Ecology and reproduction of bobcats in southeastern Montana during a period of low lagomorph density

by Gregory Lynn Risdahl

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management

Montana State University

Abstract:

The ecology and reproduction of bobcats (Fells rufus) were studied in eastern Montana from March 1986 to September 1987. Annual home range size estimates for 2 females were 24.8 and 233.5 km^2. The annual home range sizes for 4 males was 23.9 to 100.5 km^2. Annual home ranges of males and females overlapped extensively.

Overlap between males was confined to the peripheries of their home ranges. Overlap between female home ranges occurred only once. There were no significant differences ($P < .05$) in the mean distances between locations by sex or season. Creek bottom complexes and rock outcrops were used in significantly greater proportion than their availability. Gumbo/scoria badlands, badlands-brushy draws and reservoir complexes were used in proportion to their availability. Open sagebrush/grasslands were used significantly less than in proportion to their availability. Sigmodontinine and arvicolinine rodents made up the bulk of the diets of bobcats in 1986-1987; passerine birds ranked second and lagomorphs third. Pronghorn antelope, insects, domestic sheep and reptiles were also utilized as food sources. Population and harvest trend indices indicated a 35-80% decline in bobcat density from 1983-1984 to 1986-1987. The decline in bobcat density was attributed to the crash in the lagomorph population in 1983-1984. Daily activity patterns determined through 24-hour monitoring sessions indicated considerable variation in distances traveled, amount of hunting and periods of activity/inactivity. Analyses of female bobcat carcasses collected during the 1986-1987 trapping season indicated a decline in reproductive rate from carcasses collected between 1980 and 1983. The overall in utero litter size declined from 2.7 in 1980-1983 to 2.1 in 1986-1987. The overall corpora lutea count declined from 4.2 in 1980-1983 to 3.2 in 1986-1987. The highest ovulation rate (3.6) occurred in the 5+ year class in 1986-1987. No kittens and only 1 yearling occurred in the sample of carcasses collected in 1986-1987. Less than 5% of the bobcat fur harvest in MDFWP Region 7 consisted of kittens and few kittens were purchased by local fur buyers during the 1986-1987 trapping season. Basic blood parameters were analyzed from samples taken from 18 adult bobcats captured during this study. Samples were comparable with bobcat blood sample data from 2 other studies and with domestic cats.

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Gregory Lynn Risdahl

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

26 January 1988
Date

Chairperson, Graduate Committee

Approved for the Major Department

1/26/88
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Date January 26, 1988

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ABSTRACT

The ecology and reproduction of bobcats (Felis rufus) were studied in eastern Montana from March 1986 to September 1987. Annual home range size estimates for 2 females were 24.8 and 233.5 km^2. The annual home range sizes for 4 males was 23.9 to 100.5 km^2. Annual home ranges of males and females overlapped extensively. Overlap between males was confined to the peripheries of their home ranges. Overlap between female home ranges occurred only once. There were no significant differences ($P < .05$) in the mean distances between locations by sex or season. Creek bottom complexes and rock outcrops were used in significantly greater proportion than their availability. Gumbo/scoria badlands, badlands-brushy draws and reservoir complexes were used in proportion to their availability. Open sagebrush/grasslands were used significantly less than in proportion to their availability. Sigmodontinine and arvicolinine rodents made up the bulk of the diets of bobcats in 1986-1987; passerine birds ranked second and lagomorphs third. Pronghorn antelope, insects, domestic sheep and reptiles were also utilized as food sources. Population and harvest trend indices indicated a 35-80% decline in bobcat density from 1983-1984 to 1986-1987. The decline in bobcat density was attributed to the crash in the lagomorph population in 1983-1984. Daily activity patterns determined through 24-hour monitoring sessions indicated considerable variation in distances traveled, amount of hunting and periods of activity/inactivity. Analyses of female bobcat carcasses collected during the 1986-1987 trapping season indicated a decline in reproductive rate from carcasses collected between 1980 and 1983. The overall in utero litter size declined from 2.7 in 1980-1983 to 2.1 in 1986-1987. The overall corpora lutea count declined from 4.2 in 1980-1983 to 3.2 in 1986-1987. The highest ovulation rate (3.6) occurred in the 5+ year class in 1986-1987. No kittens and only 1 yearling occurred in the sample of carcasses collected in 1986-1987. Less than 5% of the bobcat fur harvest in MDFWP Region 7 consisted of kittens and few kittens were purchased by local fur buyers during the 1986-1987 trapping season. Basic blood parameters were analyzed from samples taken from 18 adult bobcats captured during this study. Samples were comparable with bobcat blood sample data from 2 other studies and with domestic cats.

INTRODUCTION

Four studies on the ecology of the bobcat (Felis rufus) in Montana have been completed (Knowles 1981, Smith 1984, Brainerd 1985 and Giddings 1986). The overall goal of these studies has been to obtain trend and status information for management purposes. MDFWP has supported regional studies of the bobcat because of increasingly high pelt prices and the difficulty in monitoring the status of populations located throughout the state. Brainerd (1985) and Giddings (1986) outline the history and motivating factors behind these studies. My study was designed to investigate the reproductive ecology, home range and movements of bobcats in eastern Montana during a period of low lagomorph density, supplementing the eastern Montana home range and movements work done at high lagomorph densities (Giddings 1986).

Studies of bobcats in low productivity populations have been undertaken in Washington (Knick and Bailey unpubl. data), Idaho (Bailey 1972), Oklahoma (Rolley 1983, 1985) and elsewhere. Researchers have suggested that depressed productivity occurs because of a decline in availability of the major prey species (Bailey 1972, Kitchings and Story 1978, Knick and Bailey unpubl. data, and Litvaitis et al. 1987). A primary component of the diets of these felids is often reported to be hares (*Lepus* spp.) or rabbits (*Sylvilagus* spp.) (Hall 1973, Bailey 1972, Berg 1979, Knick et al. 1984, Knick and Bailey unpubl. data, Litvaitis et al. 1986 and Toweill 1986).

The primary objectives of this study were to:

1) Document bobcat population trends and habitat use as reflected by changes in:

a) home range sizes and movements

b) habitat use patterns

c) prey availability and diet

d) scent post visitations

e) harvest statistics

2) Examine harvested female bobcats in MDFWP Region 7 to determine:

a) age at first breeding

b) ovulation rates

c) pregnancy rates

d) litter size

e) age and condition

Secondary objectives were to:

1) Document daylight and night movements and habitat use.

2) Determine relative differences in bobcat and coyote densities in the study area.

3) Collect baseline data on the blood parameters of bobcats in eastern Montana.

STUDY AREA

The study area was centered on the Hook Ranch located north of the Yellowstone river between Forsyth and Miles City (Fig. 1) but included portions of several additional ranches. BLM and state lands were interspersed among private holdings. The study area encompassed approximately 1,722 square kilometers (km^2) (Fig. 2).

The region is characterized by low, rugged gumbo (sodium-affected light-colored clayey soils of cool, arid and semi-arid grasslands deposited as alluvium) and scoria (brick-red to violet colored clinker produced by range fires and underground burning of clayey soils) badlands (Montagne et al. 1982) interspersed with areas of shortgrass prairie which are highly dissected by deeply cut and eroded streambeds. The dominant soil orders on the study area were camborthids, natrargrids and torriorthents which generally comprise the gumbo that is characteristic of the unglaciated sedimentary plains of eastern Montana. The gumbo and scoria hills are banded with layers of coal and sandstone.

The study area was considered part of the Hell creek formation that extends southward from its foci north of Fort Peck reservoir (Alt and Hyndman 1986). The Hell creek

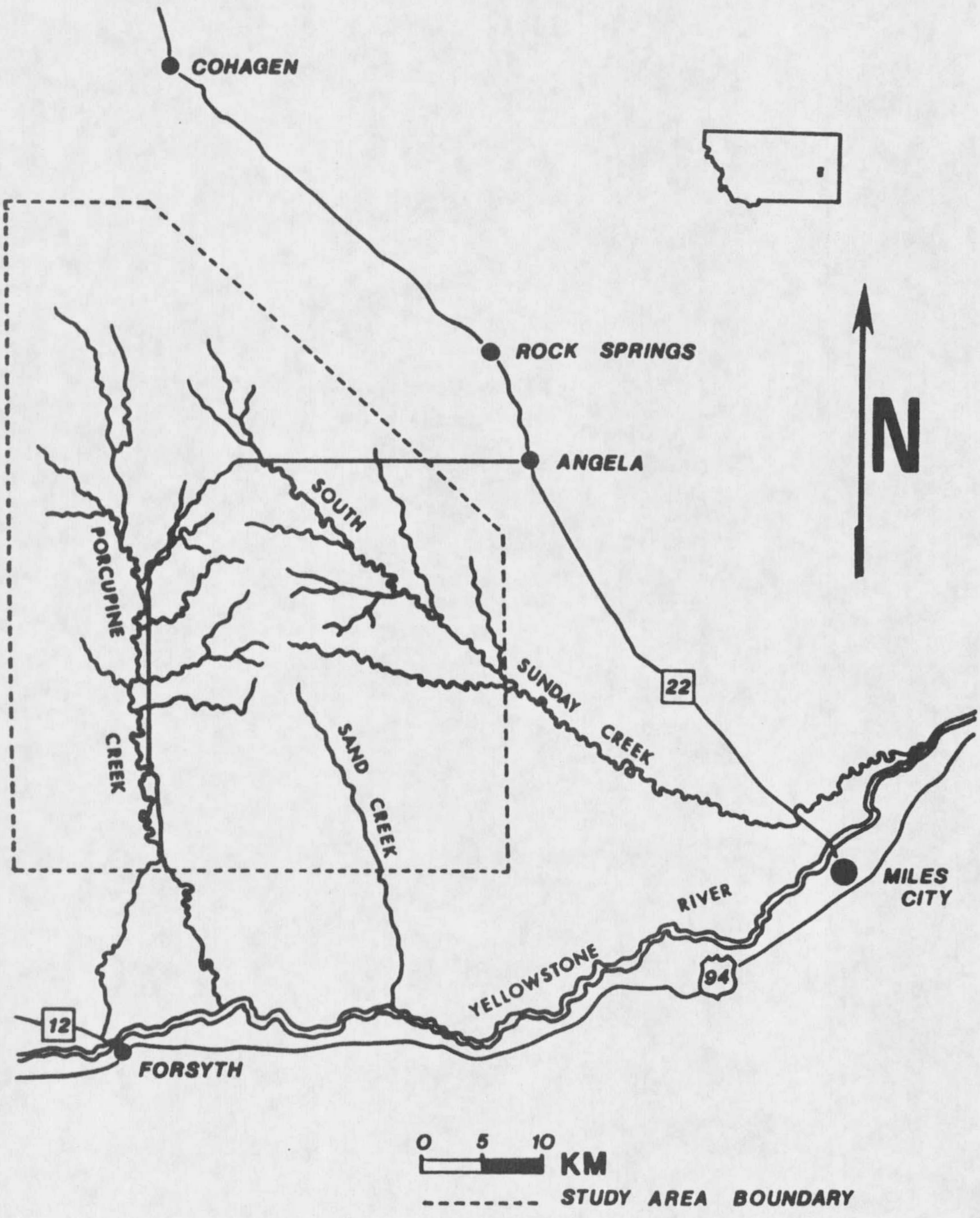

Figure 1. Location of the Hook Ranch study area.

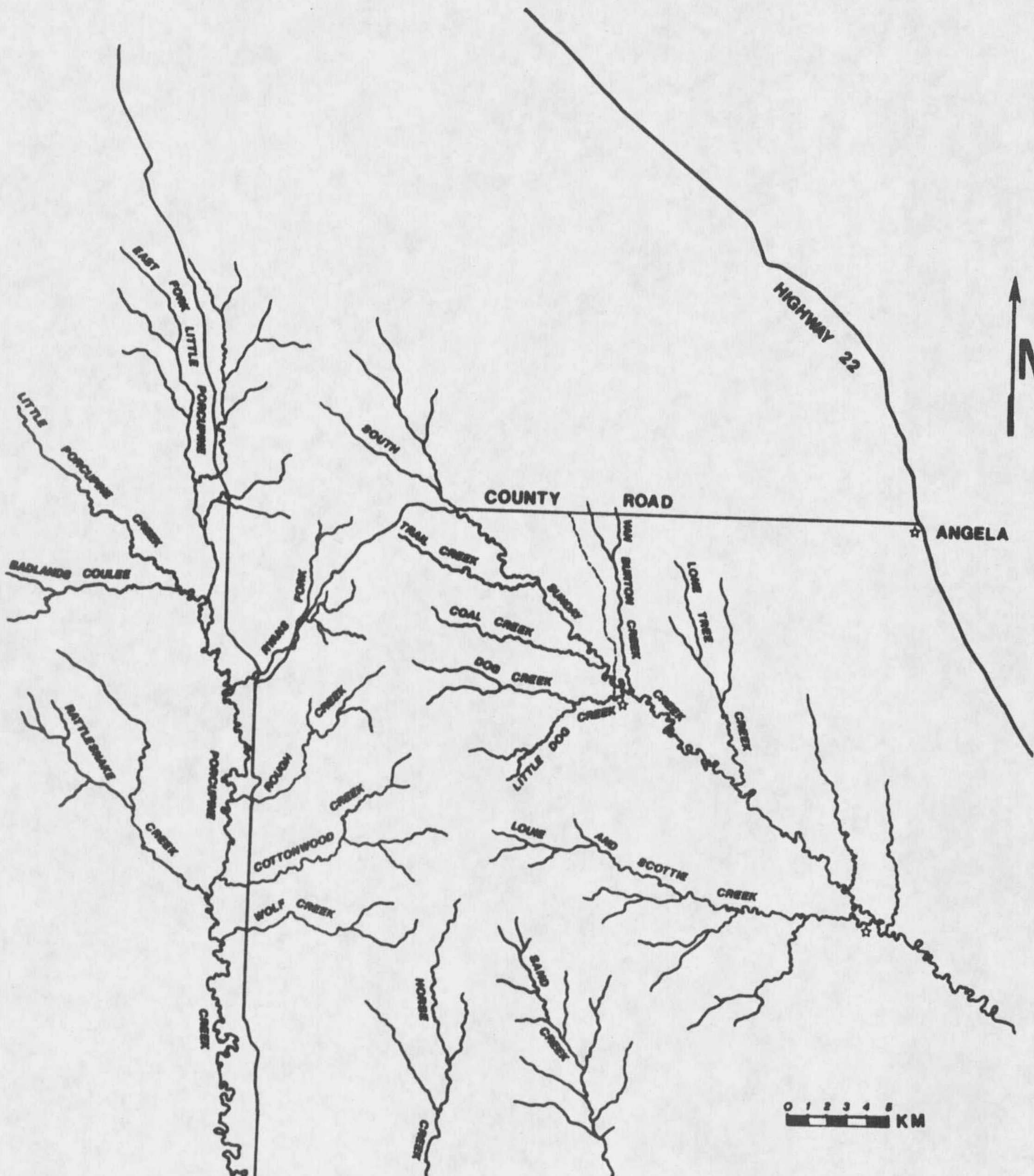

Figure 2. Hook Ranch study area showing the major stream drainages.

formation is rich in Cretaceous period fossils including several species of trees, dinosaurs, other reptiles and aquatic invertebrates. The elevational range within the study area was between 800 and 1000 meters (m).

The study area is classified as a sagebrush-saltbush rangeland type (Payne 1973). Overgrazing in the 19th and 20th centuries by wild horses, sheep and cattle is believed to have resulted in extensive changes in plant species composition. Grazing tolerant grasses such as cheatgrass (Bromus spp.), needle and thread grass (Stipa comata) and Sandberg's bluegrass (Poa sandbergii) as well as plains prickly pear cactus (Opuntia fragilis), pussytoes (Antennaria spp.), broom snakeweed (Gutierrezia sarothrae) and fringed sagewort (Artemisia frigida) have increased at the expense of some climax species. Ross and Hunter (1976) list the dominant climax vegetation for this area as big sagebrush (Artemisia tridentata), silver sagebrush (A. cana), Nuttal's saltbrush (Atriplex nuttallii), bluebunch wheatgrass (Agropyron spicatum), western wheatgrass (A. smithii), needle and thread grass, blue gramma (Bouteloua gracilis), threadleaf sedge (Carex filifolia) and a variety of legumes (e.g., Astragalus spp. and Thermopsis spp.). Trees are limited to scattered willows (Salix spp.), plains cottonwood (Populus sargenti), Russian olive (Elaegnus angustifolia) and ash (Fraxinus spp.) near stock ponds and stream drainages.

Summers in southeast Montana are typically hot and dry with temperatures ranging between 18.3 Celsius (C) and 23.6 C (Annon. 1980). Winters are cold and windy and temperatures generally range between -9.2 C and -5.5 C. The mean July temperature is 20 C and the mean January temperature is -7.4 C. Average precipitation is 30.9 centimeters (cm) (Annon. 1985) and falls primarily between April and September. Winter snowfall averages 71.1 cm. Total precipitation for 1986, recorded at the Rock Springs station, was 36.6 cm, a departure of +7.3 cm (U. S. Department of Commerce 1986). The mean annual temperature for 1986 was 7.2 C - a departure of +1.9 C for the Rock Springs station.

The major mammal species present on the Hook Ranch study area are listed by Giddings (1986). Avian species observed during the 1986-1987 field season are listed in Appendix Table 27.

The Hook Ranch and surrounding ranches have a history of sheep and cattle ranching preceded by ranging wild horses and dryland farming. Grazing by plains bison (_Bison bison_) and Audubon's bighorn sheep (_Ovis canadensis auduboni_) preceded the wild horses and dryland farming. Currently, the Hook Ranch is fenced into large pastures and the grazing rights are leased for cattle during April through October. During 1986 and 1987, about 5,400 cattle grazed the area annually. Up to 20,000 head have been run on the ranch during a single year, but numbers have been reduced in an attempt to allow the range to recover (Dickerson pers. comm.). The ranches to the north supported both cattle and sheep during the study period. Both the Hook Ranch and some of the neighboring ranches were tilled for dryland wheat, but current plans are to return some of this land to its natural state through the Conservation Reserve Program.

Primitive roads and 4-wheel drive trails allowed access to most of the study area when the ground was dry. Private trappers have used this road system to access traplines for bobcats and coyotes (Canis latrans) in most years on the Hook Ranch and surrounding ranches during the fall and winter months.

A predator control program for coyotes has been in effect on the Killen Ranch to the north for almost 75 years (Killen pers. comm.). But no predator control program has been in effect on the Hook Ranch for over 60 years. Aerial gunning of coyotes by private individuals occurs over the entire area and 3-4 trappers have trapped predators on the study area for the past decade.

METHODS

Trapping and Handling

Bobcats were captured during 3 time periods in 1986-1987. Trapping was initiated on 29 March 1986 and continued through 23 June 1986. Victor #2 "softcatch" rubber jaw coilspring traps were used exclusively at first. Later, Victor #2 offset jaw coilspring traps were included to supplement the limited supply of softcatch traps. All traps used during this first phase were dyed, waxed, and secured solidly with 0.95 cm reinforcement rod stakes. All traps had 2 to 3 in-line swivels as well as a trap and a stake swivel to prevent chain twisting/breakage and lessen foot damage.

The second attempt to capture bobcats was made from 9 September to 29 October 1986. At this time, a gradual shift to Victor #3N and #3 offset jaw longspring and Northwoods #3 offset jaw coilspring traps was made. Chains were lengthened 2 to 3 m.

The final trapping period was from 18 February to 13 March 1987. The #3 longspring and #3 coilspring traps were further modified by filing trap triggers to bare steel and attaching traps to juniper fence posts used as drags rather than securing them solidly with reinforcement rod stakes. The drag was preferred over a stationary stake because an animal was less likely to escape by pulling free. Two additional changes were implemented at all trapsites during the spring of 1987. First, 2 traps were placed at each set (a total of 4 traps at each site) to increase the odds of catching a bobcat and decrease the chances of missing a cat that spent little time investigating the set. Secondly, a switch from stiff wire screen trap pan covers to flexible fiberglass screen covers was made. These pliable covers laid more levelly over the trap pan eliminating the "bulge" and decreased the distance a bobcat had to depress the trap pan to trigger the trap. These final modifications more than doubled capture success.

During each trapping period, traps were set near fresh bobcat sign (tracks and scats). Trapping locations were established crossing areas, travel routes, attraction sites and hunting areas. During the spring of 1987, traps were also set at regularly used natural toilet sites located on the peripheries of known bobcat home ranges. These toilet sites were associated with either sinkholes used as sleeping/resting areas or attraction sites such as sandstone outcrops.

Commercial curiosity-type and gland-based lures, bobcat urine, coyote urine, bobcat and coyote scats, pieces of road-killed pronghorn antelope (Antilocapra americana), jackrabbits (Lepus townsendi), deermice (Peromyscus maniculatus), bushy-tailed woodrats (Neotoma cinerea) and feathers or wings from waterfowl or sagegrouse (Centrocerus urophasianus) were used in various combinations as lures, baits and attractants at trapsites. Sets were relured, rescented and/or rebaited every 3 to 7 days depending on the extent of evaporation, dessication or decomposition induced by varying weather conditions. Traps were checked daily in most instances to minimize foot damage to trapped cats.

Captured bobcats were restrained with a homemade snarepole, stretched laterally and drugged. An intramuscular injection of Ketamine hydrochloride was administered with a 3 cubic centimeter (cc) syringe by hand. The dosage used was 22 milligrams per kilogram (mg/kg) of estimated body weight.

Body weight and physical measurements, general condition, presence/absence of parasites, coat color and identifying markings were recorded for each captured bobcat. Sex and approximate age were determined for each individual based on weight, tooth wear, and gum line recession (Crowe 1972, 1975). A 15 milliliter (ml) vacutainer was used to draw blood from a femoral vein from each bobcat. Two cubic centimeters were transferred to another vacutainer containing the preservative EDTA and mixed to inhibit coagulation. Both samples were placed on ice and taken to Miles City within 8 hours for hematology analysis or centrifuging and freezing. The 2.0 cc EDTA preserved sample was analyzed immediately for basic blood parameters at Holy Rosary Hospital. The remaining blood was centrifuged, the serum decanted, divided into 2 equal portions and frozen at Fort Keogh, U. S. D. I. Agricultural and Range Experiment Station, Miles City. Later, 1 serum sample was analyzed by staff at Fort Keogh for hormone levels. The other serum sample was transported to the Veterinary Sciences Laboratory in Bozeman, Montana, for blood chemistry analyses.

Bobcats were marked with numbered red or yellow plastic eartags (red tags were assigned to females and yellow tags were assigned to males) and radio-collared. Some males were not collared because of monetary constraints. Each bobcat was also given an injection of 1.0 cc of an antibiotic (Combiotic, Pfizer Agricultural Division, New York, N. Y.) to prevent infection from any trap-related injury prior to being released.

Bobcats were then placed in a live-trap overnight in a relatively sheltered location with approximetely 0.5 kg of fresh meat for food and released the following day. If no live-traps were available, bobcats were hidden in a natural rock shelter, overhang, sinkhole or vegetated cubby without food to ensure the safety of the cat while the immobilizing drug was metabolized.

Radiotelemetry and Monitoring

Radio-instrumented bobcats were monitored from the ground and air to determine seasonal home range and movement patterns. A multiple channel receiver (Telonics, Mesa City, Arizona) was used to locate bobcats. Transmitters operated at frequencies between 150.034 and 151.965 kilohertz. Aerial locations were made from a Piper Supercub with a directional Yagi antenna mounted on each wing strut (Gilmer et al. 1981). Flights were made weekly from 15 May 1986 through 15 March 1987, biweekly from 1 April 1987 to 31 May 1987, and weekly from 1 June 1987 to 1 September 1987.

Ground relocations were initiated using a 4x4 vehicle with a non-directional dipole antenna mounted on the cab. When a signal was strong enough to be picked up with a 2-element hand-held directional antenna, the bobcat was followed and located on foot. I attempted to visually locate all cats each time they were monitored in order to obtain precise information on habitat use. In cases where a cat was not seen because of obstructing vegetation or topography, I circled the bobcat and pinpointed its location as accurately as possible. The open character of the study area lent itself very well to this system of radio tracking. Ground tracking was done 5 to 7 days per week from 15 May 1986 to 1 September 1987 except for a period 15 March 1987 to 15 June 1987.

Capture site locations and aerial and ground locations were combined to determine seasonal and annual home range sizes and movement patterns. Locations were plotted on 7.5-minute U. S. Geological Survey topographical maps and referenced using the Universal Tranverse Mercator (UTM) grid system. Home range sizes and movements were calculated using TELNEW - the updated edition of TELDAY - (Lonner and Burkhalter 1983), which calculates home ranges as convex polygons (Hayne 1949). Annual and seasonal home range plots and straight line distances between successive locations were generated. Seasons were delineated as spring (March-May), summer (June-August), fall (September-November) and winter (December-February). Seasonal and annual home range sizes of females and males were compared with Paired Student's t-tests (Ott 1984). Chi-square analyses assessed seasonal differences among individual bobcats.

Movement patterns in this study were compared with those recorded in 1983-1984 (Giddings 1986), using distances traveled between consecutive radio locations occurring within a 2-week period on a seasonal and annual basis as an index to movement (Smith 1984 and Giddings 1986). Paired Student's t-tests were used to test for differences in mean distances traveled between successive locations of male and female bobcats for the years 1986 and 1987 and for the years combined.

Cover Type Availability and Use

Habitat was classified on the basis of 6 vegetation-physiographic "cover" types. These cover types correspond to those of Giddings (1986) except that the categories "badlands brushy draws" and "rock outcrops" were treated as separate categories rather than subtypes within other cover types.

Availability of each cover type was calculated using a non-mapping technique (Marcum and Loftsgaarden 1980). Random points covering a minimum of 20% of the combined annual home ranges of 8 bobcats were generated from a random numbers table (Ott 1984) and plotted on an acetate overlay. Aerial photos and U. S. Geological Survey maps were used to determine in which cover type each random point fell.

The percent ground coverage of the least common cover type (reservoir complex) was plotted against the number of points in 50-point increments to determine an adequate sample size. When the percent ground coverage of this type reached an asymptotic value, the sample was considered sufficiently large. Samples exceeded the accepted minimum for use of Chi-square. No expected value was < 1 and no more than 20% of the expected values were < 5 (Cochron 1954).

Trapping and radio location data were used to determine cover type use by bobcats on a seasonal and annual basis. The Chi-square Goodness-of-fit test and Bonferroni family of simultaneous confidence intervals were used to test use relative to availability (Marcum and Loftsgaarden 1980 and Byers et al. 1984).

Population and Harvest Indices

The effect of prey population density on bobcat reproduction and kitten survival was measured indirectly by headlight counts of lagomorphs throughout the field study. Methods used were those of Giddings (1986) to provide comparable data. The scent post survey (Roughton and Sweeney 1982) initiated by Giddings was updated for 2 more years to provide comparable population trend information to that collected during 1983-1985. The survey was run for 3 days each year (from 9/10 to 9/12 in 1986 and from 8/30 to 9/1 in 1987) to provide trend information on bobcat density on the Hook Ranch study area. A combination of bobcat gland lure and bobcat urine were used in this study as recommended by Hildebrand (pers. comm.).

The 1986-1987 trapping season records in Region 7 were compared to the harvests from the previous decade to determine if any trend in harvest numbers or age/sex structure was apparent. Records of coyotes and foxes (*Vulpes vulpes*) killed in the immediate area by government trappers were examined to determine if trends in the bobcat harvest were similar to trends in the harvest of other predators (Pachl pers. comm. and Buck pers. comm.).

Food Habits

Fresh bobcat scats were collected (Murie 1954) seasonally, dried, weighed and examined macroscopically and microscopically at MDFWP research lab in Bozeman, Montana. Diet composition was determined on a seasonal and annual basis.

Records were kept of pronghorn antelope killed by bobcats on the study area in 1986 and 1987. Bobcat-killed pronghorn antelope were identified on the basis of: (1) A visual observation of a bobcat within 0 to 20 m of a freshly killed carcass, (2) A carcass that had been eaten and the devoured area covered with hair, grass, sagebrush or cow manure that had been scraped up from the surrounding area, and from (3) The location of the bite wounds and apparent mode of killing (Wade and Browns 1985).

Daily Activity Patterns

Daily activity patterns were briefly studied during 2 24-hour radio telemetry sessions and 1 tracking session that covered 24 hours of movement by a bobcat. During these sessions, the location of the radio-monitored bobcat was checked every 15 minutes. If the bobcat moved, I followed on foot or in a 4x4 vehicle at a distance of approximately 400-600 m. No attempt was made to observe bobcats during these sessions to minimize unnatural behavior due to my presence. Periods of movement, inactivity/resting, distances traveled and supplementary information were also recorded at 15-minute intervals.

Sinkhole Caverns

Holes leading to extensively eroded caverns were frequently used by bobcats as resting sites during daily movements. I compiled detailed information on 12 holes that were heavily used by radio collared bobcats during this study.

Carcass Collection

Female bobcat carcasses were obtained from local trappers in Region 7 on a voluntary basis during the 1986-1987 trapping season. Whole carcasses of 58 female bobcats were examined for age and reproductive condition. Reproductive tracts were fixed in 10% formalin. Ovaries were sectioned and *corpora lutea* and *corpora albicantia* enumerated to estimate ovulation rates. Uterine horns were split and placental scars counted to estimate pregnancy rate, litter size and age at first breeding (Crowe 1975).

Reproductive data from the female bobcat carcasses collected during this study were compared with the bobcat carcass analyses on bobcats trapped from 1979 through 1983 by the MDFWP (Brainerd 1985). A lower canine was extracted from each bobcat skull and sent to Matsons, Inc., Milltown, Montana, for sectioning and cementum annuli counts to determine ages (Crowe 1972).

A body fat index was used to give an estimate of the general health of 39 of the female bobcat carcasses. The categories high, medium and low were assigned to each carcass depending on the extent - or lack of - subcutaneous body fat. Bobcats with high amounts of body fat were those with a heavy fat layer extending across the entire breadth of the belly region and fat deposits between muscle sections on the shoulders and hindquarters. Bobcats with medium levels of subcutaneous body fat were those with strips of body fat on the belly region and on the surface of the upper legs in small amounts. Bobcats with low levels of subcutaneous body fat were those with no fat to 2 tiny strips of fat along the sides of the belly.

RESULTS

Trapping

Seventeen different bobcats were captured 21 times during the 3 trapping periods (Table 1); 11 were radio collared and subsequently monitored. Physical characteristics of the 17 individuals captured are listed in Table 2.

Trap success increased dramatically from 1 trapping season to the next. The first trapping period, in spring 1986, lasted approximately 2.5 months and resulted in 9 catches with 427.4 trap days/cat (Table 3). Trap days per cat declined to 324.5 during the fall of 1986, but only 2 bobcats were caught. The third and final trapping period in the spring of 1987 resulted in 10 catches for 71.3 trap days/cat. This increase in catch per unit effort was nearly 6-fold and was considered the exclusive result of changes in trapping techniques described in the methods section of this report.

Table 1. Data on adult bobcats captured and marked on the Hook Ranch study area, 1986-1987.

Bobcat Number	Date of Capture	Weight (kg)	Number of Locations	Last Contact	Fate[b]
F915	3/30/86	6.8	55	3/1/87	F
M965	4/21/86	11.3	63	8/21/87	S
M75,48[a]	4/23/86	9.5		8/12/87	S
M835	5/1/86	9.8	38	1/31/87	F
M114	5/2/86	11.1	35	1/22/87	F
F065	5/30/86	8.4	16	8/30/86	T
M2,4[a]	6/16/86	12.2			U
F503	10/14/86	10.0	9	12/8/86	T
M3,12[a]	10/29/86	12.7			T
F595	2/20/87	8.2	4	4/1/87	F
M034	2/20/87	12.5	11	6/27/87	F
M921	2/22/87	12.5	18	8/27/87	S
M5,6[a]	2/22/87	10.0			U
F911	3/6/87	7.9	26	8/27/87	S
M7,8[a]	3/6/87	10.7			U
M9,10[a]	3/9/87	9.1			U
M916	3/11/87	12.0	12	12/9/87	T

[a] Male bobcats released without radio collars. The 2 numbers refer to left and right ear tags.

[b] F = transmitter failure, T = trapped or trap related death, S = survived, U = unknown.

Table 2. Physical characteristics of 17 adult bobcats captured on the Hook Ranch study area, March 1986-March 1987. All measurements are in centimeters (cm) unless otherwise indicated.

Bobcat Number	Weight (kg)	Total Length	Neck Size	Tail Length	Hindfoot Length	Shoulder Height	Heart Girth	Mammae Condition[b]	Coat Color[c]
F915	6.8	92.0	20.0	17.5	18.5	39.0	35.0	SE	LT,WS
M965	11.3	104.0	25.0	20.0	20.5	46.0	44.0		T,WS
M75,48[a]	9.5	99.5	23.5	14.0	18.0	36.5	42.5		T,G,LS
M835	9.8	100.0	24.0	15.5	18.0	40.5	39.0		T,WS
M114	11.1	106.0	24.2	16.0	18.0	40.0	41.0		LT,G,WS
F065	8.4	99.0	21.8	15.0	17.2	35.8	37.0	SE	G,WS
M2,4[a]	12.2	112.5	25.0	17.0	19.6	42.0	44.0		LT,WS
F503	10.0	97.0	23.8	16.5	18.5	36.0	44.0	SE	T,WS
M3,12[a]	12.7	96.0	25.5	15.0	18.5	41.0	46.5		R,LS
F595	8.2	93.0	23.2	14.4	17.5	30.0	39.5	SE	LG,WS
M034	12.5	114.3	28.0	17.5	19.6	37.0	47.8		LT,WS
M921	12.5	102.0	30.0	16.5	20.0	40.0	47.0		LT,WS
M5,6[a]	10.0	101.0	24.0	16.5	18.5	39.0	38.5		B,WS
F911	7.9	93.0	21.6	13.2	17.5	33.5	38.0	SE	LG,WS
M7,8[a]	10.7	107.0	26.0	16.4	19.0	39.0	43.0		LG,WS
M9,10[a]	9.1	97.6	25.0	15.8	18.3	34.5	41.5		G,LS
M916	12.0	107.5	27.0	16.0	19.7	39.5	45.0		T,G,LS

[a] Male bobcats released without radio collars.

[b] SE = slightly elongated.

[c] T = tan, LT = light tan, G = grey, LG = light grey, R = reddish, B = brownish, WS = well-spotted, LS = lightly spotted.

Table 3. Bobcat trapping success on the Hook Ranch study area, 1986-1987.

Number of:	Spring 1986	Fall 1986	Spring 1987	Results
				Totals
Traps set	74	28	31	133
Locations	34	15	19	68
Trap days	3849	649	713	5211
Cats caught	9	2	10	21
				Means
Trap days/cat	427.4	324.5	71.3	274.5
Traps set/cat	8.2	14.0	3.1	8.4
Trap Locations/cat	3.8	7.5	1.9	4.2

Radio telemetry

A total of 288 capture site and radio locations provided information on home range sizes, movements and spatial separation of 5 females and 6 males. Of these locations, 37% were visual observations (Table 4). Of the 11 bobcats radio collared during this study, locations of 6 (2 females and 4 males) were used to calculate seasonal and annual home ranges from 235 locations (Table 5).

Home range size estimates for the 2 females (1 in 1986 and 1 in 1987) were 233.5 (n = 55) and 24.8 (n = 26) km^2, respectively. The annual home range sizes for males (3 in 1986 and 1 in 1987) were 23.9 (estimated from data

Table 4. Number and percent of radio locations that were visual observations of bobcats monitored between 30 March 1986 and 1 September 1987 on the Hook Ranch study area.

Bobcat Number	# of Locations	# of Visual Observations	% Visual Observations
F915	56	24	42.8
M965	63	17	27.0
F065	16	11	62.5
M114	35	13	37.1
M835	38	14	36.8
F503	9	6	66.7
F595	4	3	75.0
M034	11	4	36.4
M921	18	6	33.3
F911	26	7	26.9
M916	12	2	16.7
Totals	288	107	mean = 37.2

collected during the summer of 1987 only) to 100.5 km^2. Small sample sizes precluded statistically reliable estimates of home range size for the other 5 radio-equipped bobcats. From the limited number of locations obtained, however, home ranges for these bobcats were also quite variable.

There was no general pattern discernable in the sizes of home ranges on a seasonal basis. Female bobcat F915,

Table 5. Seasonal and annual home range sizes (km^2) of 11 radio collared bobcats on the Hook Ranch study area, 1986-1987. Numbers of locations are in parentheses.

	1986				1987		
Bobcat Number	Spring	Summer	Fall	Winter	Spring	Summer	Annual
F915[a]	27.7 (8)	35.6 (24)	78.3 (10)	181.9 (13)			233.5 (55)
M965[a]	12.7 (4)	27.8 (18)	20.0 (10)	44.5 (14)	6.7 (5)	16.8 (12)	73.3 (46)[b]
M835[a]	15.3 (4)	29.9 (18)	28.8 (9)	11.5 (7)			49.8 (38)
M114[a]	33.1 (4)	51.2 (18)	22.6 (8)	7.6 (5)			100.5 (35)
F065		50.5 (10)	12.6 (4)				113.6 (16)
F503			33.0 (7)				41.6 (9)
F595					4.3 (3)		6.2 (4)
M034					58.4 (6)	17.8 (4)	79.3 (11)
M921[a]						19.4 (15)	23.9 (18)
F911[a]					12.2 (6)	7.1 (20)	24.8 (26)
M916					48.9 (4)	12.6 (8)	52.5 (12)

[a] Bobcats used for statistical analyses in this study.

[b] The annual home range of this male bobcat was calculated from the locations obtained from spring 1986 through winter 1986-1987.

monitored during 1986, had seasonal home ranges that were smallest in spring (27.7 km^2) and largest in winter (181.9 km^2). Only spring and summer home ranges of female F911 were determined. They were 12.2 and 7.1 km^2, respectively.

Spring home ranges for males in 1986 ranged from 12.7 to 33.1 km^2 (mean = 20.4), summer home ranges ranged between 27.8 and 51.2 km^2 (mean = 36.3^2), fall home ranges were between 20.0 and 28.8 km^2 (mean = 23.8 km^2) and winter home ranges were between 7.6 and 44.5 km^2 (mean = 21.2 km^2). Male home ranges in 1987 were 48.9 km^2 in the spring and 12.6 km^2 in the summer. Home ranges were not determined for any bobcats in the fall or winter of 1987. No significant differences within yearly home range sizes were found between males and females ($P < .05$). The spatial distribution of 4 bobcats (1 female and 4 males) monitored in 1986 is diagrammed in Fig. 3. Seasonal and annual home ranges of 6 bobcats are illustrated in Figs. 4 through 13.

Annual home ranges of males and females overlapped extensively in some instances. The home range of female F911 was encompassed almost entirely by the home range of male M916 in 1987. Overlap between males was confined to the peripheries of the home ranges of each individual. There was no overlap in the home ranges of any females except in 1 instance where F065 (with a non-functional

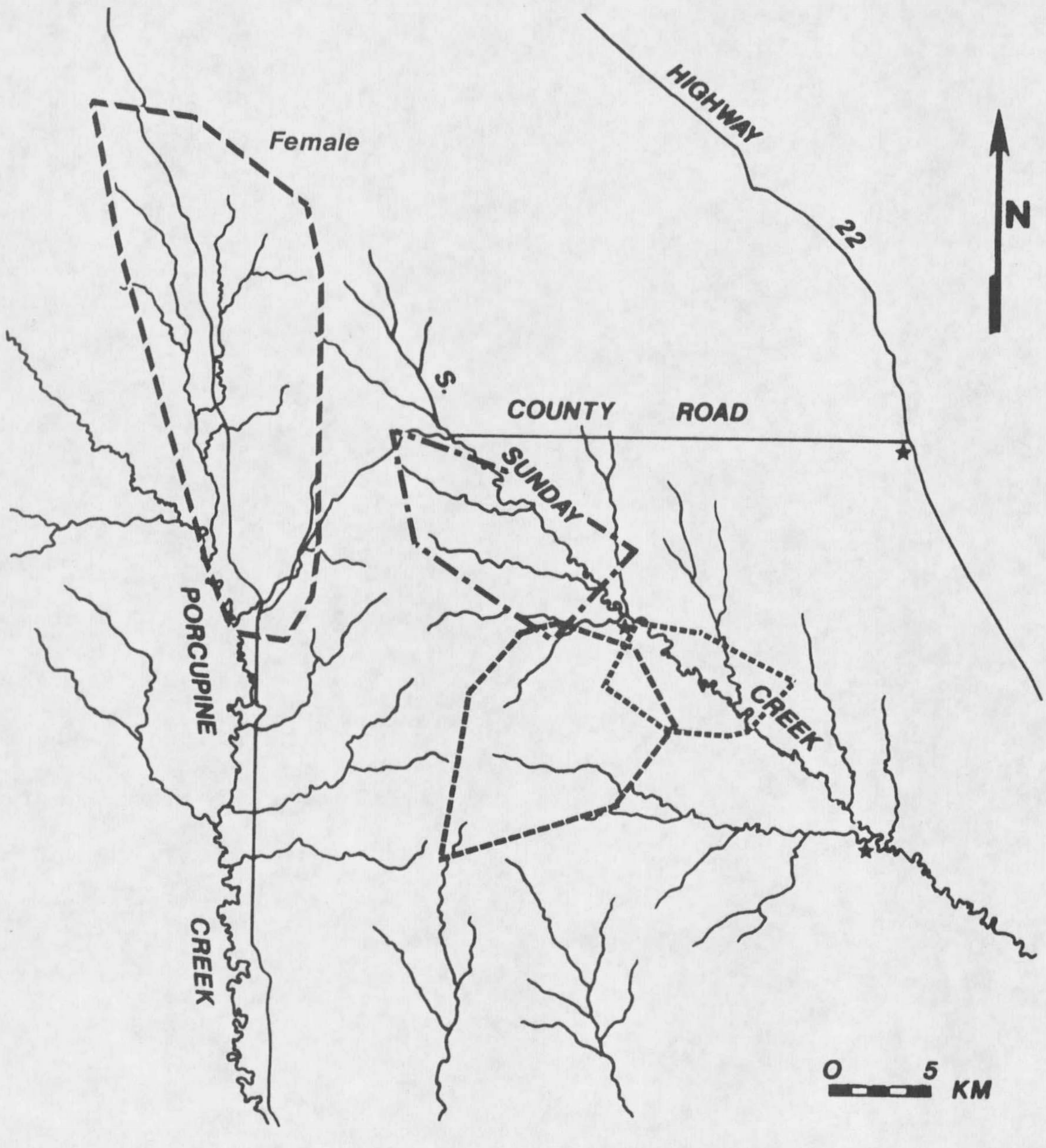

Figure 3. Annual home ranges of 4 radio monitored bobcats in 1986 (1 female, 3 males).

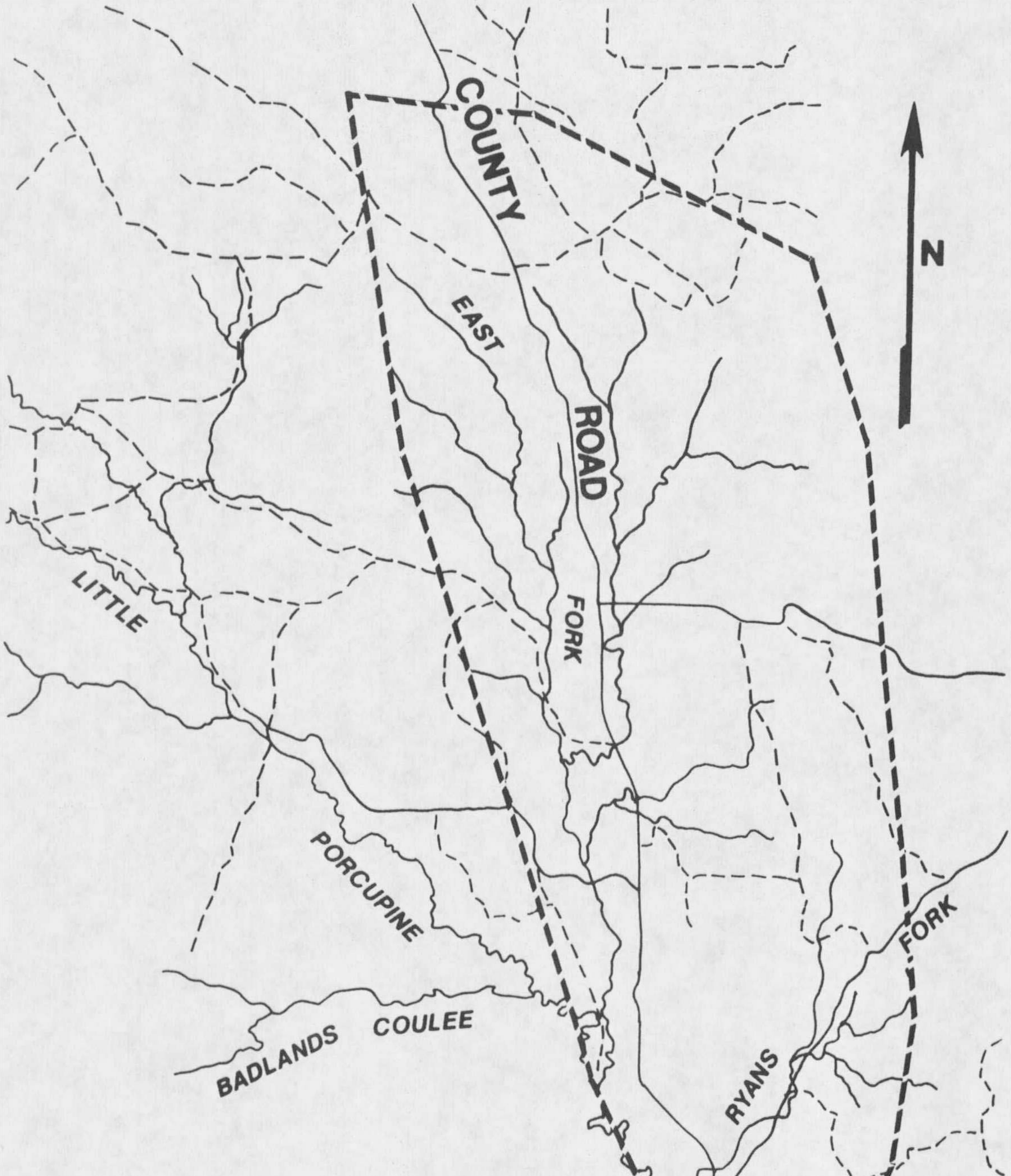

Figure 4. Annual home range of female bobcat F915.

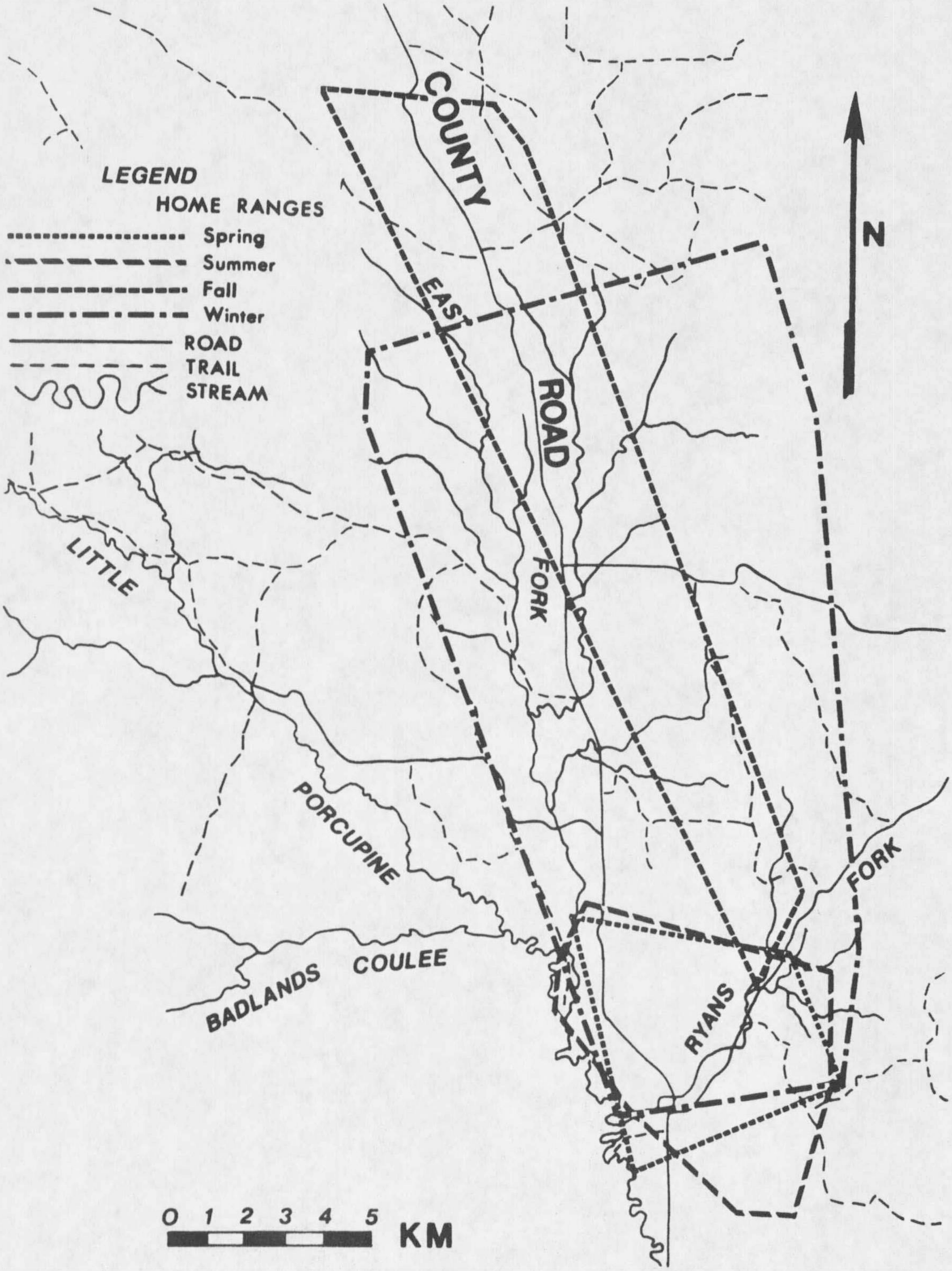

Figure 5. Seasonal home ranges of female bobcat F915.

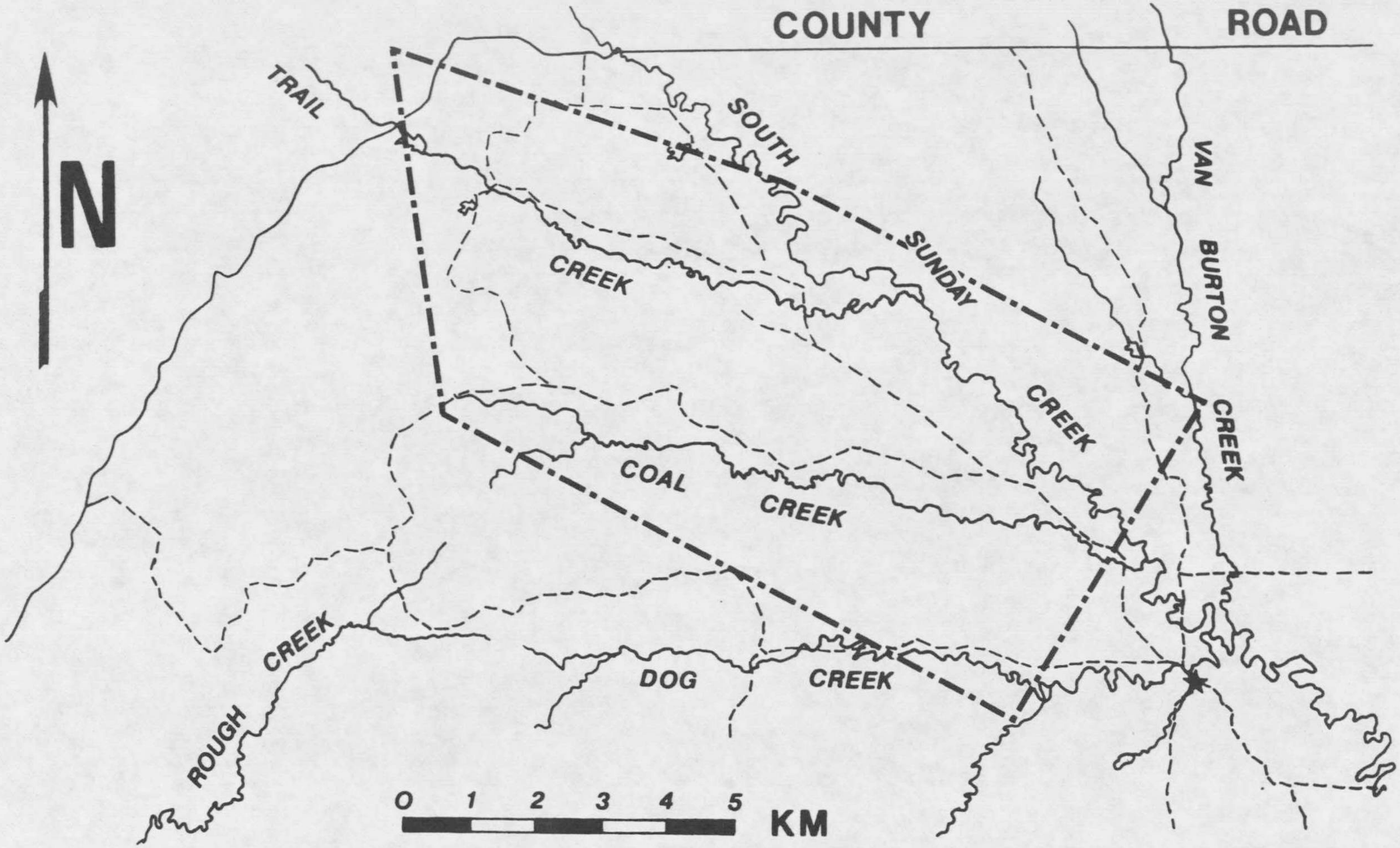

Figure 6. Annual home range of male bobcat M965.

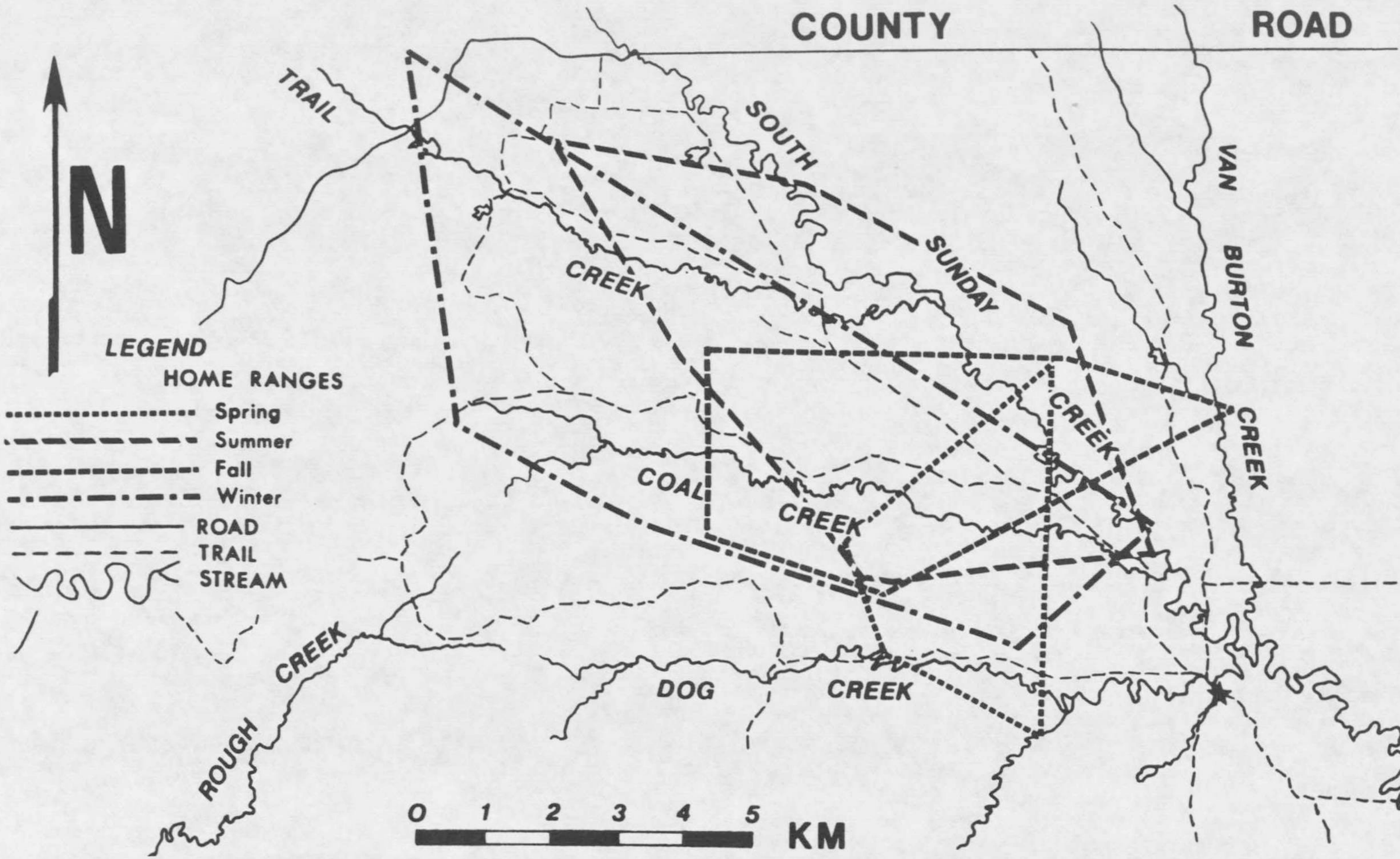

Figure 7. Seasonal home ranges of male bobcat M965.

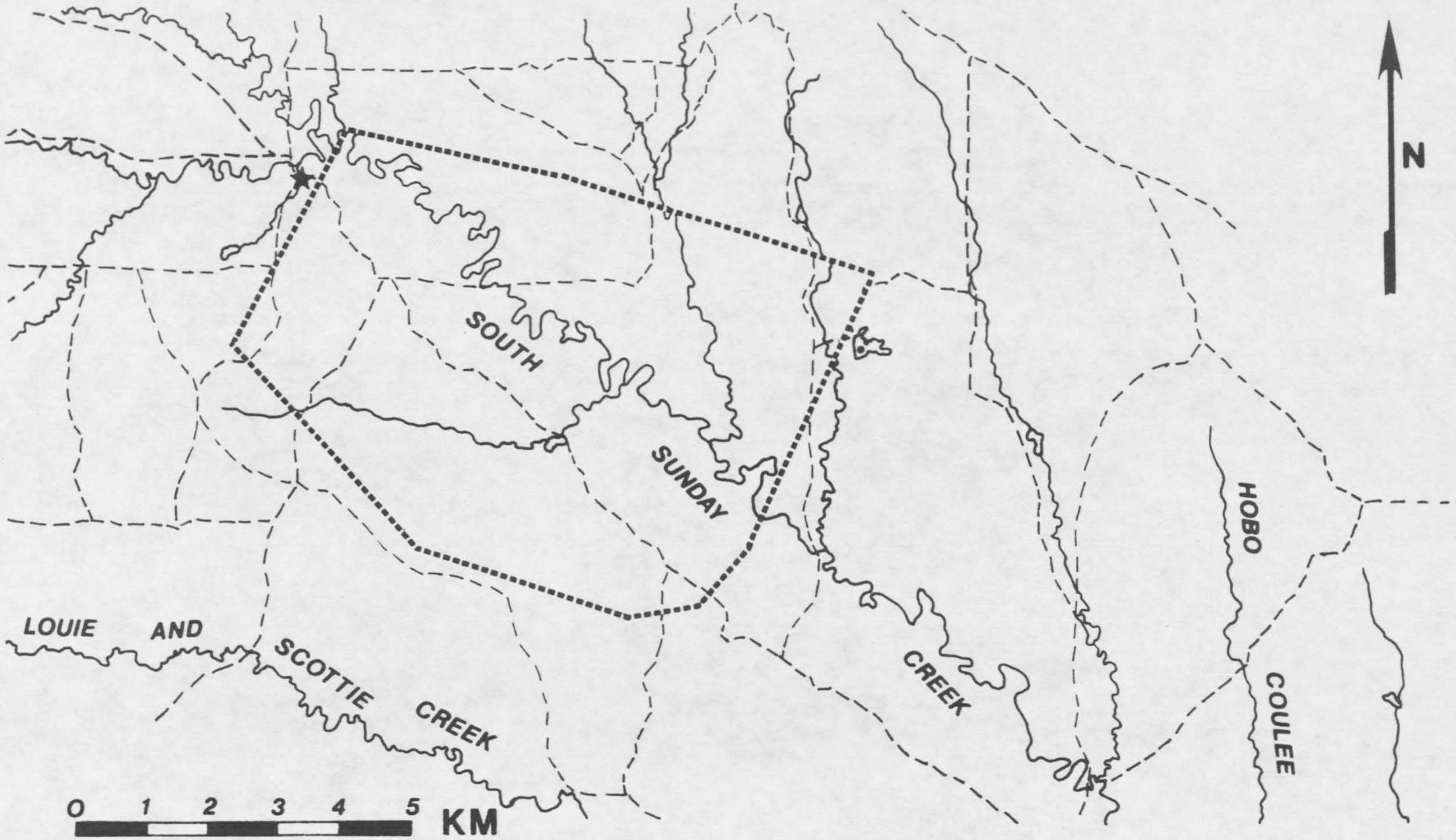

Figure 8. Annual home range of male bobcat M835.

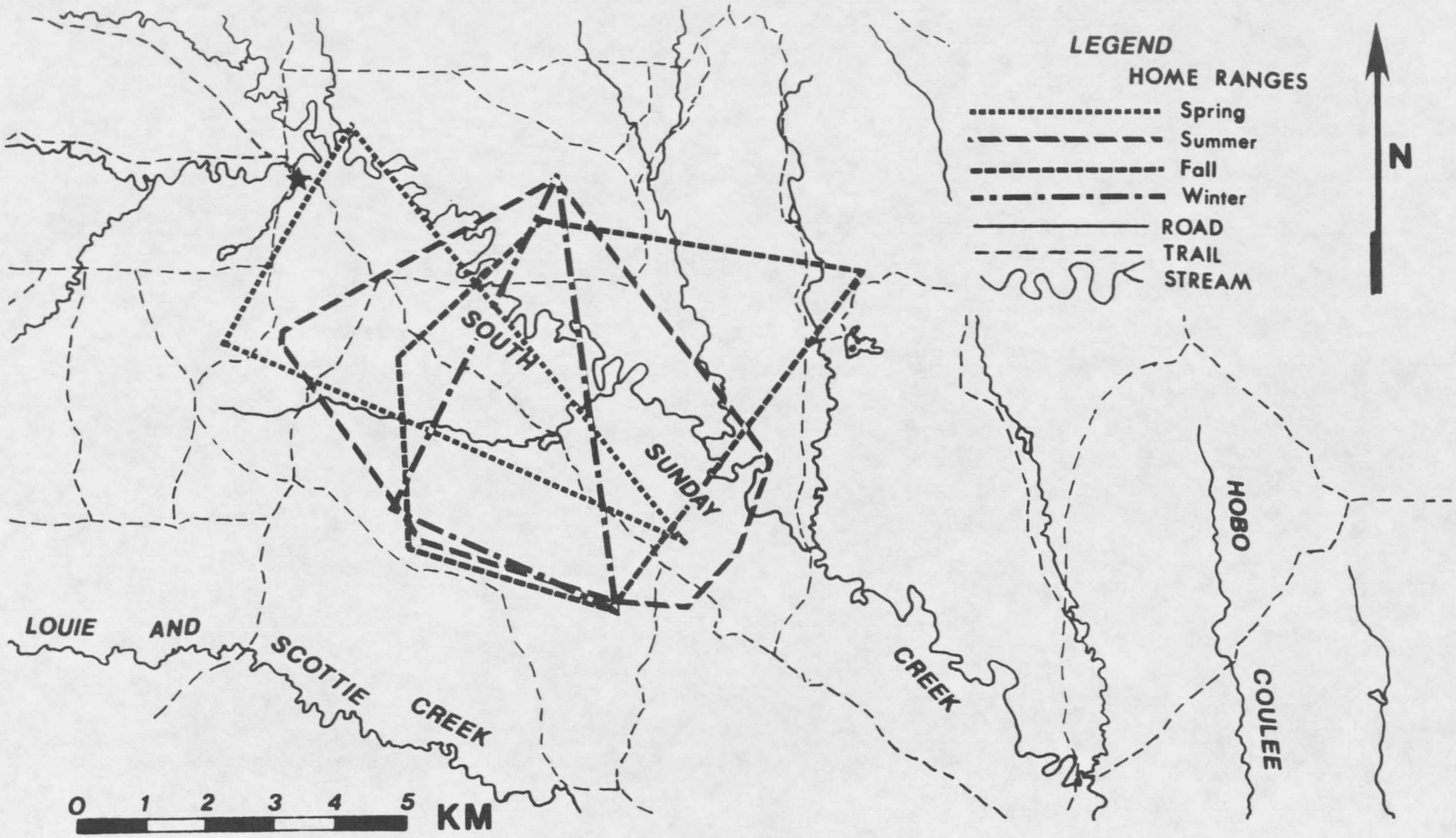

Figure 9. Seasonal home ranges of male bobcat M835.

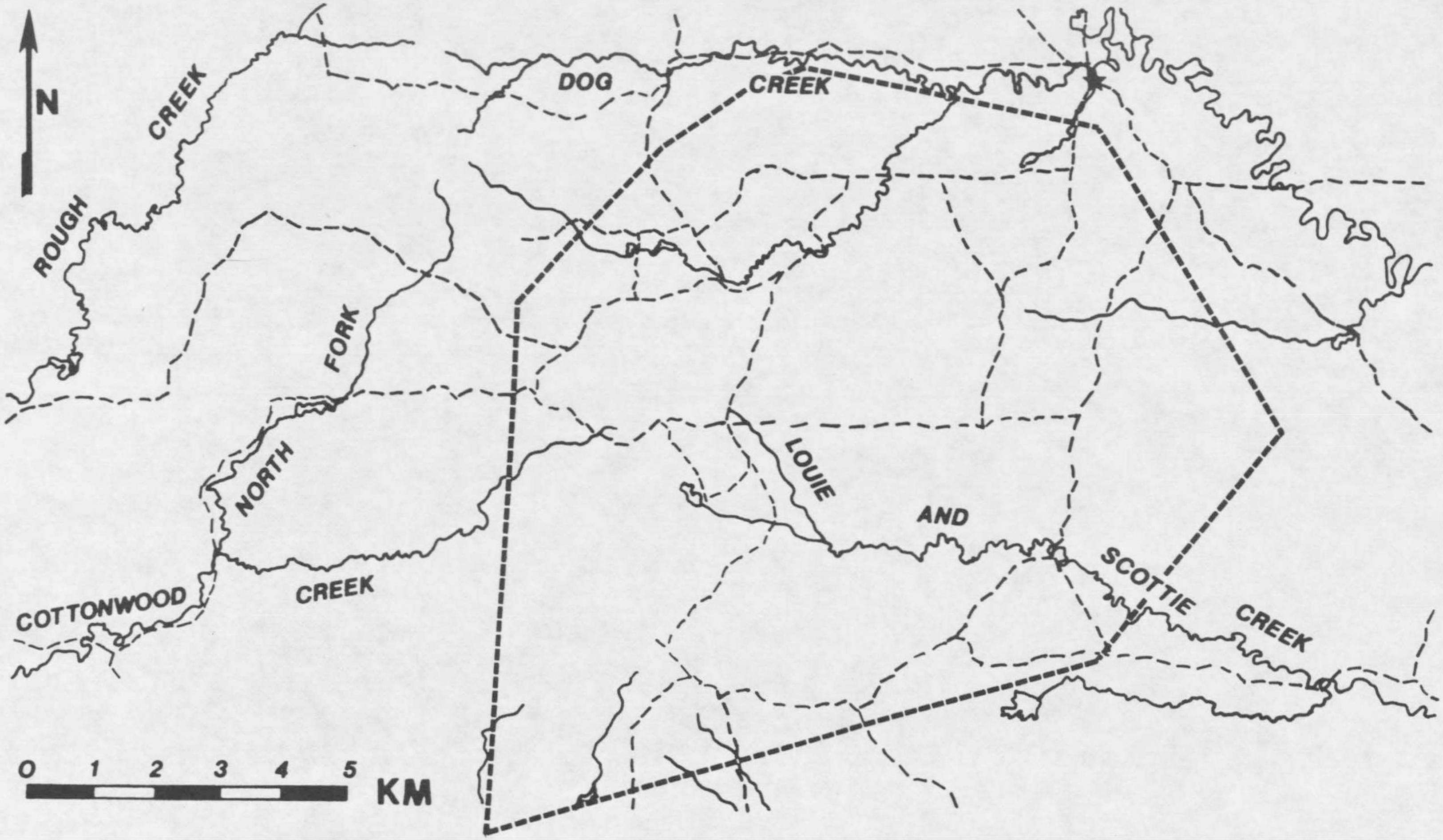

Figure 10. Annual home range of male bobcat M114.

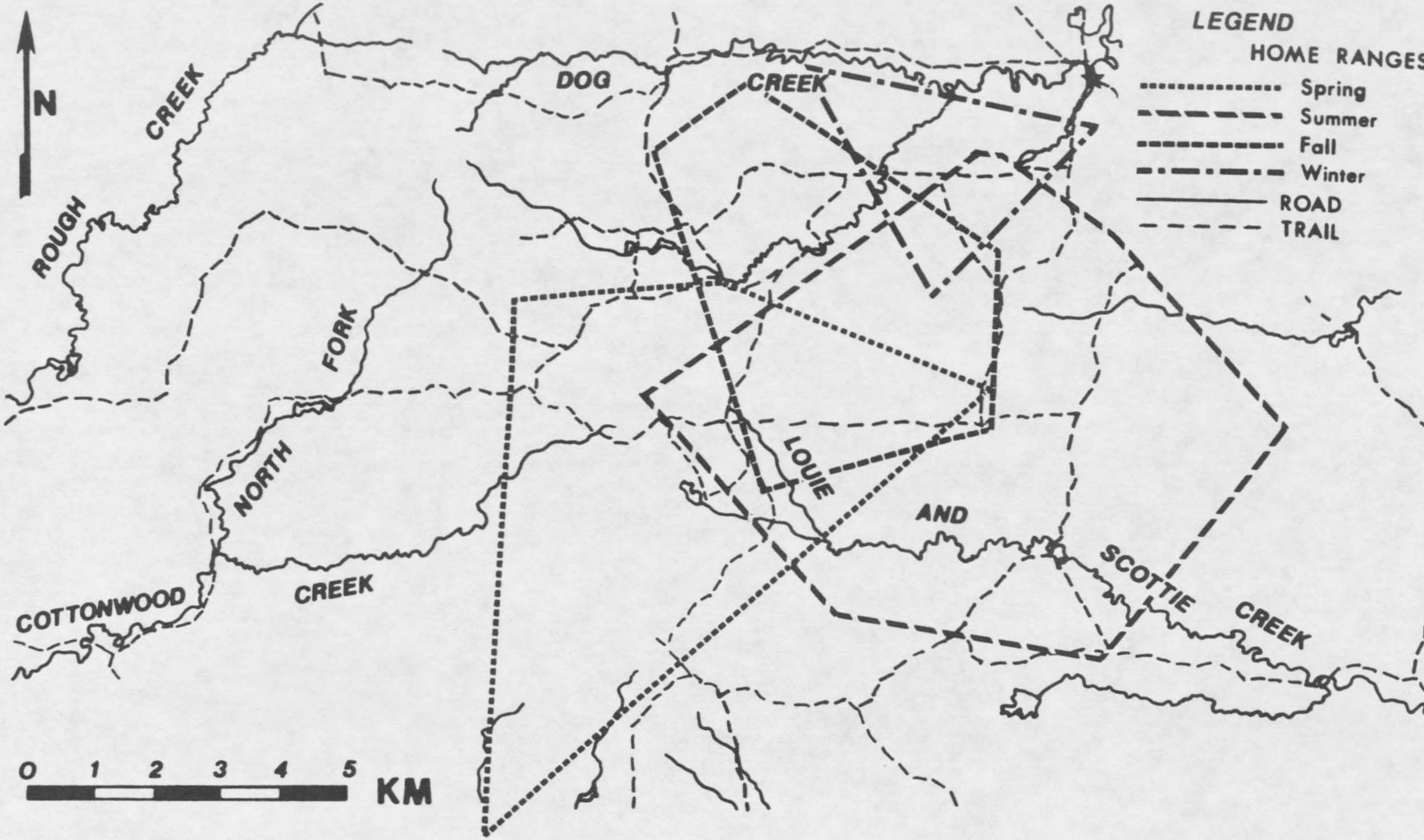

Figure 11. Seasonal home ranges of male bobcat M144.

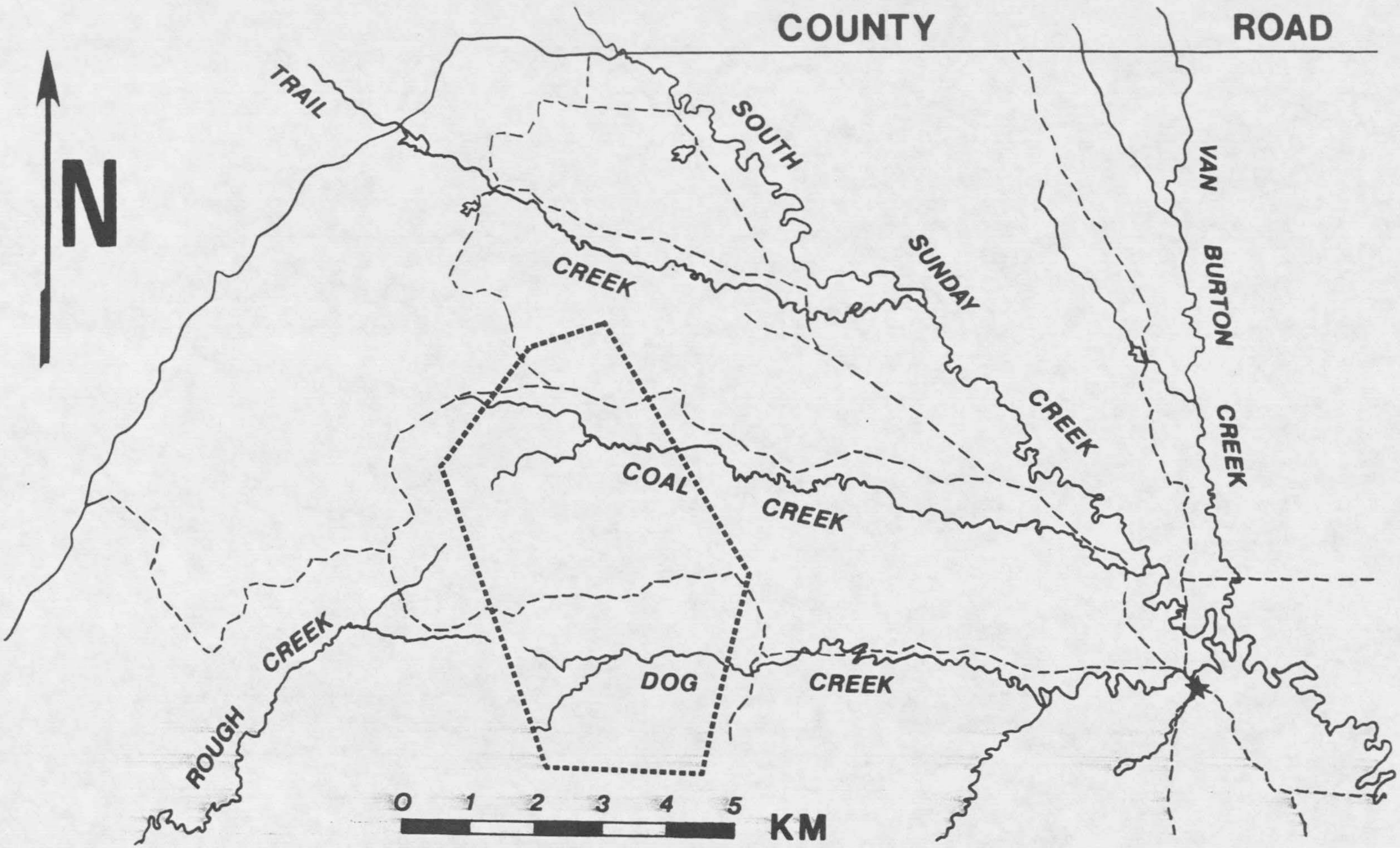

Figure 12. Annual home range of male bobcat M921.

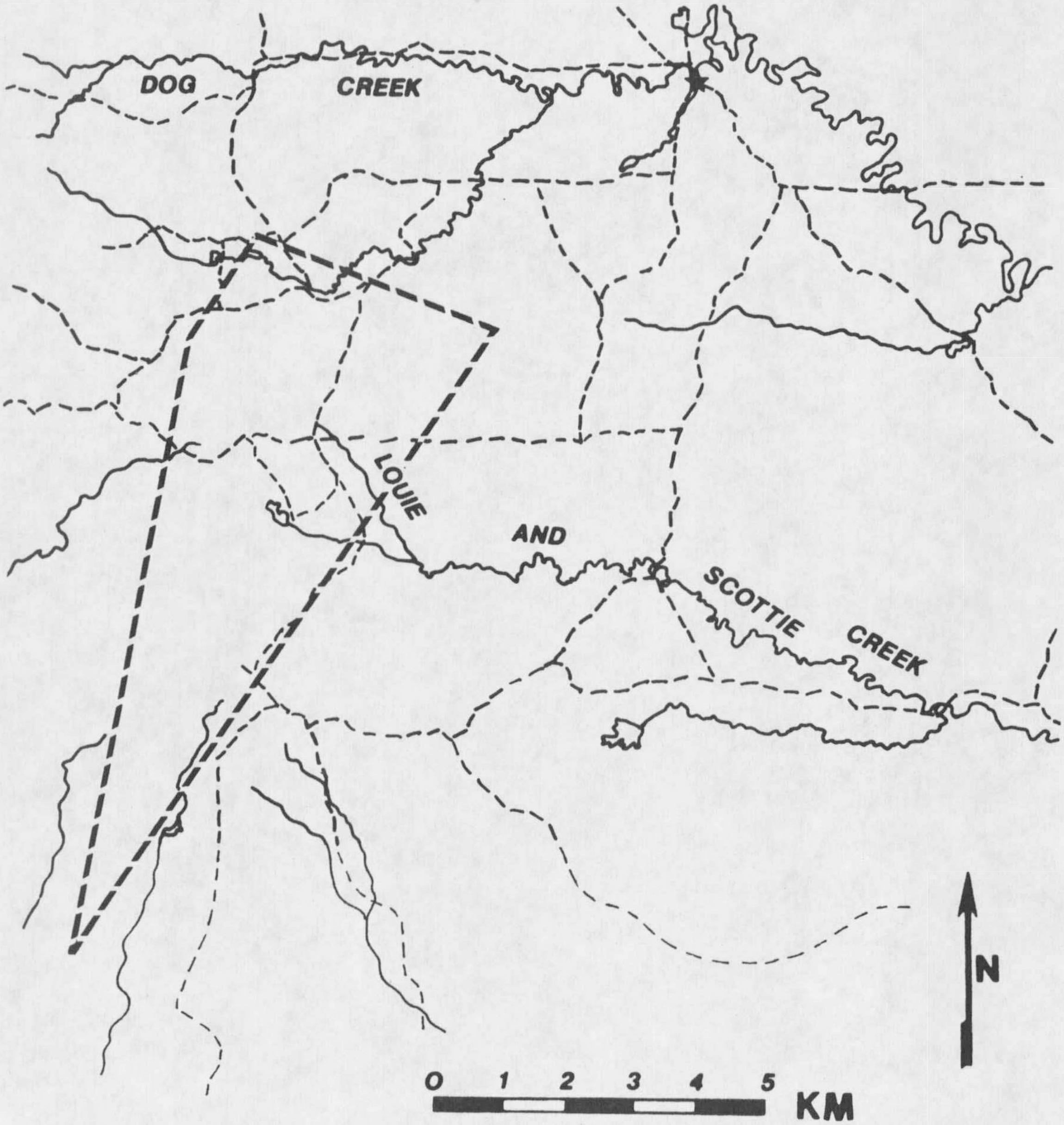

Figure 13. Annual home range of female bobcat F911.

radio) made an extensive move (relative to her previous travels) northward after having spent up to 9 days in the traps of a government trapper. This individual had 2 severely damaged legs - injuries inflicted by the 2 traps she had been caught in - and showed signs of starvation and hypothermia. She was kept in captivity for 5 days, fed, medicated and released. Within 1 week, F065 had moved north out of her former home range, crawled into a hole and died. When I located F065 for the last time, both her feet were almost severed from chewing. She weighed under 4.5 kg; and she had numerous cactus spines stuck in her underside. The location she died at was less than 1 km inside the home range of female bobcat F915.

Mean distances between locations for male and female bobcats in 1986 were both 4.2 km (Table 6). In 1987, the mean distances between locations for males and females were 5.3 and 2.8 km, respectively. Distances between locations for males and females for both years were 4.2 and 4.3 km, respectively. There were no significant differences ($P < .05$) in the mean distances between locations for either sexes or seasons in this study.

Although neither analyses of movements nor analyses of home range size showed significant differences among or between sexes, patterns of home range use varied. For example, mean movement for F915, a female with an annual home range 2.3 times larger than the next largest annual

Table 6. Mean distances (km) traveled by bobcats between consecutive locations on a seasonal and annual basis on the Hook Ranch study area, 1986-1987. Numbers of locations are in parentheses.

	1986				1987		
Bobcat Number	Spring	Summer	Fall	Winter	Spring	Summer	Annual
F915	3.0 (8)	3.8 (24)	5.0 (10)	4.2 (13)			4.1 (55)
M965	4.1 (4)	3.5 (18)	3.4 (10)	4.4 (14)	3.5 (5)	3.7 (12)	4.0[a] (46)
M835	4.1 (4)	4.3 (18)	3.8 (9)	5.1 (7)			4.5 (38)
M114	6.8 (4)	4.3 (18)	3.6 (8)	3.0 (5)			4.2 (35)
F065		1.9 (2)	5.7 (10)				4.6 (16)
F503			3.6 (7)	9.9 (2)			4.0 (9)
F595					3.2 (3)		2.9 (4)
M034					7.8 (6)	5.6 (4)	7.3 (11)
M921					4.0 (2)	2.6 (15)	2.8 (18)
F911					5.2 (6)	2.1 (20)	2.7 (26)
M916					12.8 (4)	2.9 (8)	5.8 (12)

[a] The mean annual distance traveled by this bobcat was calculated using data from the spring of 1986 through the winter of 1986-7.

home range calculated, fell within the extremes of mean distances traveled between consecutive locations for all bobcats, but her movements tended to expand her home range. This contrasts to the other bobcats which continued to use the same area but moved equal distances within it.

Habitat Use

Bobcats did not use cover types in proportion to their availability (Table 7). The open sagebrush/grassland cover type was the most common (78.4%), but only 19.7% of the radio locations were made in this cover type (Table 7). The gumbo/scoria badlands cover type represented the next most abundant cover type (12.3%), but 40.9% of all locations occurred within it. Badlands-brushy draws made up 2.3% of the available habitat, and 6.3% of all bobcat locations occurred within this cover type. Creek bottoms represented 5.8% of the area within the combined home ranges, but 26.0% of all locations fell within this category. Rock outcrops and reservoir complexes represented the least common cover types and 7.1% and 0.0% of the locations occurred within these 2 cover types, respectively.

Open sagebrush/grasslands were used significantly less than in proportion to their availability. Gumbo/scoria badlands, badlands-brushy draws and reservoir complexes were used in proportion to their availability, and creek

Table 7. Cover type categories, percent availability and percentage of bobcat locations occurring within each cover type for 8 bobcats on the Hook Ranch study area, 1986-1987. Sample sizes are in parentheses.

		1986				1987		
Cover Type	Percent Availability (1200)	Spring (20)	Summer (88)	Fall (37)	Winter (39)	Spring (15)	Summer (55)	Annual (254)
Open sagebrush/ grasslands	78.4	15.8	21.6	27.0	28.2	6.7	10.9	19.7
Gumbo/scoria badlands	12.3	25.0	29.5	35.1	46.2	53.3	61.8	40.9
Badlands brushy draws	2.3		3.4	8.1	2.6	13.3	12.7	6.3
Creek bottom complexes	5.8	40.0	38.6	21.6	12.8	26.7	12.7	26.0
Rock outcrops	0.7	20.0	6.8	8.1	10.2		1.8	7.1
Reservoir complexes	0.5							
Totals	100.0	100.0	99.9	99.9	100.0	100.0	99.9	100.0

bottom complexes and rock outcrops were used in significantly greater proportion than their availability.

Seasonal comparisons of cover types utilized determined by capture and radio locations indicated increasingly greater use of open sagebrush/grasslands from spring 1986 to winter 1986-1987. The use of badlands (both gumbo/scoria hills and brushy draws) increased throughout the study. The use of creek bottom complexes and rock outcrops decreased throughout the study period. Both were used most heavily during the spring of 1986. Use of reservoir complexes was not observed during the study. This may have been due to the abundance of water throughout the study area resulting from above normal precipitation in spring and fall, 1986.

Food Habits and Feeding Behavior

The 99 fresh scats collected throughout the study period indicated that small sigmodontinine and arvicolinine rodents made up the bulk of the diet of bobcats on the Hook ranch during 1986-1987. Lagomorphs ranked third after small rodents and passerine birds. The other 4 general food categories used, in descending rank order, were pronghorn antelope, insects, domestic sheep and reptiles (Table 8).

The percent frequency of occurrence of food categories in scats was the highest for small rodents throughout the study with 55.6 to 100.0% of seasonal samples containing remains of sigmodontinine and arvicolinine rodents (Table 9). The frequency of occurrence of Aves was second to the occurrence of small rodents. The frequency of occurence of Aves ranged from 12.0% in the winter of 1986-1987, to 77.8% in the summer of 1986.

Table 8. Mean estimated percent of each of 7 food categories occurring in 99 bobcat scats on a seasonal basis on the Hook Ranch study area, 1986-1987. Numbers of fecal samples are in parentheses.

	1986				1987	
Food Category	Spring (n=16)	Summer (n=9)	Fall (n=3)	Winter (n=50)	Spring (n=9)	Summer (n=12)
Lagomorpha	17.2		13.3	11.5	0.6	4.2
Rodentia	45.0	31.7	76.7	69.9	99.4	75.8
Antelope	5.6			12.4		8.3
Aves	29.0	42.2		6.1		5.8
Reptilia	1.9	1.7		0.1		1.3
Insecta[a]	1.3	24.4				0.4
Sheep			10.0			4.2
Totals	100.0	100.0	100.0	100.0	100.0	100.0

[a] Predominantly grasshoppers.

In the food category Aves, I identified sage grouse, ducks (<u>Anas</u> spp.), meadowlarks (<u>Sturnella neglecta</u>) and several species of Fringillidae (Table 10). Prairie rattlesnakes (Crotalus viridis viridis) and eastern horned lizards (Phrynosoma douglassi brevirostre) were identified in the reptile food category. Grasshoppers were the predominant insect observed in scats, but portions of a beetle, wood ticks, ant eggs and unidentified species were also noted. Domestic sheep wool occurred in 2 scats.

Table 9. Percent frequency of occurrence of 7 food categories in 99 bobcat scats collected seasonally on the Hook Ranch study area, 1986-1987. Numbers of fecal samples are in parentheses.

	1986				1987	
Food Category	Spring (n=16)	Summer (n=9)	Fall (n=3)	Winter (n=50)	Spring (n=9)	Summer (n=12)
Lagomorpha	25.1		66.7	14.0	11.1	8.3
Rodentia	75.0	55.6	100.0	92.0	100.0	91.7
Antelope	6.3			20.0		8.3
Aves	62.5	77.8		12.0		16.7
Reptilia	6.3	11.1		2.0		8.3
Insecta[a]	25.0	33.3				8.3
Sheep			33.3			8.3

[a] Predominantly grasshoppers.

Although the rodent category contained by far the greatest number of species, sagebrush voles (Microtus ochrogaster) and deermice (Table 10) predominated in scats. The lagomorphs were represented by white-tailed jackrabbits

Table 10. Percent frequency of occurrence of 19 food items found in 99 bobcat scats collected seasonally on the Hook Ranch study area, 1986-1987. Numbers of fecal samples are in parentheses.

	1986				1987	
Food Category	Spring (n=16)	Summer (n=9)	Fall (n=3)	Winter (n=50)	Spring (n=9)	Summer (n=12)
Lepus townsendi	18.8			10.0	11.1	
Sylvilagus spp.	6.3		66.7	4.0		8.3
Dipodomys ordi	37.5	22.2		4.0		
Perognathus fasciatus			33.3			8.3
Neotoma cinerea	12.5	11.1		10.0		50.0
Onychomys leucogaster	12.5			2.0		
Peromyscus maniculatus	6.3	33.3	100.0	36.0	22.2	16.7
Microtus ochrogaster	6.3	22.2	33.3	40.0	77.8	41.7
Microtus longicaudus				2.0		16.7
Microtus pennsylvanicus	6.3			8.0	11.1	25.0
Microtus montanus	6.3			2.0	11.1	
Microtus spp.	18.8	22.2		28.0	22.2	25.0
Antilocapra americana	6.3			20.0		8.3
Aves spp.	62.5			12.0		16.7
Snakes		11.1				8.3
Lizards	6.3			2.0		
Grasshoppers	6.3	33.3				8.3
Other insects	25.0					8.3
Domestic sheep			33.3			8.3

and cottontails (Sylvilagus spp.). Pronghorn antelope were the only indigenous ungulates identified in scats and occurred most frequently in scats during the winter of 1986-1987.

Most pronghorn kills were found during the late summer of 1986 and 1987, followed by early to mid-fall (Table 11). Only 1 pronghorn killed by bobcats was found during winter, and none were found in spring. In all documented cases, bobcat-killed pronghorn appeared to have been grasped around the chest and neck region, clawed profusely and bitten in the throat near the larynx. In each instance, there were multiple bite wounds in this region and death probably occurred by suffocation. The distance measured between marks left by canine teeth in the hide of the antelope was 1.9-2.5 cm, matching that given by Wade and Browns (1985) for bobcat-killed ungulates. Kills were covered with debris scraped from within 38 cm of the carcass as noted by Wade and Browns (1985). I also found little evidence indicating a struggle had occurred, possibly because of the hard soil surface. The neck region, however, (if not eaten) showed signs of rather extensive hemorrhaging which would indicate a prolonged or not immediate death.

The pattern of feeding on antelope carcasses varied but most frequently began at the neck region and proceded to a front shoulder. In other cases, a hindquarter was eaten first. In 1 carcass, part of a lower leg was torn slightly but feeding was initiated on a front shoulder. The gash in the leg of this pronghorn may have occurred during the death struggle. Each site at which a cat fed was meticulously cleaned to the bone before another body part was consumed. Often, the ends of the ribs were crushed and eaten but no visceri were ever observed consumed. In all cases, the area on the carcass on which the cat had fed was covered with grass, hair or other debris that was scraped up from the surrounding area.

Table 11. Number and dates of documented pronghorn antelope kills on the Hook Ranch study area, 1986-1987.

Bobcat Number	Date	Antelope Sex and Age
M835	7/17/86	Female fawn
M114	8/26/86	Male fawn
M965	8/30/86	Male fawn
F915	9/16/86	Female 2 yrs.
M114	9/16/86	Female 4 yrs.
Unknown	10/1/86	Female fawn
M835	11/29/86	Female adult
M921	8/18/87	Male fawn
M965	8/21/87	Female fawn
Unknown	1/14/87	Female adult

Bobcats were observed on several occasions lying near pronghorn carcasses. In 6 instances, I walked within 2 to 15 m of antelope kills before flushing the bobcat. On 5 of these occasions, bobcats appeared to have gorged heavily on the carcasses (evidenced by their distended bellies) and seemed reluctant to run. One male, weighing 16.5 kg, was shot by neighboring ranchers while feeding on a pronghorn kill. Its belly was extensively distended and contained about 4 kg of raw meat.

The documented bobcat kills of pronghorn included 6 fawns (3 females and 3 males) and 4 adult does (Table 11). All appeared to be in good health prior to death as indicated by bone marrow condition and color. All of the kills occurred in open sagebrush/grasslands.

Direct observations of bobcats with other prey species were rare. In 1 instance, M114 was observed carrying a sage grouse. In another, I observed F915 carrying a young robin (Turdus migratorius). I located this female 3 times near sage grouse kills. She apparently located a covey of grouse and hunted them for several days at a time.

Population and Harvest Trend Indices

The bobcat visitation rate of total scent post days was 1.7% in 1986 and 2.8% in 1987 (Table 12). From June 1986 through August 1987, 2490 km of roads were driven and lagomorphs counted. A total of 169 lagomorphs (152 jackrabbits and 17 cottontails) were observed during headlight surveys for an average of 0.05 lagomorphs per km. (Table 13). Badland cover types were underrepresented in the headlight counts of lagomorphs on the study area because roads occurred more frequently in the open prairies and less often in the rougher badlands.

Table 12. Numbers of bobcat visitations at 3 20-station scent post transects on the Hook Ranch study area, 1986-1987.

	1986			1987		
	9/10	9/11	9/12	8/30	8/31	9/1
Transect						
South line	0	0	0	1	1	0
Middle line	0	0	2	0	1	1
North line	0	1	0	0	1	1
Totals	0	1	2	1	3	2
Visitation Rate %	0.0	1.7	3.3	1.7	5.0	3.3
Overall Visitation Rate %		1.7			2.8	

Harvest data for bobcats in MDFWP Region 7, the Hook Ranch and the total study area for 1985-1986 and 1986-1987 are compared to previous years (Giddings 1986) in Table 14. Total numbers of bobcats harvested in Region 7 declined to 535 in 1985-1986 and to 451 in 1986-1987. Nine bobcats

Table 13. Monthly lagomorph densities estimated from headlight surveys on the Hook Ranch study area, 1986-1987.

Date and km Driven	Numbers of Jackrabbits	Numbers of Cottontails	Total Lagomorphs	Lagomorphs / km
Jun. 86 243.9	4	3	7	.03
Jul. 86 174.0	7	0	7	.04
Aug. 86 56.0	0	0	0	.00
Sep. 86 158.7	3	1	4	.03
Oct. 86 149.4	3	0	3	.02
Nov. 86 50.8	3	0	3	.06
Dec. 86 205.8	34	3	37	.18
Jan. 87 611.0	42	4	46	.08
Feb. 87 282.3	30	0	30	.11
Mar. 87 81.8	3	0	3	.04
Jun. 87 23.5	0	0	0	.00
Jul. 87 183.2	8	2	10	.05
Aug. 87 269.4	15	4	19	.07
Totals 2489.8	152	17	169	.70
Means 191.5	11.7	1.3	13.0	.05

were harvested on the Hook Ranch and 6 on the study area in 1985-1986. In 1986-1987, 9 bobcats were harvested on the Hook Ranch and 4 on the study area. The 1986-1987 bobcat harvest in MDFWP Region 7 was made up of 57.6% males (n = 260), 41.9% females (n = 189) and 0.4% bobcats of undetermined sex (n = 2).

Table 14. Numbers of bobcats harvested in MDFWP Region 7, the Hook Ranch and total study area, 1977-1987.

Trapping Season[a]	Region 7	Hook ranch	Study area
1977-1978	132	1	0
1978-1979	159	2	2
1979-1980	362	9	0
1980-1981	178	4	0
1981-1982	219	17	4
1982-1983	306	25	10
1983-1984	403	50	3
1984-1985	693	52	1
1985-1986	535	9	6
1986-1987	451	9	4

[a] Data for the years 1977-1985 taken from Giddings (1986).

Only 1 marked animal was lost directly to fur trapping during the 1986-1987. Female F503 was reported, by anonymous sources, to have been taken illegally. F065 died from trap inflicted injuries when captured in a federal predator control program. M965 was caught by a local trapper but escaped. Most local trappers avoided trapping predators on the study area as a cooperative effort. Therefore, it was impossible to use data from this study to develop an index to trapping mortality rates in southeastern Montana.

Numbers of coyotes and foxes destroyed by government trappers in Rosebud and Treasure Counties are presented in Table 15. The first 2 years of data are not directly comparable to the last 3 years because animals were removed by 2 different trappers. During the last 3 years, there were no major differences in the numbers of foxes and coyotes killed. The number of foxes declined slightly from 62 to 49 from 1984 to 1986, while the number of coyotes killed increased slightly from 257 to 269.

Daily Activity Patterns

Daily activity patterns observed during each of the 3 24-hour activity monitoring sessions were as follows:

8/20-21/86

F915 was initially located at 0800 hours (h) resting near the top of a high gumbo ridge. For 12 hours and 15 minutes, she remained resting/sleeping at the same location. Between 2015 h and 0515 h, F915 traveled to

Little Porcupine creek and spent approximately 4.5 hours hunting during 3 time periods (2230-0200, 0230-0300 and 0330-0400 h).

Table 15. Numbers of foxes and coyotes removed from Rosebud and Treasure counties by government trappers for the years 1982 through 1986. Predators were destroyed by trapping, snaring, aerial gunning, M44's, calling and free shots. Figures do not include predators removed by denning.

Year	Fox	Coyotes
1982[a]	58	116[c]
1983[a]	50	199
1984[b]	62	257
1985[b]	57	262
1986[b]	49	269

[a] Government trapper, M. Hogan.

[b] Government trapper, J. Pachl.

[c] Predators were not removed during the months of January and February.

Each of the hunting sessions took place in the open sagebrush/grasslands cover type. The longest hunting period lasted 3.5 hours in a thick sage prairie near the confluence of 2 creeks. F915 stopped moving at 0515 h in a wide bend of the Little Porcupine covered by an exceptionally thick, tall stand of big sagebrush. She remained in this location the remainder of the monitoring session.

During the 9 hours of activity, F915 traveled 10.5 km (straight line distance estimated between successive 15 minute intervals), across the entire breadth of her summer home range. She was in the open sagebrush/grassland cover type about 18 hours and in the creek bottom cover type about 6 hours.

12/10/86

On this date, I determined the activities of an unidentified adult bobcat over a 24-hour period by snow-tracking the animal to and from its resting site in an eroded cavern in a gumbo/scoria hill. This bobcat's diel movements were much less extensive than those of F915, covering a maximum distance of 600 m in a circular route. While traveling, this cat made a visual examination of 3 holes that cottontail rabbits had entered during the night but did not make a kill. Most of the 24-hour period (23+ hours) was spent resting in the eroded cavern. Both travel and resting occurred completely within the badlands cover type.

7/8-9/87

F911 was initially radio monitored at 1900 h denned in a sinkhole about 3/4 up a gumbo/scoria hill. She began moving at 2045 h and then traveled constantly and hunted sporadically for 5.25 hours until 0200 h. From 0200 h until 0445 h, F911 remained in a second sinkhole cavern. At 0445 h, she came out of the cavern but remained near the entrance sunning herself. F911 again began traveling that afternoon at 1330 h and continued until 1515 h. From then until the end of the 24-hour monitoring session, she remained in a third sinkhole-cavern in the badlands. Her travels occurred predominantly in the badlands cover type except for approximately 30-45 minutes while crossing a highly disected prairie between 2 badland areas. Overall, approximately 17 hours were spent resting/sleeping and 7 hours traveling/hunting. The total straight line distance traveled across successive 15-minute locations was 9.0 km.

Sinkhole Caverns

Sinkhole caverns usde by bobcats were usually on north or west facing aspects with entrances on slopes between 0 and 25^{o} (mean 10.2^{o}). Caverns were located anywhere from 1/5 to the top of slopes, most were located 1/2 to 3/4 up the hillslope. Outer sinkhole diameters ranged between 66 x 81 cm and 384 x 495 cm. The size of entrance holes varied less, ranging between 23 x 66 cm and 107 x 119 cm. Hole depths measured from the top of the sinkhole to the entrance of the cavern ranged from 107 to 290 cm. The angle of the entrance hole ranged from 0 to 90^{o} with an average of 31.5^{o} (Table 16).

Table 16. Topographical and physical characteristics of 12 sinkholes regularly used by bobcats in the badlands cover type located on the Hook Ranch study area, 1986-1987. Diameters and depths are in centimeters.

Hole #	Aspect	Elevation	Slope$^{\circ}$	Position on Hill[a]	Sinkhole Diameter	Den hole Diameter	Hole Depth[b]	Angle of Hole$^{\circ}$
1	W	2920	0	top	249 x 290	23 x 66	193	90
2	W[c]	2960	25	3/4	384 x 495	46 x 61	218	25
3	W	3040	7	3/4	366 x 427	58 x 66	229	0
						51 x 61[d]		
4	W/SW	3100	12	1/3	254 x 305	33 x 61	127	49
5	S/SW	3040	18	1/2	254 x 279	107 x 119	107	9
6	N/NE	3100	0	1/2	none	41 x 135	127[e]	25
7	N/NE	3100	18	3/4	213 x 239	41 x 94	290	90
8	SW	2960	8	3/4	300 x 381	48 x 112	196	5
9	W	2920	11	3/4	66 x 81	56 x 66	152	50
10	N	2940	0	1/5	127 x 137	25 x 81	152	30
11	N	3080	8	1/2	f	66 x 208	147	0
12	N/NW	3060	15	3/4	231 x 317	46 x 56	190	5

[a] The hole position on the hill, eg., 3/4 = 3/4ths the way up the hill.

[b] The depth from the top edge of the sinkhole to the opening of the den hole.

[c] The entrance to this hole faced east.

[d] There were 2 entrances to this den.

[e] The depth of this den hole is the actual inside dimension.

[f] Not really a sinkhole, rather, a large gully.

Vegetation characteristics inside sinkholes and around the top edges varied considerably (Table 17).

Table 17. Vegetation associated with 12 sinkholes regularly used by bobcats in the badlands cover type on the Hook Ranch study area, 1986-1987.

	Sinkhole Number											
Vegetation Species	1	2	3	4	5	6	7	8	9	10	11	12
Shrubs												
Artemisia cana	x	x					x	x				
Artemisia frigida								x		x		
Artemisia tridentata		x	x	x				x		x	x	x
Sarcobatus vermiculatus			x		x							x
Chrysothamnus spp.						x	x	x			x	x
Atriplex nuttallii			x	x	x		x	x			x	
Ribes spp.											x	
Forbs												
Antennaria spp.	x	x										
Phlox hoodii							x					x
Sphaeralcea coccinea										x		
Lomatium spp.							x					
Xanthium strumarium								x				
Grasses												
Agropyron cristatum	x											
Agropyron spicatum	x		x	x	x	x		x		x		x
Bromus spp.			x	x				x				
Festuca spp.		x		x							x	
Poa spp.											x	
Stipa comata	x											
Oryzopsis hymenoides								x				
Triticum spp.		x										

Carcass Collection

Reproductive tracts were obtained from 58 female bobcats harvested in MDFWP Region 7 during the 1986-1987 trapping season. One reproductive tract was incomplete, therefore, only 57 were used for analyses. Female carcasses ranged in age from 1 year to 11 years of age (Fig. 14), with the majority (72.4%) between 3 and 4 years of age (Table 18). These individuals were born during the peak of the lagomorph population cycle, 1982-1983. The mean age was 3.8 years.

Based on placental scar counts, in utero litter sizes ranged from 0 to 5 (Table 19). Most litters contained 2 (34.6%) or 3 (34.6%) young. Only 3 (11.5%) of the carcasses had either 4 or 5 placental scars. The 1 yearling in the sample of carcasses had 1 placental scar (Fig. 15). The overall mean number of placental scars was 1.2 for all 57 carcasses. Thirty-one (54.4%) of the 57 carcasses had no litters the previous breeding season. The mean number of corpora lutea was 3.2 and the mean number of corpora albicantia was 6.9. The lowest ovulation rate was represented by the 1 yearling female (1.0) and ascended to the highest level for bobcats 5+ years of age (3.7) (Fig. 16).

Of 39 carcasses inspected for body fat, 30.8% had high levels, 38.4% had medium levels and 30.8% had low levels (Table 20). The low and medium categories may have been over represented because a bobcat left in a trap will live on its body fat reserves for some time before it is killed by the trapper.

Figure 14. Age distribution of 58 female bobcat carcasses collected during the 1986-1987 trapping season in MDFWP Region 7.

Table 18. Age distribution of 58 trapper-harvested female bobcats from MDFWP Region 7, 1986-1987.

Bobcat Ages[a]	Number	Percent
1	1	1.7
2	5	8.6
3	24	41.4
4	18	31.0
5	3	5.2
6	1	1.7
7	3	5.2
8	2	3.4
9	0	0.0
10	0	0.0
11	1	1.7
Totals	58	99.9

[a] Ages determined by cementum annuli layering.

Blood Analyses

The number of red blood cells (RBC) for the 18 bobcats captured between 30 March 1986 and 11 March 1987 ranged from 6.85 to 10.61 x 10^6/microliter (μl) with a mean of 8.1 x 10^6/ml (Table 21). Hemoglobin (Hgb) concentrations ranged between 11.9 and 18.7 grams/deciliter (g/dl) with a mean of 14.3 g/dl. Mean corpuscular volume (MCV) was

Table 19. Numbers of placental scars (PS), *corpora lutea* (CL), *corpora albicantia* (CA) and ages of 58 female bobcat carcasses collected from 1 December 1986 to 15 February 1987 in MDFWP Region 7.

Carcass Number	PS	CL	CA	Age	Carcass Number	PS	CL	CA	Age
1	2	4	5	3	31				7[a]
2	1	4	14	4	32	0	4	0	3
3	0	1	7	3	33	0	1	15	4
4	0	2	16	4	34	2	4	8	3
5	0	0	3	3	35	3	3	28	7
6	3	6	20	7	36	0	3	0	2
7	2	4	5	3	37	0	2	0	3
8	0	2	2	3	38	0	0	0	2
9	2	4	3	4	39	0	4	0	3
10	0	4	6	4	40	2	10	10	4
11	3	8	0	3	41	1	4	0	3
12	0	4	3	3	42	0	3	12	3
13	0	3	6	3	43	0	7	0	2
14	1	2	2	3	44	0	0	14	4
15	4	4	0	4	45	0	4	4	4
16	3	5	24	6	46	0	4	8	4
17	3	3	17	11	47	1	1	14	4
18	0	4	5	4	48	0	2	4	4
19	0	4	3	3	49	0	1	0	3
20	3	4	4	3	50	0	4	14	4
21	3	3	24	8	51	0	0	6	2
22	3	4	2	5	52	0	0	5	3
23	2	4	3	4	53	5	7	6	4
24	0	0	4	3	54	2	3	5	5
25	0	4	2	3	55	1	1	1	1
26	5	6	23	8	56	0	2	5	3
27	2	3	5	3	57	0	0	11	5
28	2	3	3	4	58	0	3	0	3
29	0	2	10	4					
30	3	3	2	2					

Means	PS	CL	CA	Age
	1.2	3.2	6.9	3.8

[a] The reproductive tract was unavailable for this female.

Figure 15. *In utero* litter sizes from 57 female bobcat carcasses by age group, MDFWP Region 7, 1986-1987.

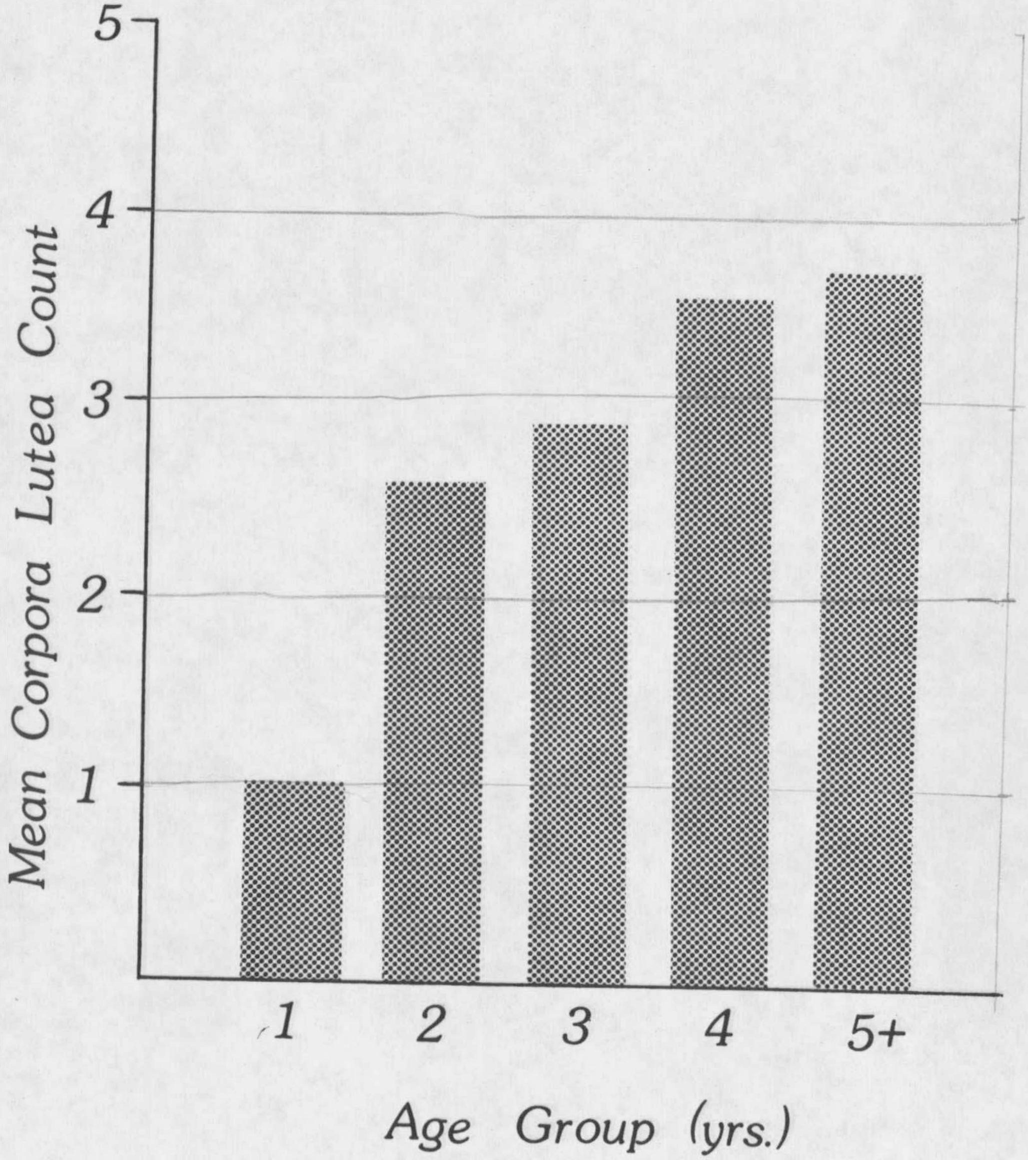

Figure 16. Bobcat corpora lutea counts by age group, MDFWP Region 7, 1986-1987.

Table 20. Relative body fat estimates determined for 39 trapper-harvested female bobcat carcasses from MDFWP Region 7, 1986-1987.

	Body Fat Index	
Fat Category	Number of Carcasses	Percent of Total
High	12	30.8
Medium	15	38.5
Low	12	30.8
Totals	39	100.00

between 49.7 and 60.3 femtoliters (fl) (mean = 54.8 fl). Mean corpuscular hemoglobin concentration (MCHC) ranged between 30.2 and 35.7% with a mean of 32.2%.

The number of white blood cells (WBC) ranged between 6.8 and 22.0 x 10^3/ml (mean = 11.3 x 10^3/ml) (Table 21). Lymphocyte, monocyte and eosinophil value ranges were 3.0-66.0, 0.0-6.0 and 0.0-6.0 x 10^3/ml, respectively (Table 22). Size, color, shape and platelet (PLT) morphology (morph) of red blood cells are presented in Table 23.

Serum urea nitrogen (BUN) values ranged between 21 and 58 milligrams per deciliter (mg/dl), with a mean of 35.5 mg/dl (Table 24). The mean BUN value for males was 34.3 mg/dl (n = 12) and the mean for females was 38.4 mg/dl (n =

Table 21. White blood cell (WBC), red blood cell (RBC), hemoglobin (Hgb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and platelet (PLT) values of bobcats captured between 30 March 1986 and 11 March 1987 on the Hook Ranch study area.

Bobcat Number	Date	WBC x 10^3/ml	RBC x 10^6/µl	Hgb g/dl	HCT vol %	MCV fl	MCH pg	MCHC %	PLT x 10^3
F915[a]	4/29/86	7.9	7.64	12.9	41.1	53.7	16.9	31.4	671
M835	5/2/86	8.9	7.08H	11.9	37.0	52.3	16.9	32.3	223
M114	5/2/86	14.9	6.85	12.1	34.0	49.7L	17.7	35.7	296
M114	5/6/86	13.3	9.85H	16.9	51.9	52.7	17.2	32.6	617
M75,48	5/8/86	9.0	7.10H	13.1	39.7	55.9	18.5	33.1	297
F065	5/30/86	10.8	7.18H	12.5	37.8	52.5	17.4	33.1	102
M2,4	6/17/86	11.2	7.89H	14.4	42.6	54.0	18.3	33.9	435
F503	10/15/86	13.5	10.21	18.7	55.9	54.7	18.3	33.5	429
M3,12	10/30/86	8.5	7.32	12.5	39.2	53.5	17.1	31.9	267
F595	2/20/87	6.8	8.23	14.5	45.3	55.0	17.6	32.1	149
M034	2/20/87	22.0	7.88	13.5	43.4	55.1	17.2	31.2	447
F915[b]	2/25/87	7.7	7.66	13.3	43.0	56.1	17.4	31.0	508
M5,6	2/25/87	22.0	8.88	16.2	53.5	60.3	18.2	30.2	278
M921	2/25/87	13.3	7.68	13.2	42.9	55.8	17.2	30.9	369
M7,8	3/6/87	10.4	7.60	13.4	43.1	56.7	17.6	31.1	478
F911	3/6/87	15.0	7.82	14.7	43.7	55.8	18.7	33.6	367
M9,10	3/9/87	9.6	10.61	18.6	60.1	56.7	17.6	31.0	383
M916	3/11/87	12.7	8.69	15.0	48.4	55.7	17.3	31.1	365

[a] Blood sample taken in 1986.

[b] Blood sample taken in 1987.

Table 22. Segmented neutrophils (Segs), bands, lymphocytes (Lymphs), monocytes (Monos), eosinophils (Eos), and other leukocyte values of bobcats captured between 30 March 1986 and 11 March 1987 on the Hook Ranch study area.

Bobcat Number	Segs	Bands	Lymphs	Monos	Eos	Other
F915[a]	70	10	20			
M835	37	14	8	6		35
M114	84	4	9	3		
F114	32	1	66	1		
M75,48	81	4	9	3	3	
F065	76	6	16	2		
M2,4	93	1	6			
F503	60	18	22			
M3,12	75	15	10			
F595	66	5	29			
M034	92	4	4			
F915[b]	62	12	20	3	3	
M5,6	62	24	8	6		
M921	69	8	12	5	6	
M7,8	86	4	10			
F911	90	6	3	1		
M9,10	80		20			
M916	86	6	8			

[a] Blood sample taken in 1986.

[b] Blood sample taken in 1987.

Table 23. Size, color, shape and platelet (PLT) morphology (morph) of red blood cells (RBC) and the number of RBC/100 white blood cells (WBC) in blood samples of bobcats captured between 30 March 1986 and 11 March 1987 on the Hook Ranch study area.

Cat #	SIZE				COLOR			SHAPE		PLT MORPH	# RBC/ 100 WBC
	Normal	Aniso	Micro	Macro	Normal	Hypo	Poly	Normal	Poik	Normal	
F915[a]	x				x			x		x	1675
M835			x			x			x		1565
M114			x		x			x			1565
M114											953
M75.48	x				x			x		x	1400
F065			x		x			x			
M2,4	x				x			x		x	1175
F503											1085
M3,12											820
F595											
M034											
F915[b]											1830
M5,6											1800
M921											
M7,8											1830
F911											1830
M9,10	x				x			x		x	1630
M916	x				x			x		x	2015

[a] Blood sample taken in 1986.

[b] Blood sample taken in 1987.

5). Values for other elements analyzed are listed in Table 24. Progesterone levels ranged widely between 0.879 and 28.000+ nanometers/milliliter (Table 25).

Table 24. Serum chemical values including: serum urea nitrogen (BUN), total protein (Tpro), albumin (Alb), calcium (Ca), magnesium (Mg), phosphorous (Phos), sodium (Na), potassium (K), alkalphosphorous (Alkp) and triglyceride (Trig) of 17 bobcats captured between 30 March 1986 and 11 March 1987 on the Hook Ranch study area.

Bobcat Number	BUN mg/dl	Tpro g/dl	Alb g/dl	Ca mg/dl	Mg mg/dl	Phos mg/dl	Na mEq/l	K mEq/l	Alkp[c] IU/l	Trig mg/dl
M965[a]	30	6.7	4.5	10.1	2.3	6.3	159	5.1		39
M3,12	29	6.8	4.3	8.9	2.0	4.1	155	4.2		25
M835	27	6.8	4.4	9.5	2.3	3.7	157	4.3		38
M2,4	28	7.1	4.2	9.3	2.0	2.6	163	4.5		34
F915	30	6.7	4.4	9.3	2.0	5.4	156	4.5		28
F065	35	6.1	3.7	9.4	2.0	5.3	152	4.4		34
M75,48	55	7.1	4.3	10.0	2.1	4.1	159	4.5		47
M114	30	7.1	4.5	9.6	2.2	4.6	153	4.3		28
M921	43	6.0	3.7	8.7	2.1	4.3	159	4.2	3	28
F915[b]	58	6.4	4.1	9.0	2.2	5.4	152	4.4	7	33
M7,8	29	6.5	3.8	8.7	2.4	5.0	156	4.3	5	20
F595	21	6.6	4.2	9.2	2.5	4.4	154	4.5	8	26
M916	35	6.4	4.3	9.8	2.4	5.3	155	3.8	2	36
F911	48	6.4	4.2	9.0	2.3	5.0	153	4.4	8	43
M034	38	6.2	4.2	9.6	2.4	4.2	154	4.3	4	20
M9,10	28	6.7	4.3	8.9	2.5	5.0	158	4.2	4	31
M5,6	39	5.7	3.4	8.7	2.3	7.6	159	4.8	3	46

[a] Blood sample taken 1986.

[b] Blood sample taken 1987.

[c] Blood samples for the first 8 bobcats were too old to determine Alkp.

Table 25. Progesterone levels in the blood of bobcats captured between 30 March 1986 and 11 March 1987 on the Hook ranch study area.

Bobcat Number	Progesterone level (nanometers/milliliter)
M965	13.132
F915[a]	27.730
M835	19.789
M114	20.192
M75,48	1.726[c]
F065	20.571
M2,4	17.533
F503	6.686
M3,12	1.968
M034	27.059
F595	19.798
M921	0.879
F915[b]	7.486
M5,6	2.869
M7,8	7.749
F911	28.000+
M9,10	14.863
M916	9.620

[a] Blood sample taken in 1986.

[b] Blood sample taken in 1987.

[c] This male bobcat was held in captivity for 2 weeks before it was drugged and a blood sample taken for analysis.

DISCUSSION

Home Range and Movements

Bobcat home range sizes in eastern Montana during 1986-1987 rank among the largest reported. Of the studies in which home ranges were calculated using the minimum convex polygon technique, larger home ranges have been reported only for male bobcats in Minnesota (range = 13-201 km^2, mean = 62 km^2, Berg 1979); none rival the range of sizes for females in this study (24.8-233.5 km^2). Use of larger areas by both male and female bobcats has been observed but these individuals were considered transients (Bailey 1974, Fuller et al. 1985 and Knick and Bailey unpubl. data). None of the bobcats monitored on the Hook Ranch were transients.

Although southeastern Montana is semi-arid, the home range sizes observed in this study did not fit home range size trends relative to climate indicated in other studies. Bobcats in arid environments are reported to have smaller home range sizes (Bailey 1972, Lembeck and Gould 1979, Knowles 1981, 1985 and Giddings 1986) than in more mesic, mountain coniferous forest regions (Berg 1979, Brainerd 1985 and Litvaitis et al. 1986). Small to mid-sized home ranges have been reported in mesic deciduous forest regions (Marshall 1969 and Fuller et al. 1985).

The great variation in home range sizes among bobcats in this study probably reflected some combination of availability of food within habitat types, the reproductive requirements of bobcats, social organization, interspecific relations and numbers of relocations (Bailey 1974, Kitchings and Story 1978, Knick unpubl. data, Litvaitis 1984 and Litvaitis et al. 1986, 1987 and Toweill 1986). Prey availability and habitat type were probably the determining factors in bobcat home range size in the southeastern Montana study area.

Home ranges encompassing a larger percentage of badlands tended to be smaller. Conversely, home ranges encompassing a larger percentage of open sagebrush/grassland habitat tended to be larger. Although little quantitative information was obtained on the relative abundances of prey species within each of the cover types, the density of cottontails in the badlands cover types increased substantially in 1987 as compared with only a slight increase in jackrabbit density in the open sagebrush/grassland areas.

The decrease in home range size between 1986 and 1987 could have been due to increases in lagomorph densities or to reduced numbers of radio locations in 1987. Toweill (1986) reported that home range size increases with the number of relocations and that 40 locations were necessary for adequate estimates of total home range and 15 for seasonal home range in the Cascade Range in Oregon. If a similar relationship occurred in southeastern Montana, home range sizes in 1987 (18-26 locations) were underestimated.

Bobcats in 1986-1987 had substantially larger home range sizes on the study area than during 1983-1984 (Giddings 1986). Female home range sizes in 1986-1987 were 24.8-233.5 km^2 (n = 2) compared with annual home ranges between 20.1 and 33.5 km^2 during 1983-1984 (n = 3). Male bobcats in this study had annual home ranges between 23.9 and 100.5 km^2. The 1 male monitored by Giddings had an annual home range size of 4.3 km^2. The 56.3% (females) to 93.1% (males) increase in home range sizes on the Hook Ranch study area in 1986-1987 relative to 1983-1984 occurred in conjunction with a 98.3% decrease in lagomorph headlight counts between the 2 periods.

Mean distances between consecutive locations also increased between 1983-1984 and 1986-1987. Bobcats monitored between 1983 and 1984 apparently traveled shorter distances within their smaller home ranges than in 1986-1987. The mean distance between consecutive locations for both males and females in 1986-1987 was 4.2 km. The mean distance traveled in 1983-1984 was 1.6 km (Giddings 1986).

The longest mean distance between consecutive locations for the female in 1986 was in fall (5.0 km), and the shortest was in spring (3.0 km). This differs from the females in Gidding's study (1986) where the greatest distance was in spring (3.4 km) and the shortest distances were in summer and fall (1.3 km each season).

The greatest mean distance between consecutive locations for male bobcats in 1986-1987 was in spring (5.0 km), and the shortest distance was in summer (4.0 km). This contrasts with the mean distance for the 1 male radio tracked in Gidding's study in summer (1.0 km) and fall (1.2 km). (This bobcat may have injured its leg when trapped, according to Giddings, which may have accounted for the short distances measured between consecutive locations.) No data were available for the winter and spring seasons in 1983-1984.

Laundre et al. (1987) found poor correlations between distances from consecutive locations at 24-hour intervals and actual distances traveled in 24 hours by bobcats. These authors suggested that for nocturnal animals, such as bobcats, radio locations made during the morning hours reflected distances between resting areas. In most locations made during the daylight hours on the Hook Ranch study area (> 75%), bobcats were resting (visual observations) or stationary (non-visual locations).

The distance between consecutive locations, however, may still be a reasonable index to effort required by bobcats to secure food. If food supplies in 1 area are plentiful, cats would be expected to remain within that area longer than if prey items were scarce. The increase in mean distances between locations in years with high lagomorph populations (1983-1984) and low populations (1986-1987) supports this idea.

Food and Habitat Use

The predominance of small rodent and bird remains in scats collected in 1986-1987 contrasts with bobcat food habits on the Hook Ranch during 1983-1984 when all scats appeared to contain the remains of rabbits (Irby pers. comm.). Even though bobcats are best adapted to hunting rabbits, they are opportunistic predators capable of changing their food habits in response to prey abundance (Beasom and Moore 1977). Bailey (1972) found that more small rodents and birds occurred in bobcat feces after a crash in the jackrabbit population in southeastern Idaho.

Cover types selected in 1986-1987 were similar to those favored during 1983-1984 (badlands and creek bottoms) despite the increase in size of home ranges and change in food habits. The importance of a given cover type within the home range of a bobcat is probably related, in part, to prey availability, but non-significance in statistical analyses of use verses availability should not discount the possible importance of types such as open sagebrush/grasslands to bobcats in eastern Montana. These open areas may contribute significantly to the diet of bobcats in the form of pronghorn antelope, sage grouse and jackrabbits when other sources of food such as cottontails are in limited supply. All of the pronghorn antelope kills documented during 1986-1987 on the Hook ranch study area occurred in the open sagebrush/grassland cover type category.

Greater seasonal use of the open sagebrush/grassland cover type by radio monitored bobcats paralleled the incidence of pronghorn kills documented in this cover type. Increased use of badlands noted in 1987 paralleled the increased numbers of cottontails observed during the field study.

Population Trend Indices

Bobcat densities have been estimated in various geographic areas based on capture rates (the number of trap nights/bobcat), home range size, harvest data and additional bobcat activity observed (Bailey 1972, Lembeck and Gould 1979, Zezulak and Schwab 1980, McCord and Cardoza 1982 and others). Each of these indices has limitations. For example, a population density estimate based on the number of trap days/bobcat capture is extremely sensitive to trapper skill and technique and probably varies regionally with trapper skill and technique among different habitat complexes. Five methods were used in this study to estimate relative changes in bobcat densities from 1983-1984 to 1986-1987.

Trap Success

In this study, trapping success varied greatly (range = 71.3-427.4 trap days/bobcat) between trapping sessions. The changes that occurred in trap success between trapping sessions occurred over too short a time period to reflect population change. The mean capture rate of 274.5 trap days/cat represented an increase of > 4 fold from rates during Giddings' (1986) study. Comparison of the trap days/bobcat in this and other studies indicated a low density in 1986-1987. In contrast, the 62.5 trap days/bobcat catch observed by Giddings in 1983-1984 was a high density; therefore indicating a bobcat population decline from 1983-1984 to 1986-1987.

Home Range Size

A density estimate based on the increased size of annual home ranges in 1986-1987 compared with those in 1983-1984 also indicated a decrease in population density in 1986-1987. Female home ranges were 4.7 times larger and male home ranges were 14.5 times larger in 1986-1987. My general observations on the study area indicated that not all the bobcats were captured, however. Overlap between home ranges would allow more animals to use the study area than is assumed with techniques in which density is estimated by dividing total area by mean home range size.

Lagomorph Counts

Headlight counts of lagomorphs (Roughton and Sweeney 1982) were used as an indirect estimate of population change in that bobcat kitten production and survival were assumed to be dependent on availability of rabbits - a preferred prey species. If this hypothesis is valid, a given percent decline in rabbits would translate into some percentage decline in bobcats 1-2 years later. The counts of lagomorphs on jeep trails and primitive roads declined dramatically from 1983 to 1987. Giddings (1986) stated that there was a tendency for lower counts throughout his study. This decline evidently continued through 1986. A 58-fold decline in the number of lagomorphs/km road occurred from 1983-1984 to 1986-1987. This represented a tremendous reduction in the availability of lagomorphs and suggested a substantial bobcat population decline.

Scent Post Transects

Scent post surveys (Knowlton and Tzilkowski 1979) are based on the assumption that visits to lures are proportional to population density. Visitation rates for scent post lines using lures which produced the highest visitation rate in 1984 (bobcat gland and bobcat urine) were 1.7% in 1986 and 2.8% in 1987. This contrasts to a visitation rate of 7.2% for 3 scent post survey lines in August 1984 on the Hook Ranch study area when bobcat gland lure was the attractant used (Giddings 1986).

Differences in visitation rates indicated a 61% decline since 1984. This apparent decline may not accurately represent changes in bobcat density because of increased movements of bobcats in 1986-1987. Bobcats appeared to expand their home ranges during this study by 4 times that of bobcats monitored in 1983-1984, and distances measured between consecutive locations increased 2.5 times. Brady (1979), Knowlton and Tzilkowski (1979) and Rolley (1985) believed that scent station transects paralleled changes in a bobcat populations. Knowlton and Tzilkowski, however, urged caution in interpretation of scent station visitation results.

Harvest Trend Analyses

A 35% decline in the bobcat harvest in MDFWP Region 7 from 1984-1985 to 1986-1987 may have indicated a population decline. This decline occurred despite mild winter weather that which allowed easy access to trapping throughout the region.

The proportion of kittens harvested in MDFWP Region 7 during the 1986-1987 trapping season was < 5% (Hildebrand pers. comm.) which indicated decreased kitten production and recruitment. Local fur buyers also reported buying few skins of kittens during this past season (Robbins pers.

comm.). The proportion of kittens in the harvest from southeastern Montana in 1986-1987 was much lower than the proportion reported for southeastern Montana from the previous 4 or 5 years (Hildebrand pers. comm.) despite stable or increased trapping pressure. This low kitten harvest probably reflectd low fecundity rather that over-harvest. If over-harvest had occurred, I would have expected an increase in kitten numbers because trappers would have been less likely to release kittens to fill their quotas with more valuable adults. Assuming an average harvest rate of 25% for kittens (extrapolated from estimates in the literature) the production rate of kittens in this study was down 80%.

The proportion of kittens in harvests has been used as an index to population change in other geographical areas (Berg 1979, Knick et al. 1985, Rolley 1985 and Toweill 1986). Decreases are assumed to reflect decreased productivity which translates into decreased populations 1-2 years later. This phenomenon may have occurred on the Hook Ranch study area between 1983-1984 and 1986-1987.

Daily Activity Patterns

Individual cats varied considerably in distances traveled, amount of hunting and periods of activity or inactivity during 24-hour periods. These differences probably resulted from differences in size of home ranges, time, when the bobcat last ate, prey availability, habitat types occurring within the home ranges of individuals, time of year and environmental conditions.

Daily activity patterns of bobcats in other geographic regions also show considerable variation (Erickson 1955, Young 1958, Marshall and Jenkins 1966, Hall 1973, Provost et al. 1973, Hall and Newsom 1976, Buie et al. 1979, Fendley and Buie 1983, Griffith et al. 1983 and Toweill 1986). As with most other studies, this study found that bobcats are crepuscular or nocturnal, but that some activity may occur during the afternoon hours.

Sinkhole Characteristics

Sinkholes were used extensively by all radio collared bobcats. Vegetation species present on the edges of sinkholes probably had less to do with cavern selection by bobcats than did some of the physical and topographical characteristics. Holes located on the peripheries of home ranges of individual bobcats were selected because they served as convenient stopping over or resting places during daily movements. Caverns with relatively stable microclimates and caverns situated so as not to take on water during a rainstorm were selected. Although no published studies were found that described characteristics of sinkhole caverns used by bobcats, caverns large enough to allow bobcats to comfortably turn around in were also likely favored.

Carcass Analyses

Analyses of 57 female bobcat reproductive tracts collected in MDFWP Region 7 in 1986-1987 indicated a decline in reproductive rates compared to 688 female carcasses collected in Montana in 1980-1983 (Brainerd 1985). The overall mean *in utero* litter size declined from 2.7 in 1980-1983 to 2.1 in 1986-1987. The average *corpora lutea* count declined from 4.2 in 1980-1983 to 3.2 during 1986-1987. Both *in utero* litter sizes and *corpora lutea* counts varied significantly between years in Brainerd's (1985) study but not between the eastern and western portions of the state.

The occurrence of *corpora lutea* within age cohorts in 1986-1987 differed substantially from that observed in the female bobcat carcasses collected from 1980-1983. The highest ovulation rate (3.6) observed in the 5+ year class in 1986-1987 was equivalent to that of the youngest (yearling) class during 1980-1983. Brainerd (1985) found the highest number of *corpora lutea* in 2-year olds (4.7). The ovulation rate then decreased with each successive age group. The lowest *corpora lutea* count was observed in the yearling class in both studies.

Reproductive rates for bobcats harvested in Region 7 in 1986-1987 are among the lowest recorded. The smallest *in utero* litter size (1.3) was documented in Kansas (Johnson and Holloran 1985). Mid to large *in utero* litter sizes (2.5-3.5) have been reported in Washington (Sweeney 1978, Knick et al. 1985), Idaho (Bailey 1972), Oregon (Toweill 1986), Minnesota (Berg 1987), Michigan (Erickson 1977), Oklahoma (Rolley 1985) and elsewhere. Reported ovulation rates from *corpora lutea* counts range between 3.3 and 9.5 (Erickson 1955, Gashwiler et al. 1961, Nelson 1966, Hall 1973, Crowe 1975, Fritts and Sealander 1978, Sweeney 1978 and Berg 1979).

Reproductive parameters supported the downward trend between 1984 to 1987 indicated in population indices. It appears that kitten production declined annually beginning in 1984 and was lowest in 1986. None of the female bobcats radio-equipped during this study had kittens, and no kitten tracks were positively identified during the entire course of the field study.

Knick (unpubl. data) suggested that bobcat reproductive rates may not exhibit inversely compensating responses to increased harvest mortality or decreases in prey populations. Rolley (1985) suggested that a decline in the cottontail population or high harvest rates may have caused a decrease in the pregnancy rate of bobcats in

Oklahoma in 1981-1982. A jackrabbit population crash was considered the cause of low kitten survival in southeastern Idaho (Bailey 1972).

The subcutaneous body fat index provided a crude index to the health of the bobcat population. It indicated most individuals in the population were apparently healthy despite the low lagomorph population and low level of kitten production. Adult bobcats may have been storing more body fat for use by their own bodies rather than using it to produce young.

Blood Analyses

Blood parameters have only recently been described for bobcats (Fuller et al. 1985, Kocan et al. 1985 and Knick and Seal in press). Red blood cell and leukocyte values in this study were generally comparable to ranges reported for bobcats in the other studies and for domestic cats (*Felis catus*) by Schalm (1965), Kaneko (1980) and Bentinck-Smith (1983) (Table 26). Values for Hgb, MCH and MCHC for bobcat blood samples in this study and in Fuller et al.'s (1985) research were also similar to ranges reported for domestic cats. Kocan et al. however, reported very high values for MCH and very low values for MCHC. In addition, Kocan et al. divided the bobcats they sampled into 2 groups; bobcats with natural infections of the erythroparasite *Cytauxzoon felis* and bobcats without observable erythroparasites.

Table 26. Mean hematologic and serum chemical values for bobcats from 3 different geographical regions in the United States and for domestic cats.

Parameter	This Study (n = 17-18)	Oklahoma[a] (n = 11)	(n = 5)	Minnesota[b] (n = 6-25)	Normal Range for Domestic Cats
		w/parasites	w/out parasites		
RBC x $10^6/\mu l$	8.1	6.1	7.7	7.9	5.0-10.0[a]
Hgb (g/dl)	14.3	13.1	12.0	13.3	8.0-15.0[a]
Hct (vol%)	44.5			38.7	24.0-45.0[a]
MCV (fl)	54.8	59.5	41.3	49.4	39.0-55.0[a]
MCH (pg)	17.6	36.1	37.7	17.4	13.0-17.0[a]
MCHC (%)	32.2	21.5	15.6	34.5	30.0-36.0[a]
WBC x 10^3/ml	11.3	10.6	14.7	15.8	5.5-19.5[a]
Neutros x 10^3/ml		8.7	13.4	14.0	2.5-12.5[a]
Lymphs x 10^3/ml	15.5	21.6	20.5	1.8	1.5-7.0[a]
Monos x 10^3/ml	1.6	0.7	0.7	0.0	0.0-0.9[a]
Eos x 10^3/ml	0.7	3.1	2.8	0.0	0.0-1.5[a]
Basos x 10^3/ml	0.0	0.3	0.4	0.0	rare[a]
BUN (mg/dl)	35.5	31.4	28.2	34.4	5.0-30.0[b]
Tpro (g/dl)	6.5	7.1	8.3	6.7	5.4-7.8[b]
Alb (g/dl)	4.1	3.6	2.7	3.6	2.1-3.5[b]
Ca (mg/dl)	9.3	9.2	8.4	9.4	6.2-11.0[b]
Mg (mg/dl)	2.2			3.0	1.9-2.3[b]
Phos (mg/dl)	4.8	5.5	5.3	4.7	3.2-8.1[b]
Na (mEq/l)	156.1	155.6	154.4	148.6	147.0-161.0[b]
K (mEq/l)	4.4	4.2	4.2	4.0	3.7-4.9[b]
Alkp (IU/l)	4.8			12.5	10.0-93.0[b]
Glucose (mg/dl)		101.8	153.6	157.2	70.0-150.0[b]

[a] From Kocan et al. (1985).

[b] From Fuller et al. (1985).

[c] From Schalm (1965).

[d] From Kaneko (1980) and Bentinck-Smith (1983).

This division may account for some of the differences observed between bobcats sampled in their study and with bobcats sampled in the other studies.

Normal leukocyte values for domestic cats range from 5.5-25 x 10^3/ml (Schalm 1965, Kaneko 1980 and Bentnick-Smith 1983) which is similar to blood values for bobcats in this study and in studies by Fuller et al. (1985) and Kocan et al. (1985). Ranges listed for lymphocytes, monocytes and eosinophils for house cats are 1.5-7.0, 0.0-0.9 and 0.0-1.5 x 10^3/ml, respectively, and appear to be generally lower than those values obtained for wild bobcats. No neutrophils were observed in the blood samples from bobcats in this study, but the values reported by Fuller et al. were considered high in comparison to normal values for domestic cats. They felt the elevated neutrophil values were probably due to the excited state and possible injuries inflicted on captured bobcats. Infection may also cause elevated neutrophil values (Picton pers. comm.). Neutrophil values reported by Kocan et al. were slightly lower than those listed by Fuller et al. (Table 26).

BUN values in wild bobcats appear slightly higher than the range listed for domestic cats (5.0-30.0). BUN values appear high in comparison with wild wolves (21 ± 10 mg/dl for males (n = 22), 14 ± 5 mg/dl for females (n = 10)) (Seal et al. 1975) and with beagles (14 ± 3 mg/dl, n = 200) as well (Brunden et al. 1970). This suggests an exceptionally high dietary intake of protein (Seal et al. 1975) by bobcats.

Glucose values were not determined for bobcat blood samples in this study, but Fuller et al. (1985) and Kocan et al. (1985) found glucose levels that were, in some of the bobcat blood samples they analysed, above the range reported for domestic cats. Fuller et al. suggested that the effect of the immobilizing drugs and stress - which increases blood glucose levels (Vander et al. 1980) - may have caused the high glucose levels observed.

Hematological and blood chemical values reported for wild-trapped bobcats must be interpreted carefully because of the stress induced on animals restrained in steel-foothold traps, stress associated with immobilization and use of ketamine hydrochloride as an immobilant (Kaneko 1980 and Kocan et al. 1985). Variations in these values may also reflect variations in nutritional status due to seasonal differences in parameters such as mineral availability.

Because progesterone is also manufactured by the adrenal cortex (Vander et al. 1980), the variation observed in individual bobcat progesterone levels may be a response to the trap-induced stress more so than to the stage of the reproductive cycle. The secretion pattern of progesterone during times of stress may be somewhat similar to that of other adrenal cortex hormones, e.g., plasma cortisol (Short pers. comm.).

CONCLUSIONS AND RECOMMENDATIONS

Although all of the population indices applied in this study (home range size, distance between consecutive radio locations, trap effort, lagomorph counts, scent post visitations and harvest trend analyses) have limitations, they all indicated a relatively large decline in bobcat densities on the Hook Ranch study area from 1983-1984 to 1986-1987. This apparent decline was probably a response to a crash in the lagomorph population. The low lagomorph population has apparently caused changes in movement patterns, use of habitat and diet on the study area by bobcats. The decreased bobcat population was reflected in increased home range sizes, increased distances between consecutive radio locations, decreased ovulation rates, decreased *in utero* litter sizes, decreased overall total harvest and a low proportion of kittens occurring in the fur harvest.

Giddings (1986) calculated an estimated density of 1 bobcat/16-22 km^2 in 1983-1984 on the Hook Ranch study area. If this density approximated the true density, then my indices indicated a population decline of 35-80% from 1983-1984 to 1986-1987, or 1 bobcat/28-85 km^2. This density estimate may be low as indicated by the presence of individuals not captured on the study area. Harvest levels on the Hook Ranch study area do not appear to have been excessive and, therefore, could not be implicated as a cause in the bobcat population decline.

Current management strategies including a regulated harvest, mandatory pelt tagging and annual harvest assessment should be continued. Records of locations of bobcat kills should be kept to identify areas where high mortality occurrs. Bobcat carcasses should be collected a minimum of every 3 to 5 years to assess age and fecundity trends relative to food availability and harvest pressure.

REFERENCES CITED

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Annon. 1980. Western Sun. Montana solar and weather information. Portland, Oregon. 47pp.

Annon. 1985. Climates of the States. Gale Research Co., Detroit, Michigan. 1:639-666.

Alt, D. D. and D. W. Hyndman. 1986. Roadside geology of Montana. Mountain Press, Missoula, Montana. 427pp.

Bailey, T. N. 1972. Ecology of bobcats with special reference to social organization. Ph. D. Thesis, Univ. Idaho, Moscow. 82pp.

______. 1974. Social organization in a bobcat population. J. Wildl. Manage. 38:435-446.

Beasom, S. L. and R. A. Moore. 1977 Bobcat food habit response to a change in prey abundance. S. W. Nat. 21:451-457.

Bentinck-Smith, J. 1983. A roster of normal blood values for dogs and cats. Pages 1206-1215 in R. W. Kirk, ed. W. B. Saunders Co., Philadelphia, Pennsylvania.

Berg, W. E. 1979. Ecology of bobcats in northern Minnesota. Proc. Bobcat Res. Conf., Natl. Wildl. Fed. Sci. Tech. Ser. 6:55-61.

Brunden, M. N., J. J. Clark and M. L. Sutter. 1970. A general method of determining normal ranges applied to blood values for dogs. Amer. J. Clin. Pathol. 53:332-339.

Brady, J. R. 1979. Preliminary results of bobcat scent station transects in Florida. Pro. Bobcat. Res. Conf., Natl. Wildl. Fed. Sci. Tech. Ser. 6:101-103.

Brainerd, S. M. 1985. Reproductive ecology of bobcats and lynx in western Montana. M.S. Thesis, Univ. Montana, Missoula. 85pp.

Buie, D. E., T. T. Fendley and H. H. McNab. 1979. Fall and Winter ranges of adult bobcats on the Savannah River, Plant, South Carolina. Pro. Bobcat Res. Conf., Natl. Wildl. Fed. Sci. Tech. Ser. 6:42-46.

Byers, R.C., R. K. Steinhorst and P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48:1050-1053.

Cochron, W. G. 1954. Some methods for strengthening the common X^2 test. Biometrics. 10:417-451.

Coles, E. H. 1974. Veterinary clinical pathology. Pages 40-98 in W. B. Saunders Co., Phildelphia, Pennsylvania.

Crowe, D. M. 1972. The presence of annuli in bobcat tooth cementum layers. J. Wildl. Manage. 36:1330-1332.

_____. 1975. Aspects of aging, growth, and reproduction of bobcats from Wyoming. J. Mammal. 56:177-197.

Erickson, A. W. 1955. An ecological study of the bobcat in Michigan. M. S. Thesis, Michigan State College, East Lansing. 133pp.

Fendley, T. T. and D. E. Buie. 1983. Seasonal home range sizes and movement patterns of adult bobcats on the Savannah River Plant. Abstract #16 in D. D. Everett and D. Miller, eds. Proc. Int. Cat Symp., Kingsville, Texas.

Fritts, S. H. and J. A. Sealander. 1978. Reproductive biology and population characteristics of bobcats (*Lynx rufus*) in Arkansas. J. Mammal. 59:347-353.

Fuller, T. F., W. E. Berg and D. W. Kuehn. 1985. Bobcat home range size and daytime cover-type use in northcentral Minnesota. J. Mammal. 66:568-571.

_______, K. D. Kerr and P. D. Karns. 1985. Hematology and serum chemistry of bobcats in northcentral Minnesota. J. Wildl. Diseases. 21:29-32.

Gashweiler, J. S., W. L. Robinette and O. W. Morris. 1961. Breeding habits of bobcats in Utah. J. Mammal. 59:347-353.

Giddings, B. J. 1986. Home range size, movements and habitat use of bobcats in a prairie rangeland habitat. M. S. Thesis, Montana State Univ., Bozeman. 64pp.

Gilmer, D. S., L. M. Cowardin, R. L. Duval, L. M. Mechlin, C. W. Schaffer and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife telemetry studies. U. S. D. I./U. S. Fish Wildl. Ser. Res. Publ. 140. 19pp.

Griffith, M. A., T. T. Fendley and M. H. Smith. 1983. Influence of density on movement, behavior and home range size of adult bobcats on the Savannah River Plant. Abstract #17 in D. D. Everett and D. Miller, eds. Proc. Int. Cat Symp., Kingsville, Texas.

Hall, H. T. 1973. An ecological study of the bobcat in southern Louisiana. M. S. Thesis, Louisiana State Univ., Baton Rouge. 132pp.

_____, and J. D. Newsom. 1976. Summer home ranges and movements of bobcats in bottomland hardwoods of southern Louisiana. Proc. Annu. Conf. S. E. Assoc. Fish Wildl. Agencies. 30:427-436.

Hayne, D. W. 1949. Calculation of size of home range. J. Mammal. 30:1-18.

Johnson, N. F. and D. S. Holloran. 1985. Reproductive activity of Kansas bobcats. J. Wildl. Manage. 49:42-46.

Kaneko, J. J. 1980. Clinical biochemistry of domestic animals. 3rd ed. Academic Press, New York. 832pp.

Kitchings, J. T. and J. J. Story. 1978. Preliminary studies of bobcat activity patterns. Proc. Ann. Conf. S. E. Assoc. Fish Wildl. Agencies. 32:53-59.

__________, and _____. 1984. Movements and dispersal of bobcats in east Tennessee. J. Wildl. Manage. 48:957-961.

______, S. J. Sweeney, J. R. Aldredge and J. D. Brittell. 1984. Autumn and winter food habits of bobcats in Washington state. Great Basin Nat. 44:70-74.

______, J. D. Brittell and S. J. Sweeney. 1985. Population characteristics of bobcats in Washington state. J. Wildl. Manage. 49:721-728.

Knowles, P. R. 1981. Habitat selection, home range size, and movements of bobcats in northcentral Montana. M. S. Thesis, Univ. Montana, Missoula. 55pp.

_______. 1985. Home range size and habitat selection of bobcats (Lynx rufus) in north-central Montana. Can. Field-Nat. 99:6-12.

Knowlton, F. F. and W. M. Tzilkowski. 1979. Trends in bobcat visitations to scent-station survey lines in the western United States, 1972-1978. Proc. Bobcat Res. Conf., Natl. Wildl. Fed. Sci. Tech. Ser. 6:8-12.

Kocan, A. A., E. F. Blouin and W. G. Bertis. 1985. Hematologic and serum chemical values for free-ranging bobcats (Felis rufus) (Schreber), with reference to animals with natural infections of Cytauxzoon felis (Kier), 1979. J. Wildl. Diseases. 21:190-192.

Lack, D. 1948. The significance of litter size. J. Anim. Ecol. 17:45-50.

Laundre, J. W., T. D. Reynolds and S. T. Knick. 1987. Accuracy of daily point relocation in assessing real movement of radio-marked animals. J. Wildl. Manage. 51:937-940.

Lehner, P. N. 1979. Handbook of ethological methods. Garland SPTM Press, New York. 403pp.

Lembeck, M. and G. I. Gould, Jr. 1979. Dynamics of harvested and unharvested bobcat populations in California. Proc. Bobcat Res. Conf., Natl. Wildl. Fed. Sci. Tech. Ser. 6:53-54.

Litvaitis, J. A. 1984. Bobcat movements in relation to prey density. Ph. D. Thesis, Univ. Maine, Orono. 103pp.

__________, J. A. Sherburne and J. A. Bissonette. 1986. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Manage. 50:110-117.

__________, J. A. Major and J. A. Sherburne. 1987. Influence of season and human-induced mortality on spatial organization of bobcats (Felis rufus) in Maine. J. Mammal. 68:100-106.

Lonner, T. N. and D. E. Burkhalter. 1983. Telemetry data analysis (TELDAY) users manual. Montana Dept. Fish, Wildl. Parks, Bozeman. 14pp.

Marcum, C. L. and D. O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44:963-968.

Marshall, A. D. 1969. Spring and summer movements and home ranges of bobcats in the coastal plain of South Carolina. M. S. Thesis, Univ. Georgia, Athens. 52pp.

________, and J. H. Jenkins, 1966. Movements and home ranges of bobcats in the upper coastal plain of west-central South Carolina. Proc. 20th Ann. Conf. S. E. Assoc. Game Fish Comm. 20:206-214.

McCord, C. M. and J. E. Cardoza. 1982. Bobcat and lynx. Pages 728-766 in J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management and economics. John Hopkins Univ. Press, Baltimore, Maryland. 1147 pp.

Montagne, C., L. C. Munn, G. A. Nielson. J. W. Rogers and H. E. Hunter. 1982. Montana Agr. Exp. Sta. Bull. 744. Montana State Univ., Bozeman. 95pp.

Murie, O. J. 1954. A field guide to animal tracks. Houghton Mifflin Co., Boston, Massachusetts. 374pp.

Nelson, C. A. 1971. Preliminary investigations on the reproduction in the bobcat (Lynx rufus) in the southeast. M. S. Thesis, Univ. Georgia, Athens. 54pp.

Ott, L. 1984. An introduction to statistical methods and data analysis. 2nd ed. PWS Publishers, Boston, Massachusetts. 775pp.

Payne, G. F. 1973. Vegetative rangeland types in Montana. Dept. of Anim. Range Sci., Montana Agric. Exper. Sta., Bozeman. 16pp.

Provost, E. E., C. A. Nelson and D. A. Marshall. 1973. Population dynamics and behavior in the bobcat. Proc. Int. Symp. World's Cats. 1:42-67.

Rolley, R. E. 1983. Behavior and population dynamics of bobcats in Oklahoma. Ph. D. Thesis, Oklahoma State Univ., Stillwater. 98pp.

______. 1985. Dynamics of a harvested bobcat population in Oklahoma. J. Wildl. Manage. 49:283-292.

______, and W. D. Warde. 1985. Bobcat habitat use in southeastern Oklahoma. J. Wildl. Manage. 49:913-920.

Ross, R. L. and H. E. Hunter. 1976. Climax vegetation of Montana based on soils and climate. U. S. D. A. Soil Cons. Ser. Bozeman, Montana. 64pp.

Roughton, R. D. and M. W. Sweeney. 1982. Refinements in scent-station methodology for assessing trends in carnivore populations. J. Wildl. Manage. 46:217-229.

Schalm, O. W. 1965. Veterinary hematology. Lea and Febiger, Philadelphia, Pennsylvania. 1287pp.

Seal, U. S., L. D. Mech and V. V. Van Ballenburghe. 1975. Blood analyses of wild wolf pups and their ecological and metabolic interpretation. J. Mammal. 56:64-75.

Smith, D. S. 1984. Habitat use, home range and movements of bobcats in western Montana. M. S. Thesis, Univ. Montana, Missoula. 58pp.

Sweeney, S. J. 1978. Diet, reproduction and population structure of the bobcat (Lynx rufus faciatus) in western Washington. M. S. Thesis, Univ. Washington, Seattle. 61pp.

Toweill, D. E. 1986. Resource partitioning by bobcats and coyotes in a coniferous forest. Ph. D. Thesis. Oregon State Univ., Corvallis. 167pp.

U. S. Department of Commerce. 1986. Climatological data - Montana. National Oceanic and Atmospheric Administration, Asheville, North Carolina. 89:10,21.

Vander, A. J., J. H. Sherman and D. S. Luciano. 1980. Human physiology - the mechanisms of body function. McGraw-Hill, Inc. 724pp.

Wade, D. A. and J. E. Browns. 1985. Procedures for evaluating predation on livestock and wildlife. U. S. D. I. U. S. Fish Wildl. Ser. Texas Agr. Exp. Sta. 42pp.

Young, S. P. 1958. The bobcat of North America. Stackpole Co., Harrisburgh, Pennsylvania. 193pp.

Zezulak, D. S. and R. G. Schwab. 1980. Bobcat ecology in a Mohave desert community. Fed. Aid Wildl. Restoration Proj. W-54-R-12, Job IV-4, Calif. Dept. Fish Game, Sacremento. 25pp.

APPENDIX

APPENDIX

Table 27. Avian species observed on the Hook Ranch study area, 1986-1987.

Common Name	Latin Name
Eared Grebe	Podiceps nigricollis
Double-crested Cormorant	Phalacrocorax auritus
Snow Goose	Chen Caerulescens
Canada Goose	Branta canadensis
Mallard	Anas platyrhynchos
Pintail	A. acuta
Gadwall	A. strepera
American Widgeon	A. americana
Shoveler	A. clypeata
Blue-winged Teal	A. discors
Green-winged Teal	A. carolinesis
Cinamon Teal	A. cyanoptera
Canvasback	Aythya valiseria
Redhead	A. americana
Ring-necked Duck	A. collaris
Lesser Scaup	A. marila
Ruddy Duck	Oxyura jamaicensis
American Harrier	Circus cyaneus
Red-tailed Hawk	Buteo jamaicensis
Ferruginous Hawk	B. regalis
Swainson's Hawk	B. swainsoni
Golden Eagle	Aquila chrysaetos
Bald Eagle	Haliaeetus leucocephalus
Prairie Falcon	Falco Mexicanus
Merlin	F. columbarius
American Kestrel	F. sparverius
Sage Grouse	Centrocerus urophasianus
Grey Partridge	Perdix perdix
Great Blue Heron	Ardea herodus
Black-crowned Night Heron	Nyticorax nyticorax
American Coot	Fulica americana
American Avocet	Recurvirostra americana
Killdeer	Charadrius vociferous
Long-billed Curlew	Numenius numenius
Greater Yellowlegs	Tringa melanoleuca
Long-billed Dowitcher	Limnodromus scolopaceus
Wilson's Phalarope	Steganopus tricolor
Northern Phalarope	Lobipes lobatus
Common Snipe	Capella gallinago
Ring-billed Gull	Larus delawarensis
Mourning Dove	Zenaida macroura

Table 27. - concluded

Common Name	Latin Name
Great Horned Owl	Bubo virginianus
Barn Owl	Asio otus
Short-eared Owl	A. flammeus
Burrowing Owl	Athene cunucularia
Common Nighthawk	Chordeiles minor
Common Flicker	Colaptes auratus
Eastern Kingbird	Tyrannus tyrannus
Western Kingbird	T. verticalis
Say's Phoebe	Sayornis saya
Horned Lark	Eremophila alpestris
Barn Swallow	Hirundo rustica
Cliff Swallow	Petrochelidon pyrrhonota
Common Crow	Corvus brachyrhynchos
Red-breasted Nuthatch	Sitta canadensis
Rock Wren	Salpinctes obsoletus
Brown Thrasher	Toxostoma rufum
American Robin	Turdus migratorius
Loggerhead Shrike	Lanius ludovicianus
Starling	Sturnis vulgaris
House Sparrow	Passer domesticus
Western Meadowlark	Sturnella neglecta
Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Red-winged Blackbird	Agelaius phoeniceus
Brewer's Blackbird	Euphagus cyanocephalus
Common Grackle	Quiscalus quiscula
Brown-headed Cowbird	Molothrus aeneus
Northern Oriole	Icterus galbula
Rufous-sided Towhee	Pipilo erythrophthalmus
Savannah Sparrow	Passerculus sandwichensis
Grasshopper Sparrow	Ammodramus savannarum
Lark Bunting	Calamospiza melanocorys
Vesper Sparrow	Pooecetes gramineus
Dark-eyed Junko	Junko aiken
Tree Sparrow	Spizella abrorea