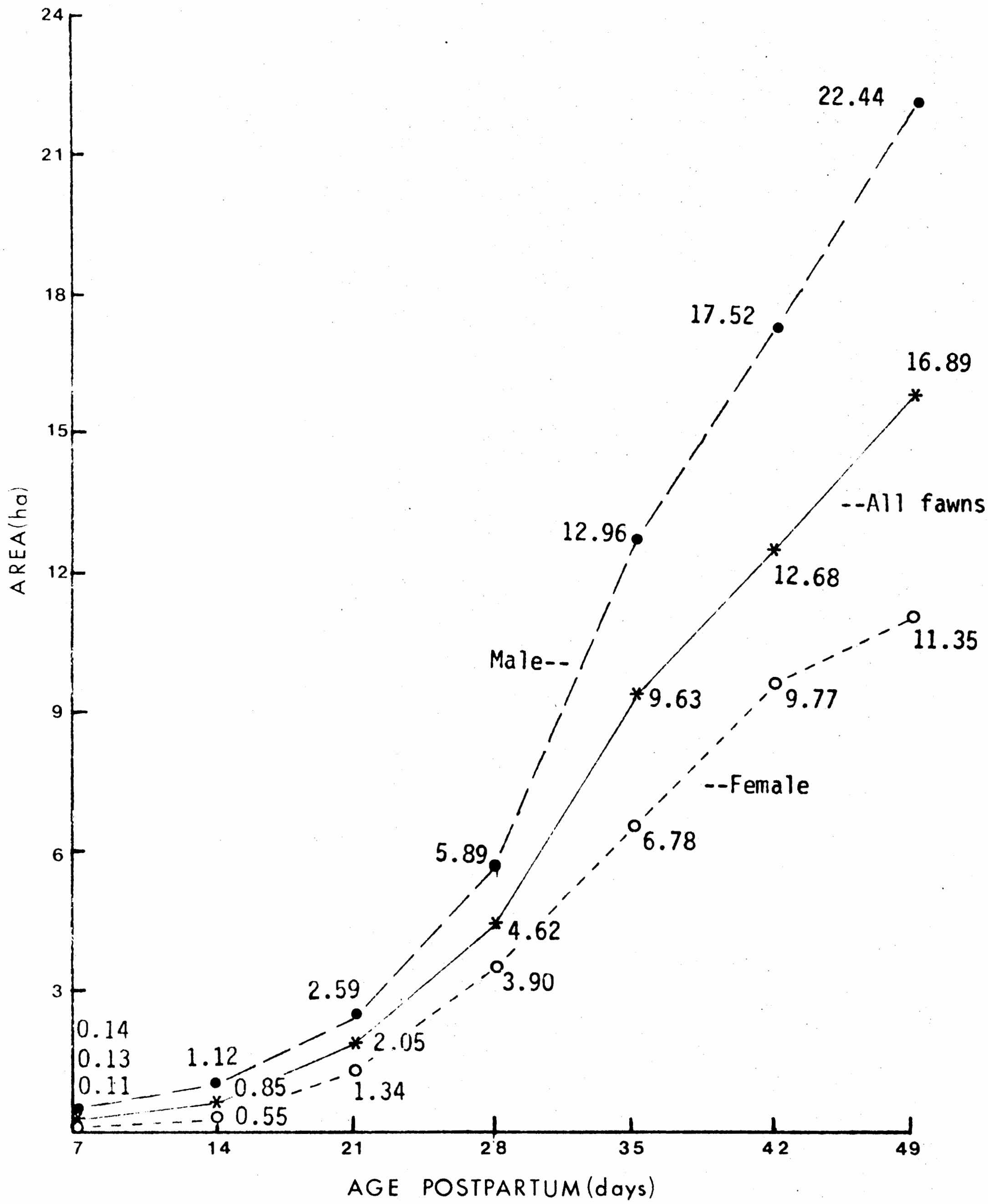

Fig. 1. Average home range of fawns at weekly age intervals, Wichita Mountains, Oklahoma, 1976 and 1977.

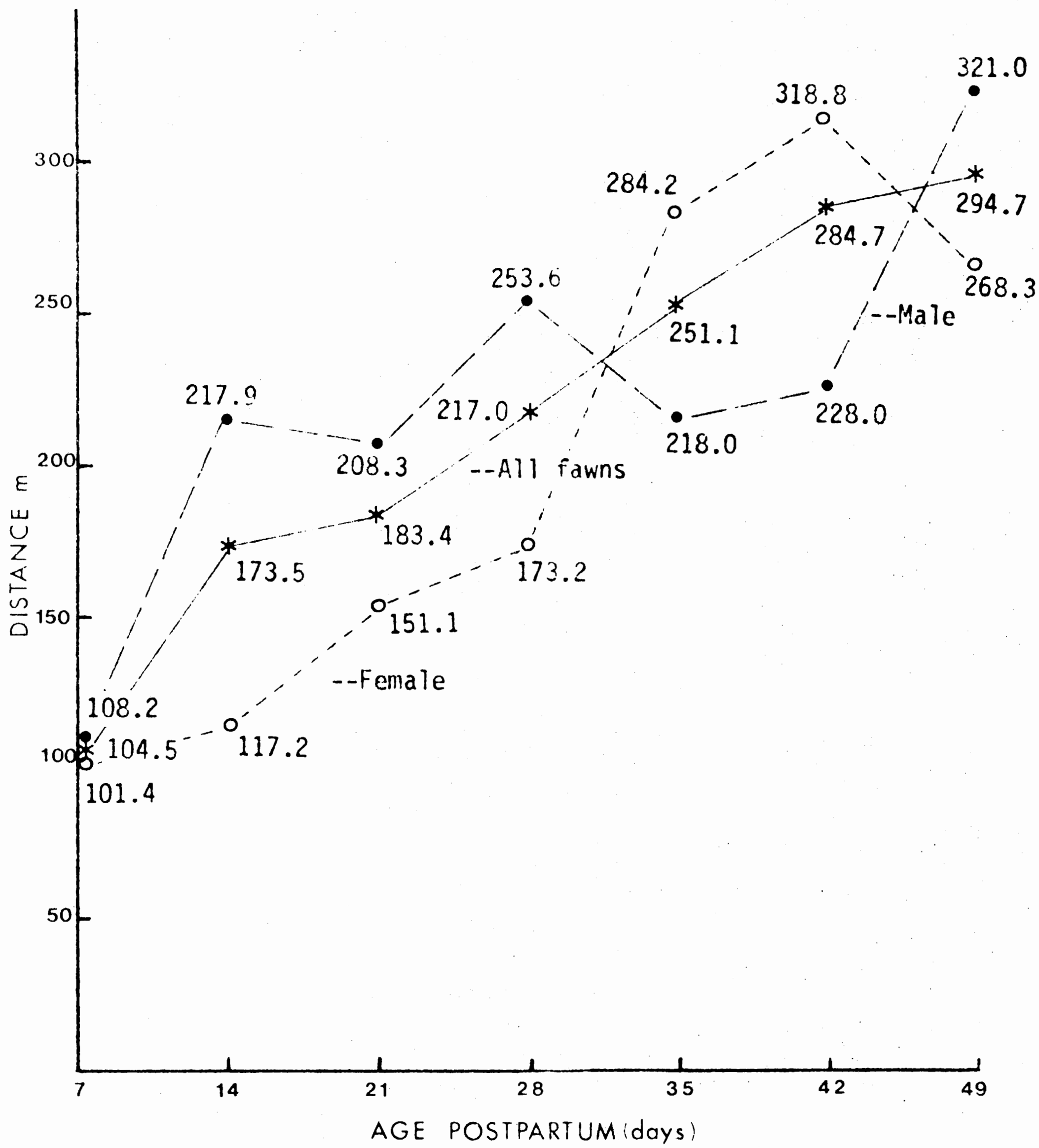

Fig. 2. Average daily movements of fawns at weekly age intervals, Wichita Mountains, Oklahoma, 1976 and 1977.

week and 7 weeks of age were significant in both home range and daily movement. Significant differences also occurred in home range between each successive week postpartum, from the first through the fifth week (i.e., 1 vs 2, 2 vs 3, etc.). Daily movement at each successive age group was only significantly different between the first and second weeks postpartum.

Home ranges and daily movements of male fawns were generally greater than those of females at each respective age group (Figs. 1 and 2); however, the only significant difference occurred in daily movement in the second week postpartum.

Treatment Comparisons

Twenty of the 24 T_1 fawns died during the study (8 in 1976, 12 in 1977). One fawn was considered abandoned, the cause of death of 1 was unknown, and the remainder were predator-associated mortalities (Table 1). The age of these fawns at capture ranged from 1 to 18 days in 1976 ($\bar{x}$ 8.7) and 1 to 16 days in 1977 ($\bar{x}$ 7.7) (Table 2). Days surviving after capture of all mortalities ranged from 1 to 49 ($\bar{x}$ 15.0) and 1 to 63 ($\bar{x}$ 18.8) in the respective years (Table 2). Two T_1 fawns tested positive for Salmonella sp. bacteria at capture but lived in excess of 2 weeks after that time. These animals appeared in good health at each observation until predator-associated mortality, and did not seem adversely affected by this microorganism.

Twenty-three of the 24 T_2 fawns died during the study (10 in 1976 and 13 in 1977) (Table 1); 1 drowned, 1 was abandoned, cause of death of 1 was unknown, and the remainder were predator-associated mortalities (Table 1). Ages at capture ranged from 1 to 10 days ($\bar{x}$ 6.5) in 1976 and 1 to 14 days ($\bar{x}$ 5.2) in 1977 (Table 2). Days alive postcapture of all mortalities were 6 to 54 days ($\bar{x}$ 17.6) and 1 to 19 days ($\bar{x}$ 9.3) respectively in 1976 and 1977 (Table 2). One T_2 fawn tested positive for *Salmonella* sp. and died 2 days after capture. The direct cause of death of the latter fawn was predation; however, the *Salmonella* may have made the fawn more susceptible to predation.

Comparisons of home range and daily movement between treatment types were not made after 7 weeks postpartum because of the small sample for comparison (6 T_1 and 2 T_2 fawns). Home range and daily movements were not significantly different between T_1 and T_2 treatments at ages 1 to 7 weeks (Table 5). The differences (although not significant) that appear to exist between treatments can be partially explained by differences in sex ratio within each treatment type. Thirty-eight percent of T_1 fawns were females, while T_2 fawns were 58 percent females. Significant differences in home range were found between sexes (Table 5) within T_1 individuals at 35- and 42-day age groups, supporting the idea that sex rather than treatment type may have a greater influence on movements and home range of

Table 5. Average home range and daily movements of fawns by 7-day age groupings, Wichita Mountains, Oklahoma, 1976 and 1977.

Age group	Home range (ha)		Daily movements (m)	
(days)	(N) Male	(N) Female	(N) Male	(N) Female
T_1				
0-7	(4) 0.2		(4) 127	
8-14	(13) 1.1	(4) 0.3	(13) 221	(4) 113
15-21	(10) 3.0	(4) 1.0	(9) 231	(4) 147
22-28	(7) 6.5	(3) 3.4	(7) 254	(3) 192
29-35	(5) 13.0[a]	(3) 5.5	(5) 218	(3) 223
36-42	(3) 17.5[a]	(3) 6.9	(3) 228	(3) 200
43-49	(3) 22.4[a]	(3) 11.8	(3) 321	(3) 289
T_2				
0-7	(2) 0.1	(6) 0.1	(2) 71	(6) 99
8-14	(6) 1.1	(11) 0.6	(6) 212	(11) 119
15-21	(4) 1.6	(7) 1.5	(4) 156	(6) 154
22-28		(2) 4.7		(2) 145
29-35		(2) 8.7		(2) 376
36-42		(2) 14.0		(2) 346
43-49		(2) 14.3		(2) 248

[a]Significantly different ($P < 0.05$) from corresponding value of female fawn.

fawns. However, no significant differences in home range or daily movement were observed between sexes of T_2 individuals.

DISCUSSION

Mortality rates of captured fawns were suspected by Cook et al. (1971) and Garner et al. (1978) to be somewhat higher than the fawn mortality that actually existed on their study areas. Fawns marked with larger ear streamers (3.8 x 15 cm) by White et al. in Texas (1972) had a higher predator-related mortality than fawns with smaller (3.8 cm^2) ear streamers. The larger ear streamers used by White et al. (1972) were almost twice as long as those used in the Wichita Mountains Study (4 x 7.5 cm). In Oklahoma there were no significant differences in fawn mortality, movement, or home range between treatments T_1 and T_2.

Differences in movement and home range between sexes within the treatment types does exist. The accelerated activity of male fawns was characterized by larger home ranges and movements than female fawns at each progressive age grouping. The increased movements and home range among male fawns is no doubt due to their greater activity than females of the same age (Jackson et al. 1972).

The fawn mortality (89.6 percent) recorded in this study was similar to the 87.9 percent mortality reported by Garner et al. (1978). Predation was also determined as the principal mortality agent of fawns, rather than disease, human disturbance (marking and monitoring), or competition for fawning sites. This project affirms the findings of Garner et al. (1978) that predators are capable of taking substantial numbers of healthy fawns in the Wichita Mountains area. Radio collars and monitoring activities may increase the susceptibility of fawns to predation; however, any such increase did not appear significant and did not change the conclusion that predators are the principal agent presently controlling deer herd growth on WMNWR. Until more sophisticated materials and techniques are devised for fawn mortality studies, it appears that discrete color marking, radio collars, and subsequent monitoring, will remain the best method for documenting the ecology of deer fawns.

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CHAPTER IV

VEGETATIONAL AND PHYSICAL COMPONENTS OF BEDSITES OF WHITE-TAILED DEER FAWNS

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Abstract: Daytime bedsites of radio-collared white-tailed deer (*Odocoileus virginianus texanus*) fawns were studied to determine the general vegetational and physical characteristics of each site. One hundred ninety-nine bedsites of fawns ranging from 1 to 90 days of age were examined in 1976 and 1977. Fifty-five percent of all bedsites occurred in prairie, 30 percent in savanna, and 15 percent in closed forest. Fawns of all age groups bedded most frequently in open prairie. Bedsites occurred on 7 of the 8 range sites present in the Wichita Mountains National Wildlife Refuge (WMNWR). Seventy-two herbaceous and woody plant species were found at the bedsites; species recorded in each range site were characteristic of the climax vegetation. Fawns utilized range sites composed primarily of woody vegetation (closed-canopy and savanna woodland) when ambient air temperatures were high and cloud cover was low. The fawns' use of bedsites in open prairie is discussed and the need to define

habitat requirements of white-tailed deer fawns in other populations is noted.

White-tailed deer populations in Texas (Cook et al. 1971, White et al. 1972, Carroll and Brown 1977) and Oklahoma (Bolte et al. 1970, Logan 1972, Garner et al. 1978) experienced high mortality of fawns due to predation, disease, parasites, or a combination of these factors. Until recently (Kjos and Montgomery 1969, Garner 1976) fawn-rearing habitat had not been studied as a vital component of fawn ecology and survival.

Radio telemetry has increased the opportunities of researchers to evaluate the ecology of secretive animals such as the white-tailed deer fawn. Kjos and Montgomery (1969) qualitatively studied fawn habitat in Illinois by placing radio collars on 2 white-tailed fawns and regularly recording general characteristics of their bedsites. Garner (1976) evaluated species composition, cover, and physical factors associated with 28 bedsites of 5 fawns to which radio transmitters had been affixed in the Wichita Mountains of southwestern Oklahoma. This paper presents characteristics of 199 bedsites used by 46 fawns and supplements the information reported by Garner (1976).

Data were collected from May through August, 1976 and 1977, in conjunction with a study of fawn mortality. Financial assistance was provided by the Oklahoma Department of Wildlife Conservation

(ODWC), Fort Sill Military Reservation (FSMR), and the Oklahoma Cooperative Wildlife Research Unit (Oklahoma Department of Wildlife Conservation, Oklahoma State University, Wildlife Management Institute, and U.S. Fish and Wildlife Service cooperating) at Oklahoma State University. Appreciation is extended to the many individuals who assisted during this project.

STUDY AREA

The study area is located in the Wichita Mountains of Comanche County, southwestern Oklahoma. The mountain complex is isolated from other deer ranges by agricultural land. The 23,917 ha WMNWR and the 38,193 ha FSMR contain most of the mountains and portions of these areas were specific study areas.

The climate is temperate, continental, and of the subhumid type (Soil Conservation Service 1967). Average yearly precipitation is 73.5 cm, with monthly temperature averages of 3.7^{o}C in January and 27.6^{o}C in August (70 years of WMNWR records, National Oceanic Atmospheric Administration 1976). The precipitation totals in 1975, 1976, and 1977 were 106.7 cm, 70.5 cm, and 76.3 cm respectively.

The topography of the Wichita Mountains ranges from nearly level prairies to rocky hillsides exceeding 20 degrees slope. The mountain complex rises to approximately 427 m above the plains outside WMNWR and FSMR. The highest peak is 755 m above sea level. Buck (1964) described the mountains as monadnocks, the igneous roots of an earlier mountain system once covered by sedimentary material. Soils are primarily derivatives of sedimentary (limestone and shale) and igneous (granite, gabbro, and rhyolite) parent materials.

The diverse vegetation types are the result of geologic and soil variations. Prairie composes the majority of the area (Garner et al. 1978). Tall grass species including big bluestem (Andropogon gerardii), little bluestem (Schizachyrium scoparium), sand bluestem (Andropogon hallii), switchgrass (Panicum virgatum), and Indiangrass (Sorghastrum nutans) predominated the areas of deep, moist soils. Short grasses like blue grama (Bouteloua gracilis), hairy grama (B. hirsuta), side-oats grama (B. curtipendula), and buffalograss (Buchloe dactyloides) occurred on droughty soils. Forbs such as Western ragweed (Ambrosia psilostachya), Louisiana sagewort (Artemisia ludoviciana), tickseed (Coreopsis tinctoria), and thelesperma (Thelesperma filifolium) were also common.

Wooded areas are found principally in creek bottoms and on coarse soils and fracture lines on the rocky uplands. Common upland tree species are blackjack oak (Quercus marilandica) and post oak (Q. stellata); creek-associated species include elm (Ulmus americana), hackberry (Celtis spp.), pecan (Carya illinoensis), and other oaks (Quercus spp.). Eastern red cedar (Juniperus virginiana) is found in both wooded communities. The intergrading of prairie and wooded habitats is common and forms what is best described as savanna. The Wichita Mountains area has been described in detail by Buck (1964) and Crockett (1964).

Eight range sites (Soil Conservation Service 1967) occur on WMNWR (eroded clay, loamy bottomland, loamy prairie, hardland, boulder ridge, hilly stony, hilly stony savanna, and hardland-slickspots). Each range site contains 1 or more soil mapping units that have unique physical features, soil type, and vegetative potential.

The Wye area (in both WMNWR and FSMR) and the Pinchot area (in WMNWR) were used as study sites for capture of fawns and study of their bedsites. Located on FSMR and WMNWR, the Wye area has elevations between 427 m and 488 m above sea level with gentle slopes rarely exceeding 10 percent. Entirely within WMNWR, the Pinchot area contains the highest elevations (up to 755 m) in the mountain complex with slopes of 10 to 20 percent common. Garner et al. (1978) described these areas in detail.

METHODS AND MATERIALS

Forty-eight fawns were captured by use of methods described by Bartush (1978) and Garner et al. (1978), radio collars were affixed, and the fawns were released at the capture site. Bedsites subsequently were located by triangulation and observation of the bedded fawns. Individual bedsites chosen for analysis were selected at regular 3-day intervals (i.e., 3, 6, 9 . . . . days after capture). Bedsites were located during daylight hours; however, they were also believed to be characteristic of nocturnal bedsites because many were selected in early morning or late evening hours and fawns are relatively inactive at night (Jackson et al. 1972). Capture locations were also included in the analysis when the fawn was observed bedded prior to capture.

Weather conditions (temperature, cloud cover, wind speed and direction) were recorded, and the site was then marked. Physical and vegetative characteristics of each site were measured within 2 weeks after the fawn had bedded there. Each bedsite location was recorded on a standardized form with an accompanying sketch map. These maps were used to find the location of the bedsites on large-scale aerial photographs. The specific mapping unit and range site was then determined by comparing the plotted location to published soil-survey photomaps (Soil Conservation Service 1967). A soil survey was not available for FSMR, but bedsites on FSMR that bordered WMNWR, and which appeared to be on the same land form and soil type, were included for analysis in the appropriate range site classification.

Vegetative and physical characteristics of the bedsites were measured by use of a combination line transect and line-intercept method (Waldrip 1977). Two bisecting perpendicular transects (20 x 2 m) were established; these intercepted at the center of the bedsite. The up-slope transect was established on the compass bearing of the bedsite's aspect; the cross-slope transect was established at 90^{o} from the up-slope bearing. The number of tree species and boulder density were recorded by direct counts on the transects. The canopy cover of tree species and boulder cover was determined by linear distance of overhead cover of trees (>2 m) and distance to boulders. Boulders (those with horizontal surface area <1 m^2) were classed by height: Class I, 0 - 0.5 m; Class II, 0.5 - 1.0 m; and Class III, >1 m.

The 4 dominant plant species (<2 m in height) at the bedsite were listed in descending order of occurrence. Four measurements of vegetation, standing litter, and visual obstruction were taken 1 m from the center of the bedsite on the 2 transects. Height of the tallest vegetation and standing litter within 10 cm of the measuring pole were recorded. Visual obstruction was judged by use of a density pole (Robel et al. 1970) read 1 m from the center of the bedsite at 0.5 m in height. Vegetative density at each bedsite was classified from 1 (sparse) to 3 (dense); factors used to subjectively establish this rating were vegetation height, density, and visual obstruction. Visual obstruction measurements and line transect data (tree density, canopy cover, boulder density and cover) were only recorded in 1977.

Physical measurements recorded at the site included aspect (compass bearing), percent slope (abney level), estimated distance to nearest woody cover, estimated distance (if <400 m) to nearest boulder (by boulder size class), and transect coordinates. Other information included on data sheets were general habitat type (prairie, closed-canopy forest, and savanna), range site, and elevation. Humidity (at noon) and other weather conditions 24 hours preceding use of the bedsite were based on FSMR weather records. Fawn age classes were categorized by 2-week age groups (0-14, 15-28, 29-42, 42+) to facilitate some analysis. Scientific names for grasses (Poaceae) were from Gould (1975); all others were from Waterfall (1972). Statistical Analysis System (SAS) computer programs were used to statistically analyze data.

RESULTS

A total of 199 daytime fawn bedsites were analyzed, 75 in 1976 and 124 in 1977. Ages of fawns using these bedsites ranged from 1 to 90 days. One hundred twenty-five bedsites were within Pinchot and 74 bedsites were at the Wye (50 on WMNWR and 24 on FSMR). Fifty-five percent (109) of all bedsites occurred in grassland, 30 percent (60) in savanna, and 15 percent (30) in closed forest (Table 1). Fawns in the Pinchot and Wye areas on WMNWR primarily used open prairie. Fawns on FSMR utilized the woody habitats (Table 1) significantly more than WMNWR individuals (x^2 = $P < 0.025$). Fawns of 4 age categories used prairie as bedsites more than the other habitat types (Fig. 1).

Seventy-two plant species were found at bedsites during the 2 years. Sixty-four species were less than 2 m in height; the remaining 8 were trees (>2 m) found along the line transects. The

Table 1. General habitat type at fawn bedsites on each study site, Wichita Mountains, Oklahoma, 1976 and 1977.

	General habitat type		
Study sites	Grassland (N) %	Closed forest (N) %	Savanna (N) %
Wye-FSMR	(7) 29	(6) 25	(11) 46
Wye-WMNWR	(29) 58	(4) 8	(17) 34
Pinchot	(73) 58	(20) 16	(32) 26
Total	(109) 55	(30) 15	(60) 30

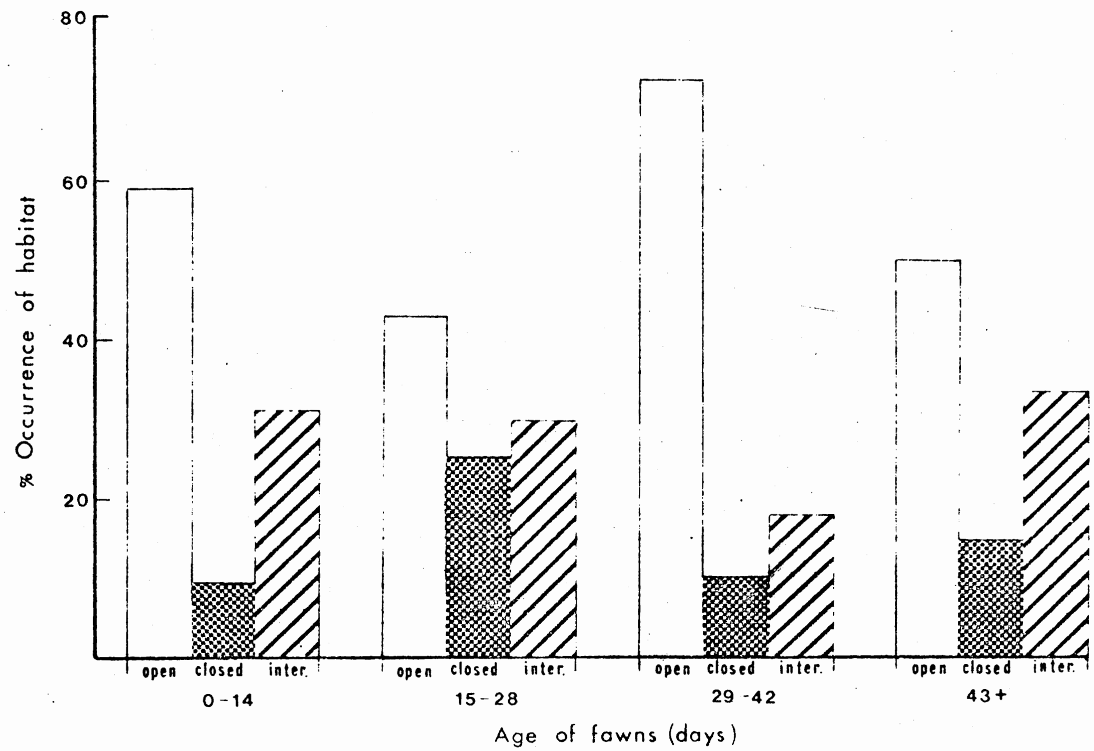

Fig. 1. Percent occurrence of open prairie, closed forest, and intermediate (includes savanna woodland and edge) habitat types surrounding bedsites of fawns of 4 age groupings, Wichita Mountains, Oklahoma, 1976 and 1977.

predominant species (< 2 m) were primarily prairie grasses and some forbs (Table 2). Taller woody cover was comprised mostly of oaks and Eastern red cedar.

No significant differences were found between up-slope and cross-slope transects of vegetation, visual obstruction, and litter heights; consequently all measurements of these categories in the 2 transects were pooled for further statistical treatment of each bedsite.

Range Site Descriptions

The designation of each bedsite into the appropriate range site appeared to be the most accurate method of describing fawn bedsites by general habitat type. These range site designations in part represent the habitat types found at the respective bedsites. Distance to nearest woody cover at each fawn bedsite indicated the general habitat type in the appropriate range site. All bedsites which occurred on the range sites supporting woody vegetation and unmapped portions of FSMR (which were primarily wooded) averaged less than 4 m from the nearest woody cover; on range sites containing mostly grassland, bedsites averaged more than 20 m to the nearest woody cover.

Seven of the 8 range sites available on the WMNWR were used by fawns as locations for bedsites. Much of the WMNWR unit of the Wye area is in the boulder ridge range site, which accounts for this site's heavy use by fawns (Table 3). Loamy bottomland, loamy

Table 2. Common name, scientific name, occurrence, and percent occurrence of the 22 predominant plant species in 2 height categories found at fawn bedsites, Wichita Mountains, Oklahoma, 1976 and 1977.

Height category and common name	Scientific name	Occurrence	% Occurrence
Vegetation < 2 m			
Little bluestem	Schizachyrium scoparium	131	17.7
Big bluestem	Andropogon gerardii	74	10.0
Indiangrass	Sorghastrum nutans	70	9.5
Western ragweed	Ambrosia psilostachya	59	7.9
Switchgrass	Panicum virgatum	53	7.2
Scribner's panicum	Panicum spp.	44	5.8
Brome	Bromus spp.	37	5.0
Sedge	Cyperus spp.	28	3.8
Tall dropseed	Sporobolus asper	27	3.7
Green muhly	Muhlenbergia racemosa	16	2.2
Buckbrush	Symphoricarpos orbiculatus	16	2.2
Vegetation > 2 m			
Blackjack oak	Quercus marilandica	80	27.3
Post oak	Quercus stellata	57	19.5
Eastern red cedar	Juniperus virginiana	46	15.7
American elm	Ulmus americana	23	8.5

Table 2. (Continued)

Height category and common name	Scientific name	Occurrence	% Occurrence
Pecan	*Carya illinoensis*	16	5.5
Hackberry	*Celtis* spp.	14	4.8
Black walnut	*Juglans nigra*	13	4.5
Chittamwood	*Bumelia lanuginosa*	10	3.4
Mesquite	*Prosopsis glandulosa*	8	2.7
Buttonbush	*Cephalanthus occidentalis*	7	2.4
Western soapberry	*Sapindus drummundii*	6	2.1

Table 3. Availability and utilization of range sites as fawn bedsites, and the number and percent of these beds occurring in the 7 range sites on the 2 major study sites in the Wichita Mountains, Oklahoma, 1976 and 1977.

Range site	(N) % Of fawn bedsites			% Available
	Pinchot	Wye	Total	on study area
Loamy bottomland	(1) 1	(9) 18	(10) 5	3
Boulder ridge	(9) 7	(39) 78	(48) 24	31
Hardland-slickspots	(28) 22		(28) 14	1
Hardland	(7) 6	(1) 2	(8) 4	6
Loamy prairie	(17) 13		(17) 8	6
Hilly stony	(31) 25		(31) 16	32
Hilly stony savanna	(32) 26	(1) 2	(33) 17	21
Eroded clay			(0) 0	<1

prairie, and hardland-slickspots range sites were used more than expected if they had been used in direct proportion to their availability (Table 3). Boulder ridge, hardland, hilly stony, hilly stony savanna, and eroded clay (which was < 1 percent of the area and was not used for a bedsite) were utilized less than expected based on their availability.

Elevations at bedsites were highest in the Pinchot area and bedsites at the more homogeneous Wye area were at lower mean elevations (Table 4). Percent slope recorded at each fawn bedsite was characteristic of the range site (Appendix D) and area where it was located (Table 4).

Ground cover (vegetation, litter, and the associated visual obstructions) was generally greatest in range sites and soil mapping units with better soils (Table 5). Similarly, those range sites with poorer soils had low visual obstruction measurements, and low height of vegetation and litter. An exception to this relationship occurred in the loamy bottomland range site, where ground cover was apparently limited by the shading effect of woody species.

Dominant vegetation types (< 2 m) found in each range site (Table 6) are characteristic of the climax species representative of that respective site. Thus, fawn bedsites were in range sites in good to excellent range condition. Height of vegetation and standing litter, and visual obstruction measurements verify that fawns selected tall dense vegetation for bedsites. The tall grass species

Table 4. Average values and percent coefficient of variation (c.v.) of physical factors recorded at fawn bedsites in each soil mapping unit of the 7 range sites at Wichita Mountains National Wildlife Refuge and at bedsites at Fort Sill Military Reservation, Oklahoma, 1976 and 1977.

Range site or area	Soil mapping unit	N	Elevation (m)		Aspect (compass °)		Slope (%)		Air temperature (°C)		Wind speed (kmph)		% Cloud cover	
			$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.
Loamy bottomland	Bk	6	1,488	1.8	228	18.0	2	55.6	29	7.4	9	44.4	18	136.9
	Pc	4	1,435	0.7	187	20.6	1	0.0	32	4.1	4	52.2	30	107.8
Boulder ridge	Go	1	1,680		74		8		21		5		75	
	Gc	56	1,608	3.1	173	53.8	4	69.0	28	8.8	8	49.5	32	92.2
Hardland slickspots	Fs	28	1,867	2.1	224	43.1	5	106.1	28	8.2	9	45.6	33	102.9
Hardland	Ft	1	1,460		275		2		21		10		85	
	Tm	7	1,911	0.9	91	48.7	4	29.2	29	11.2	12	33.0	43	84.6

Table 4. (Continued)

Range site or area	Soil mapping unit	N	Elevation (m)		Aspect (compass °)		Slope (%)		Air temperature (°C)		Wind speed (kmph)		% Cloud cover	
			$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.	$\bar{x}$	% c.v.
Loamy prairie	La	3	1,896	0.8	267	24.4	4	86.5	26	7.1	9	12.3	60	88.2
	Lf	14	1,812	0.5	162	67.0	2	51.0	29	7.6	7	38.0	32	117.2
Hilly stony	Ro	31	1,838	6.6	194	46.9	6	69.9	29	7.4	8	47.0	46	73.9
Hilly stony savanna	St	33	1,855	3.4	166	58.9	7	62.6	30	5.9	8	50.1	22	109.3
FSMR	unknown	15	1,318	0.9	167	46.5	3	106.5	29	6.6	5	60.5	24	113.3
Total		199	1,709	11.7	181	51.8	4	90.1	29	7.3	8	49.7	30	105.4

Table 5. Mean values of vegetation and litter heights, and visual obstruction measurements on the 7 range sites used as fawn bedsites at Wichita Mountains National Wildlife Refuge and Fort Sill Military Reservation in Comanche County, Oklahoma, 1976 and 1977.

Range site	Soil mapping unit	N	Height (cm) Vegetation	Height (cm) Standing litter	Visual obstruction (cm)
WMNWR					
Loamy bottomland	Bk	6	49	59	70
	Pc	4	44	49	42
Boulder ridge	Go	1	30	11	5
	Gc	47	57	77	53
Hardland-slickspots	Fs	28	57	54	64
Hardland	Ft	1	60	50	52
	Tm	7	90	123	
Loamy prairie	La	3	55	93	66
	Lf	14	73	72	77
Hilly stony	Ro	31	66	81	59
Hilly stony savanna	St	33	47	44	42
Subtotal		175	58	69	56
FSMR	unknown	24	78	63	59
Total		199	60	69	56

Table 6. The 10 species of dominant vegetation (< 2 m in height) most frequently occurring at fawn bedsites in loamy bottomland (LB), boulder ridge (BR), loamy prairie (LP), hardland (H), hardland-slickspots (H/S), hilly stony (HS), and hilly stony savanna (HSS) range sites on Wichita Mountains National Wildlife Refuge and Fort Sill Military Reservation (FSMR), Oklahoma, 1976 and 1977.

		Occurrence in range sites							Occurrence at
Common name	Scientific name	LB	BR	LP	H	H/S	HS	HSS	FSMR
Western ragweed	*Ambrosia psilostachya*	3	8			14	10	8	5
Big bluestem	*Andropogon gerardii*	3	11	13	12	8	17	4	9
Silver bluestem	*Bothriochloa saccharoides*					3			
Louisiana sagwort	*Artemisia ludoviciana*			3				3	6
Three-awn	*Aristida* spp.					3			
Heath aster	*Aster eroicoides*		1						
Hairy grama	*Bouteloua hirsuta*		4						
Brome	*Bromus* spp.	3	2	4	6	13	3	7	6
Giant sandreed	*Calamovilfa gigantea*	3							

Table 6. (Continued)

Common name	Scientific name	Occurrence in range sites LB	BR	LP	H	H/S	HS	HSS	Occurrence at FSMR
Sedge	*Cyperus* spp.	7					4	11	
Canadian wildrye	*Elymus canadensis*	3			3		3		3
Maximilian sunflower	*Helianthus maximilani*				12				
Eastern red cedar	*Juniperus virginiana*						4		
Lespedeza	*Lespedeza* spp.							4	
Green muhly	*Muhlenbergia racemosa*	14						7	
Virginia creeper	*Parthenocissus quinquefolia*								3
Scribner's panicum	*Panicum* spp.	10	8	4	6	5	3	7	
Switchgrass	*Panicum virgatum*		6	12	17	12	9		
Wild alfalfa	*Psoralea* spp.					4			
Little bluestem	*Schizachyrium scoparium*	21	24	15	9	7	21	22	12
Greenbriar	*Smilax* spp.								6
Johnsongrass	*Sorghum halapense*								4

Table 6. (Continued)

Common name	Scientific name	Occurrence in range sites							Occurrence at
		LB	BR	LP	H	H/S	HS	HSS	FSMR
Indiangrass	*Sorghastrum nutans*	7	15	12	17		13		6
Tall dropseed	*Sporobolus asper*			4	9	10			
Buckbrush	*Symphoricarpos orbiculatus*			4	6			8	
Purpletop	*Tridens flavus*		1						
Ironweed	*Vernonia baldwinii*			4					

predominated except on the hardland-slickspots range site where Western ragweed and brome grasses were prevalent. Tall grass species were also dominant on unclassified portions of FSMR, but a greater variety were recorded; the top 10 species accounted for only 60 percent (Table 6).

Woody plants at bedsites in each range site can generally be categorized as upland or bottomland species. The high percentage of blackjack and post oak occurred at 33 bedsites located on the hilly stony savanna range site (Table 7). The representative bottomland species occurred primarily in the loamy bottomland and unclassified FSMR sites. The understory vegetation at wooded range sites also offered some concealment at fawn bedsites (Table 5), but it was generally less than in the prairie.

Cover provided by boulders did not appear to be a major component of fawn bedsites. Only 2 bedsites at the Wye (3 percent)--1 each in the boulder ridge and hilly stony savanna--contained boulders within 400 m. In Pinchot, 55 (44 percent) of the bedsites had boulders within this distance. These bedsites occurred in the loamy prairie, boulder ridge, hardland-slickspots, hilly stony, and hilly stony savanna range sites. The distances from the bedsites to boulders ranged from 1 m, in a single boulder ridge site, to 44 m (mean value at 20 bedsites) in the hardland-slickspots range site.

Four of the 199 bedsites were known to be parturition sites and these were concealed from all directions by boulders and/or dense

Table 7. Woody vegetation > 2 m in height along transects at fawn bedsites in loamy bottomland (LB), boulder ridge (BR), loamy prairie (LP), hardland (H), hardland-slickspots (H/S), hilly stony (HS), and hilly stony savanna (HSS) range sites on Wichita Mountains National Wildlife Refuge and Fort Sill Military Reservation (FSMR), Oklahoma, 1976 and 1977.

		Occurrence in range sites							Occurrence at
Common name	Scientific name	LB	BR	LP	H	H/S	HS	HSS	FSMR
False indigo	*Amorpha fruiticosa*					2			
Chittamwood	*Bumelia lanuginosa*		5					2	
Pecan	*Carya illinoensis*								15
Buttonbrush	*Cephalanthus occidentalis*	3	2	1				1	
Hackberry	*Celtis* spp.		3				2	2	7
Hawthorne	*Crataegus* spp.		1						
Black walnut	*Juglans nigra*	4	5						4
Eastern red cedar	*Juniperus virginiana*	6	5			4	9	20	2
Cottonwood	*Populus deltoides*	1							

Table 7. (Continued)

Common name	Scientific name	Occurrence in range sites							Occurrence at
		LB	BR	LP	H	H/S	HS	HSS	FSMR
Mesquite	*Prosopsis glandulosa*								8
Wild plum	*Prunus* spp.			1					
Blackjack oak	*Quercus marilandica*	8	25	1		4	7	34	1
Post oak	*Quercus stellata*	9	10			1	1	31	5
Smooth sumac	*Rhus glabra*		3					1	
Western Sopberry	*Sapindus drummundii*								6
American elm	*Ulmus americana*	2		6				2	15
Wild grape	*Vitis* spp.							1	

vegetation. These beds were located in boulder ridge, loamy prairie, hilly stony, and hilly stony savanna range sites; the first 2 were in grassland. The hilly stony site contained a small group of blackjack oak and boulders (10 m in circumference) surrounded by open prairie. The hilly stony savanna site was occupied by closed forest containing some boulders.

Garner (1976) and Kjos and Montgomery (1969) noted that fawns selected bedsites cooler than the ambient air temperature. Waldrip (1977) found the same selectivity by elk (*Cervus canadensis*) calves. The data also indicates that fawns bed in open prairie sites on days when temperatures were $\leq 29^{o}C$ (Table 4). They frequently bedded in forested range sites (loamy bottomland and hilly stony savanna) when air temperatures were $\geq 29^{o}C$ and there was less cloud cover; grassland was utilized when air temperature was low and cloud cover was greater.

DISCUSSION AND CONCLUSIONS

The most obvious characteristic of these bedsites was the fawns' general selection for open areas. Bedsites in woody range sites only accounted for about 25 percent of the total number. Open prairie and savanna generally were preferred by fawns. Fawns captured on FSMR, however, bedded more frequently in savanna and closed forest than in the prairie.

Garner (1976) described the preference of fawns for bedsites in open areas; 78 percent were in open prairie range sites. Data from the current project confirms Garner's conclusion that fawns use a greater proportion of open prairie areas for bedsites in the Wichita Mountains.

Kjos and Montgomery (1969) studied 17 bedsites of 2 radio-collared fawns in Illinois. Five (29.5 percent) were in dense canopy cover, 5 in moderately dense canopy cover, and 7 (41 percent) lacked overhead cover. The Illinois study indicates a slightly greater use of woody cover, but due to the small sample size and the fact that 1 fawn was considered tame, the conclusions may not be comparable to bedsites of free-ranging fawns.

Lund (1975) described areas and methods for capturing fawns in New Jersey. He described major fawning areas as hay meadows, even though woody cover was available. Descriptions of parturition sites in these hay meadows and the high success in capturing fawns within these open areas infer that deer in this area of New Jersey prefer open meadows with dense herbaceous cover as parturition sites and fawn bedsites.

In a study of elk calving sites conducted at the WMNWR simultaneous to my project, Waldrip (1977) noted that woody cover, boulders, and steeper slopes were preferred. In contrast, fawns preferred level open areas without boulder cover. Waldrip postulated that elk may be competing with deer for rearing sites and thereby moving the deer into marginal fawning areas. This theory was based on the fact that deer fawns sustained a high neonatal loss due to predation, whereas mortality of elk calves was minimal. This was further supported by the fact that fawns captured on FSMR (where the elk population was sparse) bedded in woody cover more frequently than fawns on WMNWR. However, the fawn loss on FSMR was high even though these animals primarily used the wooded habitat for bedsites. It seems possible that the greater human disturbance on FSMR (army maneuvers, frequent wildfires, mowing of hay, etc.) may be a more substantial factor influencing the selection by fawns of wooded areas for bedsites.

Lindzey (1951) and Halloran and Glass (1959) stated that the deer in the Wichita Mountains were descendants of the native subspecies *O. v. texanus*. This subspecies, described by Kellogg (1956), undoubtedly is adapted to the prairie woodland habitat in this region. Fawns in this study preferred to bed in open prairie habitats with good to excellent herbaceous cover. The role of bedsite cover as a factor in fawn survival is obvious and should be described for other populations of deer in order to define the basic habitat requirements of fawns.

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APPENDIX A

MISCELLANEOUS VITAL STATISTICS AND

HOME RANGE SIZE OF ADULT DEER,

WICHITA MOUNTAINS, OKLAHOMA,

1976 AND 1977

Adult deer were captured in box traps on the Wichita Mountains National Wildlife Refuge during January and February, 1976 and 1977. Total trap nights spent in capturing these deer were 72 in 1976 and 50 in 1977. Combined average success was 6.7 trap nights per deer (excluding recaptures).

Tables 1 and 2 list sex and age data and blood values of the trapped adult deer. Total protein values of Wichita Mountains deer were generally greater than values (range 3.8 - 8.3) reported in other studies (White, M., and R. S. Cook. 1974. Blood characteristics of free-ranging white-tailed deer in southern Texas. J. Wildl. Dis. 10(1):18-23). Packed cell volume, hemoglobin, and white blood cell values were also slightly higher than blood values of deer collected in southern Texas (Blankenship, L. H., and L. W. Varner. 1978. Factors affecting hematological values of white-tailed deer in South Texas. Proc. Southeastern Assoc. Game and Fish Commissioners 30: (In press)).

Mean and standard deviation of measurements from does captured on the Wichita Mountains National Wildlife Refuge appear in Table 3. The weights of these deer are comparable to weights of does harvested in Oklahoma in the fall hunting seasons.

Deer captured on the Wichita Mountains National Wildlife Refuge were fitted with radio-transmitter collars; their home range sizes are listed in Table 1. Most deer were within a home range less than 1.6 km wide. However, doe O_b had a faulty radio and was observed 3 months later on Fort Sill Military Reservation 2.7 km southwest of her capture location. During the fall gun hunting season in 1977 (9 months after capture), this same doe was killed 4.8 km east of the last observed location on FSMR. Two adult males also had large home ranges; Rm_2 moved

5.6 km after capture, and then established a stable home range (154 ha) from April to the end of this study (7 months). The other radio-tagged buck, DkB_2, made no long movement, but had a "linear" home range 3.6 km long and 1.5 km wide.

Home ranges of 11 adult does and 3 adult bucks appear in Figs. 1 - 14.

Table 1. Month and year captured, color code, sex, age at capture, site of capture, number of relocations, home range, and status of adult deer on WMNWR, Oklahoma, 1976 and 1977.

Year/month capture and color code	Sex	Age	Capture site	Number of relocations	Home range (ha)	Status Oct 1977
1976/Jan						
LB_2	F	3.5	W[a]	52	61.4	Surviving
Wh_1	F	3.5	W	70	94.7	Surviving
Bl	F	4.5	W	30	56.4	Dead June 1976
O_a	F	4.5	W	0		Unknown (never located)
DkB_1	F	0.5	W	8	0.8	Unknown after Feb 1976
Rm_1	M	1.5	W	39	26.7	Dead Oct 1976
Y_a	F	5.5	W	3		Dead Feb 1976
Gr	F	6.5	W	24	89.5	Dead June 1976
1976/Feb						
Y_1	F	6.5	P	41	54.7	Dead Jan 1976
LB_1	F	1.5	P	45	69.5	Surviving

Table 1. (Continued)

Year/month captured and color code	Sex	Age	Capture Site	Number of relocations	Home range (ha)	Status Oct 1977
R	F	3.5	P	101	62.1	Surviving
Y_b	F	3.5	W	1		Dead Feb 1976
DkB_2	M	1.5	W	60	189.6	Unknown
1977/Feb						
Wh_2	F	4.5	P	80	41.9	Surviving
O_b	F	1.5	W	3		Dead Oct 1977
Rm_2	M	4.5	W	9	154.1	Surviving
Y_2	F	3.5	P	24	23.4	Surviving
O	F	1.5	P	47	64.1	Surviving

[a]W indicates Wye study site; P indicates Pinchot study site.

Table 2. Hematological values of adult deer captured at the Wichita Mountains, Oklahoma.

Year and sex	Packed cell volume (%)	Hemoglobin (gm/100 ml)	White bc ($10^3/mm^3$)	Total protein (gm %)
1976				
F	42.5	15.6	3,500	8.4
F	45.0	15.5	5,000	7.3
F	45.0	14.8	4,200	8.8
M	45.5	15.4	5,600	
F	52.5	16.9	4,100	7.0
F	49.5	17.2	5,600	7.6
F	51.5	17.0	4,700	7.3
F	47.5	15.8	9,200	6.5
M	51.5	17.0	5,400	7.2
1977				
F	46.0	15.5	7,800	5.8
F	46.5	16.3	4,800	6.0
M	50.0	17.3	3,400	6.9
F	54.5	18.8	3,900	6.5
F	52.0	18.1	6,100	6.3
Mean ± SD	48.5 ± 3.6	16.5 ± 1.1	5,240 ± 1,630	7.0 ± 0.9

Table 3. Mean and SD of physical measurements taken from doe deer captured on WMNWR, Oklahoma, 1976 and 1977.

Deer age group and sample size (n)	Total weight (kg)	Length (cm)					
		Total	Tail	Head	Nose	Hind foot[a]	Mid-neck circumference
Does 2.5 years of age or older (n = 11)							
Mean	47.9	169.7	20.8	30.1	14.9	41.3	35.3
SD	4.4	6.6	2.6	1.8	1.0	1.2	2.5
Does 1.5 years of age (n = 3)							
Mean	47.7	169.5	22.7	29.7	15.3	42.1	35.3
SD	3.8	6.7	1.3	1.1	0.7	1.2	1.6

[a]Average of both hind feet measurements.

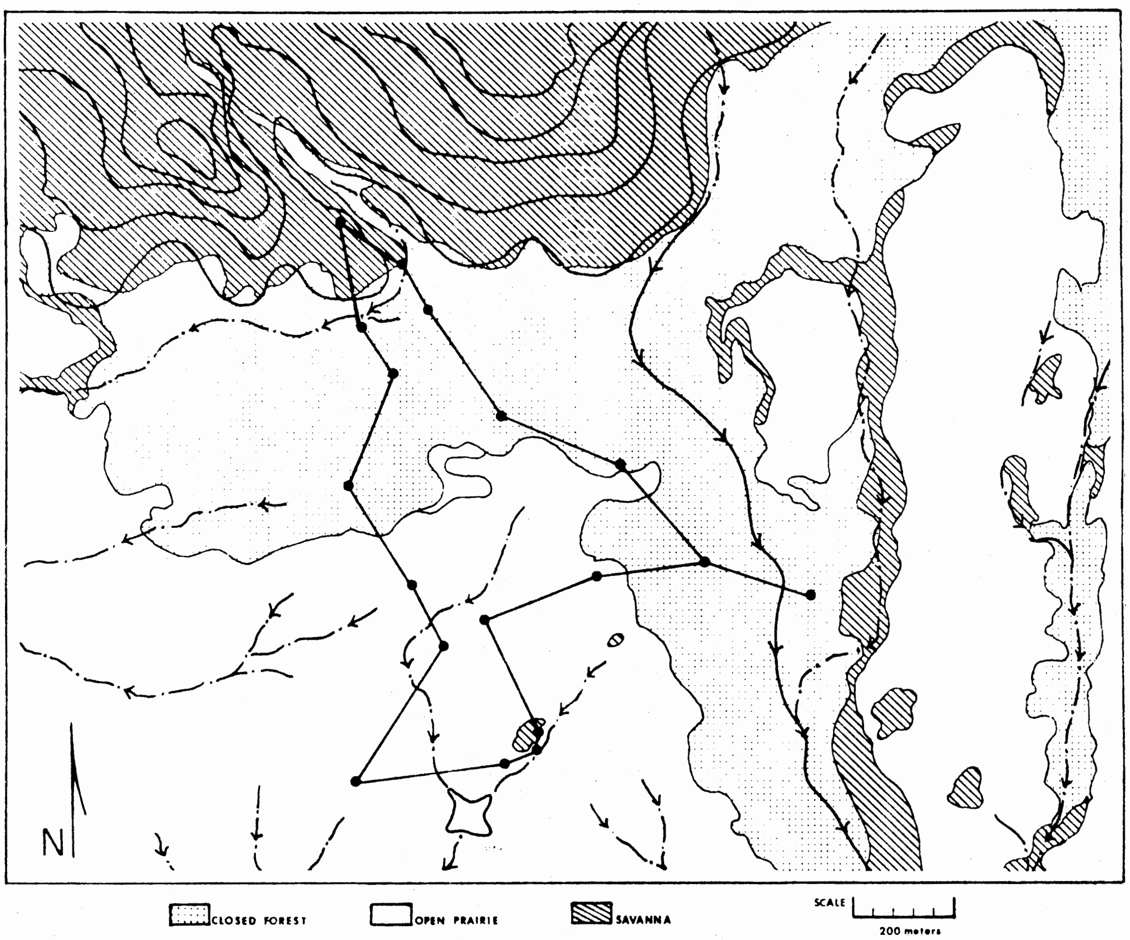

Fig. 1. Home range of doe B1 in relation to habitat type in the Wye area of WMNWR, Oklahoma, January to June 1976.

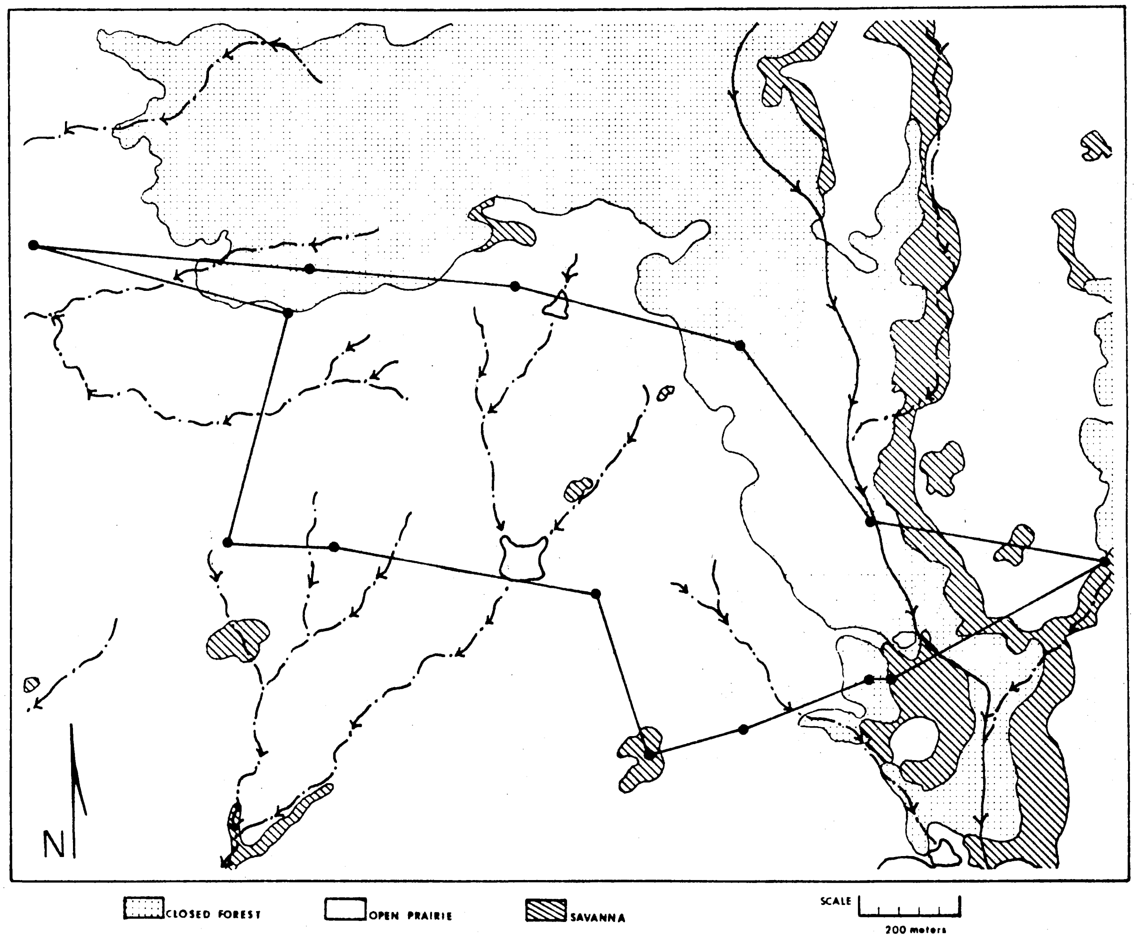

Fig. 2. Home range of doe Gr in relation to habitat type in the Wye area of WMNWR, Oklahoma, January to May 1976.

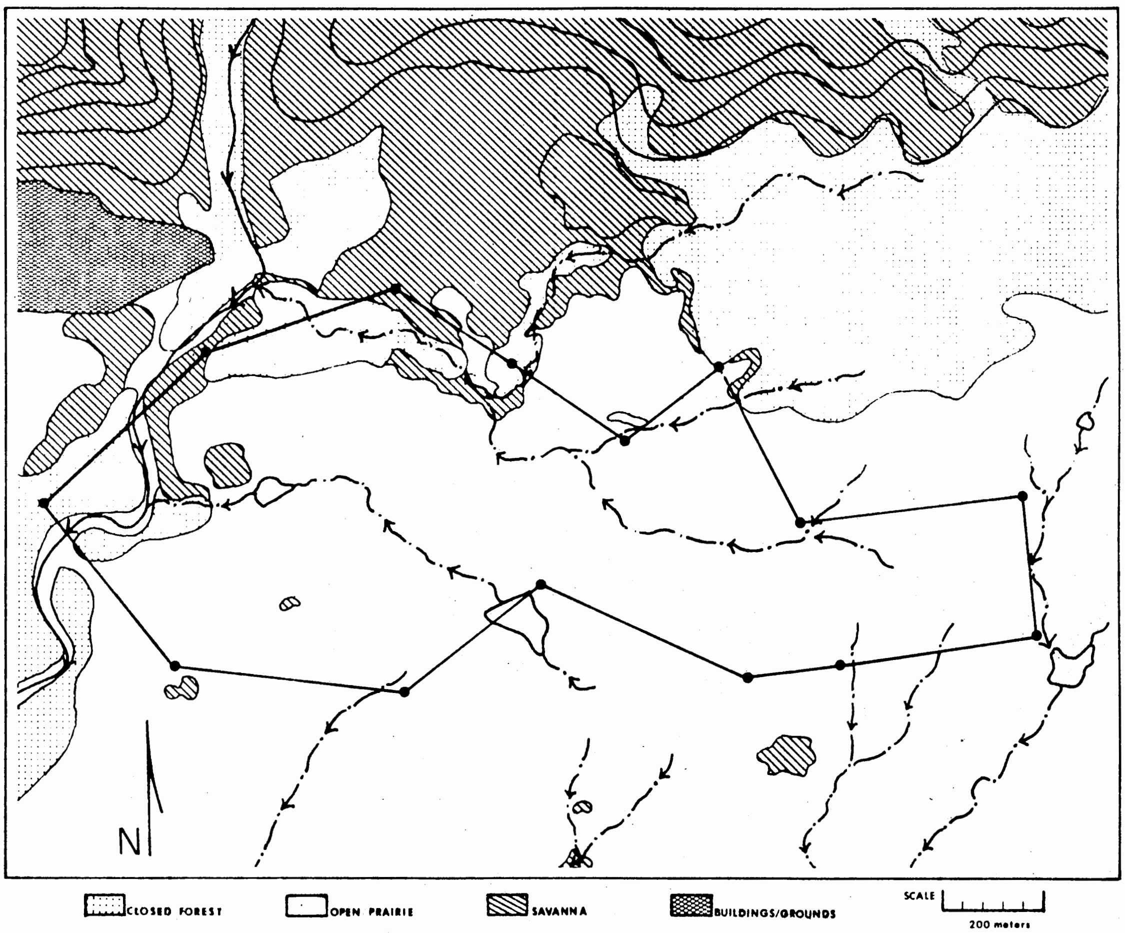

Fig. 3. Home range of a doe marked during the study of Garner (1976) in relation to habitat type in the Wye area of WMNWR, Oklahoma, January 1976 to October 1977.

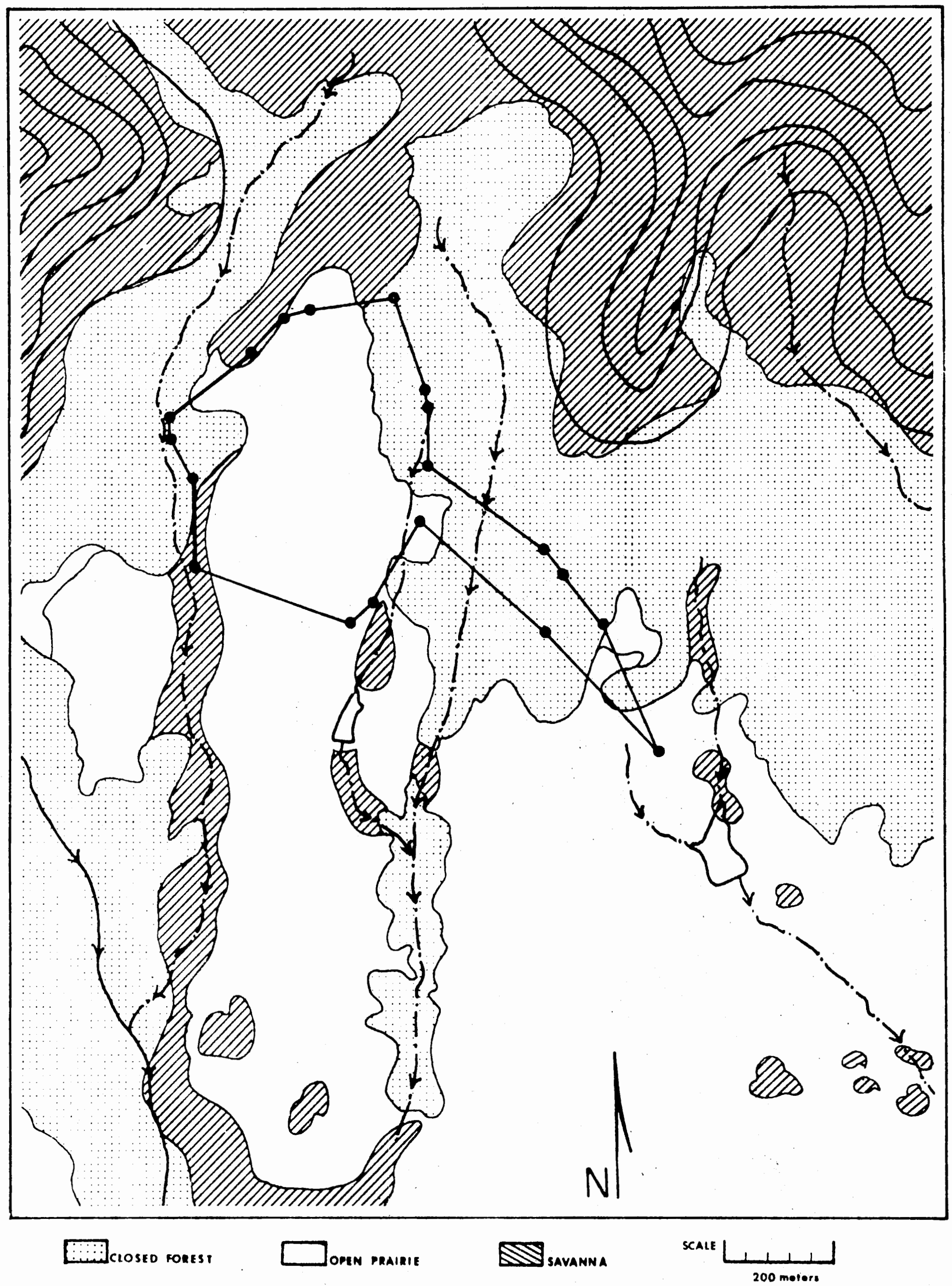

Fig. 4. Home range of 1.5 year old male Rm_1 in relation to habitat type in the Wye area of WMNWR, Oklahoma, January to October 1976.

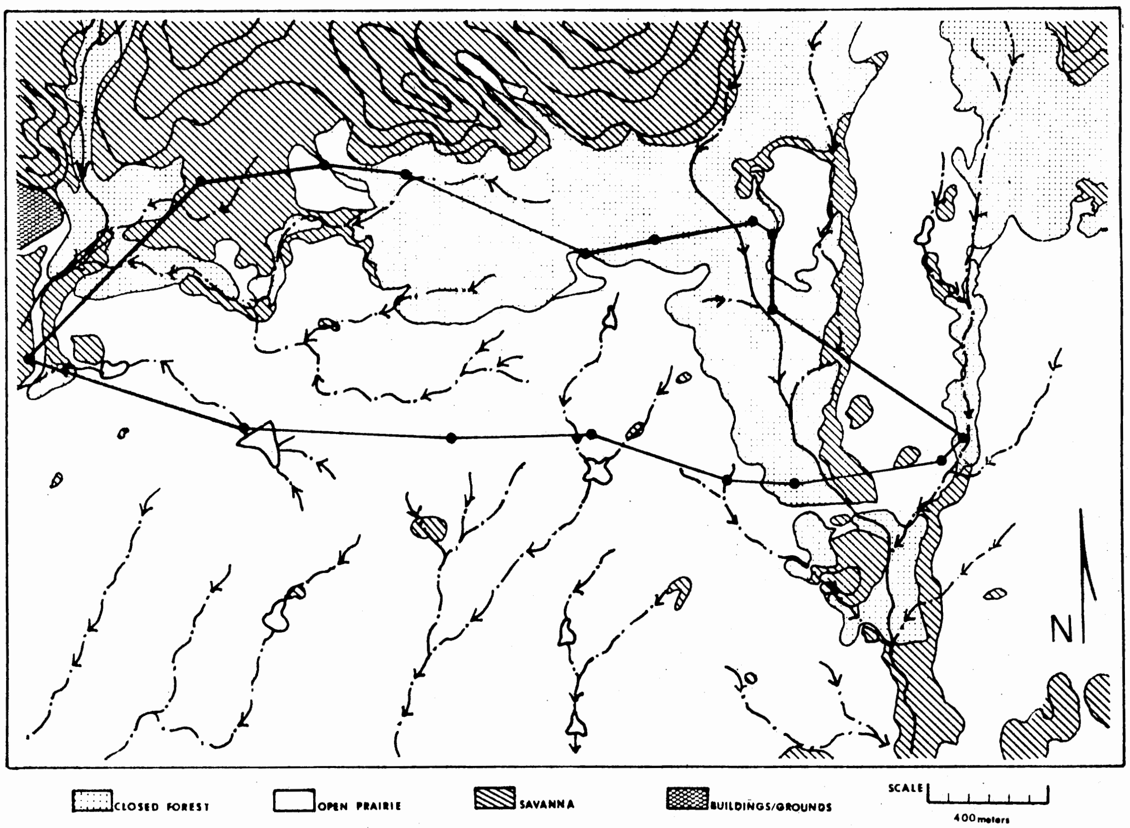

Fig. 5. Home range of adult buck DkB_2 in relation to habitat type in the Wye area of WMNWR, Oklahoma, February 1976 to October 1977.

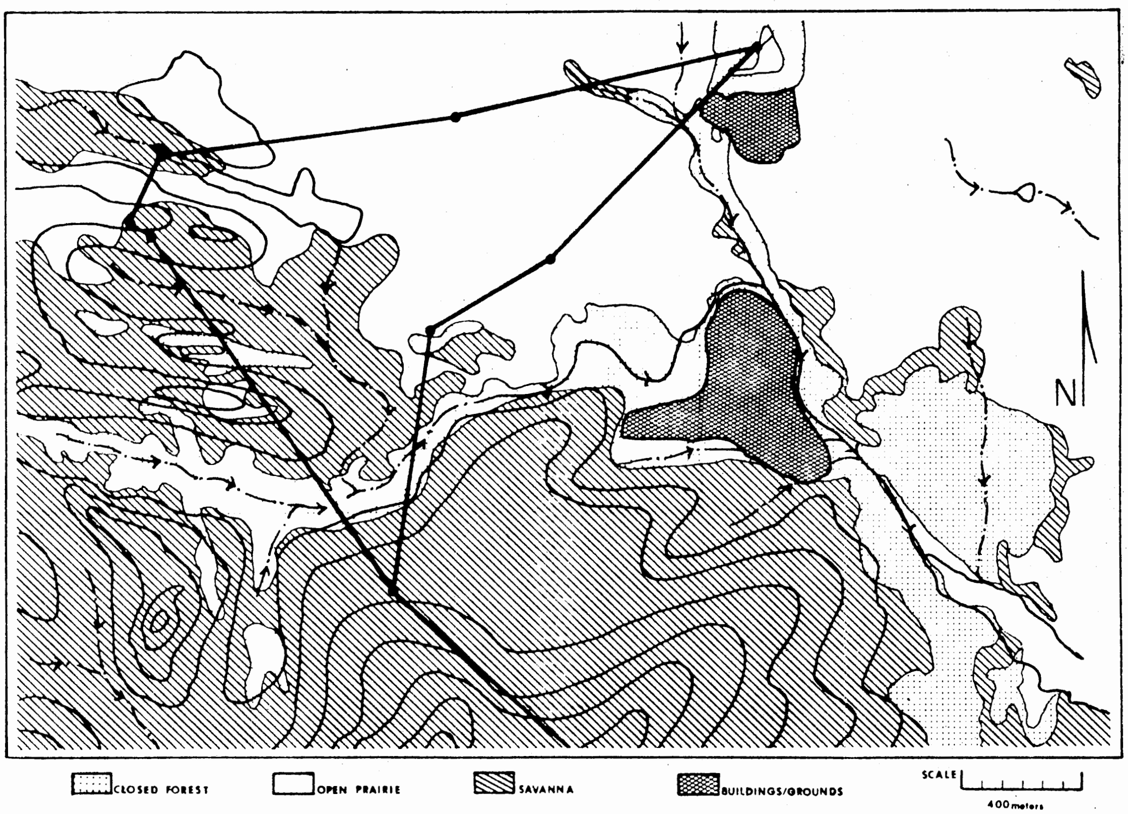

Fig. 6. Home range of adult buck Rm_2 in relation to habitat type in WMNWR, Oklahoma, February to October 1977.

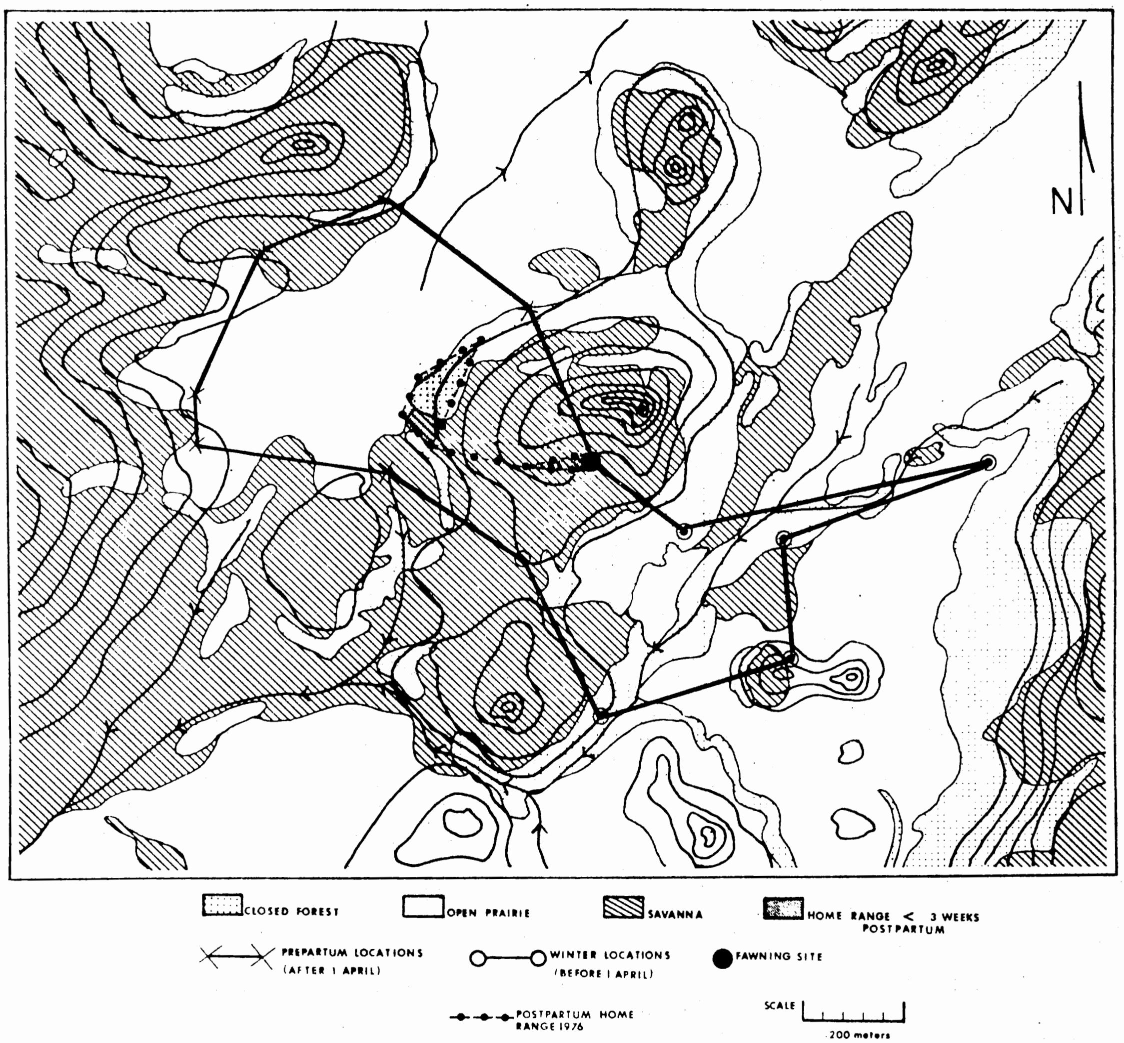

Fig. 7. Home range of doe Y_1 in relation to habitat types, showing winter range, and spring prepartum range, fawning site, and early postpartum home range, in the Pinchot area, WMNWR, Oklahoma, February to December 1976.

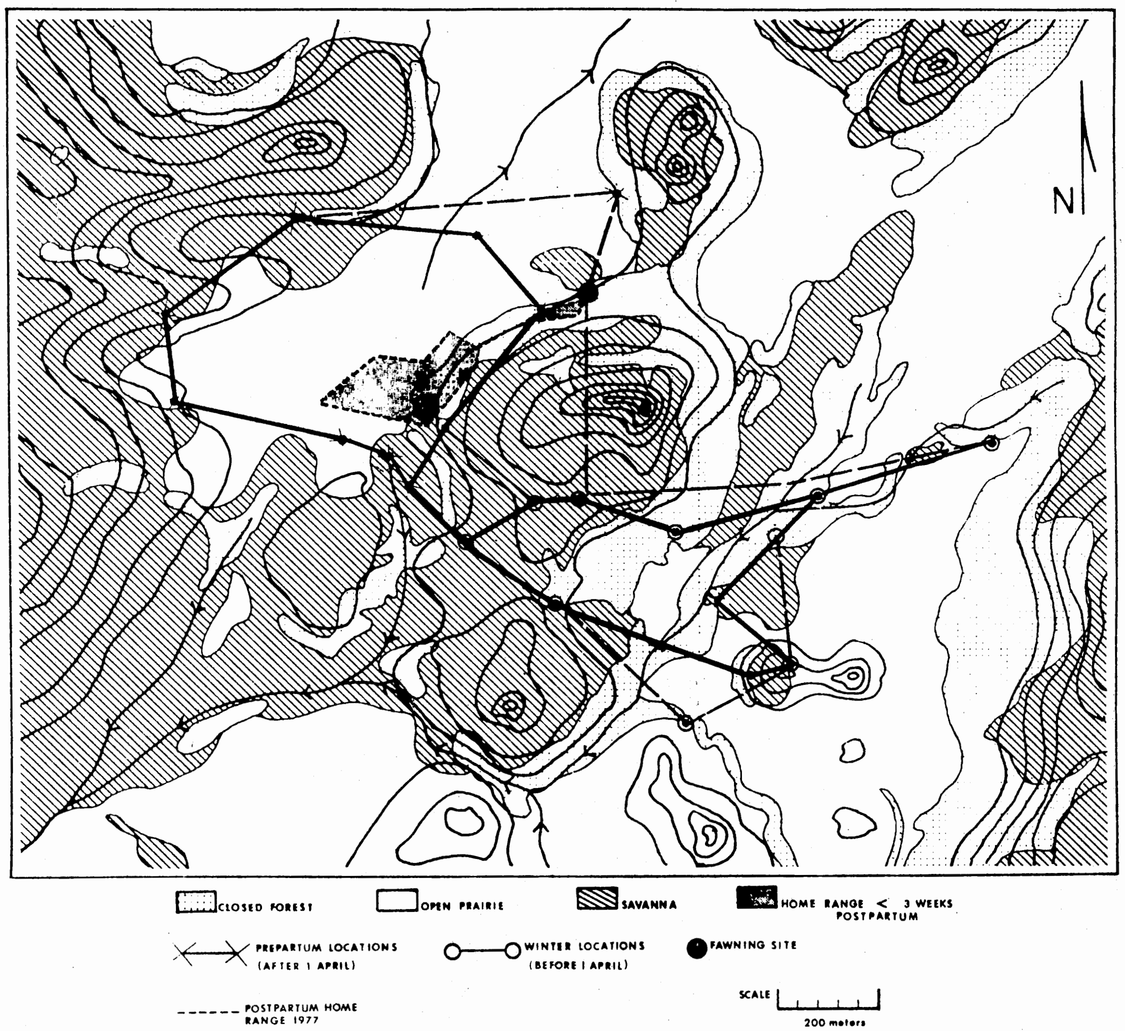

Fig. 8. Home range of doe R in relation to habitat types showing winter home range, prepartum (spring) home range, and early postpartum home range, in the Pinchot study site, WMNWR, Oklahoma, February 1976 to October 1977.

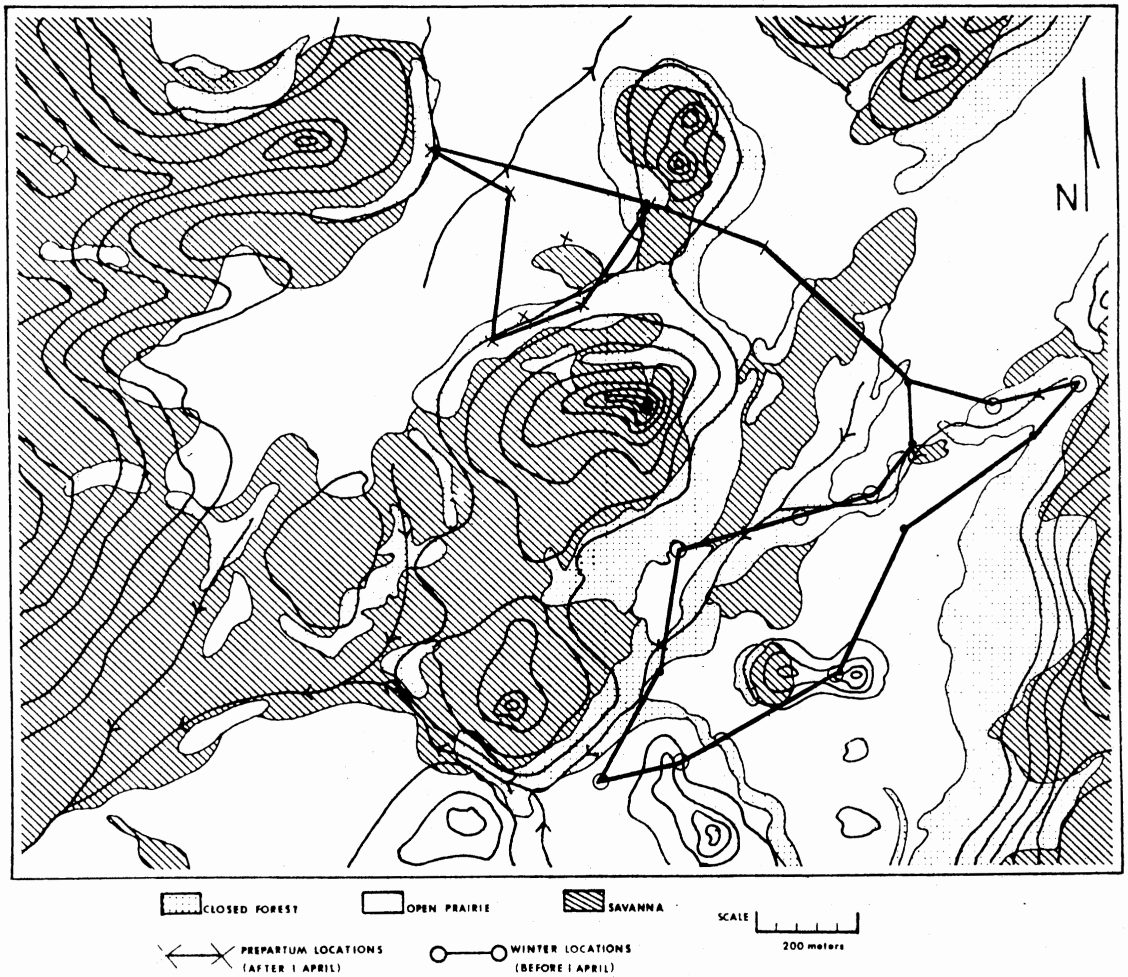

Fig. 9. Home range of doe Y_2 in relation to habitat type showing winter and spring prepartum locations in the Pinchot study site, WMNWR, Oklahoma, February to October 1977.

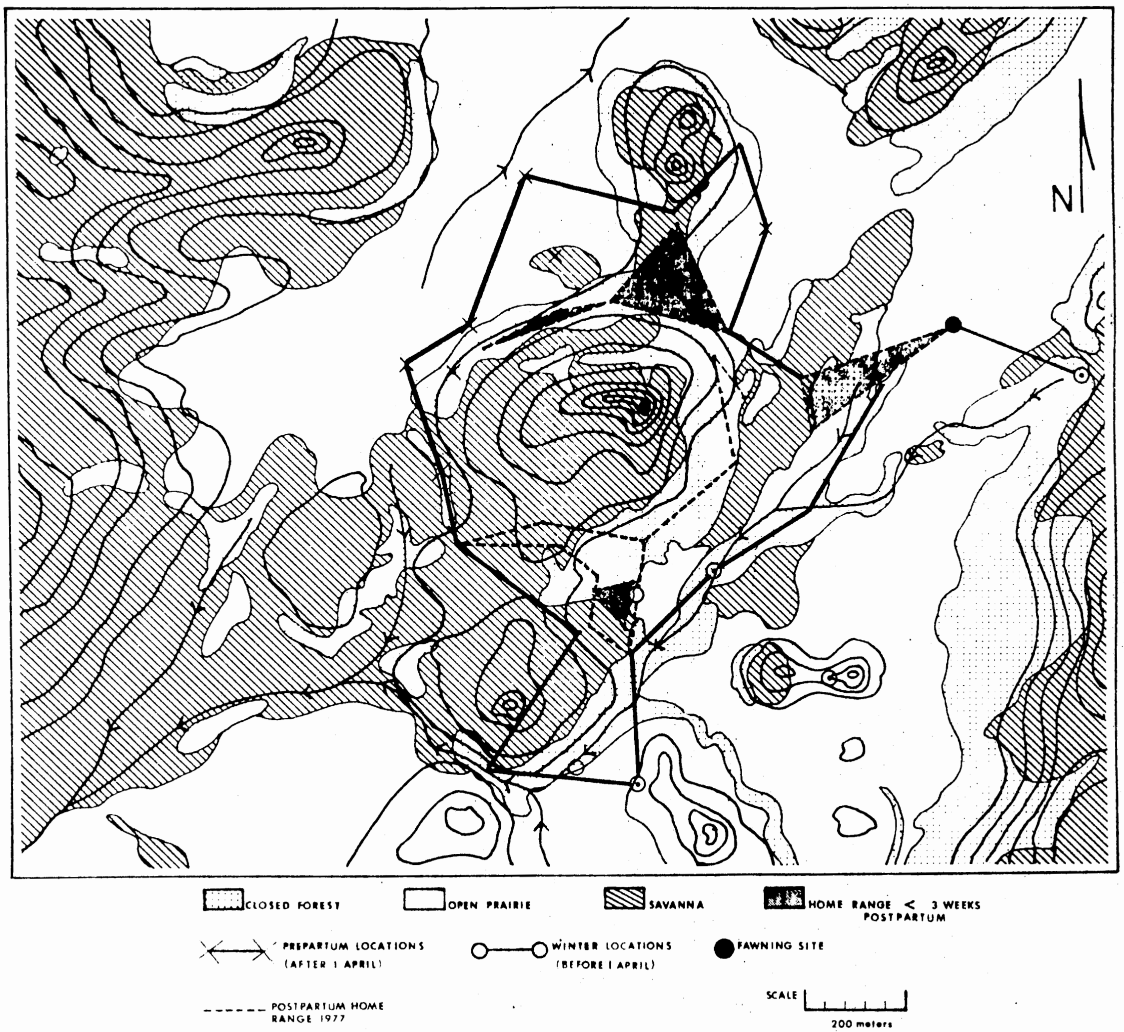

Fig. 10. Home range of doe O in relation to habitat type showing winter and prepartum locations, fawning site, and postpartum home range use in the Pinchot study site, WMNWR, Oklahoma, February to October 1977.

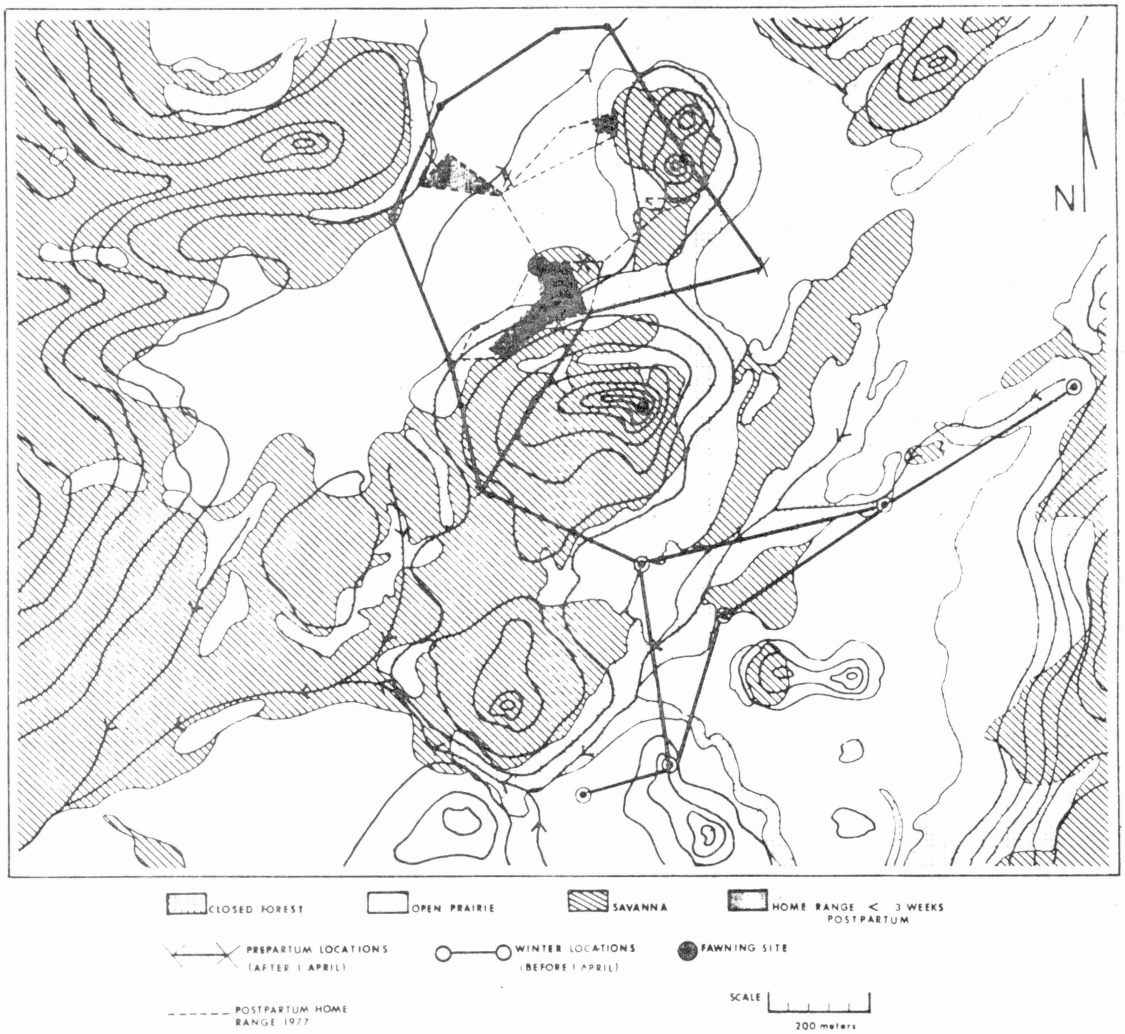

Fig. 11. Home range of doe Wh_2 in relation to habitat types showing winter and prepartum locations, fawning site, and early postpartum home range in the Pinchot study site, WMNWR, Oklahoma, February to October 1977.

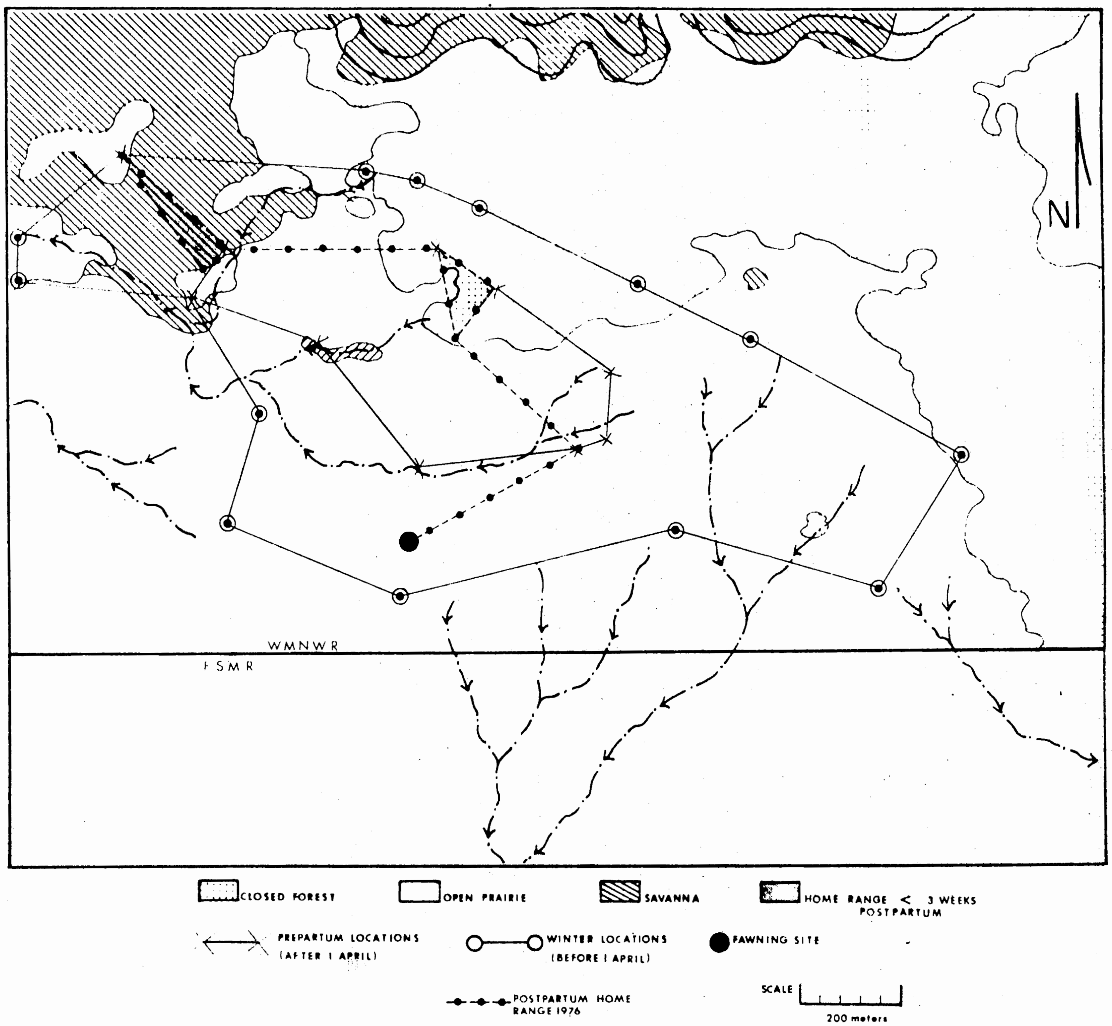

Fig. 12. Home range of doe Wh_1 in relation to habitat showing winter and prepartum locations, fawning site, and early postpartum home range in the Wye study site, WMNWR, Oklahoma, January 1976 to October 1977.

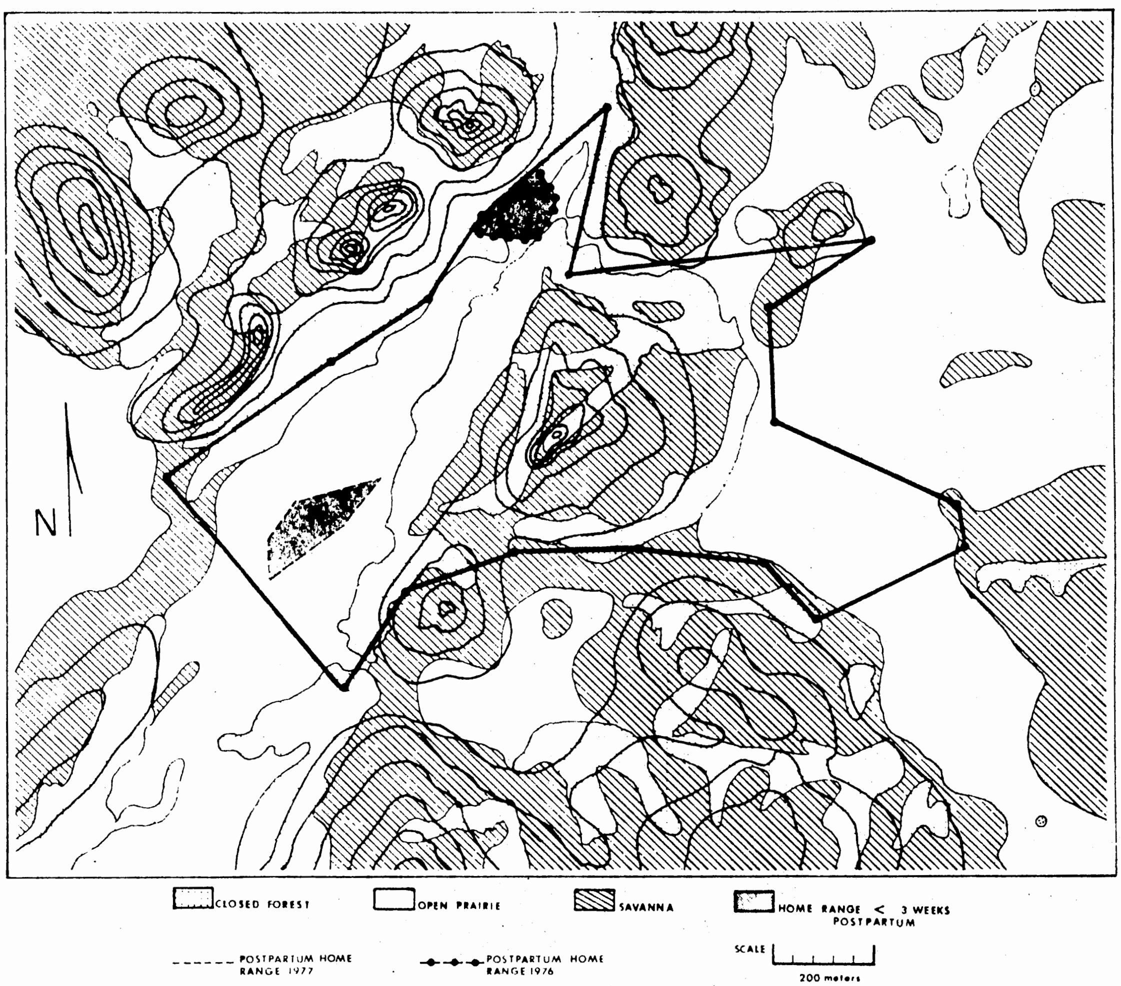

Fig. 13. Home range of doe LB_1 in relation to habitat type showing early postpartum area used in the Pinchot study site, WMNWR, Oklahoma, February 1976 to October 1977.

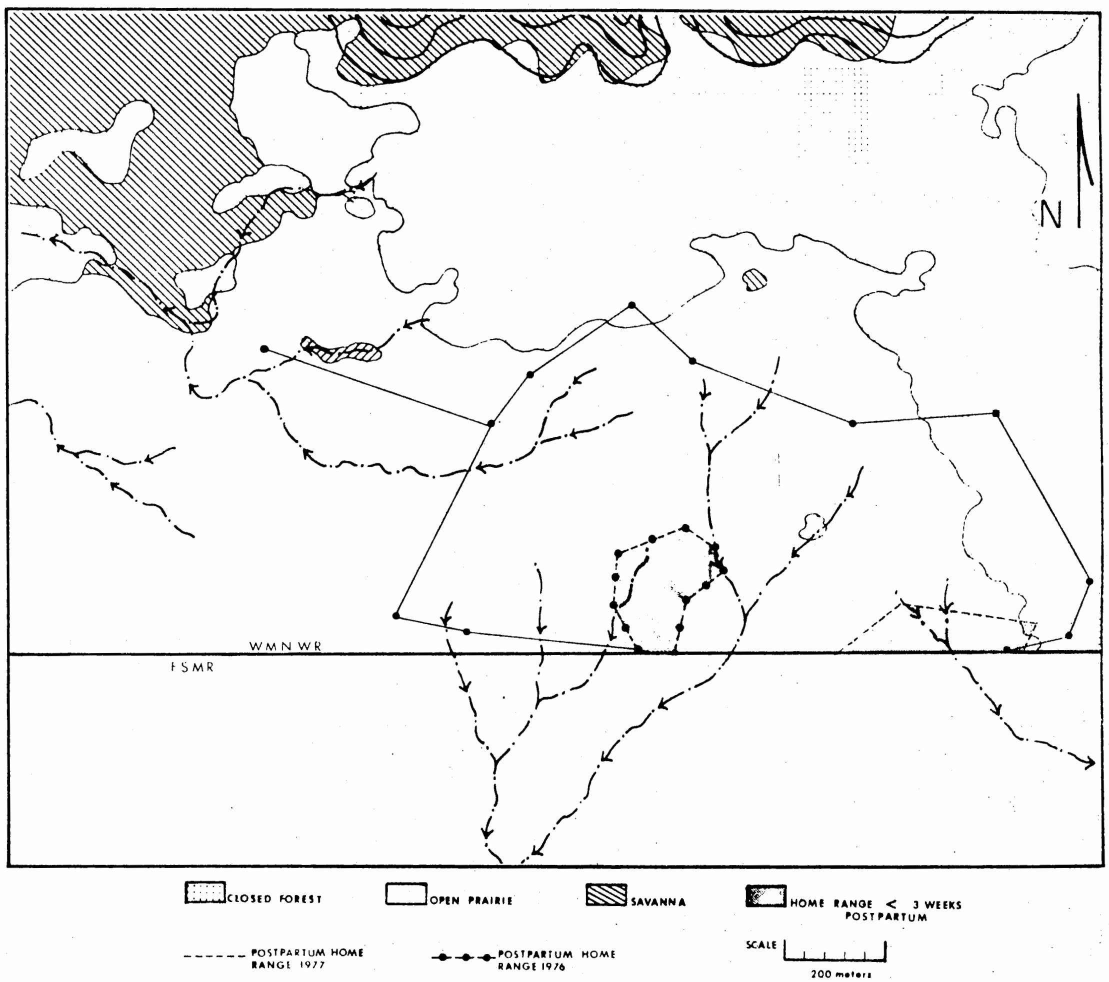

Fig. 14. Home range of doe LB_2 in relation to habitat type showing early postpartum home range in the Wye study site, WMNWR, Oklahoma, January 1976 to October 1977.

APPENDIX B

MISCELLANEOUS VITAL STATISTICS AND HOME RANGE OF FAWNS, WICHITA MOUNTAINS, OKLAHOMA, 1976 AND 1977

Physical measurements of fawns were recorded at the time of capture (Table 1) and are illustrated in Figs. 1-4. Criteria used to determine the involvement of predators in fawn mortality during this study (Table 2) were from Garner et al. (1978). Characteristics of each fawn mortality recorded during this project provided evidence that was used to determine the primary decimating agent (Table 3).

Average daily movement of each fawn--1 to 3 days postcapture and 4 to 6 days postcapture (Table 4)--was used to determine the influence of capture and handling on fawn movement (Chapter II).

Only 6 fawns survived more than 5 months (Table 5). Their home ranges were similar to the home ranges of adult deer. Fawns C 6 and C 9 were captured in 1976 and their home ranges are based on observations made through 18 months postcapture. Fawn C 9 had a large home range, exceeding 2.8 km in length (Fig. 5); fawn C 6 established a smaller home range (Fig. 6). C 6 was triangulated outside of this home range only once; he was then 1 year old. The movement outside the home range was brief because he was located in the usual home range 48 hours before and after the movement outside. This movement occurred during the peak fawning period when this yearling was observed with a young doe (believed to be his twin) 7.2 km north of his established home range. This extensive movement may have been the result of C 9's dam becoming more aggressive towards her previous offspring.

The remaining 3 fawns were only monitored for 5 months postcapture, through the termination of this project. Home ranges of T 12, D 6, and D 14 appear in Figs. 6, 7, and 8, respectively.

Table 1. Mean and SD of measurements of fawns at various ages, Wichita Mountains, Oklahoma, 1976 and 1977.

Age (days)	Sample size	Weight (kg)	Mean length (cm) ± SD: Total	Head	Nose	Hind foot[a]	Head width (cm)
1	8	2.55 ± 0.44	60.8 ± 5.2	15.45 ± 0.96	5.66 ± 0.6	22.13 ± 1.44	6.2 ± 0.94
2	2	1.99 ± 0.42	57.1 ± 0.94	14.45 ± 0.49	5.3 ± 0.14	20.5 ± 2.68	5.5
3	4	2.79 ± 0.21	62.6 ± 3.0	15.2 ± 0.26	5.8 ± 0.3	22.62 ± 1.09	6.13
5	2	3.25 ± 0.02	66.6 ± 4.6	13.8 ± 0.57	5.85 ± 0.21	23.1	5.9
6	4	4.22 ± 0.42	68.8 ± 4.3	16.4 ± 0.63	6.45 ± 0.26	24.8 ± 0.26	6.36 ± 0.25
7	7	4.13 ± 0.39	66.8 ± 4.3	16.1 ± 0.53	6.11 ± 0.52	24.1 ± 0.39	6.27 ± 0.12
8	6	4.08 ± 1.15	65.5 ± 7.9	15.8 ± 0.56	5.68 ± 0.41	24.6 ± 1.69	6.23 ± 0.38
9	3	4.95 ± 1.77	75.4 ± 6.6	17.1 ± 1.01	6.6 ± 0.36	25.6 ± 1.01	6.37 ± 0.45
10	5	5.12 ± 0.66	72.5 ± 4.8	16.3 ± 0.29	6.6 ± 0.29	25.37 ± 0.92	6.3 ± 0.34
12	2	4.85 ± 0.18	71.5 ± 4.4	16.45 ± 0.42	6.45 ± 0.07	25.05 ± 1.0	6.47
14	2	6.17 ± 0.85	86.9 ± 0.99	17.8 ± 1.13	6.5 ± 0.42	27.8 ± 1.98	6.94

[a]Hind foot measurements for individual deer were an average of right and left.

Table 2. Criteria developed by Garner et al. (1978) which were used to identify the species in predator-involved mortalities, Wichita Mountains, Oklahoma, 1976 and 1977.

Criteria	Interpretation
1. Characteristics of wounds or death site	
A. Blood around wounds, in nostrils, ears, throat and around mouth	predator involved
B. Blood not around wounds, carcass remains show no evidence of bruises or hemorrhaging	predator scavenged
C. Blood on grass in area and/or evidence of struggle by fawn at death site	predator involved
D. Fawn observed within 48 hours prior to location of carcass and at that time appeared in good physical condition according to criteria outlined by Cook et al. (1971:49)	predator involved
E. Carcass lacks signs of being bitten	predator not involved
2. Carcass Disposition	
A. Laying in open, no attempt at concealment, carcass remains not scattered	unknown predator
B. Laying in open, no attempt at concealment, remains scattered	probable coyote
C. Buried underground	probable coyote
D. Partially covered with ground litter or leaves with evident fan-like scraping pattern	bobcat

Table 2. (Continued)

Criteria	Interpretation
3. Carcass Injuries	
A. Skull punctured or crushed	coyote
B. Underside of neck bruised but without puncture wounds	probable coyote
C. Underside of neck bruised and small puncture wounds evident	bobcat
D. Narrow scratch marks on ears, neck, forelegs, or back	probable bobcat
E. Broad scratch (bruises) marks on back of neck and throat	probable coyote
4. Carcass Consumption	
A. All consumed	unknown predator
B. All consumed except for bone chips, ear tags, bits of skin, etc.	unknown predator
C. All consumed except for scattered leg bones, bone fragments, etc.	probable coyote
D. Small fawns ($<$60 days old) all viscera consumed	unknown predator
E. Large fawns ($>$60 days old) all viscera except intestines and rumen consumed	unknown predator
F. None	unknown predator

Table 2. (Continued)

Criteria	Interpretation
5. Collar Conditions	
A. Collar expanded or unexpanded, large tooth marks on transmitter, bloody collar	probable coyote
B. Collar not expanded, no tooth marks, collar not bloody	unknown predator
6. Predator Signs in Areas	
A. Fresh coyote tracks	probable coyote
B. Fresh bobcat tracks	probable bobcat
C. Coyote fur around carcass	coyote

Table 3. Characteristics of fawn carcasses and criteria used to determine predator species involved in mortality, Wichita Mountains, Oklahoma, 1976 and 1977.

Fawn number	Estimated % carcass remaining	Time interval since last observed in good condition	Characteristics of kill site and carcass (Table 2)
C 1	99	23 hours	1A & D, 2A, 3B, 4F, 5A, 6A
C 2	1	40 hours	1D, 2B, 4B, 5A
C 3	100	24 hours	1E
C 4	15	16 hours	1A & D, 2C, 3A & B, 4B, 5A
C 5	35	25 hours	1A & D, 2C, 3A, 3B & C, 4D, 5A, 6C
C 7	5	42 hours	1D, 2B, 4B & D, 5A, 6C
C 8	15	22 hours	1A & D, 2C, 3A, 3B & E, 5A
C 10	0	15 days	4A, 5A
Z 1[a]	0	41 hours	1D, 4A, 5A, 6A
Z 2	1	6 days	2B, 4B & D, 5A, 6A & C
Z 3	12	4 days	1A, 2B, 3A & E, 4B & D, 5A, 6A
Z 4	2	17 days	2B, 3A, 4B, 5A
Z 5	0	11 days	4A, 5A
Z 6	0	9 days	4A, 5A
Z 7	6	12 days	1C, 2B, 4C & D, 5A, 6C

Table 3. (Continued)

Fawn number	Estimated % carcass remaining	Time interval since last observed in good condition	Characteristics of kill site and carcass (Table 2)
Z 8	1	44 hours	1D, 2B, 4B, 5A, 6A & C
Z 9	0	14 days	4A, 5A
Z 10	8	3 days	1C, 2B, 4B & E, 5A, 6A & C
D 1	100	25 hours	1A & D, 2A, 3A & E, 4F, 5A
D 2	4	32 hours	1D, 2B, 4C & E, 5A
D 3	2	26 hours	1D, 2B, 4A, 5A
D 4	1	21 hours	1C & D, 2B, 4B, 6C
D 5	80	26 hours	1A, 1C & D, 3C & D
D 7	0	24 hours	1D, 4A, 5A
D 8	2	35 hours	1D, 2B, 4B, 5A
D 9	10	17 hours	1A & D, 2C, 3A & E, 6C
D 10	100	19 hours	1A & D, 2A, 4F, 5B
D 11	12	18 hours	1C & D, 2B, 4C
D 12	20	52 hours	1A & C, 2B, 3A & E, 4D
D 13	8	22 hours	1A & D, 3A, 3B & E, 5A
T 1	15	3 days	1A, 2C, 3A, 5A, 6A & C
T 2	8	20 hours	1A & D, 2C, 3A & E, 5A, 6A & C
T 3	5	22 hours	2D, 4B
T 4	0	8 days	1C, 2B, 4A, 5A, 6C

Table 3. (Continued)

Fawn number	Estimated % carcass remaining	Time interval since last observed in good condition	Characteristics of kill site and carcass (Table 2)
T 5	100	48 hours	1A & D, 3A & E, 4F, 5A
T 6	0	7 days	4A, 5A
T 7	100	47 hours	1D & E
T 8	1	50 hours	1C, 2B, 4B, 5A
T 9	0	17 days	4A, 5A
T 10	10	4 days	1A, 2C, 3A & E, 5A
T 11	25	3 days	1A, 2C, 3A & E, 4D, 5A
T 13	1	5 days	2B, 4B, 5A
T 14	100	4 days	1E, 4F

[a] Z and T prefixes designate fawns in T_1 treatment group which were not intentionally observed at each daily triangulation made after capture and release.

Table 4. Mean daily movement of marked fawns 0 - 3 and 4 - 6 days postcapture in the Wichita Mountains, Oklahoma, 1976 and 1977.

Fawn ID No.	Age at capture (days)	Sex	Mean daily movement (m) by days postcapture 0-3	4-6
Z 7	3	F	33	105
C 7	9	M	239	496
Z 8	8	F	146	113
C 6	10	M	146	134
Z 10	10	M	134	46
Z 2	5	F	444	117
C 4	9	M	370	194
C 5	1	M	306	146
Z 6	1	M	193	67
Z 5	14	F	142	117
Z 4	8	F	130	88
C 1	6	M	155	255
C 8	7	M	113	108
C 10	10	M	302	528
C 9	10	M	469	51
Z 9	10	F	63	126
Z 1	10	M	624	188
Z 3	6	M	109	180
D 7	7	M	167	105

Table 4. (Continued)

Fawn ID No.	Age at capture (days)	Sex	Mean daily movement (m) by days postcapture 0-3	4-6
D 9	14	M	193	63
D 10	15	F	268	113
T 9	8	M	29	54
T 11	1	F	38	54
T 1	3	F	33	25
T 2	7	F	147	79
D 1	3	M	138	126
T 4	8	F	88	71
T 5	3	F	138	119
T 8	7	M	302	176
T 10	14	M	67	75
D 2	7	F	55	96
D 4	7	M	71	201
D 8	8	F	126	46
D 5	8	M	167	226
D 11	16	F	138	142
T 12	3	F	92	130
D 13	1	M	25	121
D 12	1	M	46	50
D 14	12	F	256	67

Table 4. (Continued)

Fawn ID No.	Age at capture (days)	Sex	Mean daily movement (m) by days postcapture	
			0-3	4-6
D 6	1	F	101	130
T 6	6	F	42	25
Total			6,843	5,355
Mean ± SD			166.9 ± 131.9	130.6 ± 103.1

Table 5. Sex, date, and area of capture, number of relocations, and home range of fawns surviving to 31 October 1977, in the Wichita Mountains, Oklahoma.

Deer number	Sex	Capture date (month and year)	Area	Number of relocations	Monitoring period (months postcapture)	Home range (ha)
C 6	M	6/76	P[a]	90	17	39.9
D 9	M	6/76	P	70	17	119.4
D 6	F	5/77	P	77	5	34.9
T 12	F	6/77	P	65	5	52.3
D 14	F	6/77	W_f	56	5	17.2

[a]P indicates the Pinchot area; W_f indicates the FSMR portion of the Wye area.

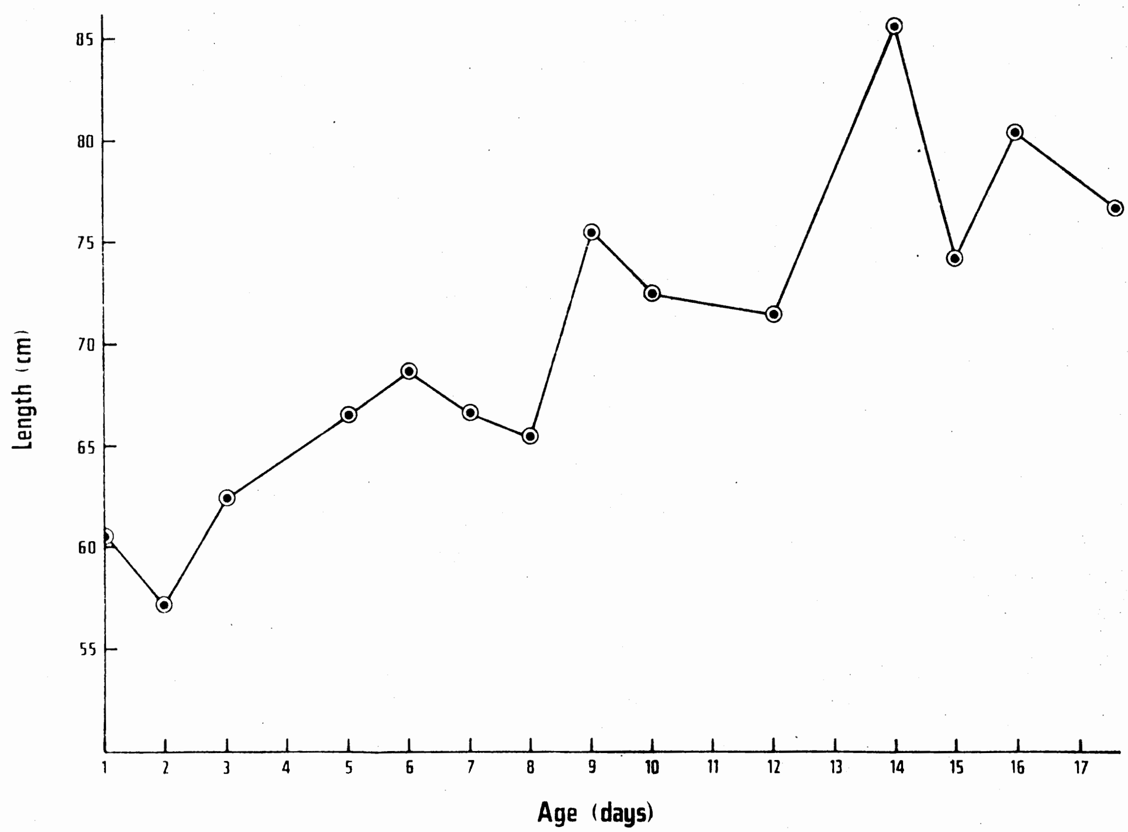

Fig. 1. Average total length of fawns grouped by daily age categories, Wichita Mountains, Oklahoma, 1976 and 1977.

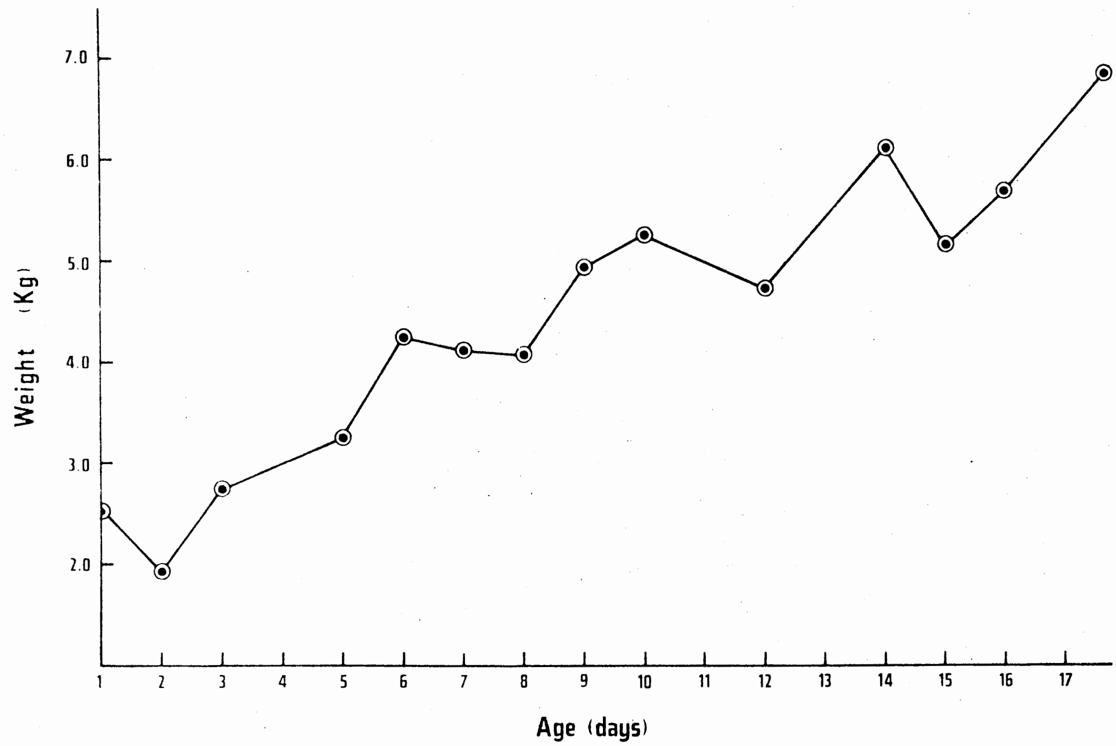

Fig. 2. Average body weight of fawns grouped by daily age categories, Wichita Mountains, Oklahoma, 1976 and 1977.

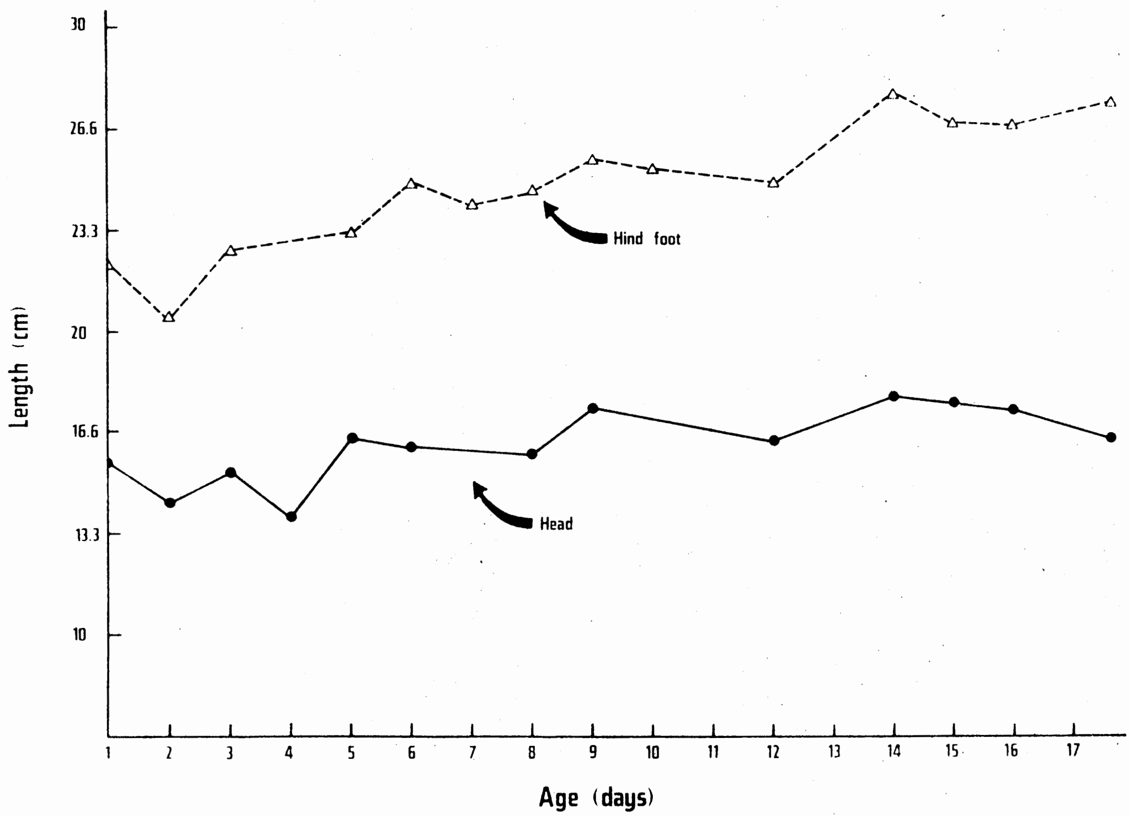

Fig. 3. Average hind foot and head lengths of fawns grouped by daily age categories, Wichita Mountains, Oklahoma, 1976 and 1977.

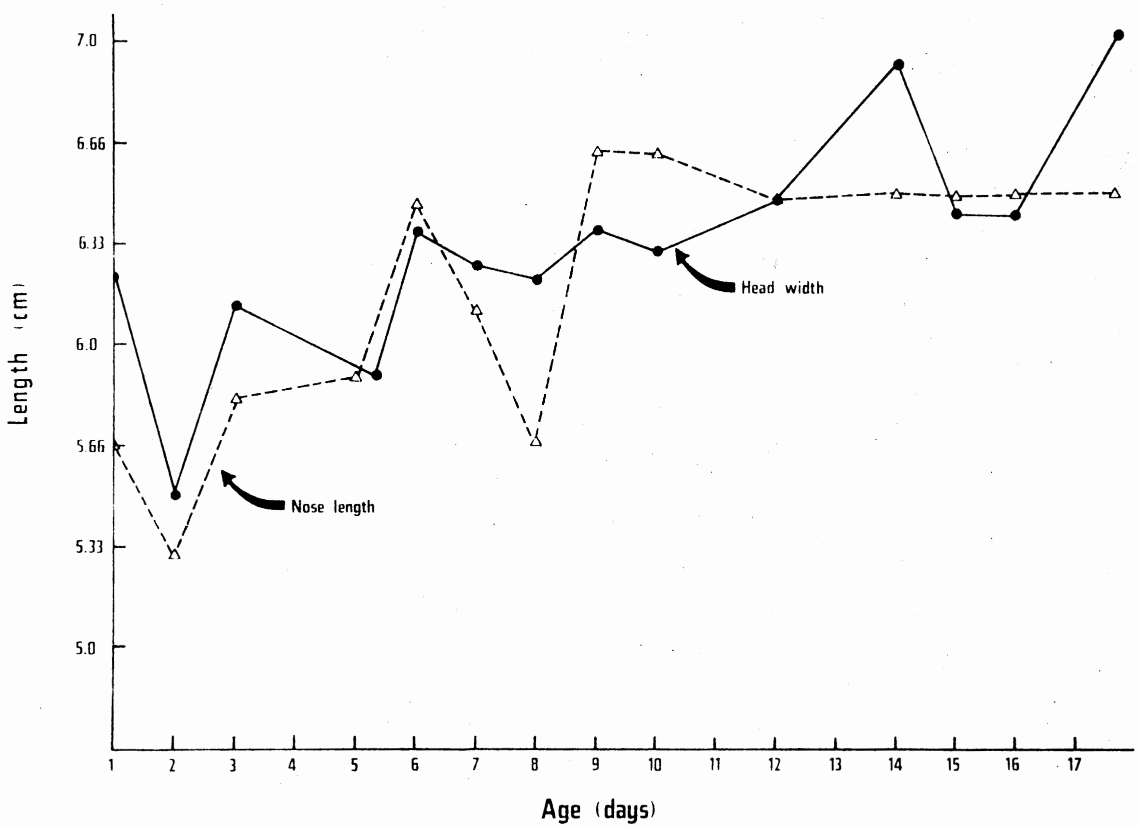

Fig. 4. Average nose length and head width of fawns grouped by daily age categories, Wichita Mountains, Oklahoma, 1976 and 1977.

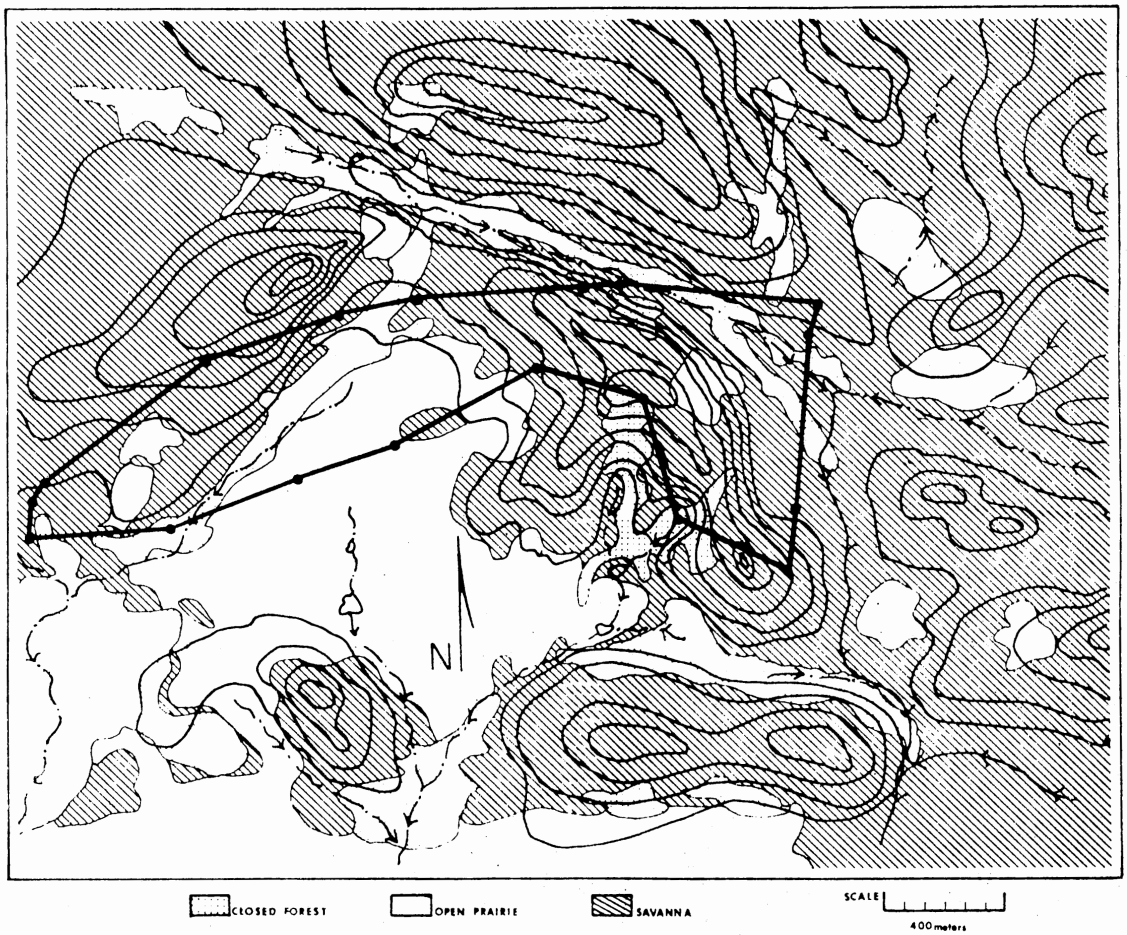

Fig. 5. Home range of fawn C 9 (through 18 months of age) in relation to habitat type in the Pinchot area of WMNWR, Oklahoma, 1976 and 1977.

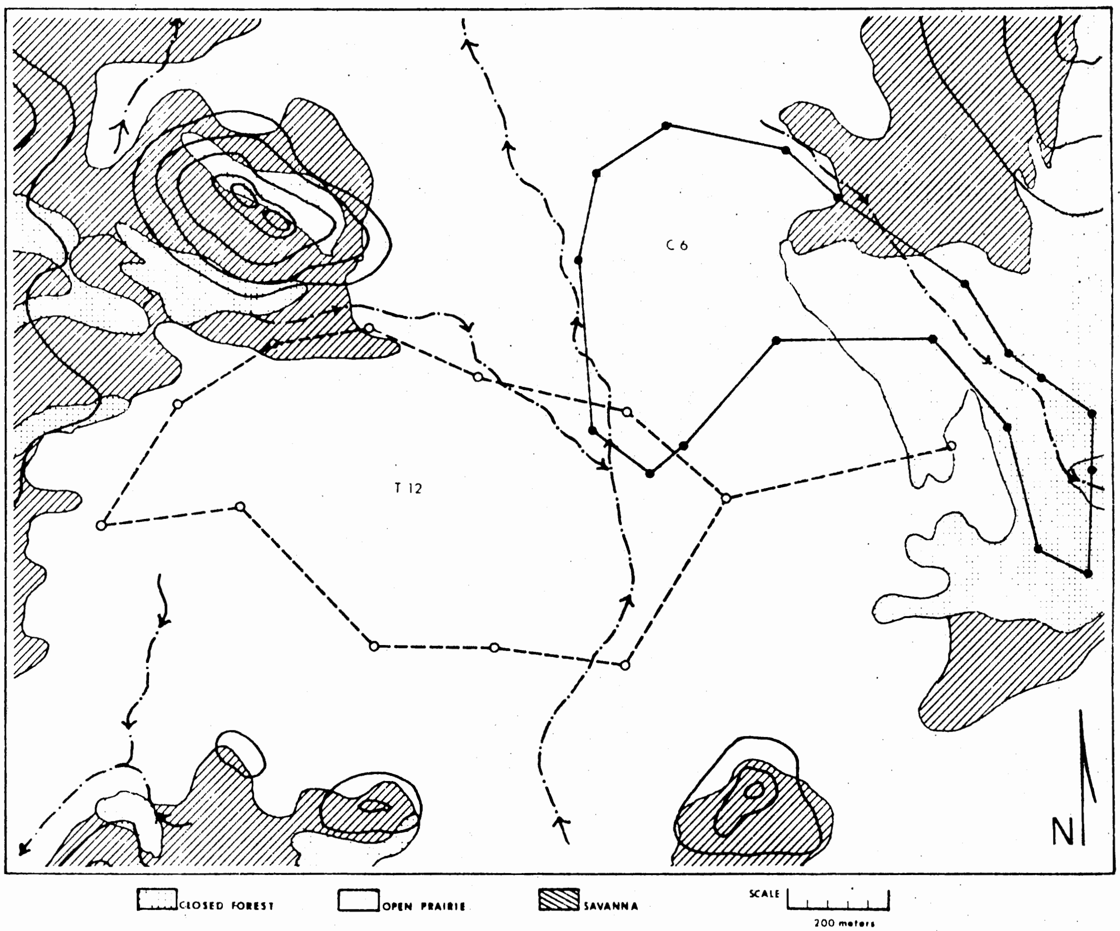

Fig. 6. Home ranges of fawns T 12 (through 5 months of age) and C 6 (through 18 months of age) in relation to habitat type in the Pinchot area of WMNWR, Oklahoma, 1976 and 1977.

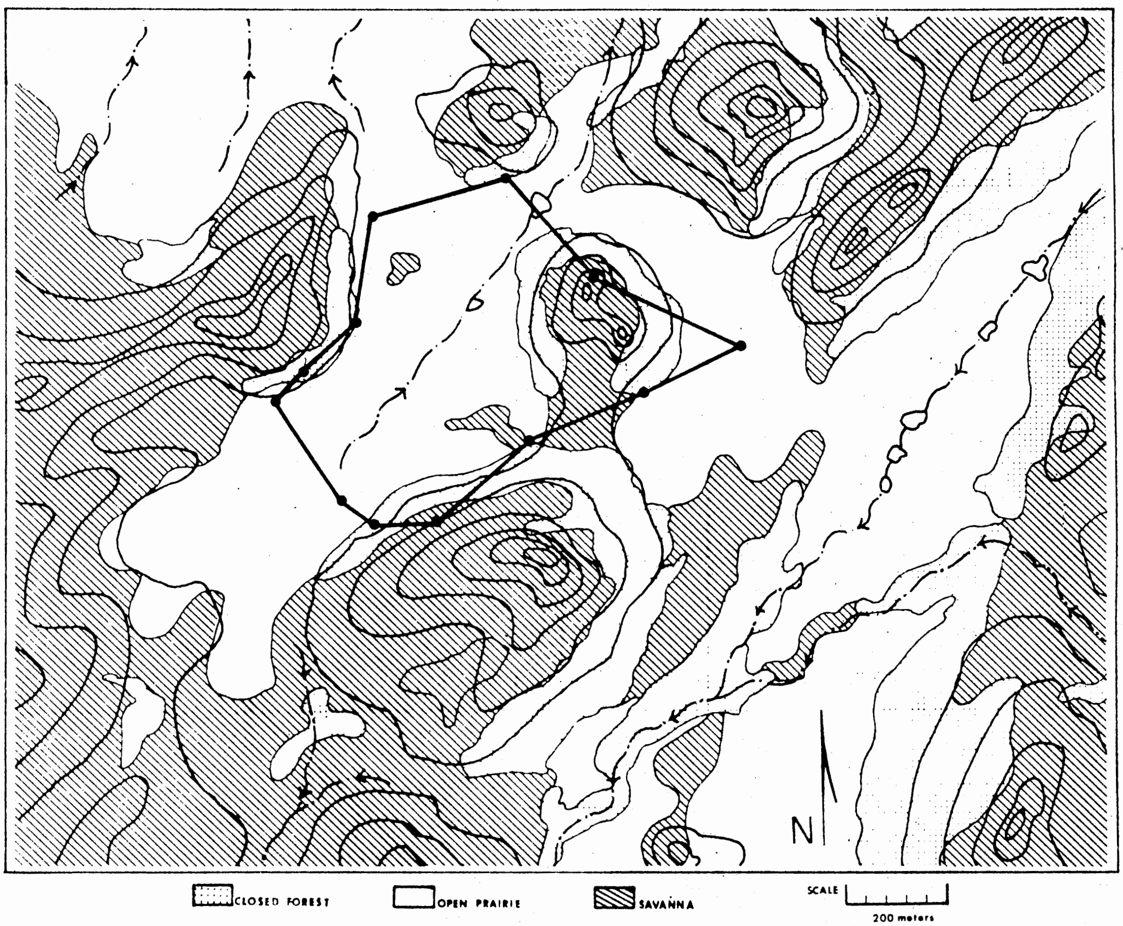

Fig. 7. Home range of fawn D 6 (through 5 months of age) in relation to habitat type in the Pinchot area of WMNWR, Oklahoma, 1977.

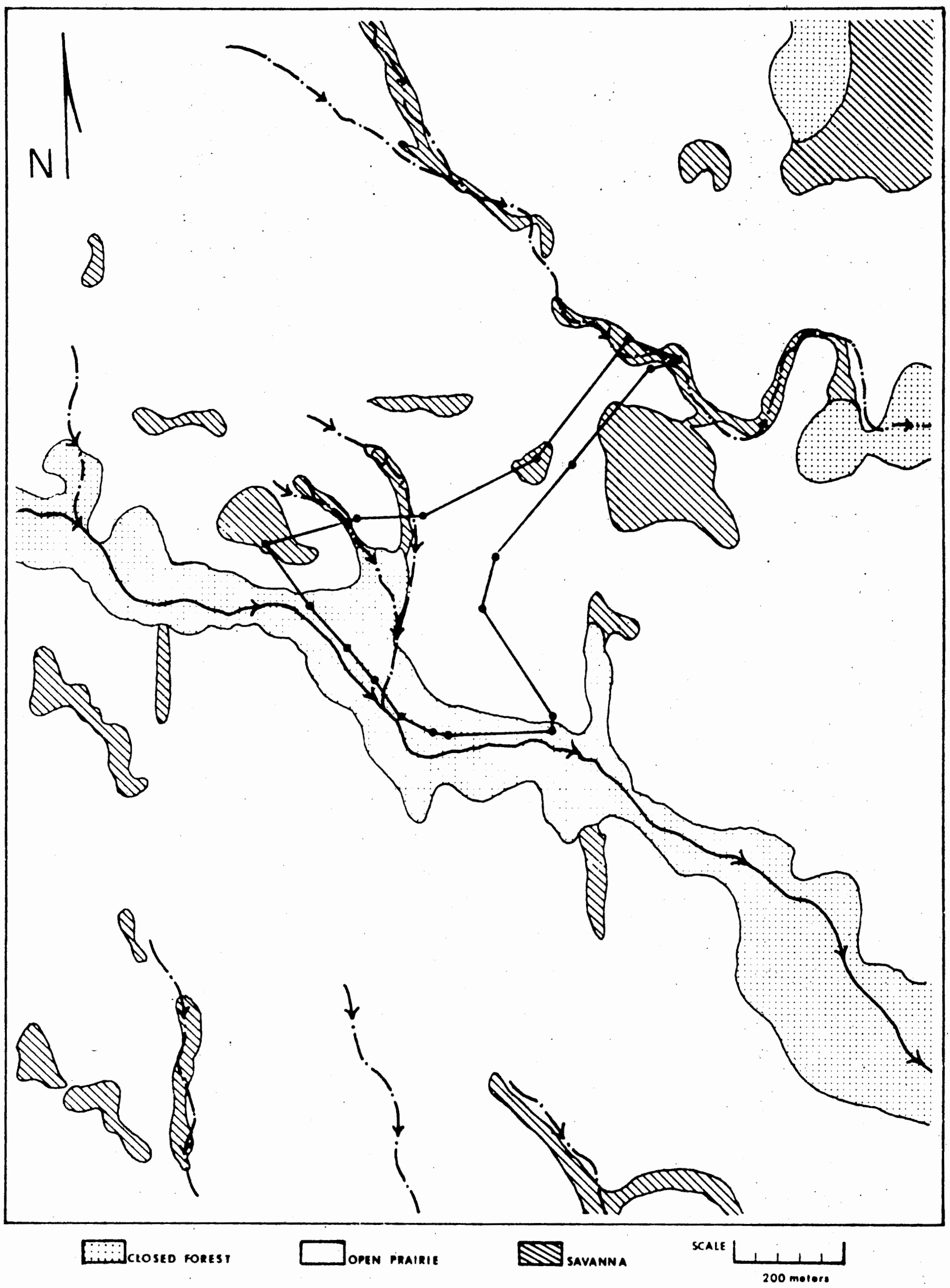

Fig. 8. Home range of fawn D 14 (through 5 months of age) in relation to habitat type on FSMR of the Wye area, Wichita Mountains, Oklahoma, 1977.

APPENDIX C

DATA SHEETS USED TO RECORD PHYSICAL AND VEGETATIVE CHARACTERISTICS OF FAWN BEDSITES AND COMPUTER INPUT AND PROCEDURE STATEMENTS USED FOR STATISTICAL ANALYSIS OF BEDSITE DATA FROM THE WICHITA MOUNTAINS, OKLAHOMA, 1976 AND 1977

- ID
- Date
- Animal
- Age
- Bedsite
- Time
- Card
- Air Temperature
- Shade/Open
- Wind Direction
- Wind Speed
- % Cloud Cover
- Habitat Type
- Range Site
- Elevation
- Aspect
- Slope
- Weather Past 24 Hours
- Humidity

- ID
- Date
- Animal
- Age
- Bedsite
- Time
- Card
- Dominant #1
- Dominant #2
- Dominant #3
- Dominant #4
- Distance Woody Cover
- Species
- Distance Boulder Cover
- Class
- Distance Next Boulder
- Class

- ID
- Date
- Animal
- Age
- Bedsite
- Time
- Card
- Trans.
- Coord.
- Class I Density
- Class I Boulder Cover
- Class II Density
- Class II Boulder Cover
- Class III Density
- Class III Boulder Cover
- Woody sp. #1
- Canopy Cover #1
- Density #1

- ID
- Date
- Animal
- Age
- Bedsite
- Time
- Card
- Trans.
- Coord.
- Woody sp. #2
- Canopy Cover #2
- Density #2
- Woody sp. #3
- Canopy Cover #3
- Density #3
- Woody sp. #4
- Canopy Cover #4
- Density #4

- ID
- Date
- Animal
- Age
- Bedsite
- Time
- Card
- Trans.
- Coord.
- Up Right — Visual Ob.
- Down Left — Visual Ob.
- Up Right — Veg. Height
- Down Left — Veg. Height
- Up Right — Litter Height
- Down Left — Litter Height
- Density Class

```
DATA ONE;
INPUT YEAR 4   DATE 6-8 ANIMAL $ 10-12 AGE 14-15 BEDSITE $ 17-18 TIME 20-23
AREA $ 24 CARD  25 AIR_TIMP 27-28 BED_TEMP 30-31 SHD_OPN $ 33 WD_DIR $ 35-36
WD_SP 38-39 PER_CC 41-43 CVR_CLS $ 45-46 RAN_ST $ 48-49 ELEV 51-54 ASPECT
   56-58 SLOPE 60-61 PRE_WTAR $ 63-66 HUMID 68-70;
IF SHD_OPN EQ 'O' THEN NSHD_OPN =  2;
IF SHD_OPN EQ 'S' THEN NSHD_OPN =  1;
IF CARD NE 1 THEN ERROR
   'CARD1 VALUE INCORRECT';
IF  WD_DIR = 'NO' THEN WD = 1;
IF  WD_DIR = 'NE' THEN WD = 2;
IF  WD_DIR = 'EA' THEN WD = 3;
IF  WD_DIR = 'SE' THEN WD = 4;
IF  WD_DIR = 'SO' THEN WD = 5;
IF  WD_DIR = 'SW' THEN WD = 6;
IF  WD_DIR = 'WE' THEN WD = 7;
IF  WD_DIR = 'NW' THEN WD = 8;
IF 0<=AGE<=14 THEN AGE_GRP = 1;
IF 15<=AGE<=28 THEN AGE_GRP=2;
IF 29<=AGE<=42 THEN AGE_GRP=3;
IF AGE>=43 THEN AGE_GRP=4;
IF CVR_CLS = 'OP' THEN HABITAT = 1;
IF CVR_CLS = 'CL' THEN HABITAT = 2;
IF CVR_CLS ¬= 'OP' AND CVR_CLS ¬= 'CL' THEN HABITAT=3;
IF RAN_ST='BK' OR RAN_ST='PC' THEN R_S=1;
IF RAN_ST = 'GC' OR RAN_ST = 'GO' THEN R_S = 2;
IF RAN_ST = 'LA' OR RAN_ST = 'LF' THEN R_S = 3;
IF RAN_ST = 'FT' OR RAN_ST = 'TM' THEN R_S = 4;
IF RAN_ST = 'FS' THEN R_S = 5;
IF RAN_ST = 'RO' THEN R_S = 6;
IF RAN_ST = 'ST' THEN R_S = 7;
IF ASPECT < 145 | ASPECT > 315 THEN ASP_TYP='N';
IF ASPECT > 134 & ASPECT < 225 THEN ASP_TYP='S';
IF ASPECT > 44 & ASPECT < 135 THEN ASP_TYP='E';
IF ASPECT > 224 & ASPECT < 316 THEN ASP_TYP='W';
IF ASPECT > 45 & ASPECT < 226 THEN ASPEC = (225-ASPECT)/180;
IF ASPECT > 225 & ASPECT < 361 THEN ASPEC = (ASPECT-225)/180;
IF ASPECT >= 0 & ASPECT < 45 THEN ASPEC = (270+(2*ASPECT))/360;
MEI=ASPEC *SLOPE;
DATA TWO;
INPUT DATE 6-8 ANIMAL $ 10-12 CARD 25 DOM_1 $ 27-30 DOM_2 $ 32-35
 DOM_3 $ 37-40 DOM_4 $ 42-45 DNWC 47-50 SPECIES $ 52-55 DNBLDR 57-60
   CLASS 62 DNBC 64-67 CLASS 69;
IF CARD NE 2 THEN ERROR
   'CARD2 VALUE INCORRECT';
DATA THREE;
INPUT DATE 6-8 ANIMAL $ 10-12 CARD1 25 TRANS1 $ 28 COORD1 30-32 CL1_DNU 34-35
CL1_BCU 37-40 CL2_DNU 42-44 CL2_BCU 45-48 CL3_DNU 50-51 CL3_BCU 53-56 WSP1_U $
58-61 CC1_U 63-66 DN1_U 68-69 #2 CARD2 25 TRANS2 $ 28 COORD2 30-32
CL1_DNC 34-35 CL1_BCC 37-40 CL2_DNC 42-44 CL2_BCC 45-48 CL3_DNC 50-51 CL3_BCC
53-56 WSP1_C $ 58-61 CC1_C 63-66 DN1_C 68-69;
IF CARD1 ¬= 3 THEN ERROR 'CARD3_1 VALUE INCORRECT';
IF CARD2 ¬= 3 THEN ERROR 'CARD3_2 VALUE INCORRECT';
IF TRANS1 ¬= 'U' | TRANS2 ¬= 'C' THEN ERROR 'TRANS ERROR';
DATA FOUR;
INPUT DATE 6-8 ANIMAL $ 10-12 CARD1 25 TRANS1 $ 28 COORD1 30-32 WSP2_U $  34-37
CC2_U 39-42 DN2_U 44-45 WSP3_U $ 47-50 CC3_U 52-55 DN3_U 57-58 WSP4_U $ 60-63
CC4_U 65-68 DN4_U 70-71
#2 CARD2 25 TRANS2 $ 28 COORD2 30-32 WSP2_C $ 34-37 CC2_C 39-42 DN2_C 44-45
WSP3_C $ 47-50 CC3_C 52-55 DN3_C 57-58 WSP4_C $ 60-63 CC4_C 65-68 DN4_C 70-71;
IF CARD1 ¬= 4 THEN ERROR 'CARD4_1 VALUE INCORRECT';
IF CARD2 ¬= 4 THEN ERROR 'CARD4_2 VALUE INCORRECT';
IF TRANS1 ¬= 'U' | TRANS2 ¬= 'C' THEN ERROR 'TRANS ERROR';
DATA FIVE;
INPUT DATE 6-8 ANIMAL $ 10-12 CARD 25 TRANS $ 27 COORD 29-31 VISOB_UU 33-36
   VISOB_DU 38-41 VEGHT_UU 43-46 VEGHT_DU 48-51 LTRWT_UU 53-56 LTRWT_DU
   58-61 CLASS 66 #2 CARD2 25 TRANS2 $ 27 VISOB_UC 33-36 VISOB_DC 38-41 VEGHT_UC
 43-46 VEGHT_DC 48-51 LTRWT_UC 53-56 LTRWT_DC 58-61;
IF CARD LT 5 OR CARD GT 6 THEN ERROR
   'CARD5 VALUE INCORRECT';
IF TRANS NE 'U' OR TRANS2 NE 'C' THEN ERROR
'TRANS ERROR';
IF CARD2 LT 5 OR CARD2 GT 6 THEN ERROR
'CARD5 VALUE INCORRECT';
VISOB=(VISOB_UU+VISOB_DU+VISOB_UC+VISOB_DC)/4;
VEGHT=(VEGHT_UU+VEGHT_DU+VEGHT_UC+VEGHT_DC)/4;
LTRWT=(LTRWT_UU+LTRWT_DU+LTRWT_UC+LTRWT_DC)/4;
```

```
PROC SORT DATA=ONE;
BY DATE ANIMAL;
PROC SORT DATA=TWO;
BY DATE ANIMAL;
PROC SORT DATA=THREE;
BY DATE ANIMAL;
PROC SORT DATA=FOUR;
BY DATE ANIMAL;
PROC SORT DATA=FIVE;
BY DATE ANIMAL;
DATA COMB;
MERGE ONE TWO THREE FOUR FIVE;
BY DATE ANIMAL;
DATA YEAR77; SET COMB; IF YEAR=7;
IF CC1_U = . THEN CC1_U=0;
IF CC1_C = . THEN CC1_C=0;
IF CC2_U = . THEN CC2_U=0;
IF CC2_C = . THEN CC2_C=0;
IF CC3_U = . THEN CC3_U = 0;
IF CC3_C = . THEN CC3_C=0;
IF CC4_U = . THEN CC4_U=0;
IF CC4_C = . THEN CC4_C=0;
IF DN1_U = . THEN DN1_U=0;
IF DN1_C = . THEN DN1_C=0;
IF DN2_U = . THEN DN2_U=0;
IF DN2_C = . THEN DN2_C=0;
IF DN3_U = . THEN DN3_U=0;
IF DN3_C = . THEN DN3_C=0;
IF DN4_U = . THEN DN4_U=0;
IF DN4_C = . THEN DN4_C=0;
CC=CC1_U+CC1_C+CC2_U+CC2_C+CC3_U+CC3_C+CC4_U+CC4_C;
DN=DN1_U+DN1_C+DN2_U+DN2_C+DN3_U+DN3_C+DN4_U+DN4_C;
PROC SORT DATA=YEAR77; BY RAN_ST;
PROC MEANS DATA=YEAR77; VARIABLES CC DN;
PROC MEANS DATA=YEAR77; VARIABLES CC DN; BY RAN_ST;
PROC SORT DATA=YEAR77; BY HABITAT;
PROC MEANS DATA=YEAR77; VARIABLES CC DN; BY HABITAT;
DATA WSPECIES; SET YEAR77;
WSP=WSP1_U; OUTPUT;
WSP=WSP1_C; OUTPUT;
WSP=WSP2_U; OUTPUT;
WSP=WSP2_C; OUTPUT;
WSP=WSP3_U; OUTPUT;
WSP=WSP3_C; OUTPUT;
WSP=WSP4_U; OUTPUT;
WSP=WSP4_C; OUTPUT;
PROC FREQ DATA=WSPECIES; TABLES WSP WSP*RAN_ST WSP*HABITAT;
INPUT ID $ 1-4 DATE 6-8 ANIMAL $ 10-12 AGE 14-15 BEDSITE $ 17-18 TIME 20-23
PROC SORT DATA=COMB; BY AREA RAN_ST;
PROC FREQ DATA=COMB; TABLES AREA*RAN_ST*CVR_CLS;
PROC MEANS DATA=COMB; VARIABLES VISOB DNWC DNBLD ELEV ASPECT SLOPE AIR_TEMP
WD_SP PER_CC; BY AREA RAN_ST;
PROC SORT DATA=COMB; BY RAN_ST AGE_GRP;
PROC MEANS DATA=COMB; VARIABLES VISOB; BY RAN_ST AGE_GRP;
DATA UP_CR; SET COMB;
WSP1=WSP1_U; CC1=CC1_U; DN1=DN1_U;
WSP2=WSP2_U; CC2=CC2_U; DN2=DN2_U;
WSP3=WSP3_U; CC3=CC3_U; DN3=DN3_U;
WSP4=WSP4_U; CC4=CC4_U; DN4=DN4_U; OUTPUT;
WSP1=WSP1_C; CC1=CC1_C; DN1=DN1_C;
WSP2=WSP2_C; CC2=CC2_C; DN2=DN2_C;
WSP3=WSP3_C; CC3=CC3_C; DN3=DN3_C;
WSP4=WSP4_C; CC4=CC4_C; DN4=DN4_C; OUTPUT;
PROC FREQ;
TABLES WSP1 WSP2 WSP3 WSP4;
PROC MEANS;
VARIABLES CC1 CC2 CC3 CC4;
PROC MEANS;
VARIABLES DN1 DN2 DN3 DN4;
DATA ALL; SET UP_CR;
WSP=WSP1; CC=CC1; DN=DN1; OUTPUT;
WSP=WSP2; CC*CC2; DN=DN2; OUTPUT;
WSP=WSP3; CC=CC3; DN=DN3; OUTPUT;
WSP=WSP4; CC=CC4; DN=DN4; OUTPUT;
PROC FREQ DATA=ALL; TABLES WSP;
PROC MEANS DATA=ALL; VARIABLES CC DN;
```

```
VARIABLES AGE CLASS;
PROC SORT DATA=COMB; BY PER_CC;
PROC SCATTER DATA=COMB;
PLOT AIR_TIMP*TIME;
PLOT AIR_TIMP*ASPECT;
PLOT AIR_TIMP*SLOPE;
PLOT AGE*AIR_TIMP;
PLOT AGE*MEI;
PLOT AIR_TIMP*MEI;
PLOT MEI*DNWC;
PROC SORT DATA=COMB; BY AGE_GRP PER_CC;
PROC SCATTER DATA=COMB; BY AGE_GRP;
PLOT AIR_TIMP*TIME;
PLOT AIR_TIMP*ASPECT;
PLOT AIR_TIMP*SLOPE;
PLOT AGE*AIR_TIMP;
PLOT AGE*MEI;
PLOT AIR_TIMP*MEI;
PLOT MEI*DNWC;
DATA UP_CR; SET COMB; IF ID='WSB7';
VISOB=(VISOB_UU+VISOB_DU)/2;
VEGHT=(VEGHT_UU+VEGHT_DU)/2;
LTRHT=(LTRWT_UU+LTRWT_DU)/2;
SLOPETYP='U'; OUTPUT;
VISOB=(VISOB_UC+VISOB_DC)/2;
VEGHT=(VEGHT_UC+VEGHT_DC)/2;
LTRHT=(LTRWT_UC+LTRWT_DC)/2;
SLOPETYP='C';OUTPUT;
PROC TTEST DATA=UP_CR; CLASSES SLOPETYP;
VARIABLES VISOB VEGHT LTRHT;
PROC SORT DATA=UP_CR; BY ASP_TYP;
PROC TTEST DATA=UP_CR; CLASSES SLOPETYP; BY ASP_TYP;
VARIABLES VISOB VEGHT LTRHT;
DATA UP_DWN; SET COMB; IF ID='WSB7';
VISOB=(VISOB_UU+VISOB_UC)/2;
VEGHT=(VEGHT_UU+VEGHT_UC)/2;
LTRHT=(LTRWT_UU+LTRWT_UC)/2;
L_R='U'; OUTPUT;
VISOB=(VISOB_DU+VISOB_DC)/2;
VEGHT=(VEGHT_DU+VEGHT_DC)/2;
LTRHT=(LTRWT_DU+LTRWT_DC)/2;
L_R='D'; OUTPUT;
PROC TTEST DATA=UP_DWN; CLASSES L_R;
VARIABLES VISOB VEGHT LTRHT;
PROC SORT DATA=UP_DWN ; BY ASP_TYP;
PROC TTEST DATA=UP_DWN ; CLASSES L_R; BY ASP_TYP;
VARIABLES VISOB VEGHT LTRHT;
PROC SCATTER DATA=COMB;
PLOT AIR_TIMP*SLOPE;
PLOT DNWC*SLOPE;
PLOT AIR_TIMP*ASPECT;
PLOT DNWC*ASPECT;
PLOT WD*ASPECT;
PLOT ASPECT*TIME;
PLOT SLOPE*TIME;
PLOT AIR_TIMP*TIME;
PLOT CLASS*AGE;
PROC SORT; BY AGE_GRP;
PROC SCATTER DATA=COMB; BY AGE_GRP;
PLOT AIR_TIMP*SLOPE;
PLOT DNWC*SLOPE;
PLOT AIR_TIMP*ASPECT;
PLOT DNWC*ASPECT;
PLOT WD*ASPECT;
PLOT ASPECT*TIME;
PLOT SLOPE*TIME;
PLOT AIR_TIMP*TIME;
PLOT CLASS*AGE;
PROC SCATTER DATA=COMB;
PLOT AGE*VEGHT;
PLOT AGE*LTRHT;
PLOT AGE*VISOB;
PLOT AGE*ASPECT;
PLOT AGE*SLOPE;
PLOT AGE*DNWC;
PLOT AGE*DNBC;
```

```
PROC SORT;
BY AGE_GRP;
PROC SAS72;
PARMCARDS4;
PROC REGR;
MODEL AIR_TIMP=ASPECT TIME;
PROC REGR; BY AGE_GRP;
MODEL AIR_TIMP=ASPFCT TIMF;
PROC REGR;
MODEL SLOPE=AIR_TIMP TIME;
PROC REGR; BY AGE_GRP;
MODEL SLOPE=AIR_TIMP TIME;
;;;;
PROC FREQ; TABLES HABITAT;
PROC FREQ;
BY AGE_GRP;
TABLES HABITAT;
PROC FREQ;
TABLES HABITAT*AREA;
PROC FREQ; TABLES (DOM_1-DOM_4)*R_S AREA*(DOM_1-DOM_4)*R_S;
PROC SORT;
BY HABITAT AREA;
PROC MEANS;
VARIABLES DNWC DNBLDR;
BY HABITAT;
PROC MEANS;
VARIABLES DNWC DNBLDR;
BY HABITAT AREA;
PROC SAS72;
PARMCARDS4;
PROC REGR;
MODEL VISOB=VEGHT LTRHT CLASS;
;;;;
PROC SORT;
BY AREA AGE_GRP;
PROC MEANS;
VARIABLES VEGHT LTRHT;
BY AREA;
PROC MEANS; VARIABLES VEGHT LTRHT;
BY AREA AGE_GRP;
PROC SORT;
BY RAN_ST;
PROC MEANS;
VARIABLES VEGHT LTRHT;
BY RAN_ST;
PROC SAS72;
PARMCARDS4;
PROC REGR;
MODEL AGE_GRP = CLASS;
;;;;
PROC SCATTER;
PLOT AGE_GRP * CLASS;
DATA OPEN; SET COMB; IF CVR_CLS='OP';
PROC SAS72;
PARMCARDS4;
PROC REGR;
MODEL AGE_GRP = CLASS;
;;;;
PROC SCATTER;
PLOT AGE_GRP * CLASS;
PROC MEANS DATA=COMB; BY AREA RAN_ST; VARIABLES MEI;
PROC SORT DATA=COMB; BY AREA RAN_ST;
PROC SORT DATA=COMB; BY AGE_GRP;
PROC MEANS DATA=COMB; BY AGE_GRP;
```

```
PROC SAS72 DATA=COMB;
PARMCARDS4;
PROC REGR S;
MODEL TIME = ASPECT SLOPE ELEV;
PROC REGR S;
MODEL TIME=AIR_TIMP WD_SP PER_CC HUMID WD;
PROC REGR S;
MODEL ELEV=DNWC AIR_TIMP WD;
PROC REGR S;
MODEL ASPECT= DNWC AIR_TIMP WD;
PROC REGR S;
MODEL SLOPE=DNWC AIR_TIMP WD;
;;;;
PROC SORT DATA=COMB; BY AREA;
PROC SAS72 DATA=COMB;
PARMCARDS4;
PROC REGR S; BY AREA;
MODEL TIME=ASPECT SLOPE ELEV;
PROC REGR S; BY AREA;
MODEL TIME=AIR_TIMP WD_SP PER_CC HUMID WD;
 PROC REGR S; BY AREA;
MODEL ELEV=DNWC AIR_TIMP WD;
PROC REGR S; BY AREA;
MODEL ASPECT=DNWC AIR_TIMP WD;
PROC REGR S; BY AREA;
MODEL SLOPE=DNWC AIR_TIMP WD;
;;;;
PROC MEANS;
VAR NSHD_OPN ELEV ASPECT HUMID;
PROC CORR; VARIABLES AGE; WITH CLASS;
DATA OPEN; SET COMB; IF CVR_CLS='OP';
PROC SAS72 DATA=OPEN;
PARMCARDS4;
PROC REGR C; MODEL AGE=CLASS;
;;;;
PROC CORR DATA =COMB;
VARIABLES VISOB VEGHT LTRHT; WITH CLASS;
PROC STEPWISE DATA=COMB;
MODEL LTRHT=VISOB VEGHT CLASS/MAXR;
PROC SORT DATA=COMB; BY AREA;
PROC CORR DATA=COMB; BY AREA;
VARIABLES VISOB VEGHT LTRHT;
WITH CLASS;
PROC STEPWISE DATA=COMB; BY AREA;
MODEL LTRHT=VISOB VEGHT CLASS/MAXR;
PROC MEANS;
```

APPENDIX D

MISCELLANEOUS FAWN BEDSITE ANALYSIS INFORMATION
INCLUDING RANGE SITE DESCRIPTIONS
AND PLANT SPECIES COMPOSITION,
WICHITA MOUNTAINS, OKLAHOMA,
1976 AND 1977

Table 1. Characteristics of range sites containing fawn bedsites, Wichita Mountains, Oklahoma. (Soil Conservation Service. 1967. Soil Survey, Comanche County, Oklahoma. Soil Cons. Ser., U. S. Dept. Agric., Washington, D. C. 58 pp.)

Range site	Range site description	Soil mapping units
Loamy bottomland	Deep loam to clay loam soils in bottomlands; occasional moisture from stream overflow; tall grass species, bottomland deciduous trees	Bk - Breaks--alluvial complex, 0-20% slope Pc - Port clay loam
Boulder ridge	Rolling to steep; dissected hills and ridges; deep, loamy soils with many cobblestones, scattered boulders, large amount of gravel; primarily tall grass species	Gc - Granite cobbly land, 25-70% cobblestones, 5-40% slope Go - Granite outcrop, 90% exposed bedrock
Loamy prairie	Level to moderately steep, productive, loamy soils; tall grass species predominate	La - Lawton loam, 3-5% slope Lf - Lawton-Foard complex, 3-5% slope

Table 1. (Continued)

Range site	Range site description	Soil mapping units
Hardland	Level to gently sloping clay and silt loams with heavy clay subsoil; absorbs water slowly, moisture penetrates less than 120 cm during the growing season; short and tall grass species	Ft - Foard and Tillman soils, 1-3% slope Tm - Tillman clay loam, 3-5% slope
Hardland–slickspots	Hardland with slickspot soils; clay and clay loams on more upland sites; slickspot soils have crusty surface with whitish appearance when dry; plants associated with slickspots must tolerate varying degrees of alkalinity	Fs - Foard-slickspots complex, 1-3% slope
Hilly stony	Gently sloping to steep slopes, varying depths of soil over granite bedrock; exposed granite outcrops; short and tall grass species	Ro - Rockland, 15-50% Go, 10-50% gently sloping to steep shallow soils

Table 1. (Continued)

Range site	Range site description	Soil mapping units
Hilly stony savanna	Gently sloping to very steep; very shallow to deep, stony soils; tall grass species are more common; varying amounts of upland woody species	St - Stony rock land, 15-50% slope, 15-50% Go, 10-30% shallow soils, 15-70% deep stony soils

Table 2. Code letters, scientific names, and common names of 64 species of vegetation (< 2 m tall) within 4 dominance classes, and total occurrence at fawn bedsites, Wichita Mountains, Oklahoma, 1976 and 1977.

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Acla	*Achillea lanulosa*	Western yarrow		1			1
Amfr	*Amorpha fruiticosa*	False indigo		2	1		2
Amps	*Ambrosia psilostachya*	Western ragweed	2	19	23	15	59
Amtr	*Ambrosia trifida*	Giant ragweed		2			2
Ange	*Andropogon gerardii*	Big bluestem	16	33	17	8	74
Ansa	*Bothriochloa saccharoides*	Silver bluestem	1	2	4	1	8
Arlu	*Artemisia ludoviciana*	Louisiana sagewort	1	3	2	7	13
Arsp	*Aristida* spp.	Three-awn	1	2	6		9
Aser	*Aster ericoides*	Heath aster			2	2	4
Bocu	*Bouteloua curtipendula*	Side-oats grama				2	2
Bogr	*Bouteloua gracilis*	Blue grama		1	1	3	5

Table 2. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Bohi	*Bouteloua hirsuta*	Hairy grama	4	3	2	3	12
Bosp	*Bouteloua* spp.	Grama		1			1
Brsp	*Bromus* spp.	Brome	8	10	12	7	37
Buda	*Buchloe dactyloides*	Buffalograss		1			1
Bula	*Bumelia lanuginosa*	Chittamwood			1		1
Cagi	*Calamovilfa gigantea*	Giant sandreed	1	1			2
Ceoc	*Cephalanthus occidentalis*	Buttonbush	1				1
Cisp	*Cirsium* spp.	Thistle			1	1	2
Cogr	*Coreopsis grandiflora*	Bigflower coreopsis			2		2
Cola	*Coreopsis lanceolata*	Lanceleaf coreopsis		1			1
Cosp	*Coreopsis* spp.	Coreopsis			2		2
Coti	*Coreopsis tinctoria*	Plains coreopsis		1		2	3
Cyda	*Cynodon dactylon*	Bermudagrass	1				1

Table 2. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Cysp	Cyperus spp.	Sedge	1	7	13	7	28
Elca	Elymus canadensis	Canadian wildrye		6	2	5	13
Elvi	Elymus virginicus	Virginia wildrye		1	1		2
Eran	Eriogonum annum	Annual buckwheat			1		1
Ersp	Agropyron spp.	Wheatgrass			1	1	2
Grsq	Grindelia squarrosa	Curlycup gumweed		1			1
Hema	Helinathus maximilani	Maximilian sunflower	6				6
Hesp	Hedyotis spp.	Bluet	1		1		2
Juni	Juglans nigra	Black walnut				1	1
Jusp	Juglans rupestris	Little walnut	2				2
Juvi	Juniperus virginiana	Eastern red cedar	1	2	4	3	10
Lesp	Lespedeza spp.	Lespedeza		3	3	2	8
Lipu	Liatris punctata	Dotted gayfeather				2	2

Table 2. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Mura	Muhlenbergia racemosa	Green muhly	10	2	2	2	16
Paqu	Parthenocissus quinquefolia	Virginia creeper		5		1	6
Pasp	Panicum spp.	Scribner's panicum	1	6	13	24	44
Pavi	Panicum virgatum	Switchgrass	33	8	5	7	53
Pham	Phytolacca americana	Pokeberry			1		1
Plsp	Plantago spp.	Plantain			1	1	2
Prgl	Prosopsis glandulosa	Mesquite				1	1
Pssp	Psoralea spp.	Wild alfalfa	1	1	3	2	7
Rhar	Rhus aromatica	Lemon sumac	1			1	2
Rhgl	Rhus glabra	Smooth sumac	1				1
Rhra	Rhus radicans	Poison ivy			2		2
Rusp	Rubus spp.	Blackberry		2	2	1	5
Scsc	Schizachyrium scoparium	Little bluestem	85	21	11	14	131

Table 2. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Smbo	*Smilax bona-nox*	Saw greenbriar	3	1	1	2	7
Smsp	*Smilax* spp.	Greenbriar				1	1
Soca	*Solanum carolinense*	Buffalo burr			1	1	2
Soha	*Sorghum halapense*	Johnsongrass	3	1			4
Sonu	*Sorghastrum nutans*	Indiangrass	5	34	24	7	70
Sosp	*Solidago* spp.	Goldenrod	1			1	2
Spas	*Sporobolus asper*	Tall dropseed	3	9	13	2	27
Syor	*Symphoricarpos orbiculatus*	Buckbrush	4	8	1	3	16
Thsp	*Thelesperma* spp.	Greenthread		1			1
Trda	*Tripsacum dactyloides*	Eastern gamagrass			1		1
Trfl	*Tridens flavus*	Purpletop	1		4	1	6
Ulam	*Ulmus americana*	American elm			1	1	2

Table 2. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Unla	Uniola latifolia	Broadleaf uniola	2				2
Veba	Vernonia baldwinii	Ironweed		2	2	3	7

Table 3. Code letters, scientific names, and common names of 17 woody plant species (> 2 m tall) within 4 dominance classes, and total occurrence at fawn bedsites, Wichita Mountains, Oklahoma, 1977.

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Amfr	*Amorpha fruiticosa*	False indigo	2	1			3
Bula	*Bumelia lanuginosa*	Chittamwood	2	2	4	2	10
Cail	*Carya illinoensis*	Pecan	9	6		1	16
Ceoc	*Cephalanthus occidentalis*	Buttonbush	5		1	1	7
Cesp	*Celtis* spp.	Hackberry	1	3	10		11
Crsp	*Crataegus* spp.	Hawthorne	1				1
Juni	*Juglans nigra*	Black walnut	4	4	3	2	13
Juvi	*Juniperus virginiana*	Eastern red cedar	19	19	6	2	46
Pode	*Populus deltoides*	Cottonwood			1		1
Prgl	*Prosopsis glandulosa*	Mesquite	3	4	1		8
Prsp	*Prunus* spp.	Wild plum	1				1

Table 3. (Continued)

Code letters	Scientific name	Common name	Occurrence in dominance class 1	2	3	4	Total occurrence
Quma	*Quercus marilandica*	Blackjack oak	53	21	3	3	80
Qust	*Quercus stellata*	Post oak	22	29	5	1	57
Rhgl	*Rhus glabra*	Smooth sumac	2	2			4
Sadr	*Sapindus drummundii*	Western soapberry	5			1	6
Ulam	*Ulmus americana*	American elm	13	7	3		23
Visp	*Vitis* spp.	Wild grape			1		1

Table 4. Mean, minimum, and maximum values of woody vegetation, canopy cover, and density recorded at fawn bedsites in the soil mapping units of the respective range sites on Wichita Mountains National Wildlife Refuge (WMNWR) and areas on Fort Sill Military Reservation (FSMR), Wichita Mountains, Oklahoma, 1977.

Range sites	Soil mapping unit	Canopy cover (m^2) $\bar{x}$	Canopy cover Minimum	Canopy cover Maximum	Density (trees/76 m^2) $\bar{x}$	Density Minimum	Density Maximum
WMNWR							
Loamy bottomland	Bk	2.5	0	41.0	5.4	0	15.0
	Pc	4.5	29	56.0	5.7	8	30.0
Boulder ridge	Gc	1.3	0	58.0	5.8	0	29.0
	Go	0.6			1.0		
Loamy prairie	La	0.3			0		
	Lf	0.8	0	38.0	0.4	0	2.0
Hardland-slickspots	Fs	0.2	0	29.0	1.0	0	10.0
Hilly stony	Ro	1.3	0	66.0	1.9	0	9.0
Hilly stony savanna	St	10.3	0.8	85.5	7.1	1	14.0
FSMR		2.8	0	67.0	6.1	0	21.0

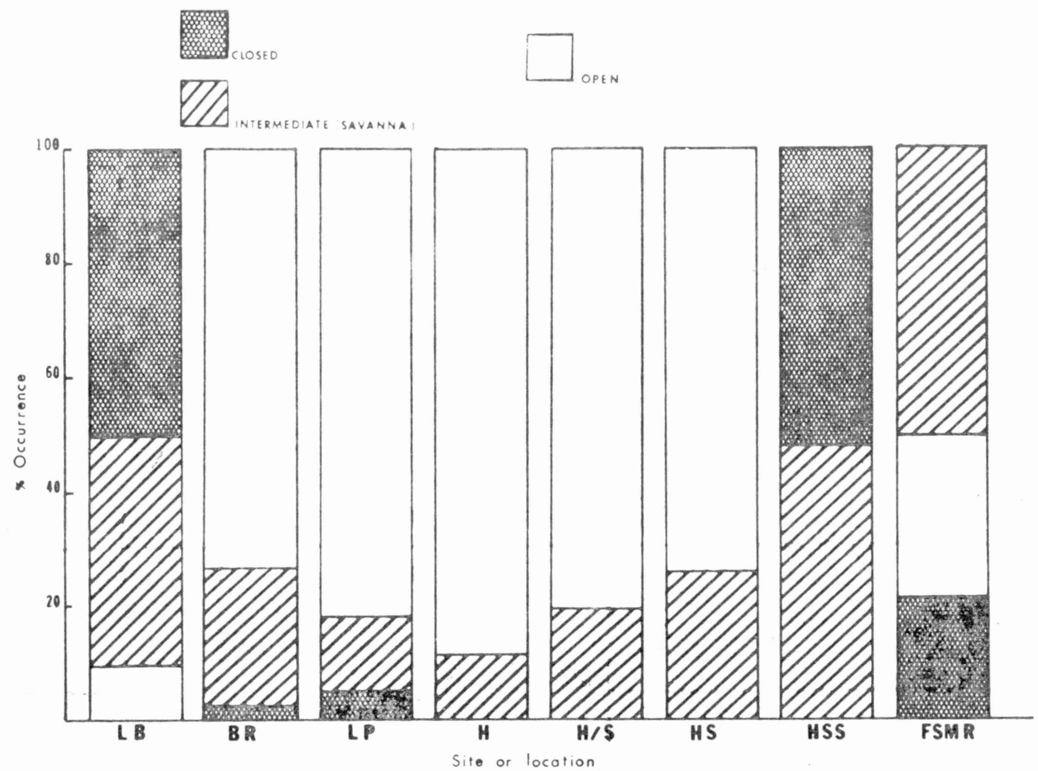

Fig. 1. Percent occurrence of the general habitat types at fawn bedsites in the loamy bottomland (LB), boulder ridge (BR), loamy prairie (LP), hardland (H), hardland-slickspots (H/S), hilly stony (HS), and hilly stony savanna (HSS) range sites of the Wichita Mountains National Wildlife Refuge and in Fort Sill Military Reservation, Comanche County, Oklahoma, 1976 and 1977.

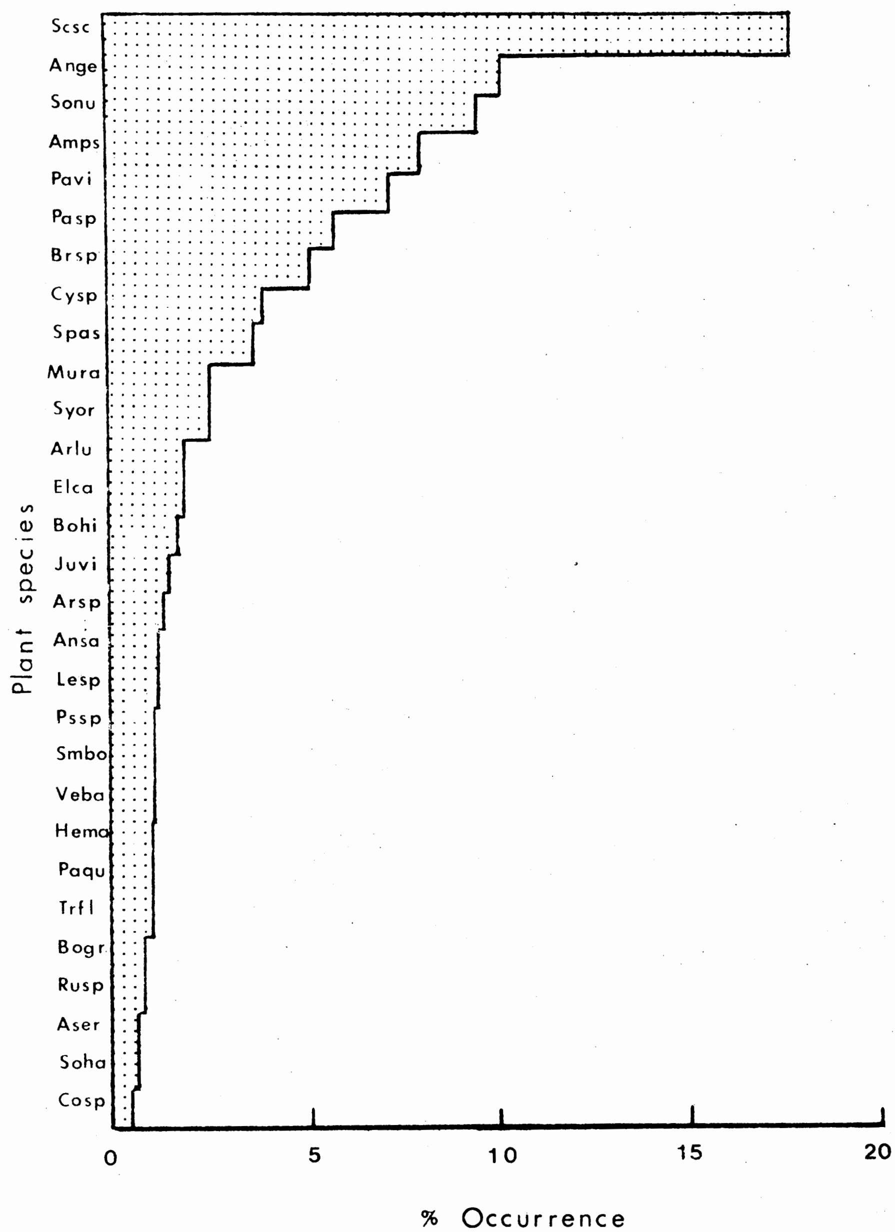

Fig. 2. Percent occurrence of 29 plant species (< 2 m tall) found most frequently at fawn bedsites, Wichita Mountains, Oklahoma, 1976 and 1977.

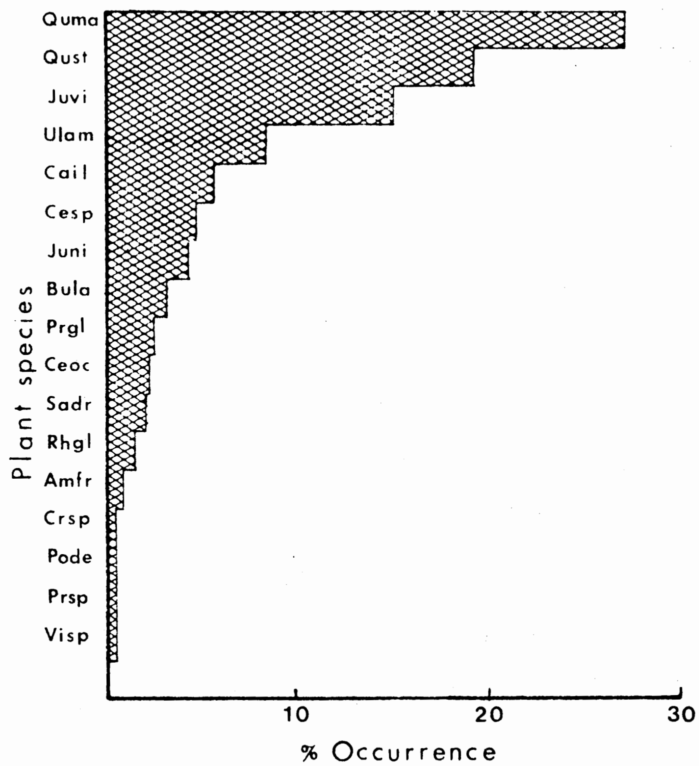

Fig. 3. Percent occurrence of 17 woody plant species (>2 m tall) found at fawn bedsites, Wichita Mountains, Oklahoma, 1977.

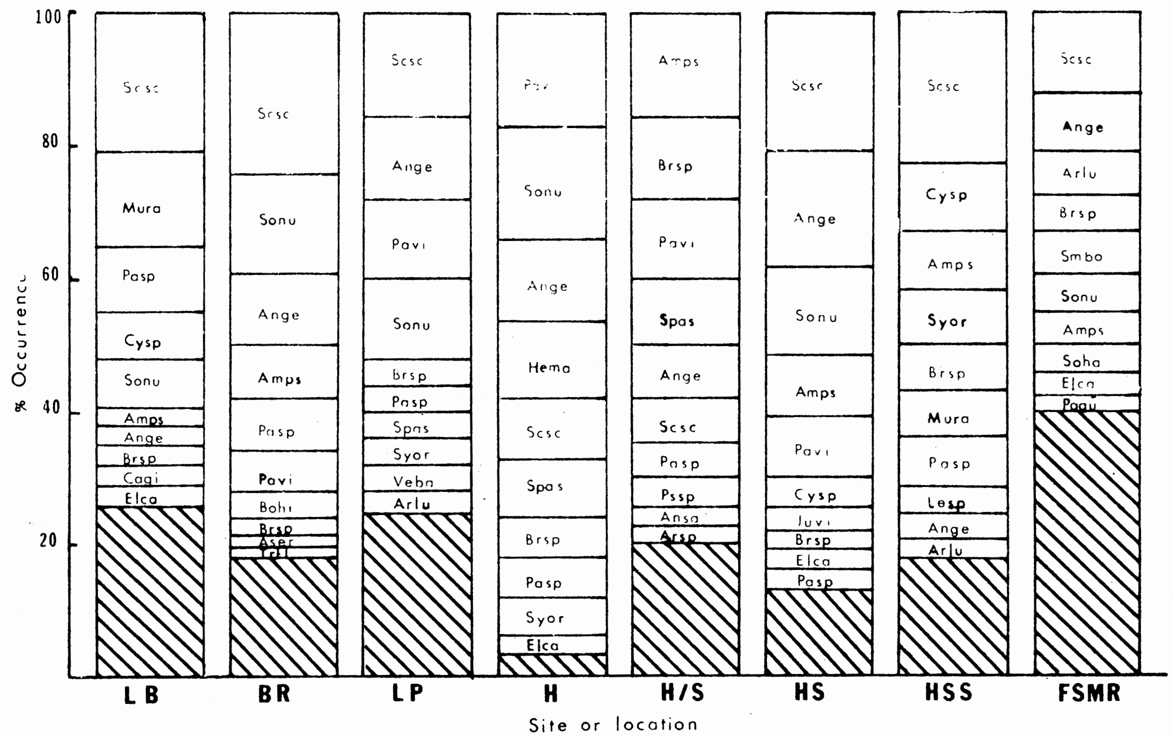

Fig. 4. The 10 species of dominant vegetation (< 2 m in height) most frequently occurring at 199 fawn bedsites in the loamy bottomland (LB), boulder ridge (BR), loamy prairie (LP), hardland (H), hardland-slickspots (H/S), hilly stony (HS), and hilly stony savanna (HSS) range sites of Wichita Mountains National Wildlife Refuge and on the Fort Sill Military Reservation, Comanche County, Oklahoma, 1976 and 1977.

APPENDIX E

MANAGEMENT RECOMMENDATIONS FOR WHITE-TAILED DEER IN THE WICHITA MOUNTAINS, COMANCHE COUNTY, OKLAHOMA

This study provided insight into the mechanisms controlling the white-tailed deer population of the Wichita Mountains. Natality, or in-utero production, was relatively high; does normally produced twins at age 3 years. Fawn mortality was high and was primarily due to predation by coyotes and bobcats, which resulted in low recruitment of fawns into the adult population. Losses of radio-tagged adult deer indicated that accidental death and hunter kill were the principal mortality factors of adults. Although disease organisms (Salmonella sp, Theileria sp.) have been isolated from some fawns and adults, there was no indication that disease was a major factor limiting deer populations. Body size, antler growth, and physical condition indicated that deer in the Wichita Mountains had adequate food resources, and the population was not exceeding the capacity of the range to provide required nutritional elements.

Basic management strategies for the white-tailed deer in the Wichita Mountains are complex because 3 categories of ownerships exist; WMNWR, FSMR, and owners of various-sized ranches are the controlling agencies or individuals. Implications of the findings of this study, to management of the deer herd, will be discussed separately for each agency.

The U.S. Fish and Wildlife Service in recent years developed a strategy of "natural" regulation of deer on WMNWR. Since 1969 it appears that the deer herd has remained stable, fluctuating little after the cyclic population changes of the late 1950's and early 1960's. The high mortality of fawns apparently stabilized the deer herd within refuge boundaries; this natural predator-prey relationship is consistent with management strategy. This strategy is successful at the present time but it depends on predator populations which may be highly variable in the future. The importance of predators for the maintenance of a stable deer population leaves a potential for future problems (i.e., widely fluctuating deer populations similar to the extreme high population peaks of the early 1960's) which in turn would be conducive to range depletion and/or herd epizootics. This situation would not benefit the deer or other animal populations within WMNWR.

The WMNWR deer population should be monitored yearly to document population trends and changes in survival of fawns (doe:fawn counts, total numbers, and sex ratios) in order to establish a yearly population index. Some form of direct deer population control may be necessary in the future because the potential exists for an irruptive cycle in the herd, particularly if the predator population declines and becomes incapable of stabilizing the deer population. One means of directly controlling the deer herd would be sport hunting. Sport hunting is consistent with national policy on federal wildlife refuges, and could be administered similar to the elk hunts held annually at WMNWR.

FSMR has managed the deer herd within its jurisdiction for both quantity and quality. In addition to the high fawn mortality, between 80 (buck only, 1968) and 200 (either sex, 1977) deer have been harvested annually for the past 10 years. Predator control might be initiated with the goal of determining if deer production would increase without detrimental effects on other wildlife populations. A deer population increase would have to be countered by increased harvest, a strategy consistent with FSMR management. Deer population trends would have to be closely monitored if predator control were implemented.

Private land holdings outside both WMNWR and FSMR were not included in the intensive study areas of this project but high fawn mortality may also be a factor in this segment of the Wichita Mountains deer herd. Further study by state personnel (doe:fawn counts and radio-tagging of fawns) would confirm or deny this hypothesis and an appropriate management scheme, consistent with state policy, could then be implemented.

At the present, predators are a major agent controlling the deer population. If increased survival of fawns is desirable to increase the deer population, then control of predators might be initiated in an attempt to achieve this goal. Predator control might not result in a permanent deer population increase because some other mortality factor may replace predators as a major factor limiting population increase.

VITA 2

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Master of Science

Thesis: MORTALITY OF WHITE-TAILED DEER FAWNS IN THE WICHITA MOUNTAINS, COMANCHE COUNTY, OKLAHOMA, PART II

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