MOVEMENTS AND HABITAT USE OF COYOTES ON THE WICHITA MOUNTAINS NATIONAL WILDLIFE REFUGE

By

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WILDLIFE REFUGE

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PREFACE

The purpose of this study was to determine the movement patterns and habitat utilization of coyotes on the Wichita Mountains National Wildlife Refuge. Radio-location telemetry was used to monitor coyotes throughout the study. Home range size, habitat use, and seasonal food habits were determined.

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The coyote (Canis latrans) is one of the most adaptable mammalian predators in North America. Prior to the arrival of Europeans, the coyote ranged only in the western plains and mountains (Young and Jackson 1951). The introduction of livestock, habitat alteration and extirpation of the gray wolf (Canis lupus) from a large portion of its range facilitated an expansion of the coyote's distribution (Young and Jackson 1951). Concurrent with its range expansion, the coyote has become a controversial predator coming into conflict with crop and livestock growers. This controversy has stimulated much research into the biology and ecology of coyotes as summarized by Bekoff (1974).

Investigations of coyotes in Oklahoma have included taxonomy (Freeman 1976), reproduction (Dunbar 1973), parasites (Self and McKnight 1950, Ellis 1955), food habits (Ellis 1958, Holle 1977), coyote-deer interactions (Garner 1976), socio-economic impact (Mincolla 1977), and aging techniques (Utsler 1974). Information on coyote movements and habitat use is noticeably lacking in Oklahoma and elsewhere on the southern plains.

Coyote movements have been investigated by tag-recapture (Robinson and Cummings 1951, Young and Jackson 1951, Hawthorne 1971, Nellis and Keith 1976), by tracking in snow (Stebler 1951, Ozoga 1963, Ozoga and Harger 1966, Hilton 1976), and by using radio telemetry (Gipson and Sealander 1972, Andelt 1976, Danner 1976, Preece 1976,

Berg et al. 1977, paper presented at the Midwest Coyote Workshop, Ames, IA, Hallet 1977, Hibler 1977). Yet, few generalizations can be made concerning coyote movements. Habitat use by coyotes has been investigated by visual observations (Reichel 1976) and tracking in snow (Ozoga 1963, Hilton 1976). However, information on coyote habitat use within home ranges is lacking.

This study was initiated to investigate coyote movements, habitat use, and the factors that influence these characteristics. Specific objectives were to (1) determine coyote home ranges and movements by use of data obtained through radio telemetry and (2) describe habitat use within observed home ranges.

STUDY AREA

The study was conducted on the 23,917 ha Wichita Mountains National Wildlife Refuge (WMNWR) located in the Central Rolling Red Plains of southwestern Oklahoma (Gray and Galloway 1969) (Fig. 1). The area supports approximately 600 bison (Bison bison), 300 longhorn cattle (Bos taurus), 500 white-tailed deer (Odocoileus virginianus), and 550 elk (Cervus canadensis) (refuge personnel pers. comm. 1978). Surplus bison and longhorn are removed through annual public auctions, and elk numbers are reduced by controlled hunts. The deer population has not been harvested since live-trapping and transplanting ceased in 1965 (Steele 1969).

The climate of the area is temperate, continental, and subhumid (S.C.S. 1967). Annual precipitation recorded from 1958 to 1977 averaged 73.4 cm. The average temperature in January was 3.2 degrees C and 27.2 degrees C in August during this same period (N.O.A.A. 1958 - 1977).

Topography of the area is a mosaic of wide, rolling valleys and rugged, granite hills. Elevations range from 152.4 to 426.7 m above the surrounding plains. Mount Pinchot, the highest point, is 755.6 m above sea level.

Vegetational diversity results from varied soil types and topographic relief. The refuge contains 12,505 ha of woodland, 8,547 ha of prairie, and 405 ha of marsh and water. Wooded areas are found along stream courses and fracture lines of the hills. Post oak

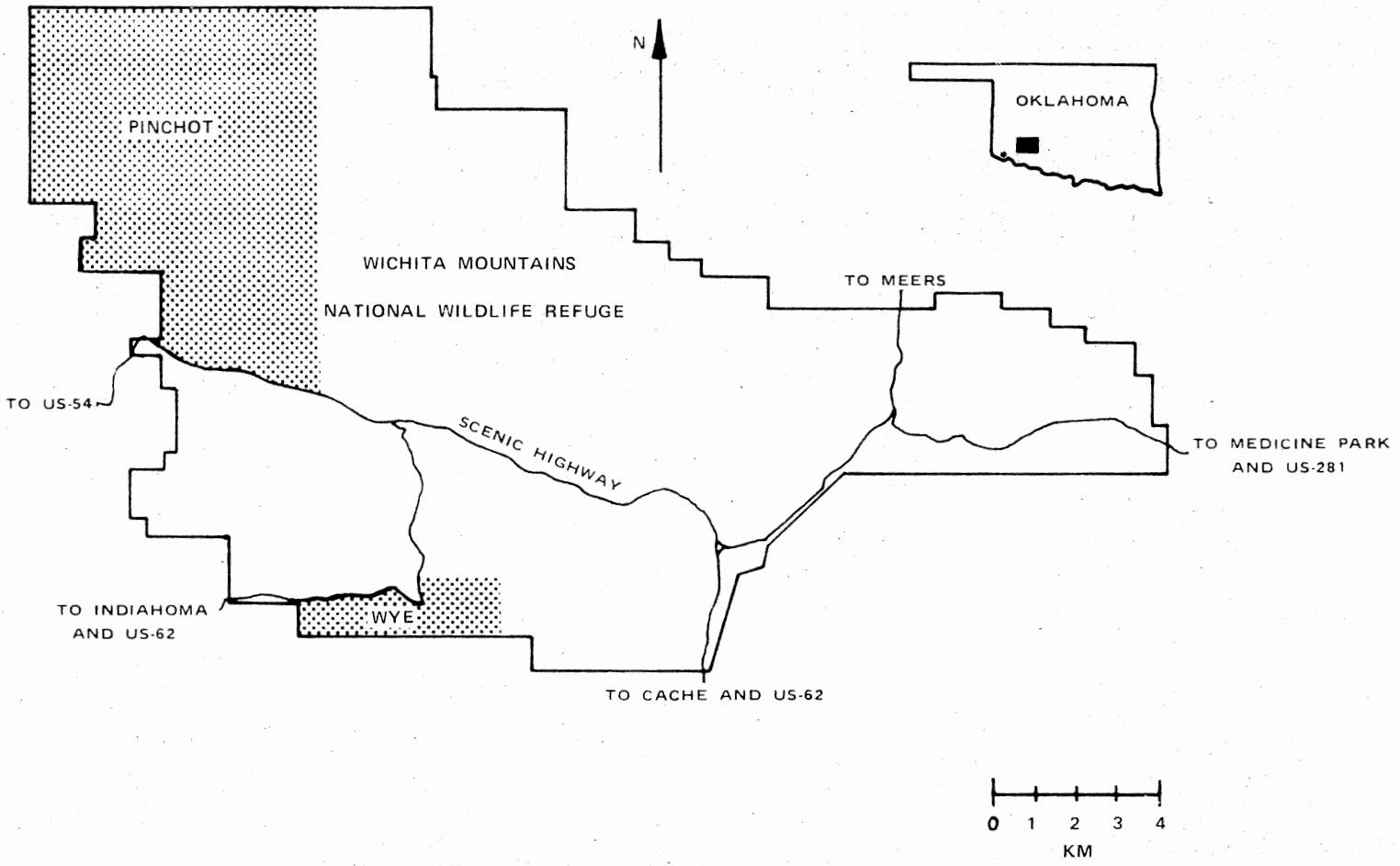

Fig. 1. Location of areas selected for trapping of coyotes within the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma.

(Quercus stellata) and blackjack oak (Q. marilandica) dominate the fractures, while American elm (Ulmus americana) and hackberry (Celtis spp.) are common along the stream courses (Buck 1964). Mixed grasses occupy the prairie including big bluestem (Andropogon gerardi), little bluestem (Schizachyrium scoparium), Indian grass (Sorghastrum nutans), blue grama (Bouteloua gracilis), and hairy grama (B. hisuta) (Crockett 1962).

The refuge is bordered by Fort Sill Military Reservation to the south and by farms, rangeland, and private residencies to the north, east and west. A 2.4 m fence surrounds the refuge.

Two areas were selected for trapping coyotes. The Pinchot area, containing numerous hills, prairie flats, and wooded drainages, includes the northwest corner of the refuge (Fig. 1) and is approximately 6700 ha. The Wye area is located in the southwest corner of the refuge (Fig. 1). It contains several wooded drainages passing through a prairie and is approximately 300 ha. Both areas also were selected for a concurrent study of fawn mortality (Bartush pers. comm. 1978).

METHODS AND MATERIALS

Capture and Marking

Coyotes were trapped with No. 3 steel leg-hold traps (Animal Trap Co.[1], Lititz, PA) having offset, padded jaws. Each trap was equipped with a 2-prong drag and 1 tranquilizer tab (Balser 1965) containing 80 mg of Tranvet (Diamond Laboratories, Des Moines, IA). Traps were set in areas of maximum coyote sign (i.e., tracks, scats). Trapped coyotes were restrained while weight, sex, and age (yearling/adult) were determined. All coyotes were then ear tagged and fitted with a radio transmitter collar having a unique pulsation rate and frequency in the 164 MHz range (model LP-21100-HDA, Wildlife Materials Inc., Carbondale, IL). Each collar weighed 233 g, less than 6% body weight, as recommended by Brander and Cochran (1971).

Coyote pups were located by frequent observations of collared adults, and incidently captured during other field activities. Age of pups was estimated by weight and development (Gier 1968, Bekoff and Jamieson 1975). Those estimated to be 6 weeks of age or greater were ear tagged and fitted with an expandable radio-collar (model LP-2140-LDMU, Wildlife Materials Inc., Carbondale, IL) with a mean weight of 131 g.

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

Home Range

Tracking

Tracking on the ground was done with a portable receiver (model LA 12, AVM Corp., Champaign, IL) and a 4 element yagi antenna. A non-directional whip antenna was used during aerial searches of wide ranging coyotes. Ground-to-ground range of the receiver-transmitter system was estimated to be 0.5 - 9.0 km.

Triangulation was the principle relocation method. At least 2 compass bearings of the radio signal were taken from known locations. The signal bearings were later plotted on aerial photographs (scale= 1:7920) to estimate the coyote's location. Accuracy of this technique was determined by blind placement and subsequent relocation of collars in the field. The predicted bearings were compared to known bearings to determine error. Error was estimated to be $\pm 5^{o}$. An attempt was made to make relocations within 1 km of transmittered coyotes to minimize actual location error. Relocation times of each coyote also varied to assure locations were obtained throughout the day, with the majority of locations being made from May through August 1976 and 1977 from 0600-2000 hours.

Home range determination

Home range and seasonal home ranges occupied during 2 of the 6 biological seasons of the coyote (Andelt 1976) were plotted. The home range included the capture site, all relocations, and the carcass or collar recovery site. The seasonal home range determined for the pup nursing season included only the relocations obtained during the period

of intensive pup care (pup birth to approximately 2 months old), estimated to be 16 April - 15 June. Pups are sedentary during that time, and mated coyotes remain in close association with the pups (Fichter 1950, Gier 1975). The seasonal home range occupied during the pup training season included the relocations obtained from 16 June - 15 August, the period that pups and adults are loosely associated with the den (Young and Jackson 1951).

Home range boundaries were determined using the minimum area (Mohr 1947) and modified-minimum area (Harvey and Barbour 1965) methods. Seasonal home range boundaries for the pup nursing and pup training seasons were determined using the modified-minimum area method. All areas were measured with a compensating polar planimeter from aerial photographs of the study area.

Movement

Daily movement of coyotes was evaluated by plotting the straight line distance between consecutive daily locations. In addition, coyotes were located every 2.5 hours during 6 continuous 24-hour monitoring sessions.

Habitat Use

Habitats available on the study area included prairie, prairie-creek ecotone, savanna, and woodland. All locations within 75 m of a prairie creek (estimated error at a distance of 1 km from the radio transmitter) were considered to be in the prairie-creek ecotone. Creeks in the savanna and woodland could not be distinguished on the aerial photographs and therefore were not treated in the same manner.

The percentage of each habitat within the minimum area home range was determined using a modified acreage grid (Mosby 1971) and soil survey maps (scale=1:20000) (S.C.S. 1967). Available habitat for each coyote was delineated by the animal's minimum-area home range. Habitat use by each individual was determined by comparing the number of relocations in each habitat to the predicted number of relocations expected on the basis of random distribution of relocations within each habitat. A Chi-square test (Steele and Torrie 1960) was then performed to test the null hypothesis that relocations were randomly distributed in relation to the habitats.

Habitat preferences of age/sex classes were determined using the method described by Follmann (1973). Habitat preference was expressed as a percentage of the expected value: $\frac{\text{OBSERVED-EXPECTED}}{\text{EXPECTED}} \times 100$. Positive (+) and negative (-) values indicate if the use was greater or less than expected. T-tests (Steele and Torrie 1960) were then performed to test the null hypothesis that mean use values were not significantly different from expected.

Food habits and prey abundance

Coyote food habits and the abundance of several prey groups were investigated to aid evaluation of habitat use. Seasonal food habits were determined using scat analysis. Three collection routes totaling 12.8 km were established to include all habitats. Scats were collected bi-weekly, placed in individual paper bags and labeled with collection route and date. Scats were then dried in a desiccating oven at 105 degrees C prior to storage in sealed plastic bags.

Food items were separated from scats and compared with a reference

collection of hair, skulls, skins, and seeds from the Oklahoma State University Museum. A hair key (Nunley et al. 1970) and dissection scope aided identification. All food items were recorded by percent occurrence.

Spatial and temporal variations in abundance of small mammals and lagomorphs were sampled since these groups have been observed to be major prey of coyotes (Murie 1940, Sperry 1941, Gier 1968). Garner et al. (1976) reported high coyote predation on radio-collared white-tailed deer fawns on the Wichita Mountains. Therefore, fawn abundance was also surveyed.

Relative abundance of small mammals was sampled bi-monthly. Snaptraps were placed along transects 292 m in length with 3 traps set within a 1.5 m radius at 15.4 m intervals. One transect passed through savanna into woodland and another was located exclusively in prairie. Traps were baited with a peanut butter, raisin, and oat mixture and checked and rebaited for 3 consecutive evenings per trapping period.

Roadside counts (Lord 1961) were used as indices of lagomorph populations. Each count was conducted at approximately 0.5 hours before sunrise or 1 hour after sunset. The 32 km route was driven on a bi-weekly basis at 32 km per hour with headlights on.

White-tailed deer fawn drop was monitored daily throughout the fawning season during the concurrent study of fawn mortality (Bartush pers. comm. 1978). The period of maximum abundance of fawns was assumed to coincide with the peak period of fawn births estimated from captured fawns.

Food habits and prey abundance data were evaluated seasonally in the following manner: spring (April, May, June), summer (July,

August, September), fall (October, November, December), and winter (January, February, March).

RESULTS

Capture and Marking

Thirteen adult, 5 yearling and 4 coyote pups were captured, marked, and released. A brief description and fate of each radio-collared coyote is given in Appendix A. Eleven (79%) coyotes were trapped on the periphery (within 0.5 km of the boundary) or outside of their subsequent modified-minimum home ranges (Appendix B). Two of the 3 remaining coyotes (all females) captured within their home ranges were yearlings.

Home Range

A total of 948 locations was obtained to permit estimation of home ranges for 18 coyotes (Table 1). No home ranges were plotted with fewer than 13 locations. Size of home ranges plotted by the minimum and modified-minimum area methods varied between and within age/sex classes (Table 1). A comparison of mean home ranges plotted by these 2 methods revealed that the modified-minimum area home range averaged only 45% of the area estimated using the minimum area method, yet included 97% of all locations. Therefore, the modified-minimum area home range more precisely describes the intensity of use of resources utilized by coyotes in this study.

Mean home range size appeared to be influenced by sex, age and reproductive state. The mean modified-minimum area home range for

Table 1. Summary of minimum and modified-minimum area home ranges of 18 radio-collared coyotes, WMNWR 1976-1977.

Age/sex class	Period monitored (Days)	No. of locations		Home range size (km^2) Min. area	Mod.-min. area
Adult males					
2	5 March-11 July 1976 (129)	36		4.0	2.6
3	6 March-2 August 1976 (150)	54		7.5	4.8
4	6 March-11 February 1977 (342)	53		23.5	9.6
6	7 March-9 October (217)	36		106.2	45.8
10	7 February-15 August 1977 (190)	95		15.4	12.3
			Mean	31.3	15.0
			S.D.	42.5	17.6
Adult females					
*5	1 April-15 August 1977 (137)	65		4.9	2.5
9	6 February-15 August 1977 (191)	89		12.2	8.6
12	7 February-15 August 1977 (190)	47		233.0	46.6
13	17 February-15 August 1977 (180)	73		31.3	10.3
15	18 February-2 August 1977 (166)	43		20.3	10.9

Table 1. Continued.

Age/sex class	Period monitored (Days)	No. of locations		Home range size (km^2) Min. area	Mod.-min. area
16	19 February-15 August 1977 (178)	40		110.3	88.3
			Mean	68.7	27.9
			S.D.	89.1	33.5
Yearling females					
1	29 February-14 June 1976 (107)	22		12.3	1.2
*5	6 March 1976-31 March 1977 (390)	44		76.2	50.8
11	11 February-15 August 1977 (190)	78		26.6	16.1
14	18 February-15 August 1977 (179)	80		44.5	17.1
			Mean	39.9	21.3
			S.D.	27.6	21.0
Pups					
7	16 June-29 June 1976 (14)	13		0.6	0.1
8	25 June-2 August 1976 (39)	32		0.5	0.2
17	5 July-15 August 1977 (42)	30		2.0	0.9

Table 1. Continued.

Age/sex class	Period monitored (Days)	No. of locations		Home range size (km^2) Min. area	Mod.-min. area
18	27 July-15 August 1977 (20)	18		0.9	0.3
			Mean	1.0	0.4
			S.D.	0.7	0.4

*Female 5 is reported as a yearling and as an adult.

adult females was 1.9 times larger than the mean home range of adult males but this difference was not significant ($t=0.77$, $p<0.50$, d.f.=9). The mean home range of adult females was 1.3 times larger than yearling females but this difference also was not significant ($t=0.35$, $p>0.50$, d.f.=8). Coyotes 1, 2, 3, 4, adult 5, 9, 10, 11, 13, 14, and 15 exhibited a concentration of locations during the pup nursing season. Preece (1976) observed a similar trend for female coyotes in Minnesota and considered the coyotes to be involved in pup rearing. Since pups require frequent care, denning coyotes would be frequently located at the den site. Therefore, if the aforementioned coyotes in this study are assumed to be denning, the adjusted mean modified-minimum area home range for denning adult male, adult female, and yearling females is 7.3, 8.1, and 11.5 km^2 respectively. These means did not significantly differ from one another ($p>0.05$).

Seasonal home ranges were plotted for 9 coyotes (Table 2). The mean home range size increased from the pup nursing to pup training season for all age/sex classes. This increase, however, was not significant for adult males ($t=0.89$, $p<0.50$, d.f.=2), adult females ($t=0.53$, $p>0.50$, d.f.=3), or yearling females ($t=0.16$, $p>0.50$, d.f.=1) (Table 2).

Home ranges of adjacent females overlapped, as did adjacent male-female home ranges when plotted by the minimum and modified-minimum area methods. The amount of overlap varied from the slight overlap of home range boundaries, to the complete encompassing of a small home range within the area of a large one. An insufficient number of adjacent males was radio-collared to measure spatial overlap of their home ranges. Temporal overlap was not determined.

Table 2. Seasonal modified-minimum area home ranges occupied by 9 radio-collared coyotes during the pup nursing and pup training seasons and their respective percentages of the entire modified-minimum area home range, WMNWR 1976 and 1977.

Age/sex class	Pup nursing season			Pup training season		
	Home range (km^2)	No. of locations	% of entire home range	Home range (km^2)	No. of locations	% of entire home range
Adult males						
3	0.5	16	10.4	1.0	16	20.8
4	1.1	15	11.5	2.6	15	27.1
10	3.7	30	30.1	3.4	30	27.6
Mean	1.8		17.3	2.3		25.2
S.D.	1.7		11.1	1.2		3.8
Adult females						
5	0.3	19	12.0	0.4	19	16.0
9	1.3	40	15.1	4.6	40	53.5
13	2.5	25	24.3	2.4	25	23.3
15	2.2	13	20.2	1.2	13	11.0
Mean	1.6		17.9	2.2		26.0
S.D.	1.0		5.4	1.8		19.0

Table 2. Continued.

Age/sex class	Pup nursing season			Pup training season		
	Home range (km^2)	No. of locations	% of entire home range	Home range (km^2)	No. of locations	% of entire home range
Yearling female						
11	6.4	25	39.8	1.5	25	9.3
14	5.4	36	28.8	13.2	36	74.6
Mean	5.9		34.3	7.4		42.0
S.D.	0.7		7.8	8.3		46.2

Movement

The mean distance between consecutive daily locations was similar for adult males, adult females, and yearling females (Table 3). Distance measured during the 24-hour monitoring sessions averaged approximately 3 times greater than observed between consecutive daily locations (Table 4). Coyotes tended to travel circular routes beginning and ending near the den or rearing site. During the evening portion of one 24-hour monitoring session, coyote 3 was triangulated in an area in which it had not previously been located. This location resulted in an increase in home range size of coyote 3, thereby suggesting that other home ranges may have been underestimated since the majority of the locations were diurnal.

Habitat Use

Chi-square analysis indicated that habitat use was not random (Table 5). All age/sex classes avoided prairie, and preferred the other habitats (Table 6) in relation to their availability. As a group, radio-collared coyotes were located significantly less frequently in the prairie ($t=2.49$, $p<0.05$, d.f.=18) and more frequently in the savanna ($t=2.43$, $p<0.05$, d.f.=18) than expected by the availability of these habitats (Table 6).

Food habits and prey abundance

A total of 361 coyote scats was collected from May 1976 - September 1977. Detailed results of the analysis are given in Appendix C. The major food groups included rodents, fruits and seeds,

Table 3. Mean distance between consecutive daily locations of 18 radio-collared coyotes, WMNWR 1976-1977.

Age/sex class	No. of consecutive days located	Mean distance (km)	Range (km)
Adult males	104	1.7	0.1-5.4
Adult females	154	1.7	0.1-7.9
Yearling females	106	1.9	0.6-10.1
Pups	53	0.4	0.1-2.6

Table 4. Mean distance traveled by radio-collared coyotes during 24-hour monitoring sessions, WMNWR 1976-1977.

Age/sex class	Mean distance (km)	Range
Adult males	6.3 (n=3)	3.6-7.7
Adult females	6.0 (n=2)	5.9-6.1
Pups	1.6 (n=1)	-

Table 5. Habitat composition of the minimum area home range and the number of observed (Obs.) and expected (Exp.) locations in each habitat of 18 radio-collared coyotes, WMNWR 1976-1977.

Age/sex class	Prairie			Prairie-Creek			Savanna			Woodland		
	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.
Adult males												
*2	64.8	13	23.3	19.0	12	6.8	10.9	9	3.9	5.3	4	1.9
*3	53.0	17	28.6	21.4	16	11.6	12.4	12	6.7	13.2	9	7.1
*4	78.1	26	41.1	6.5	7	3.4	2.1	11	1.1	13.4	9	7.1
*6	37.1	4	13.4	3.9	2	1.4	44.3	21	15.9	14.6	9	5.3
*10	73.6	32	69.9	13.2	24	12.5	12.7	34	12.1	0.5	5	4.8
Mean	61.3			12.8			16.5			9.4		
S.D.	16.6			7.6			16.1			6.2		
Adult females												
*5	53.9	7	52.8	6.5	4	6.7	30.1	54	16.0	9.5	0	5.3
*9	50.9	4	45.3	4.7	8	4.2	6.9	13	6.1	37.4	63	23.6
12	50.3	28	23.6	7.2	1	3.4	31.3	13	14.7	11.1	5	5.2
*13	84.2	47	61.5	9.8	22	7.2	4.4	4	3.2	1.6	0	1.2
*15	5.0	2	2.2	0.9	0	0.4	23.9	27	10.3	70.3	14	30.2
*16	52.7	7	21.1	3.6	2	1.4	25.3	19	10.1	18.5	12	7.4
Mean	49.5			5.5			20.3			24.7		
S.D.	25.4			3.1			11.7			25.4		

Table 5. Continued.

Age/sex class	Prairie			Prairie-Creek			Savanna			Woodland		
	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.	% of Min. area home range	Locations Obs.	Exp.
Yearling females												
1	61.1	8	13.4	10.2	5	2.2	21.6	6	4.8	7.1	3	1.6
*5	67.9	17	28.5	8.4	12	3.5	20.1	10	8.4	3.6	3	1.5
11	52.5	40	41.0	14.6	15	11.4	25.6	20	20.0	7.4	3	5.8
*14	66.0	32	52.8	8.4	4	6.7	20.0	31	16.0	5.6	13	5.3
Mean	61.9			10.4			21.8			5.9		
S.D.	6.9			2.9			2.6			1.7		
Pups												
*7	74.3	2	8.9	9.9	0	1.2	9.1	10	1.1	6.7	0	0.8
*8	67.1	7	21.4	23.2	19	7.4	5.0	6	1.4	4.7	0	1.5
*17	62.7	10	18.8	6.6	3	2.0	19.4	9	5.8	11.3	8	3.4
*18	78.6	10	14.1	5.5	2	1.0	7.5	6	1.4	8.3	0	1.5
Mean	70.7			11.3			10.3			7.8		
S.D.	7.1			8.2			6.3			2.8		

Female 5 reported as yearling and adult.

*Significantly disproportionate use of habitat as determined by Chi-square analysis ($P<0.05$).

Table 6. Habitat utilization by radio-collared coyotes presented as the difference between observed and expected values, expressed as a percent of the expected value. Positive (+) and negative (-) signs indicate whether the use was greater or less than expected, WMNWR 1976-1977.

Age/sex class	Habitat			
	Prairie	Prairie-Creek	Savanna	Woodland
Adult males	-47.9	+70.9	+114.1	+37.4
Adult females	-59.6	+56.1	+103.1	+27.4
Yearling females	-28.5	+56.1	+ 36.2	+54.9
Pups	-54.1	+106.9	*+213.1	+11.1
All coyotes	*-47.4	+65.0	*+ 92.3	+31.8

*Habitat significantly selected for (+) or against (-) as determined by t-tests ($p<0.05$).

deer, insects, birds, and lagomorphs. Utilization of these food groups varied seasonally (Fig. 2).

Rodents occurred in 54.3% of all scats collected. Cotton rats (Sigmodon hispidus), eastern woodrats (Neotoma floridana) or white-footed mice (Peromyscus spp.) occurred in 48.2% of the scats. Rodents were most frequently consumed in winter (Fig. 2).

Fruits and seeds were the second most frequently consumed food group, occurring in 31.6% of the scats. Most of the small quantities of grasses and leaves found in a majority of the scats were possibly ingested incidentally as coyotes fed on other food items. However, due to the small quantities found in the scats, grasses and leaves were excluded from the category of fruits and seeds. Highest occurrence of fruits and seeds was in the fall (Fig. 2) when persimmons (Diospyros virginiana) were found in 11.1% of the scats collected. When large amounts of fruit are consumed, the resulting scats are loose in structure and difficult to identify. Scats of questionable origin were not collected, so the importance of fruits and seeds was probably underestimated.

Hair of white-tailed deer was found in 20.2% of the scats. Fawn hair occurred in 14.4% of the scats and adult hair occurred in 5.8%. Fawn remains were found in scats collected from late May to September (Fig. 3), coinciding with the period of coyote predation upon fawns reported by Garner et al. (1976) and Bartush (pers. comm. 1978) on the Wichita Mountains. The peak occurrence of fawn remains was estimated to be 3 - 15 July 1976 and 15 - 30 June 1977 (Fig. 3).

Insect remains occurred in 19.4% of all scats. Peak utilization of insects was during summer (Fig. 2) when grasshoppers (Order

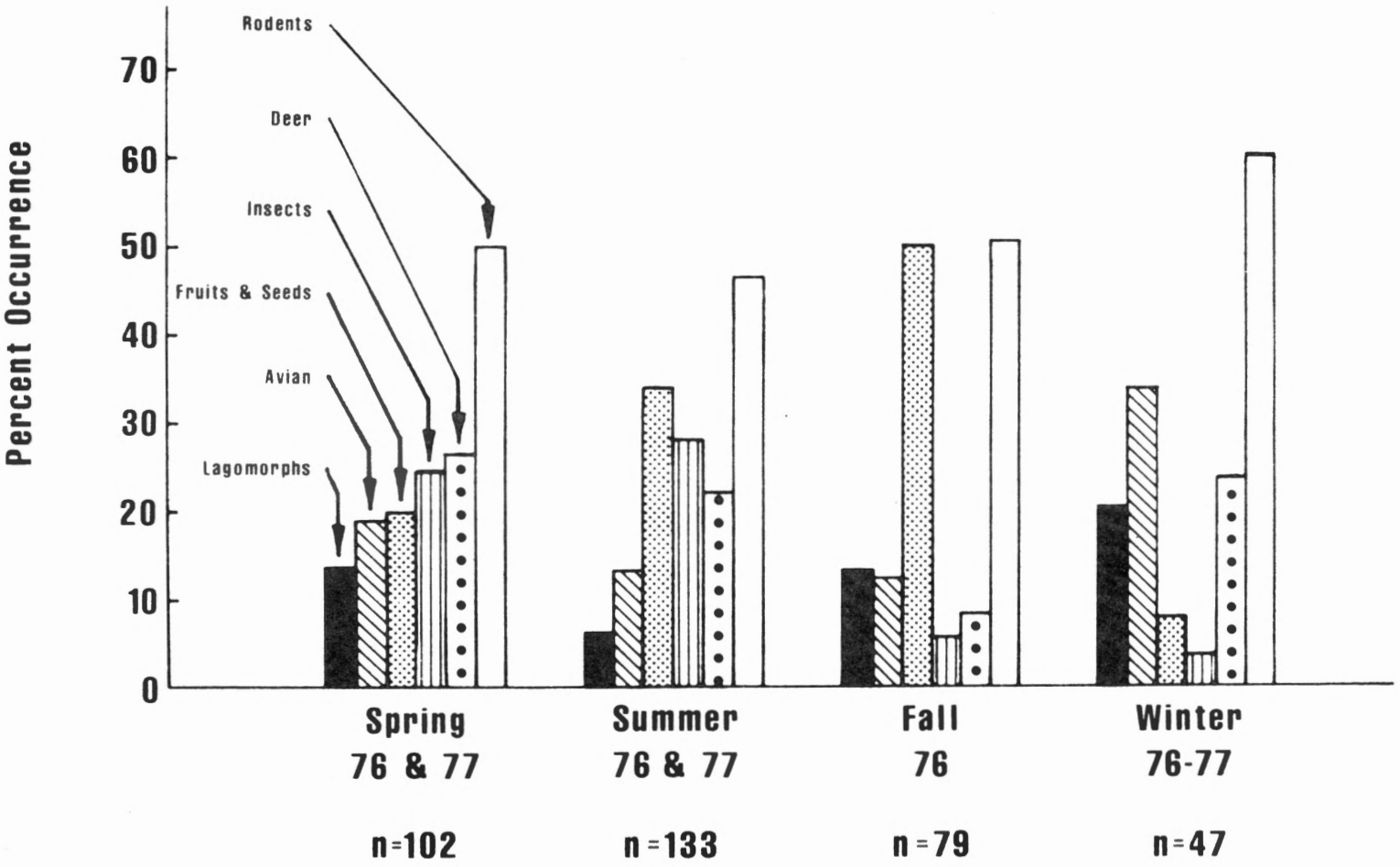

Fig. 2. Seasonal variation of occurrence of major food groups identified in 361 coyote scats collected on the WMNWR during May 1976 - September 1977.

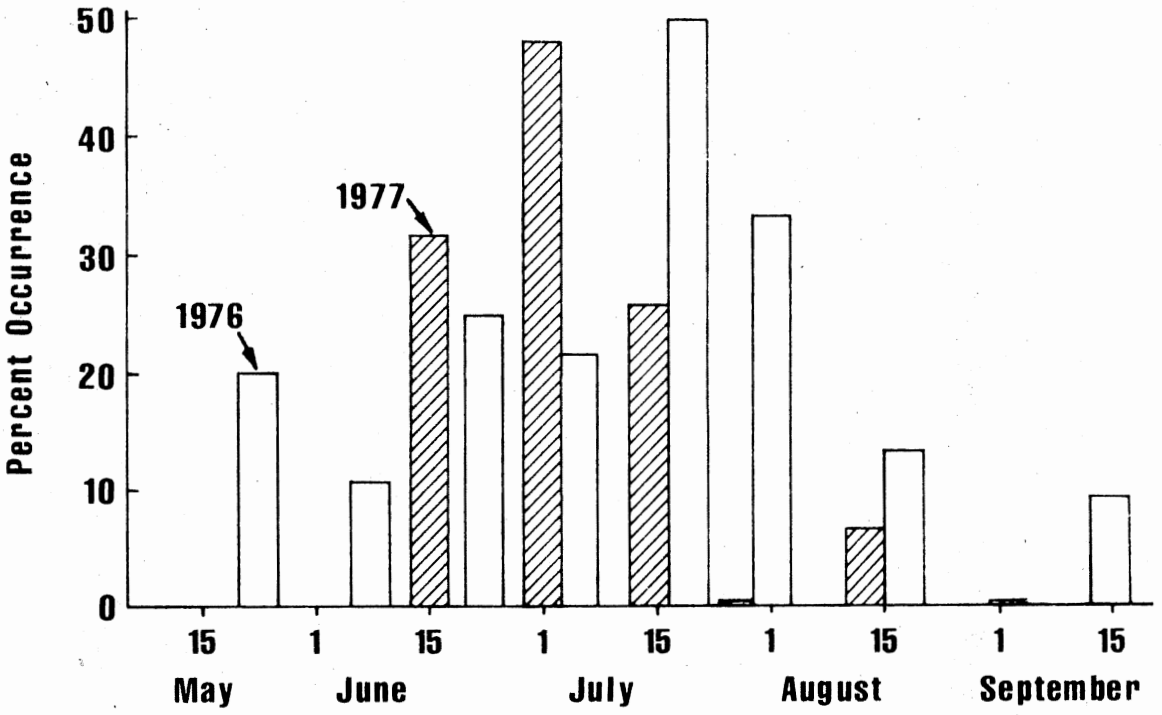

Fig. 3. Percent occurrence of white-tailed deer fawn hair in coyote scats collected during known intervals on the WMNWR 1976 and 1977.

Orthoptera) occurred in 26.3% of the collected scats. Avian remains, including eggs, were found in 18.6% of the scats, most frequently in winter (Fig. 2). Species identification was not attempted.

Lagomorph remains were found in 11.1% of the scats. Eastern cottontail rabbits (Sylvilagus floridanus) were found in 10.0% and black-tailed jackrabbits (Lepus californicus) in 0.6% of the scats. Unidentified remains contributed the balance. Lagomorphs were most frequently consumed in winter (Fig. 2).

Spatial and temporal variations in abundance occurred in those prey species sampled. Success of trap-line captures of small mammals was greater in the savanna and woodland (9.6%) than in the prairie (0.6%) (Appendix D). Small mammals were captured in greatest numbers in winter on both traplines.

Lagomorphs were not abundant in the study area. An average of 1.7 cottontail rabbits was observed per 100 km driven (Appendix D). Black-tailed jackrabbits were observed on the refuge at other times, but were never recorded during the roadside counts.

The peak of fawn births was estimated to occur during 24 May - 7 June during 1976 and 1977 (Bartush pers. comm. 1978) (Appendix D).

The opportunity to observe scavenging by coyotes was presented on several occasions. Six road-killed bison were deposited by refuge personnel in various areas of the refuge during summer 1976 and summer 1977. Daily visits were made to the carcasses to determine how quickly coyotes would scavenge on the carrion. Initiation of scavenging varied from within 24 to greater than 72 hours.

DISCUSSION

Home Range

The concept of home range and its application to wildlife studies is ill-defined (Sanderson 1966). The home range of coyotes in this study is considered to be the area that is habitually traversed by an animal within a specific period of time (after Hibler 1977). Such movements as sallies, dispersal, homing, or migration are not incorporated by home ranges according to this definition. The modified-minimum area home range estimate (excluding sallies) fulfills the above definition of home range. The minimum area home range estimate, however, results in a more liberal estimation of home range size and is only presented to allow comparison with other studies.

No significant differences were observed in mean modified-minimum area home ranges between age/sex classes of adults and yearlings, although more intensive monitoring might detect differences. Several coyotes (yearling 5, adults 6, 12, 16) occupied much larger areas than the mean home range of their respective age/sex classes. These individuals did not appear to have centralized home ranges and were probably not involved in pup rearing. Hibler (1977) termed such wide ranging coyotes "wanderers". Christian (1970) reported that most mammals operate to reduce exposure to new and changing habitats. Familiarity with an area allows predators to utilize the food resources more efficiently (Tinbergen 1957). However, such conditions as

resource limitations or intraspecific stress may alter this (Hibler 1977). Wide ranging coyotes therefore may be a result of limited prey or these may be subordinant individuals. Such coyotes may establish a centralized home range after a suitable area is vacated, or repopulate decimated areas as observed in mountain lions (Felis concolor) (Seidensticker et al. 1973).

The minimum area home ranges determined in this study did not compare closely with those reported in other areas (Appendix E). Adult males occupied smaller home ranges than reported by other researchers using telemetry (Andelt 1976, Danner 1976, Berg et al. 1977 paper presented at the Midwest Coyote Workshop, Ames, IA, Hibler 1977). Variations in prey and coyote density, seasons in which movements were assessed, and sampling technique may have contributed to the observed differences. Mean adult female home ranges on the WMNWR were larger than reported for coyotes in Arizona (Danner 1976), Minnesota (Berg et al. 1977) and Nebraska (Andelt 1976), and smaller than observed in Idaho and Utah (Hibler 1977). Yearling females occupied smaller areas than in Idaho and Utah (Hibler 1977), but larger than reported in Arizona (Danner 1976) and Minnesota (Berg et al. 1977).

Habitat Use

Habitat use of radio-collared coyotes appeared to be influenced by the availability of food and cover. Coyotes were located in the prairie less than expected by the availability of this habitat. Prey indices indicated that rodents and lagomorphs were in low abundance in this habitat. Cover was also limited in the prairie.

The apparent preference by coyotes for savanna in relation to its

availability, may have resulted from the interspersion of prairie and woodland producing a greater rodent population than the prairie. Savanna also contained mesquite beans, persimmons, plums, and other fruits and seeds eaten by coyotes. Although no prey indices were conducted in the prairie-creek ecotone, the interspersion there probably favored several prey species.

Woodland provided abundant cover and was preferred by coyotes in relation to its availability. Two of the 3 natal dens located were in the woodland. Several other dens were also suspected in this habitat by concentrated locations of radio-collared coyotes.

Other researchers have found coyotes to use the habitats containing the most prey. Hilton (1976) tracking coyotes in snow, found they traveled most often through riparian and old cut areas. Both habitats contained higher concentrations of winter prey than did other available habitats. Reichel (1976) observed that coyotes in Montana hunted brushy washes, and swales, and riparian areas significantly more than expected by their availability ($p<0.05$). These habitats contained a greater abundance of small rodents as did the savanna and woodland on the WMNWR.

Food habits and prey abundance

Results from the scat analysis and prey surveys indicated that coyotes were opportunistic and consumed those foods found in greatest abundance. Rodents were the staple of coyotes on the WMNWR. Peak use of rodents coincided with the peak trapping success of rodents during winter. Other investigators have observed the same trend (Fitchter et al. 1955, Gier 1968, Nellis and Keith 1976, Niebauer and Rongstad

1977).

A disparity of 21-35 days was observed between peak abundance of fawns and the peak occurrence of fawn hair in the collected scats. Garner et al. (1976) reported that the peak of coyote predation upon radio-collared fawns on the Wichita Mountains occurred in the 14 - 24 day age class. During the first 2 weeks of life fawns occupied small home ranges and moved short distances (Garner and Morrison 1977). Therefore, fawns may not have been as vulnerable to coyotes until their second week of life. The bi-weekly scat collection schedule may also have influenced the observed disparity. However, the former explanation is more plausible.

SUMMARY

The objectives of this study included the estimation of coyote home range size, daily movements, habitat use, seasonal food habits, and prey abundance on the WMNWR.

Twenty-two coyotes were captured and radio-collared. Eighteen coyotes were monitored sufficiently to determine home range boundaries. Seventy-nine percent of yearling and adult coyotes were captured on the periphery or outside of their subsequent home ranges. This was probably the result of setting traps in areas of maximum coyote sign along existing home range boundaries.

Home range size varied by age, sex, reproductive state, and season monitored. The mean modified-minimum area home range of adult females (27.9 km^2) was approximately twice the size of adult male home ranges (15.0 km^2) and larger than yearling female home ranges (21.3 km^2). Adjacent female home ranges overlapped, as did adjacent male-female home ranges. An insufficient number of adjacent males was radio-collared to investigate overlap. Temporal overlap was not determined.

Daily movements of coyotes were measured by 2 methods. The distance between consecutive daily locations was similar for adults (1.7 km) and yearlings (1.9 km). This method was a poor estimator of movement, averaging only 29 percent of the distance measured during 24-hour monitoring sessions.

Coyote habitat use appeared to be based on the abundance of prey

and cover. Coyotes significantly ($p<0.05$) avoided prairie and preferred savanna in relation to the availability of these habitats. Rodents, the staple of coyotes on the WMNWR, were captured in greatest numbers on the savanna/woodland trap line and least on the prairie trap line. Savanna also contained other prey consumed by coyotes. Coyotes showed a preference for the prairie-creek ecotone and woodland. The ecotone of the prairie-creek areas was probably favorable to prey. Woodland was considered the most used habitat for denning.

A total of 361 coyote scats was collected from May 1976 - September 1977, to investigate seasonal food habits. Coyote food habits reflected prey abundance. The annual feeding regime of coyotes is as follows: spring-rodents were the major food, with an intensive use of deer fawns in late spring, insects, fruits and seeds were consumed in lesser amounts; summer--rodents were supplemented with fawns and an increased use of grasshoppers and plums; fall--rodents and persimmons comprised the bulk of foods used in this season with small amounts of rabbits and birds; winter--rodents and birds were utilized most during this season with adult deer and rabbits in lesser amounts.

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APPENDIX A

DESCRIPTION AND FATE OF 22 COYOTES CAPTURED AND RADIO-COLLARED ON THE WMNWR 1976 - 1977

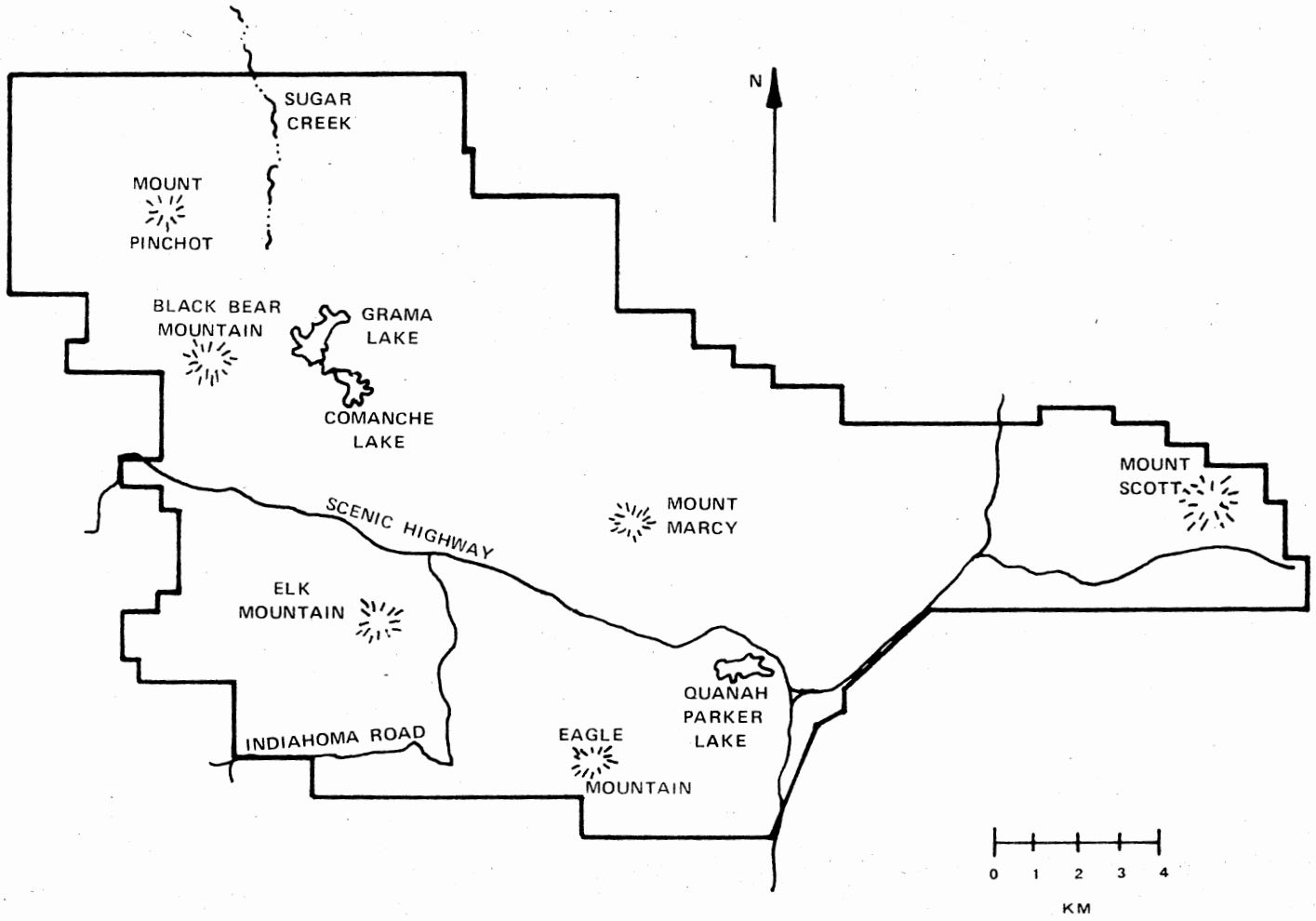
Coyote designation	Sex	Age	Weight (kg)	Capture date	Status and last relocation
1	F	Y	-	29 February 1976	Collar malfunction: 14 June 1976
2	M	A	-	5 March 1976	Collar malfunction: 11 July 1976
3	M	A	-	6 March 1976	Dead: 2 August 1976
4	M	A	-	6 March 1976	Collar malfunction: 2 February 1977
5	F	Y	-	6 March 1976	Terminated relocations: 15 August 1977
6	M	A	-	7 March 1976	Status unknown: 9 October 1976
7	F	P	2.2	16 June 1976	Dead: 29 June 1976
8	M	P	2.7	25 June 1976	Dead: 2 August 1976
9	F	A	12.0	17 February 1977	Terminated relocations: 15 August 1977
10	M	A	15.2	7 February 1977	" " "
11	F	Y	11.1	17 February 1977	" " "
12	F	A	11.1	7 February 1977	" " "
13	F	A	14.4	17 February 1977	" " "
14	F	Y	12.4	18 February 1977	" " "
15	F	A	11.7	18 February 1977	Status unknown: 2 August 1977

Coyote designation	Sex	Age	Weight	Capture date	Status and last relocation
16	F	A	11.3	19 February 1977	Terminated relocations: 15 August 1977
17	M	P	5.0	5 July 1977	" " "
18	M	P	5.0	27 July 1977	" " "
19	F	A	-	29 February 1976	Dead: 10 April 1976
20	M	Y	-	29 February 1976	Collar malfunction: 10 April 1976
21	M	A	14.2	18 February 1977	Status unknown: 16 March 1977
22	F	A	11.9	6 February 1977	Collar malfunction: 10 February 1977

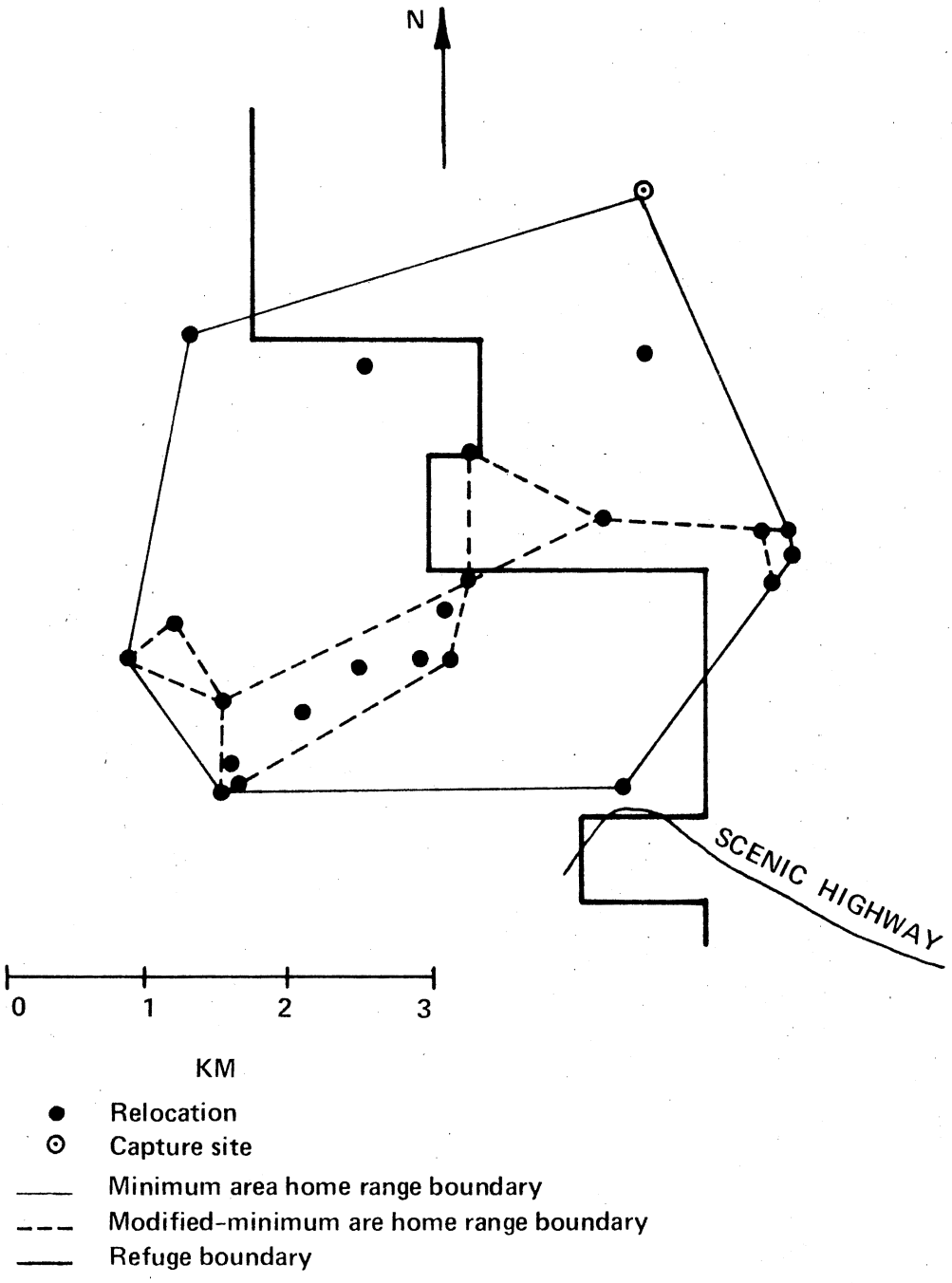
A = adult
Y = yearling
P = pup

APPENDIX B

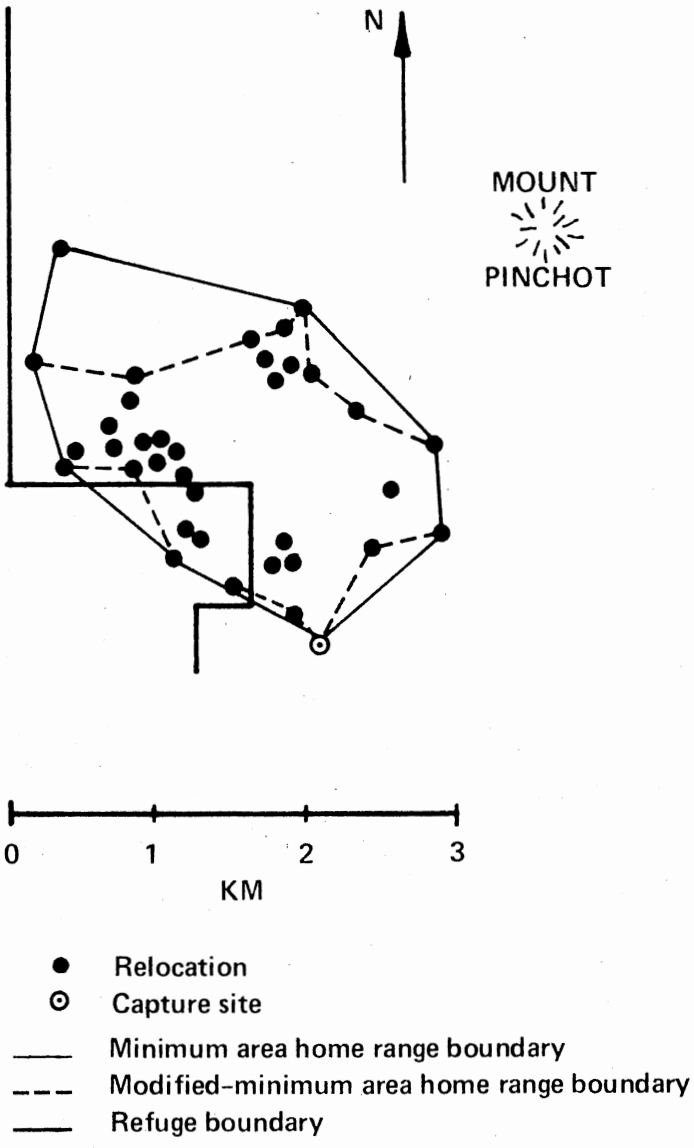
HOME RANGES AND LOCATIONS OF 18 RADIO-COLLARED COYOTES ON THE WMNWR 1976 - 1977



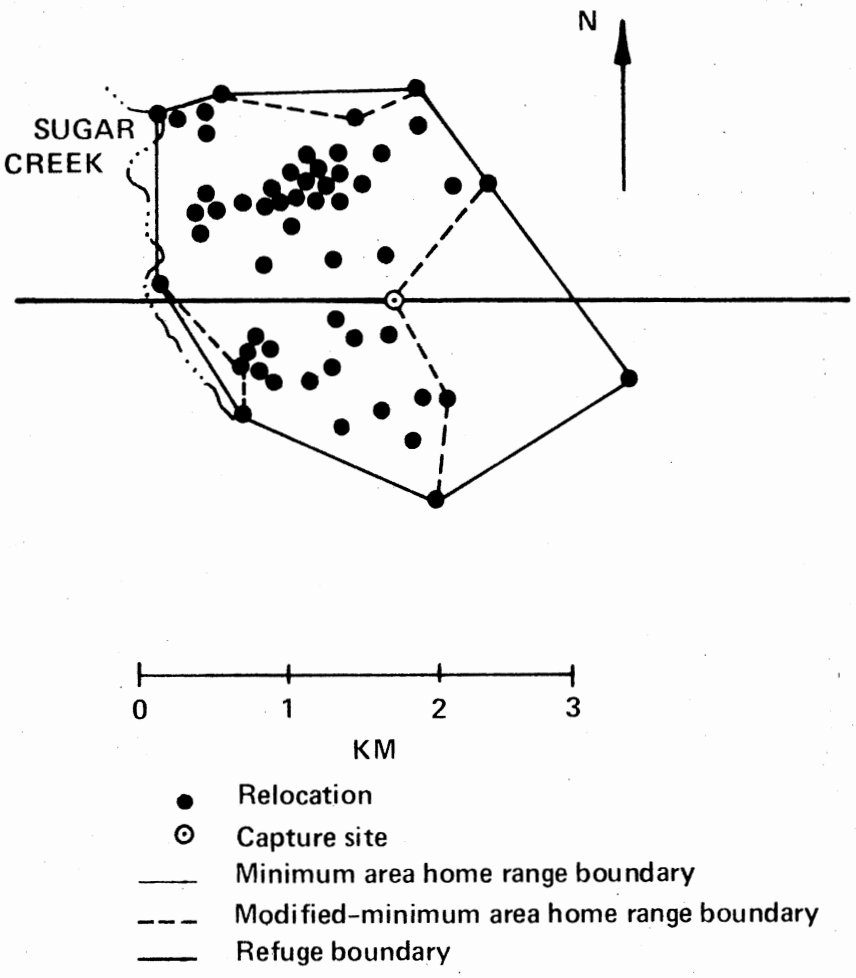
The study area.



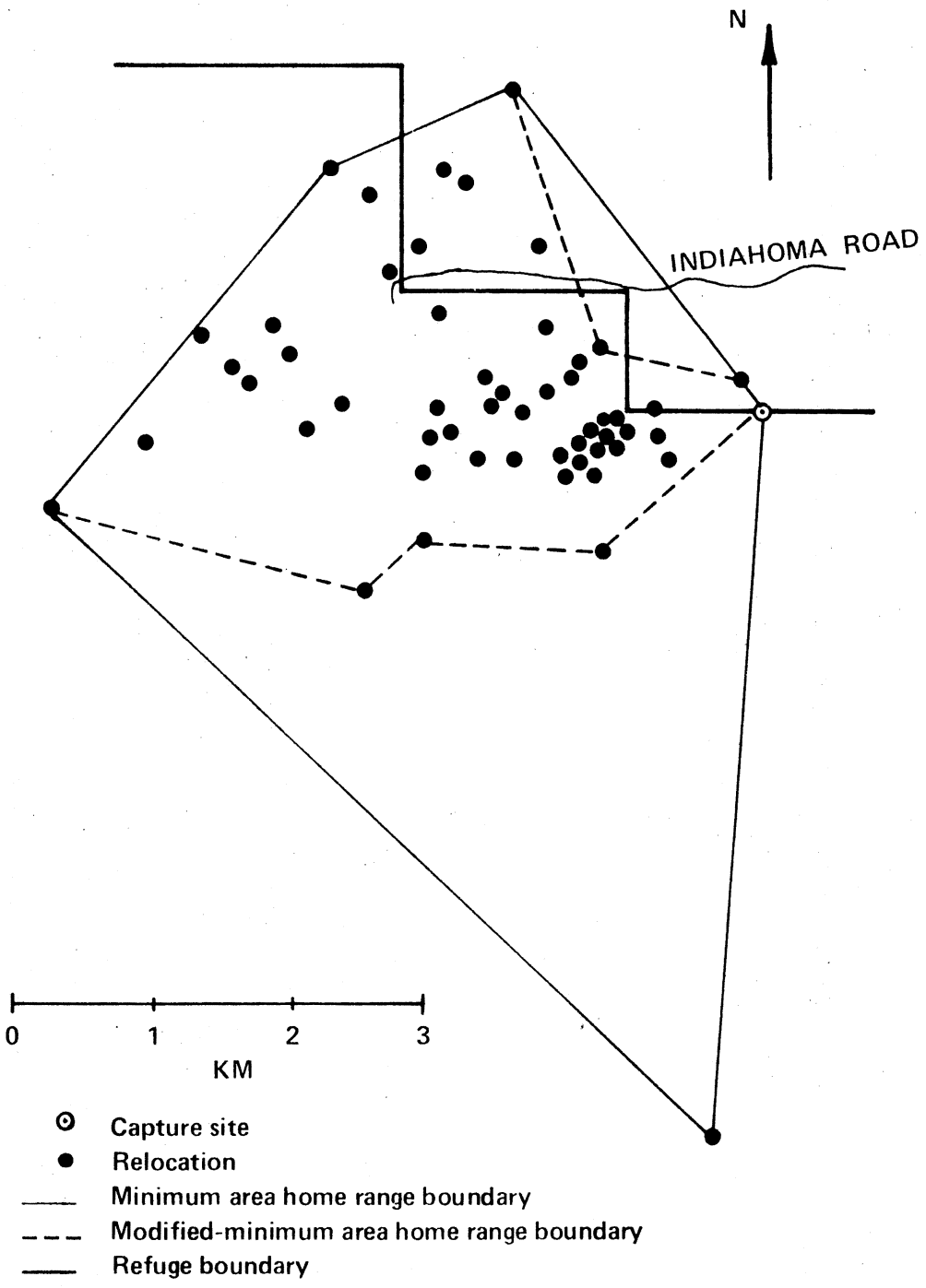
Locations of yearling female 1.



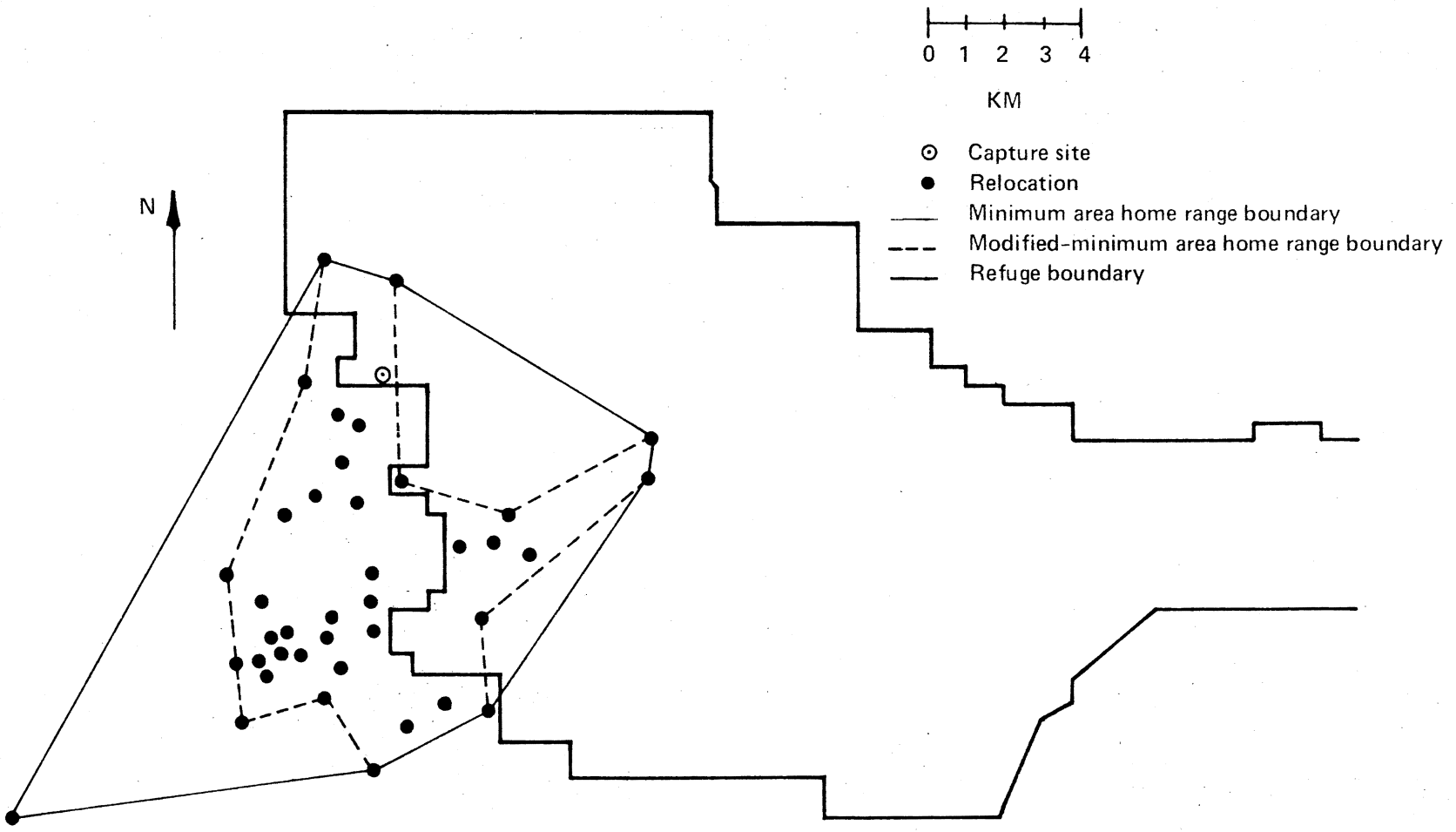
Locations of adult male 2.



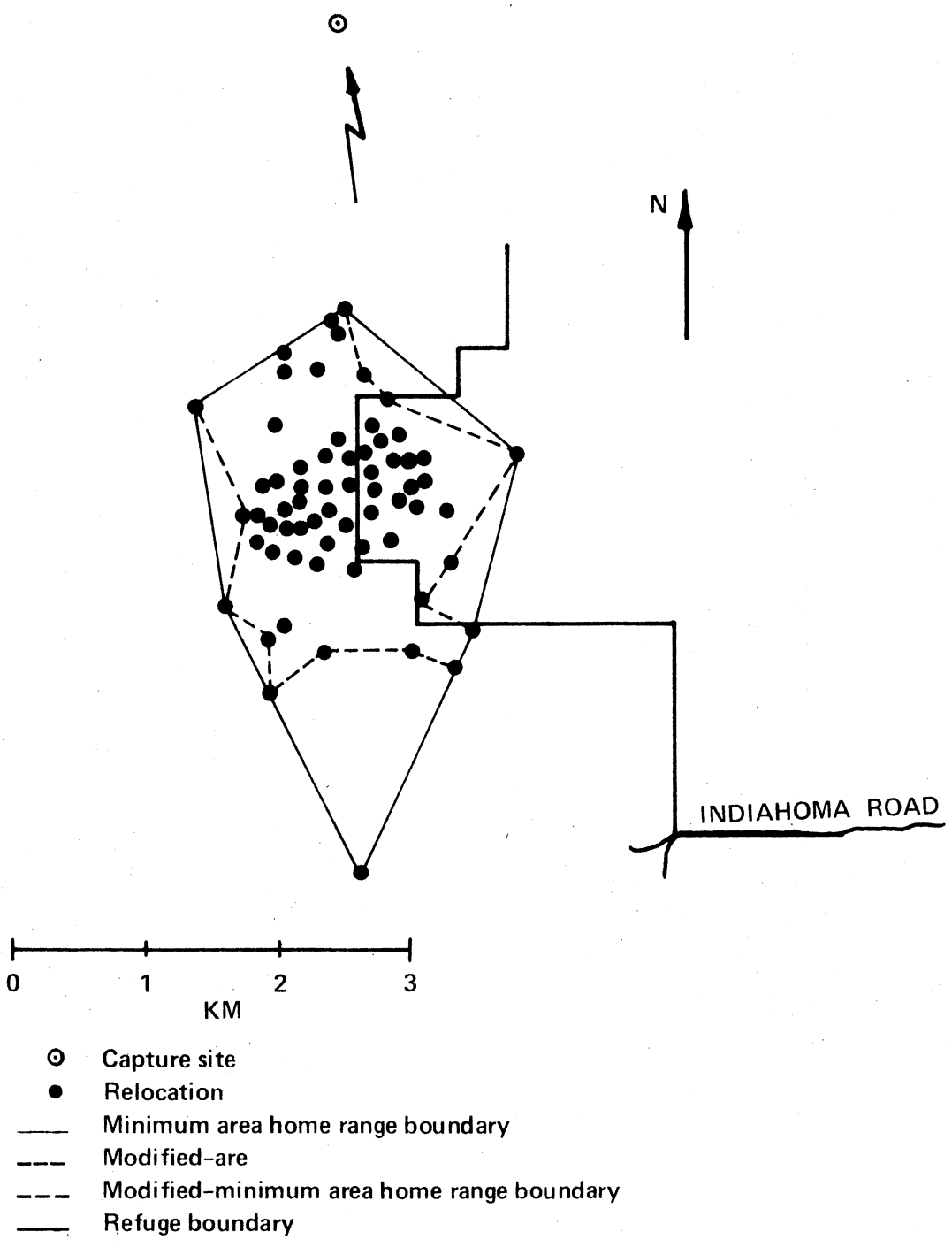
Locations of adult male 3.



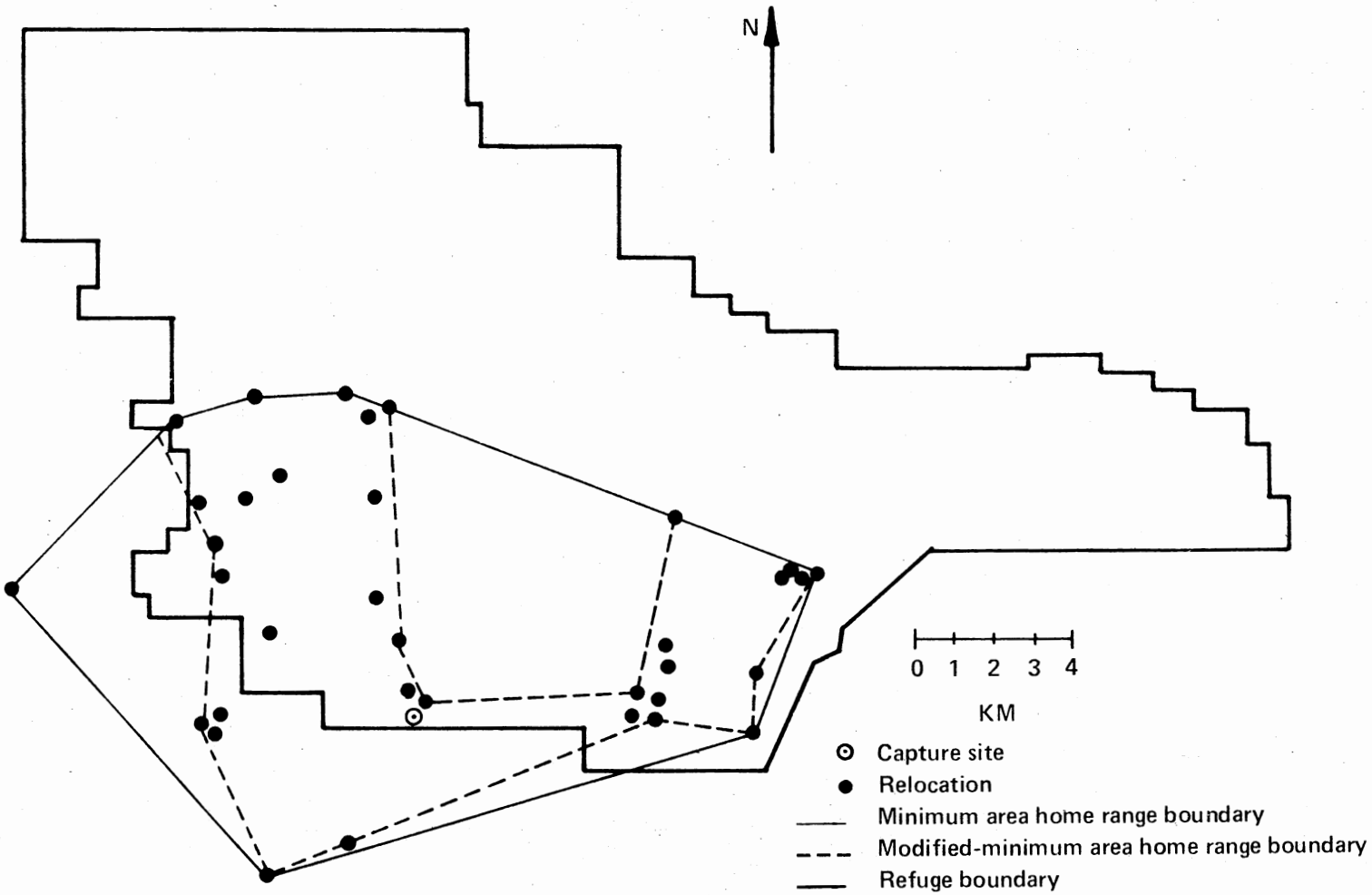
Locations of adult male 4.



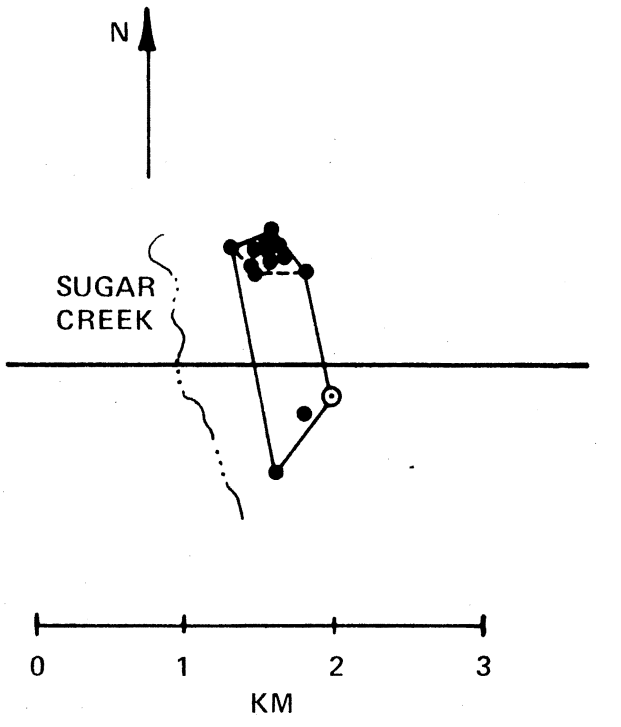
Locations of yearling female 5.



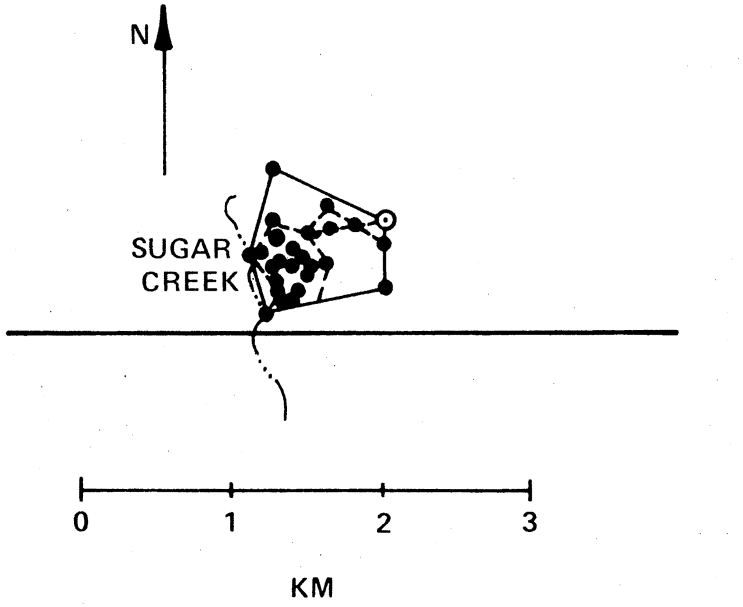
Locations of adult female 5.



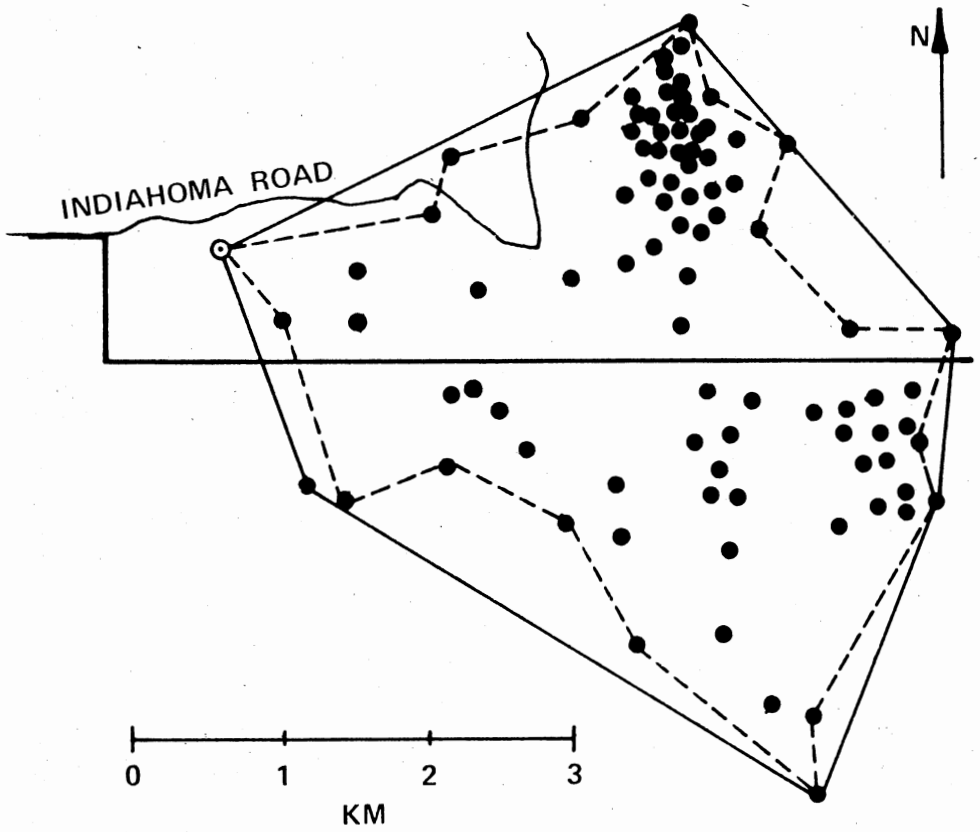
Locations of adult male 6.



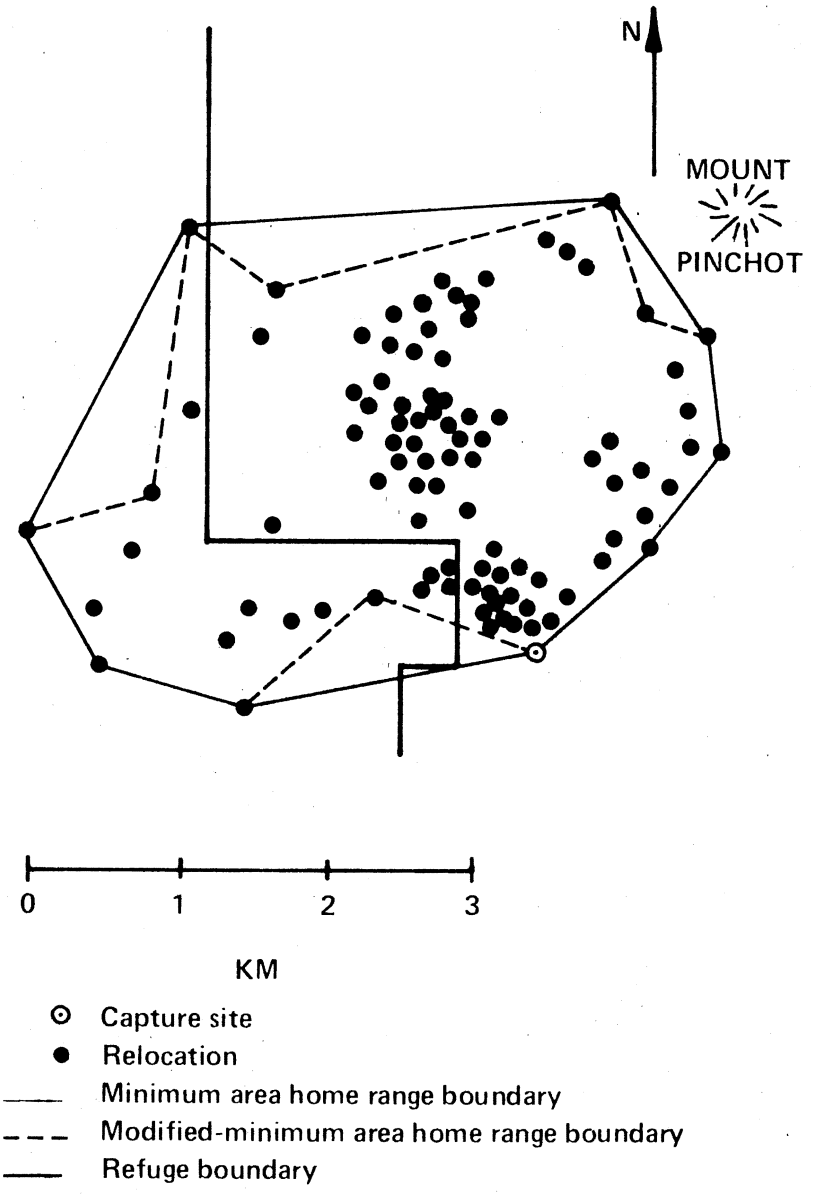
Locations of pup female 7.



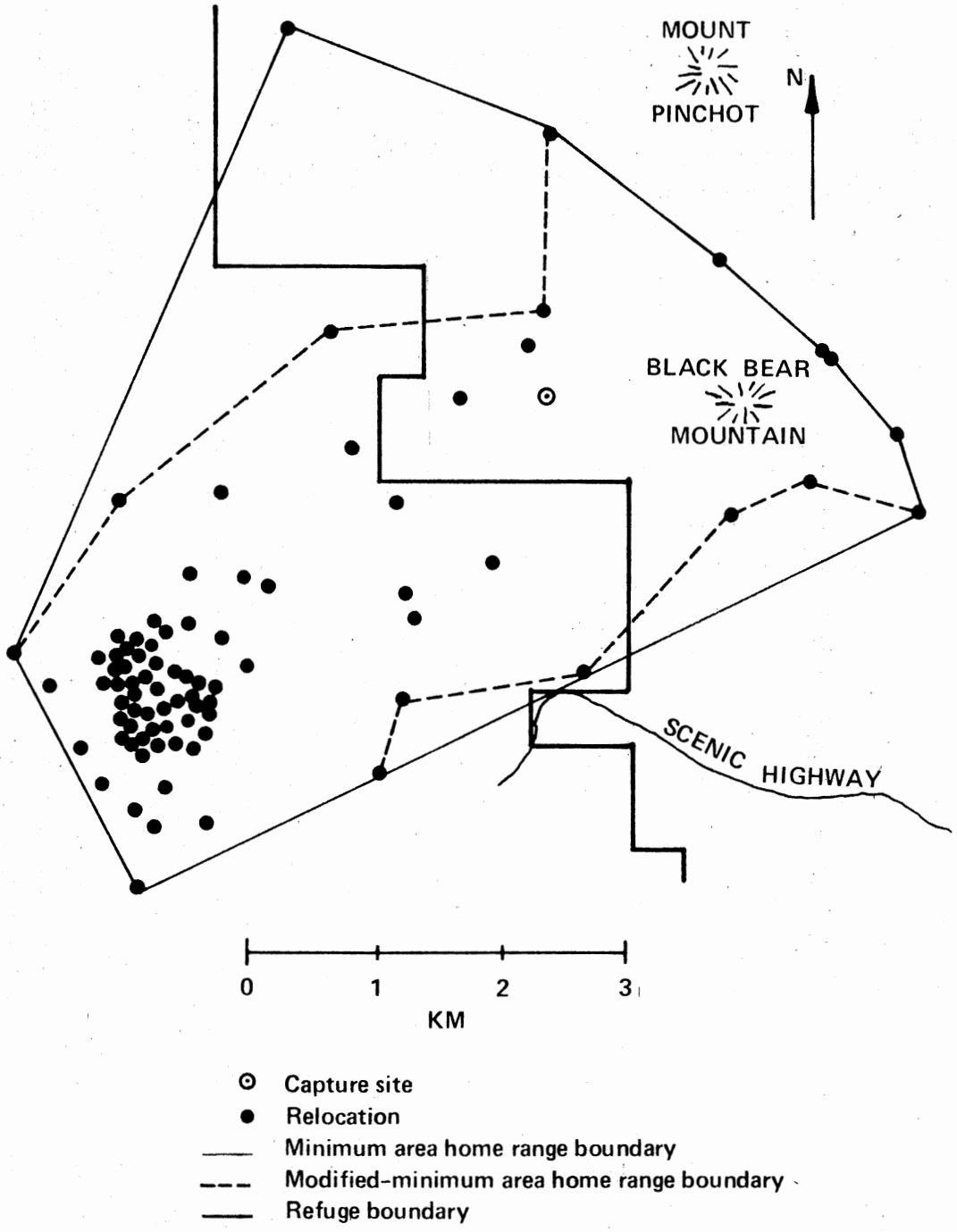
Locations of pup male 8.



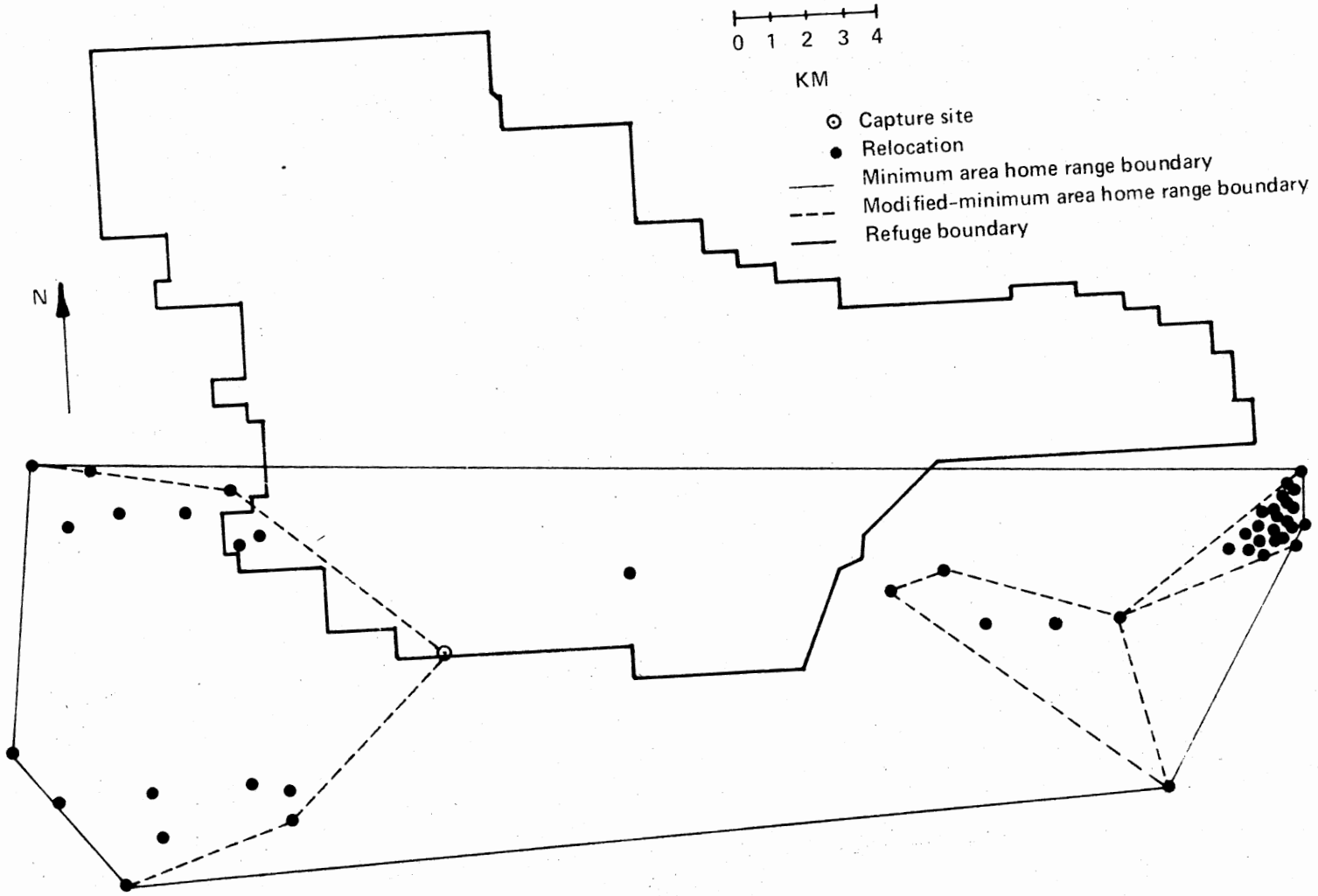
Locations of adult female 9.



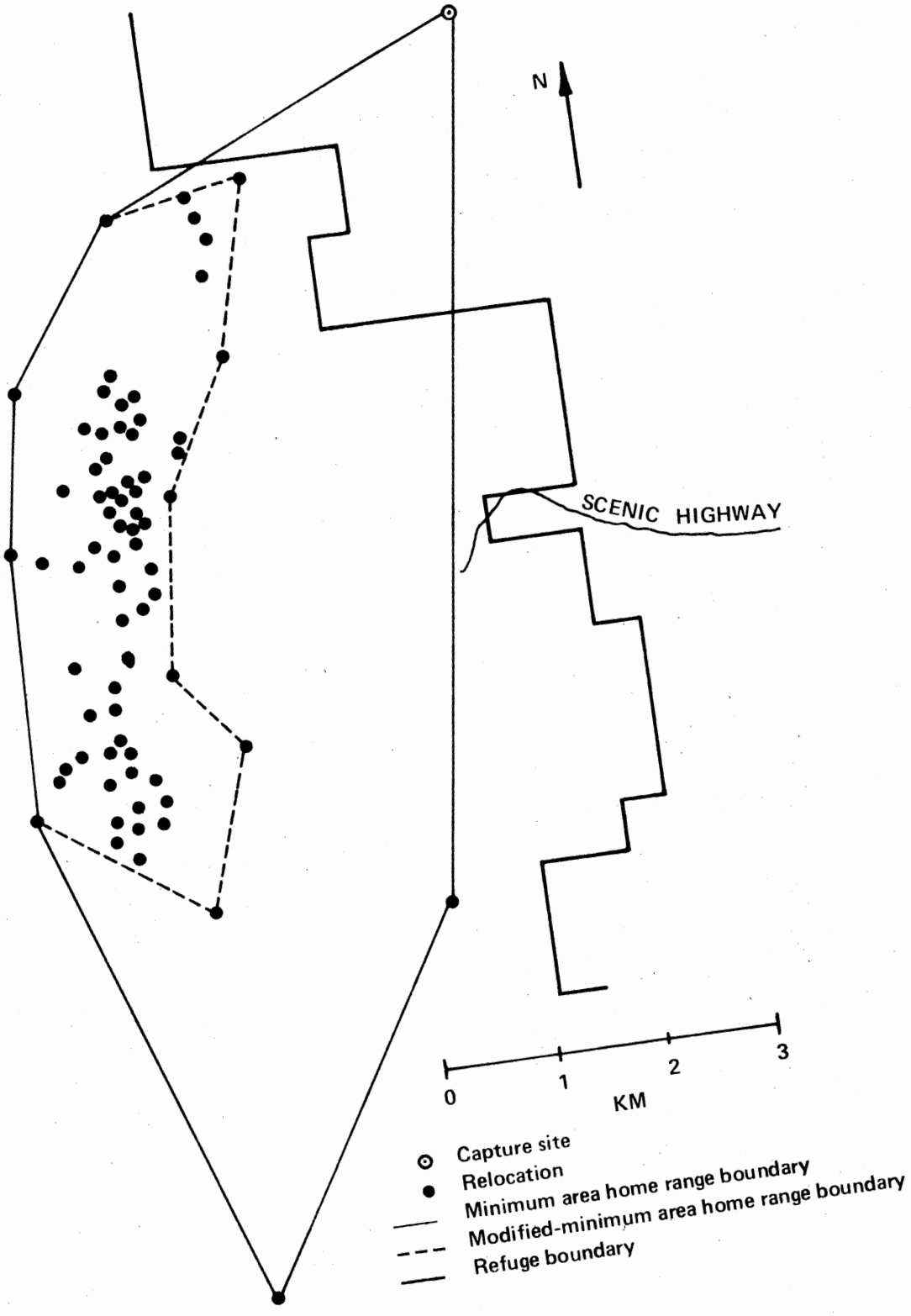
Locations of adult male 10.



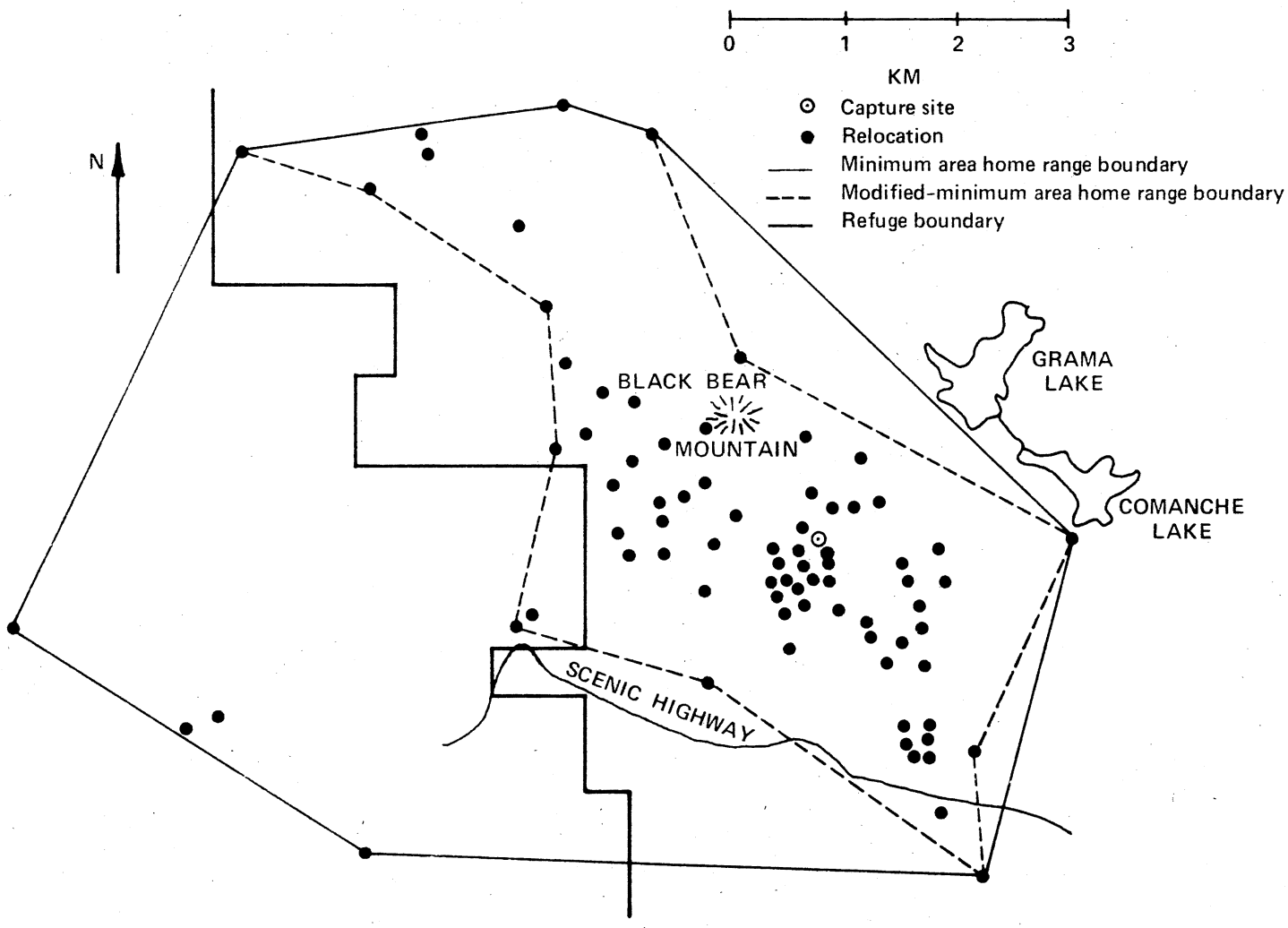
Locations of yearling female 11.



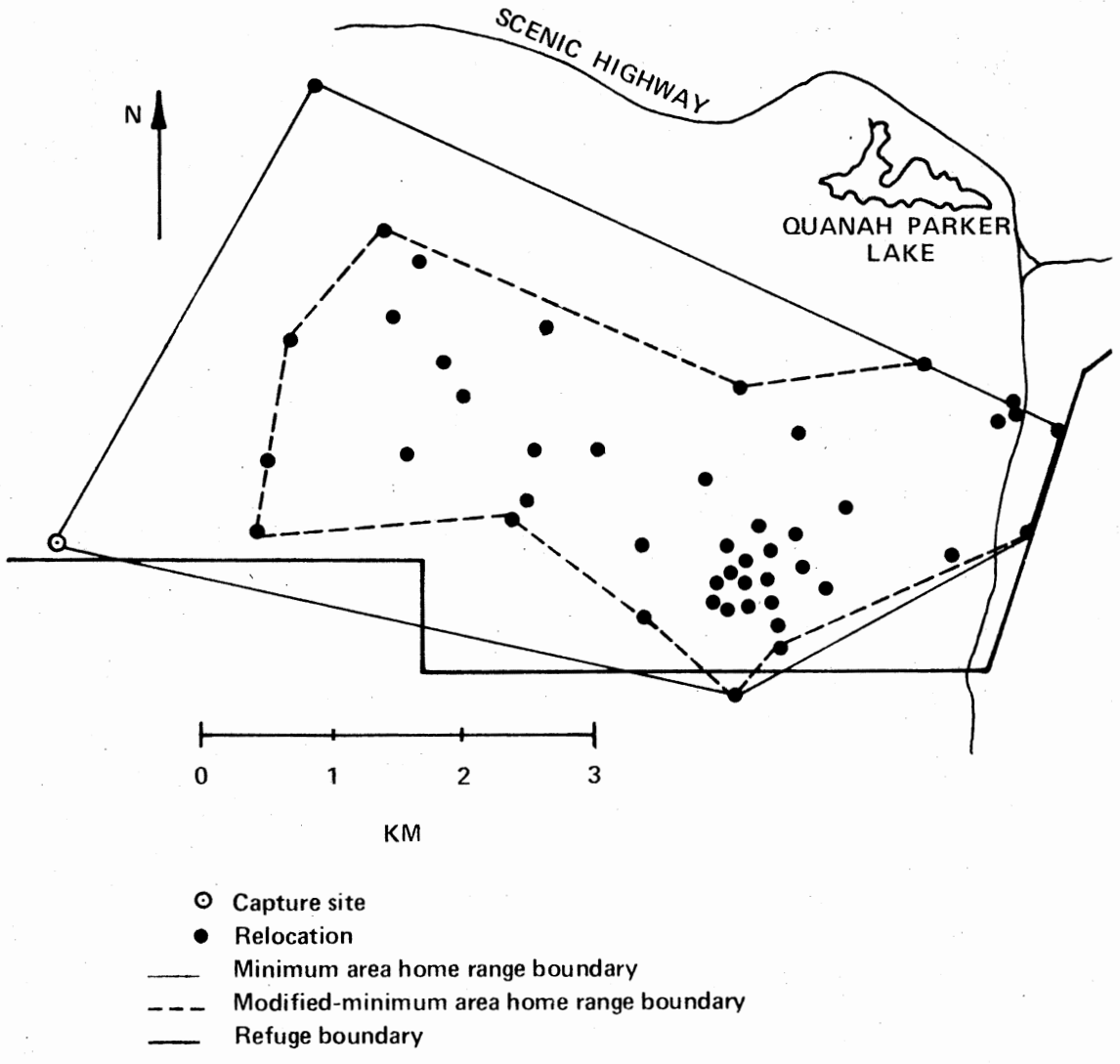
Locations of adult female 12.



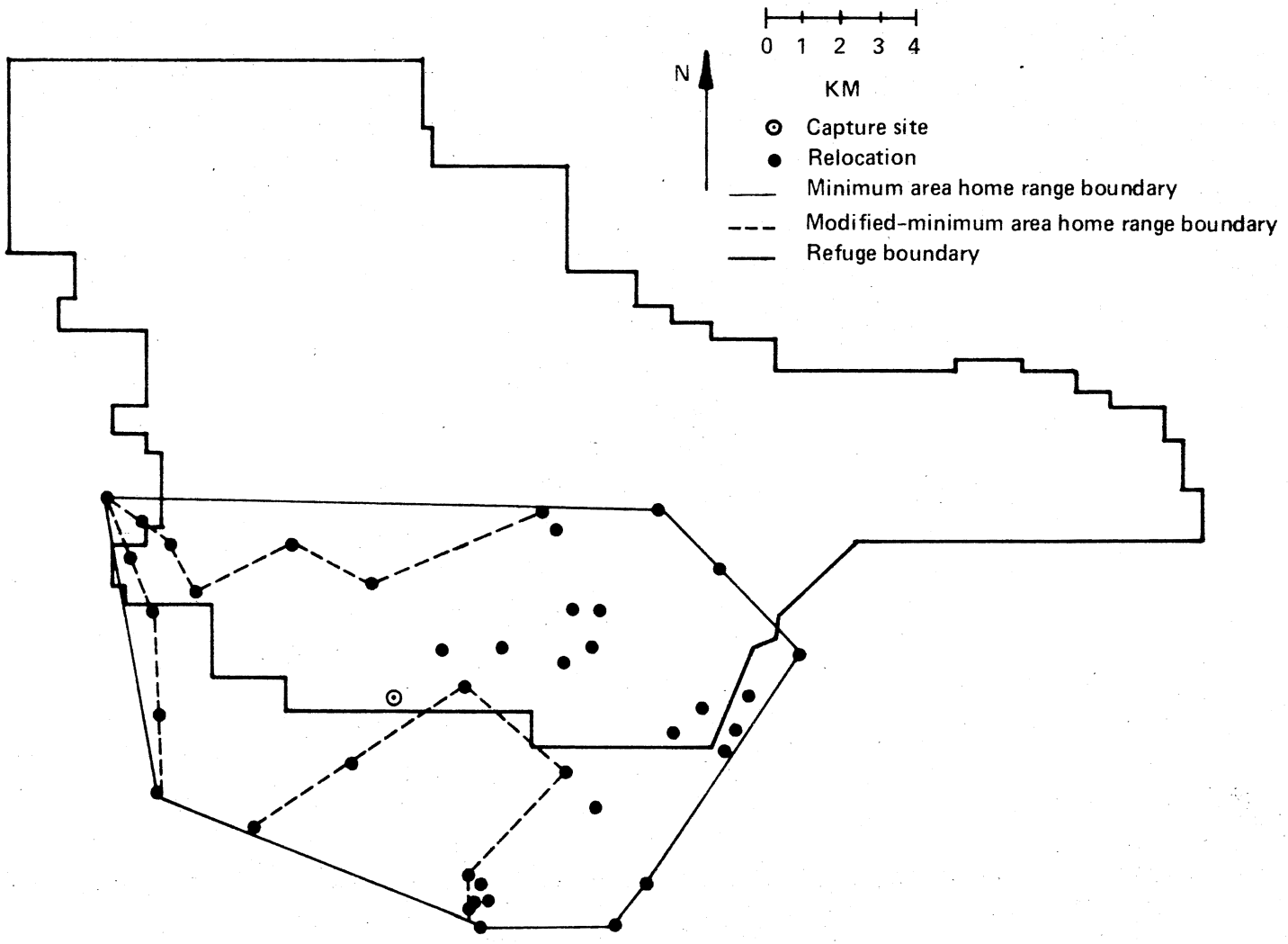
Locations of adult female 13.



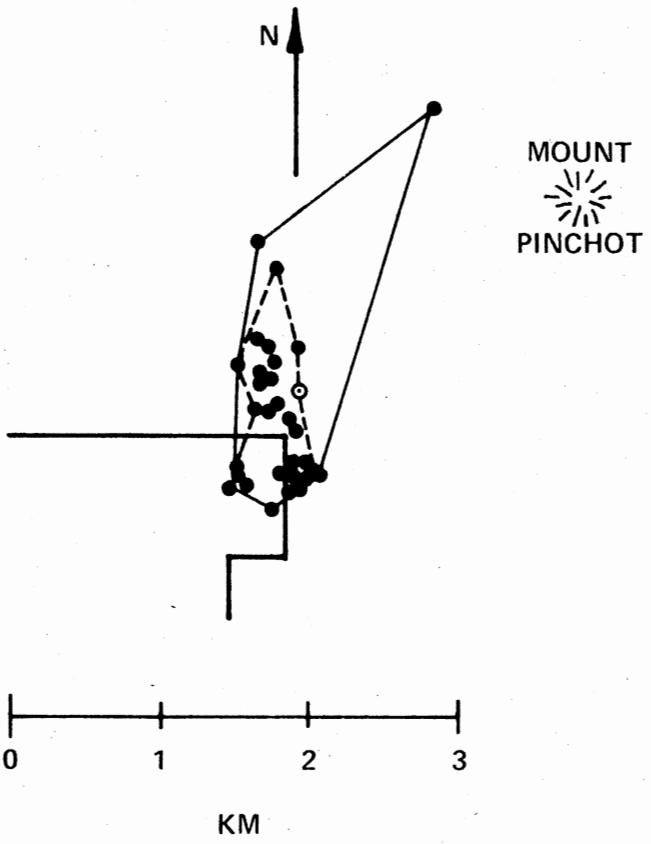
Locations of yearling female 14.



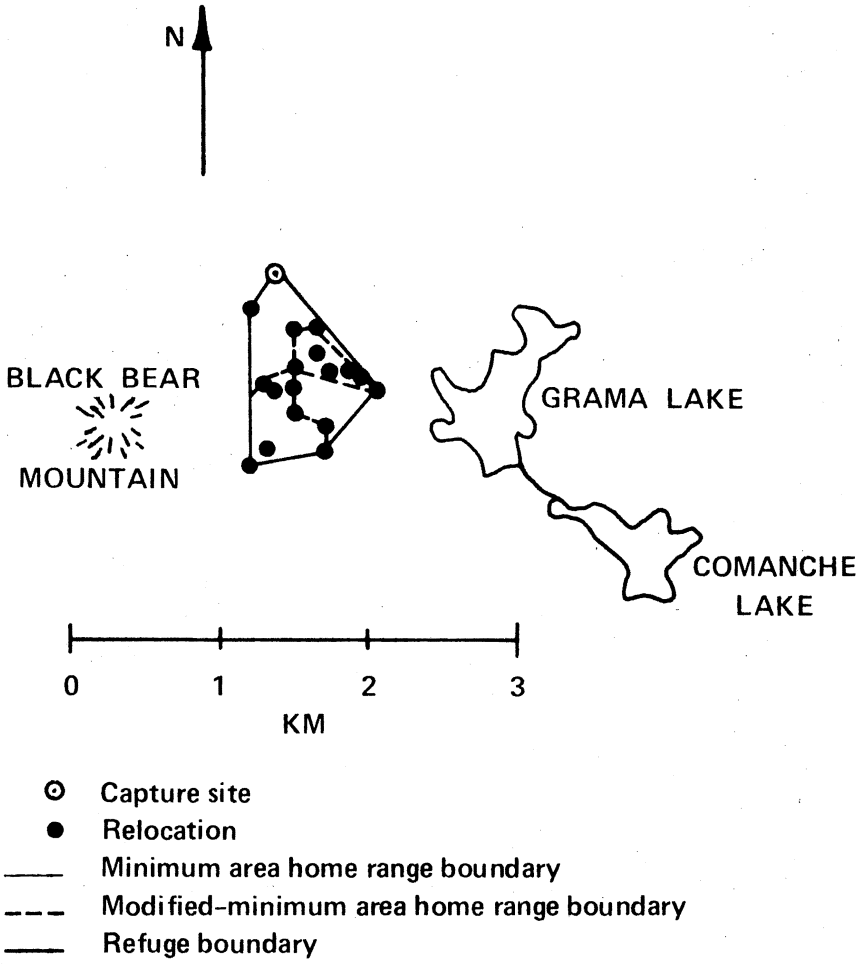
Locations of adult female 15.



Locations of adult female 16.



Locations of pup male 17.



Locations pup male 18.

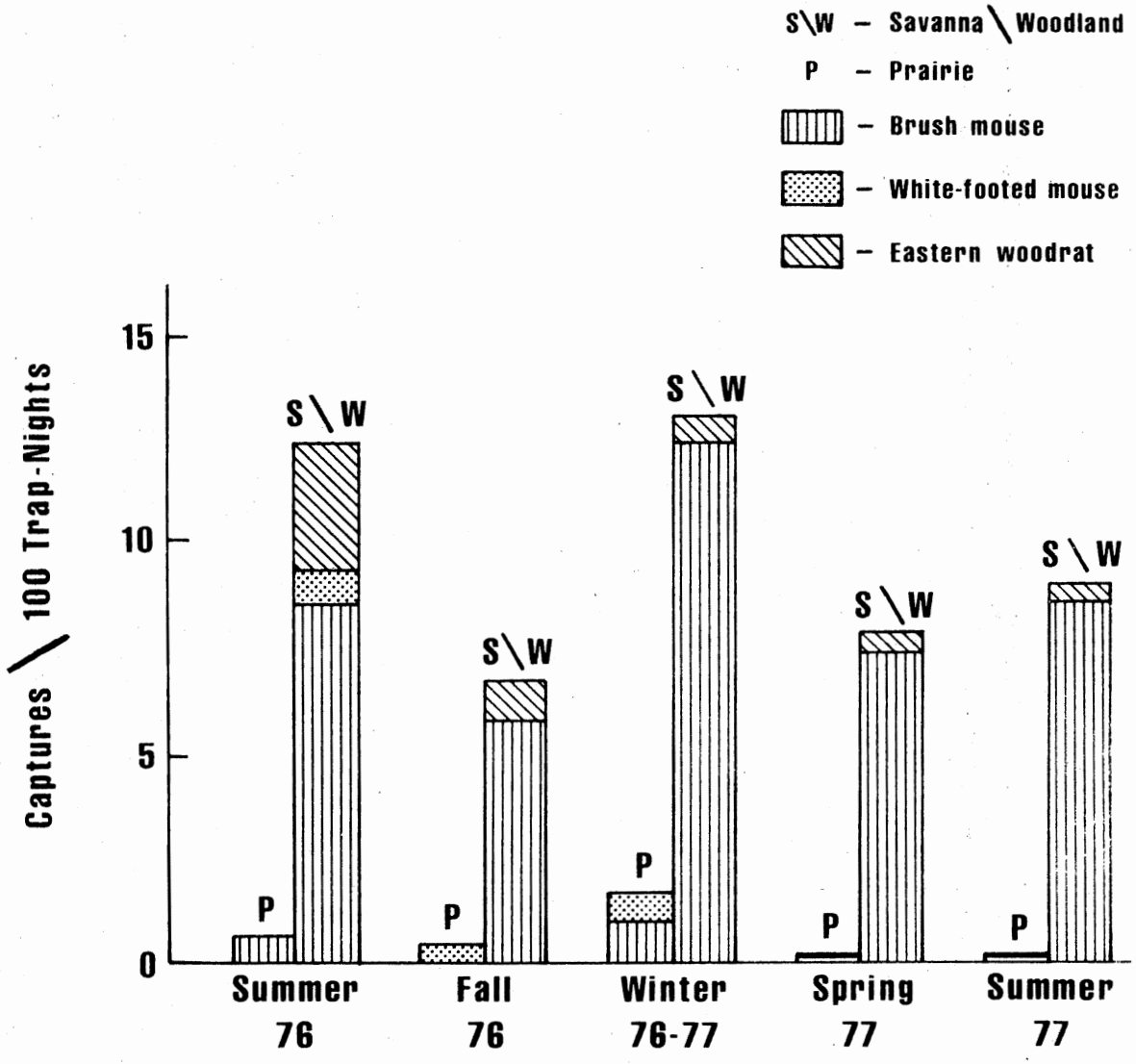
APPENDIX C

FREQUENCY OF OCCURRENCE OF FOOD ITEMS IDENTIFIED IN 361 COYOTE SCATS COLLECTED ON THE WMNWR MAY 1976 - SEPTEMBER 1977

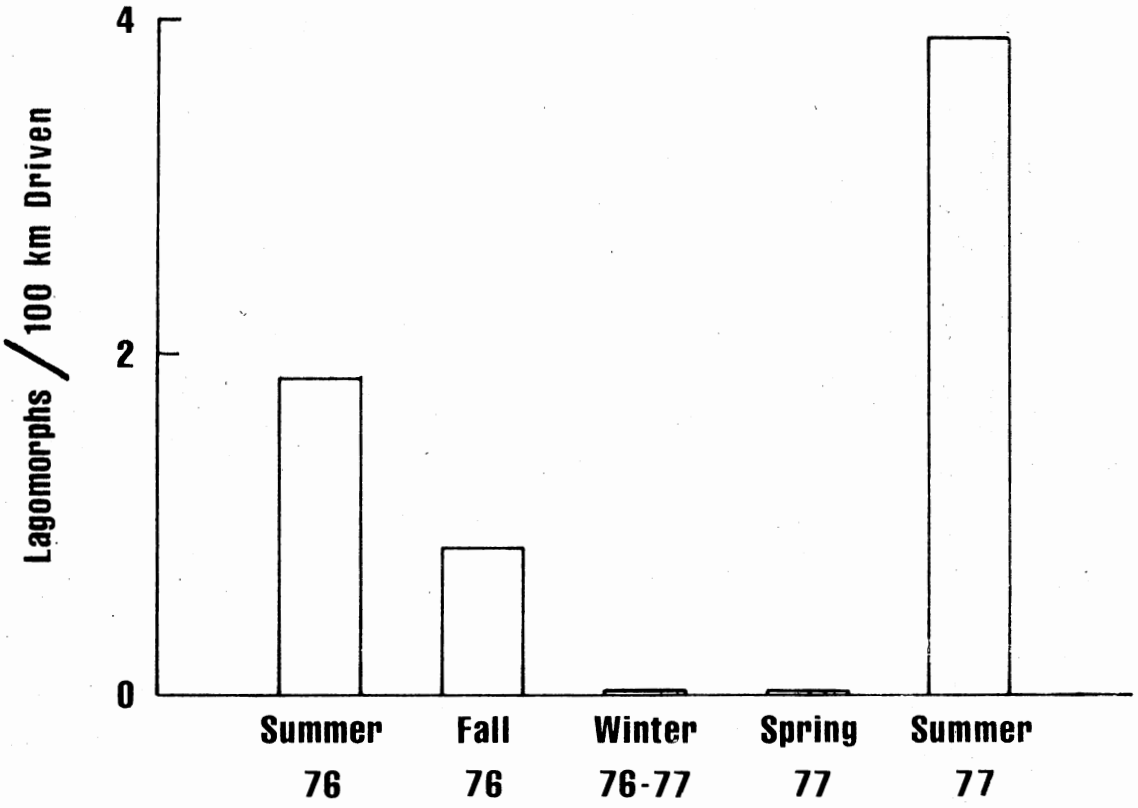
Food item	Frequency of occurrence (number)	(percent)
MAMMALS	322	89.2
Rodents	196	54.3
Cotton rat	120	33.2
Woodrat	42	11.6
Deer mice	28	7.8
Fox squirrel	17	4.7
Pine vole	10	2.8
Hispid pocket mouse	3	0.8
Harvest mouse	2	0.6
Ungulates	101	28.0
White-tailed deer	73	20.2
adult	21	5.8
fawn	52	14.4
Cow	21	5.8
Bison	4	1.1
Elk	3	0.8
Lagomorphs	40	11.1
Eastern cottontail	36	10.0
Black-tailed jackrabbit	2	0.6
Unknown lagomorph	2	0.6
Armadillo	32	8.9
Raccoon	3	0.8
Skunk	3	0.8
Unknown mammals	27	7.5
PLANT MATERIAL	273	75.6
Grasses	239	66.2
Persimmons	40	11.1
Leaves	34	9.4
Plum	21	5.8
Mesquite bean	8	2.2
Acorns	4	1.1
Unknown plant material	60	16.6
INSECTS	70	19.4
Grasshoppers	45	12.5
Unknown insects	37	10.2
AVIAN	67	18.6
Birds	65	18.0
Eggs	13	3.6
REPTILES	13	3.6
MISCELLANEOUS (Unknown bones, Refuse, etc.)	25	6.9

APPENDIX D

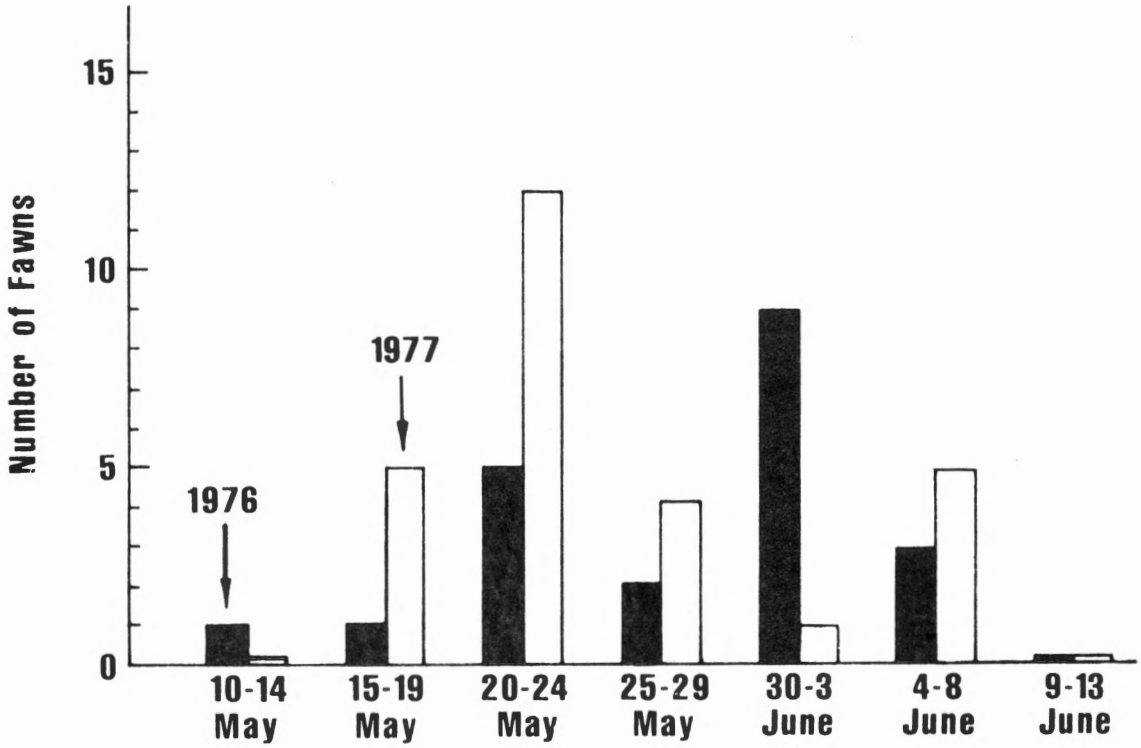
INDICIES OF ABUNDANCE OF SMALL MAMMALS, LAGOMORPHS, AND WHITE-TAILED DEER FAWNS ON THE WMNWR 1976 - 1977



Mean capture success of small mammals from traplines in savanna/woodland and prairie habitats during 5 seasons on the WMNWR 1976-1977.



Mean number of lagomorphs observed per 100 km driven during 5 seasons on the WMNWR 1976-1977.



Estimated birth dates of white-tailed deer fawns captured on the WMNWR, 1976 and 1977.

APPENDIX E

COMPARISON OF COYOTE HOME RANGES (MINIMUM AREA) DETERMINED BY RADIO-TELEMETRY IN VARIOUS AREAS

Age/sex class	Location of study					
	Arizona (Danner 1976)	Idaho/Utah (Hibler 1977)	Minnesota (Berg et al. 1977)	Nebraska (Andelt 1976)	Oklahoma (This study)	
Adult males	52.5 (--)	90.4 (16.8-427.6)	67.3 (**)	56.9 (8.9-107.8)	31.3 (4.0-106.2)	59.7 (4.0-427.6)
Adult females	54.9 (6.5-76.7)	137.9 (29.0-469.1)	15.5 (**)	55.2 (8.8-173.6)	68.7 (4.9-233.0)	66.4 (4.9-469.1)
Yearling males	1.0 (--)	67.5 (13.4-181.7)	7.8 (**)	--	--	25.4 (7.8-181.7)
Yearling females	8.3 (--)	46.0 (8.7-100.4)	7.8 (**)	--	39.9 (12.3-76.2)	25.5 (8.7-100.4)
Pups	--	--	--	--	1.2 (0.5-2.0)	1.2 (0.5-2.0)

(--) only 1 animal reported
(**) only mean reported

VITA 2

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Master of Science

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Professional Experience: Botany Lab Assistant, University of New Hampshire, spring, 1974; Biologists Aide, U.S. Fish and Wildlife Service, summer, 1974; Wildlife Research Technician, University of New Hampshire, 1974-1975; Graduate Teaching Assistant, Institute of Natural and Environmental Resources, University of New Hampshire, 1975-1976; Graduate Research Assistant, Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University, 1976-1977.

Professional Organizations: The Wildlife Society, Oklahoma State University Chapter of the Wildlife Society, National Wildlife Federation, American Society of Mammalogists.