



Home range size, movements and habitat use of bobcats in a prairie rangeland environment
by Brian Joseph Giddings

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

Montana State University

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Abstract:

A radio telemetry study of bobcats (*Felis rufus*) was conducted in eastern Montana between June 1983 and September 1984 to determine home range size, movements, and habitat use. A total of 154 radio locations were obtained on one adult male and four adult female bobcats. Calculated mean home range size was 27.6 km² for the females and 4.3 km² for the male. Seasonal movements were greatest during winter months, probably as a result of breeding activity. Use of badlands, creek bottoms, and stock reservoirs was greater than expected while the open sagebrush/grassland habitat appeared to be avoided. Characteristics of the badlands habitat suggest it served as security cover for bobcats. Bobcat harvest levels in the study area during 1977-85 seemed to be within sustainable yield limits. Decreases in bobcat numbers due to a decreased prey base or increases in numbers of trappers could change this relationship. A bobcat population trend index was developed and initiated in conjunction with lagomorph head light surveys. The advantages of eliminating outliers and identifying core areas when accessing annual and seasonal range delineations and habitat utilization are discussed.

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IN A PRAIRIE RANGELAND ENVIRONMENT

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Brian Joseph Giddings

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of the requirements for the degree

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APPROVAL

of a thesis submitted by

Brian Joseph Giddings

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.

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TABLE OF CONTENTS

	Page
APPROVAL	ii
STATEMENT OF PERMISSION TO USE	iii
VITA	iv
ACKNOWLEDGMENTS	v
TABLE OF CONTENTS	vi
LIST OF TABLES	vii
LIST OF FIGURES	ix
ABSTRACT	x
INTRODUCTION	1
DESCRIPTION OF STUDY AREA	4
Hook Ranch	4
METHODS	11
RESULTS	18
Trapping and Density Estimates	18
Home Range Size and Movements	18
Habitat Use	25
Population Trend Analysis	33
DISCUSSION	38
Population Density	38
Home Range Size	40
Movements	44
Habitat Use	44
Population Trend Analysis	47
Management Considerations	48
LITERATURE CITED	51
APPENDIX	57

LIST OF TABLES

Table		Page
1	Physical characteristics, number of locations, and fate of bobcats captured on the Hook Ranch study area	19
2	Individual home range sizes (km ²) of instrumented bobcats	21
3	Estimated bobcat home range sizes (km ²) based on the number of animal locations (N)	23
4	Individual bobcat home range sizes (km ²) by seasonal period (breeding-non/breeding)	26
5	Distribution of distances between consecutive radio locations of 14 days or less and average distance traveled by adult bobcats by sex and season	27
6	Distribution of distances between consecutive radio locations of 14 days or less and average distance traveled by adult bobcats by sex and seasonal period	28
7	Cover type categories, percent availability, and percentage of bobcat locations falling within the cover types for all bobcats	30
8	Analysis of all bobcat home ranges comparing habitat availability and use based on 100%, 90%, and 50% of relocations	32
9	Comparisons between roughness availability and use within individual bobcat home ranges within areas of increasing use	33
10	Productivity of bobcat lures used in scent-post survey with visitation rate/lure type	35

LIST OF TABLES-Continued

Table		Page
11	Monthly lagomorph densities estimated from head light surveys	36
12	Bobcat harvest numbers by region, hunting district, Hook Ranch, and study area for the period 1977-1985 . . .	37
13	Home range size estimates for bobcats from several regions of the United States	39
14	Mammal species present on the Hook Ranch study areas (Burt and Grossenheider 1976, Hoffman and Pattie 1968)	58
15	Physical measurements of bobcats captured in eastern Montana, Hook Ranch, Montana, 1983	59
16	Vegetational characteristics and species composition of delineated cover types from Pfister plots, shown in % a, b	60
17	Vegetational characteristics of delineated cover types from Daubenmire plots, percent canopy coverage) ^{a, b}	61
18	Species list and species composition of plants identified in 0.1 m ² Daubenmire plots per cover type on the Hook Ranch Study Area, Montana	62

LIST OF FIGURES

Figure		Page
1	Location of study area in eastern Montana	5
2	The Hook Ranch study area	6
3	Home ranges of study animals in the Hook Ranch study area between March 1983 and January 1985	22
4	Bobcat F1637 home range illustrating areas of intensive use based on the percentage (100%, 905, 509%) of locations used (Harestad, 1981)	24

ABSTRACT

A radio telemetry study of bobcats (Felis rufus) was conducted in eastern Montana between June 1983 and September 1984 to determine home range size, movements, and habitat use. A total of 154 radio locations were obtained on one adult male and four adult female bobcats. Calculated mean home range size was 27.6 km^2 for the females and 4.3 km^2 for the male. Seasonal movements were greatest during winter months, probably as a result of breeding activity. Use of badlands, creek bottoms, and stock reservoirs was greater than expected while the open sagebrush/grassland habitat appeared to be avoided. Characteristics of the badlands habitat suggest it served as security cover for bobcats. Bobcat harvest levels in the study area during 1977-85 seemed to be within sustainable yield limits. Decreases in bobcat numbers due to a decreased prey base or increases in numbers of trappers could change this relationship. A bobcat population trend index was developed and initiated in conjunction with lagomorph headlight surveys. The advantages of eliminating outliers and identifying core areas when accessing annual and seasonal range delineations and habitat utilization are discussed.

INTRODUCTION

In response to the recent reclassification of the bobcat (Felis rufus) from predator to furbearer status in most western states, the bobcat has become a target species for intensive research efforts by state wildlife management agencies. According to McCord and Cardoza (1982), recognition of the bobcat's predatory role in ecosystems, a tremendous increase in the value of bobcat pelts, and listing of the bobcat in Appendix II of the Convention on International Trade in Endangered Species (CITES) have all contributed to the need for careful management of the species. State wildlife management agencies were, therefore, politically and economically motivated to reclassify the bobcat to justify harvest regulations under CITES and to obtain federal financial support for research. The Bobcat Research Conference Proceedings (1979), Stiver (1982), and McCord and Cardoza (1982) provide current reviews of federal authority over state bobcat management and describe the intensity of current research.

The bobcat received furbearer status in Montana in 1977, prior to which bobcat research in the state was limited. In the late 1950's, bobcat and coyote movements were compared (Robinson and Grand 1958), and during the 1970's an uncompleted telemetry study was attempted in

southeastern Montana (Phillips 1976 in Knowles 1981). These efforts were deemed inadequate to satisfy CITES requirements.

The Montana Department of Fish, Wildlife and Parks (MDFWP) initiated bobcat research in 1977 with the appointment of the first state furbearer biologist and a mandatory bobcat pelt tagging program. Hash (1981) is developing maps illustrating gross habitat characteristics along with corresponding bobcat population densities and distribution in Montana from harvest and observation data. A 5-year mandatory bobcat carcass collection program was in operation from 1978-82 to determine sex and age structure, food habits, reproductive status and history, general condition, and disease and parasite loads in Montana bobcats (Hash 1981, Greer and Palmisciano 1981). From 1979-81 a study of habitat selection, home range size and movements was conducted in the Charles M. Russell National Wildlife Refuge (CMR) in northcentral Montana (Knowles 1981). A 5-year study examining the ecology of bobcats and lynx (Felis lynx) in a coniferous forest environment in western Montana was also initiated in 1979 by the MDFWP. The first 3 years of this study concentrated on investigating habitat use, home range size and movements of bobcats and lynx (Smith 1984). The last 2 years emphasized bobcat and lynx breeding ecology and an analysis of bobcat carcass data collected between 1978-82

analysis of bobcat carcass data collected between 1978-82 (Brainard 1985).

This project, the ecology of the bobcat in a prairie rangeland-agricultural environment in eastern Montana, was initiated in 1983 by the MDFWP to supplement research in western Montana. The study area was selected because it represented one of the habitat complexes in which bobcat population densities and harvest numbers were highest in the state (Cada 1983). Study objectives and design parallel those of studies in the coniferous forest environment in western Montana (Cada 1983).

My study, the first phase of the 5-year project, has three primary objectives: 1) to determine annual and seasonal home range size of individual radio collared bobcats; 2) to determine annual and seasonal movement patterns of individual radio collared bobcats; and 3) to describe habitat availability and use within individual bobcat home ranges. Secondary objectives included: 1) developing a bobcat population trend field index; and 2) determining the proportion of radio collared bobcats harvested in the study areas.

DESCRIPTION OF STUDY AREA

Hook Ranch

The Hook Ranch study area was located in Rosebud County, 32 km northwest of Miles City and comprised 250 km² of prairie rangeland habitat (Fig. 1). This area was characterized by a continuous low elevation ridge extending across the study area in a northwest-southeast direction (Fig. 2). Drainages originating along the east side of this ridge flow into South Sunday Creek while creeks on the west side flow into Little Porcupine Creek. Both creeks are part of the lower Yellowstone River system. Dryland wheat farming occurred along the northern boundary of the study area and stock reservoirs were scattered throughout.

The Hook Ranch lies within the unglaciated eastern sedimentary plains of Montana (Montagne et al. 1982). Soils within the study area were formed as weakly developed, shallow clayey residuum from calcarous platy shale (Montagne et al. 1982). Ross et al. (1976) and Montagne et al. (1982) consider this area a silty-clayey range site complex characterized by undulating and strongly sloping to steeply dissected terrain interspersed with breaks. Elevations ranged between 868 and 994 m within the study area.

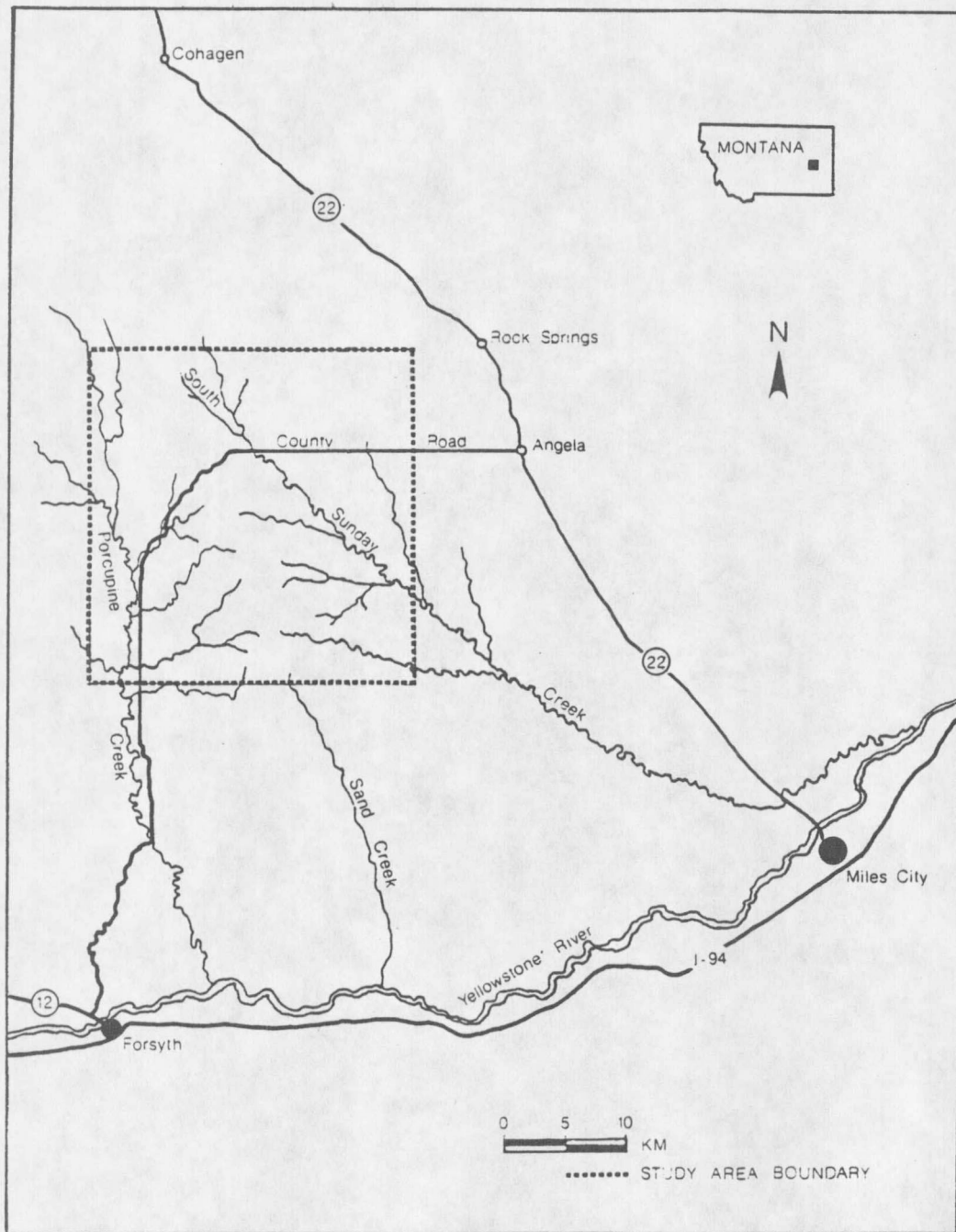


Figure 1. Location of study area in eastern Montana.

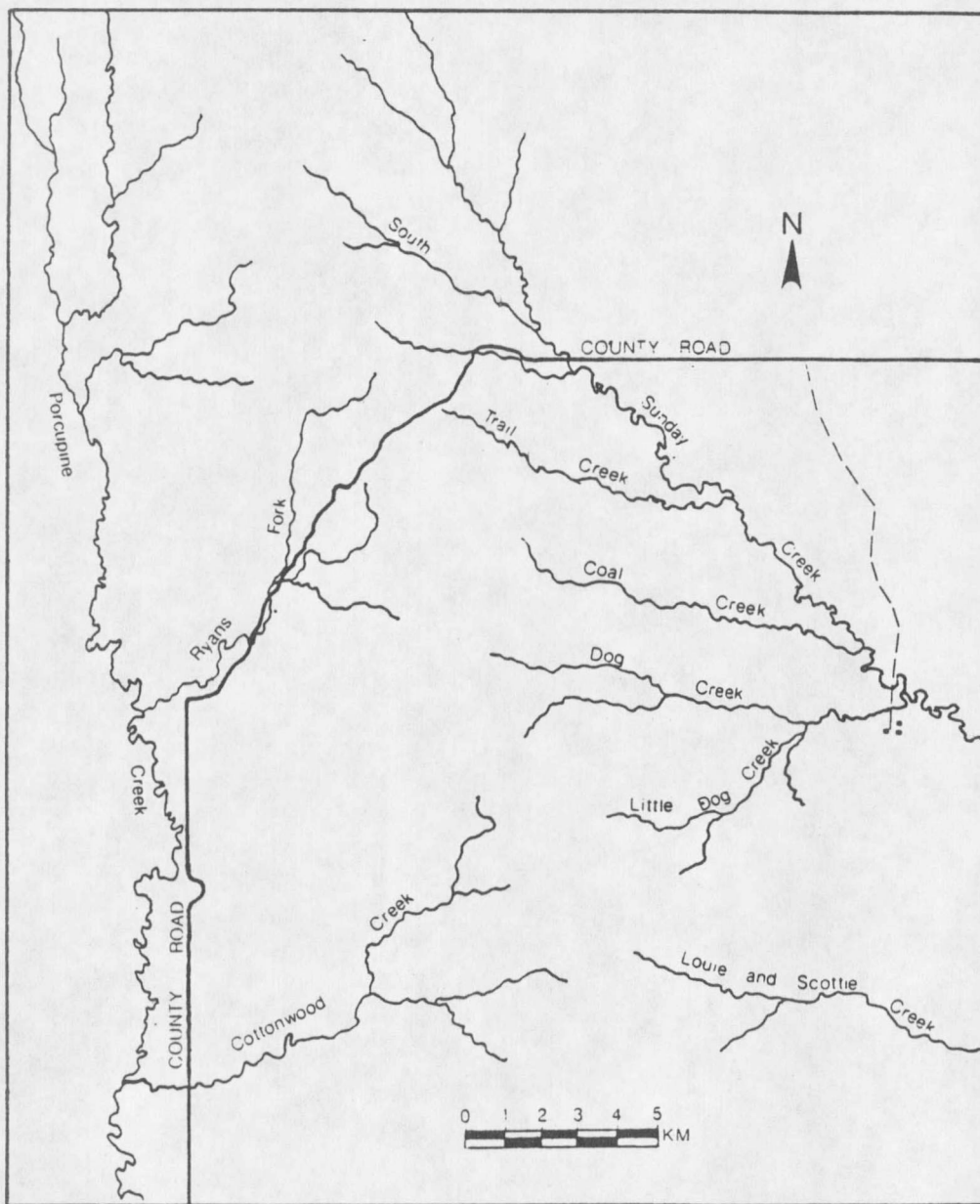


Figure 2. The Hook Ranch study area.

The average annual temperature for the area is 6.1 C with the long-term July average of 20.0 C and long-term January average of -7.4 C. Average annual precipitation is 30.5 cm with 80% of this amount falling during April to September (U.S. Climatological Data 1984, SCS Technical Guide 1981). Snowfall averages 71.1 cm annually, occurring mainly during late winter or early spring (SCS Technical Guide 1981). Winds are common throughout the year although most prevalent during the spring. During the study period, the annual temperature and precipitation departed from normal by +0.6 C and -26.0 cm, respectively, in 1983. In 1984, these departures were +0.3 C and -26.3 cm, respectively.

Payne (1978) described the study area as a sagebrush-saltbrush rangeland type. Dominants in the climax vegetation include big sagebrush (Artemisia tridentata), silver sagebrush (A. cana), Nuttall saltbrush (Atriplex nuttallii), western wheatgrass (Agropyron smithii), bluebunch wheatgrass (A. spicatum), needle and thread (Stipa comata), blue grama (Bouteloua gracilis), native legumes, and threadleaf sedge (Carex filifolia) (Ross and Hunter 1976).

Dominant vegetation, however, have been replaced or reduced on many sites on the study area due to livestock grazing pressure. Some common species that increase with grazing pressure include Sandberg's bluegrass (Poa

sandbergii), fringed sagewort (A. frigida), plains pricklypear (Opuntia fragilis), broom snakeweed (Gutierrezia sarothrae), and pussytoes (Antennaria spp.) (Ross and Hunter 1976). Tree species such as plains cottonwood (Populus sargentii) and willow (Salix spp.) were present but restricted to areas bordering stock reservoirs and creek drainages.

Major mammalian carnivores present on the Hook Ranch include bobcats, coyotes (Canis latrans), and red fox (Vulpes vulpes). Indigenous ungulates are represented by mule deer (Odocoileus hemionus) and pronghorns (Antilocapra americana). Small mammals include white-tail jackrabbits (Lepus townsendii), desert cottontails (Sylvilagus auduboni), mountain cottontails (S. nuttallii), and various rodent species (Peromyscus spp., Microtus spp.). Black-tailed prairie dogs (Cynomys ludovicianus) are found in the surrounding area although none were observed in the study area. Bird species occurring on the study area include game species such as sage grouse (Centrocercus urophasianus) and a variety of waterfowl species (Anas spp., Branta canadensis). Refer to Appendix Table 14, for a more complete species list of the mammals present.

The Hook Ranch was first fenced and improved by the Lockie brothers during the early 1900's (Corbin pers. comm.). Sheep were grazed almost exclusively on the ranch

until about 1920 when they were replaced by cattle. The Western Cattle Company purchased the ranch in 1959 and continued to run cattle. Currently, the ranch has an absentee ownership status and provides domestic cattle grazing on a leased basis. Approximately 1700 head of cattle were grazed in or adjacent to the study area during the summer months.

Intensive predator control programs directed towards coyotes, potential competitors of bobcats, have not been conducted in the study area since the early 1920's (Corbin pers. comm.). However, extensive coyote control programs have been implemented on surrounding sheep ranches. The Killen Ranch to the north has had an active control effort since 1914. Schladweiler and Dood (1980) reported on an experimental coyote removal program conducted from 1976-78 on an area southwest of the Hook Ranch study area. Apparently, aerial shooting occurred before and after this removal program.

Bobcat harvest averaged 20 per year during eight trapping seasons (1977-1985) on the entire Hook Ranch. Harvest numbers increased from one individual during the 1977-78 season to 52 during the 1984-85 season (MDFWP P.R. reports, Helena). Although access into the study area is provided through primitive roads and jeep trails from all directions, snow and mud during late winter through early spring close the majority of these to vehicle traffic and

thereby reduce trapper access. The portion of the ranch in which the study area was located has seldom been utilized by more than one or two trappers during any of the past 8 years.

METHODS

Field work during this study was conducted from June 1983 through September 1984. However, all study animals were captured during March and April of 1983 by private trappers under contract with the MDFWP. Bobcats were captured in #3 and #4 unpadded steel jaw traps, and in one or two instances, wire snares originally set for coyotes. Scent lures were used at all trap sets.

All captured bobcats were processed by department biologists. Animals were immobilized with injections of ketamine hydrochloride (Ketaset) at a dosage of 22 mg/kg. After immobilization, ear tags and radio transmitters were attached and general biological data such as weight, age and sex class, and physical measurements were taken and recorded. Lightweight radio collars (127 g) were manufactured by H. Hash (MDFWP, Missoula). Prior to release, each bobcat was injected with an antibiotic (Combiotic) to prevent infection from any injury sustained during trapping or handling.

Bobcat relocations were attained by ground triangulation and fixed wing aircraft (Piper Supercub) flights. Grandfixes were attempted on a daily basis. Aircraft were fitted with a two-element directional antenna mounted on each wing strut. Flights were generally made at 1-2 week intervals. Fixed-antenna

receiving stations were used briefly on an experimental basis.

Aerial, ground and capture site locations were combined for individual bobcats to determine annual and seasonal home range sizes and movements. Each relocation was recorded using coordinates from the Universal Transverse Mercator (UTM) grid system on U.S. Geological Survey (USGS) 1:24,000 scale topographical maps. The date, time, weather, habitat, and activity of the bobcat were also recorded.

Records were kept of all unidentified bobcat tracks and visual sightings throughout the field period. These were recorded as UTM coordinates and plotted to show additional bobcat activity within the study area.

UTM coordinates were entered into two computer programs designed for constructing animal home ranges and illustrating movements. The Telemetry Data Analysis (TELDAY) program developed by Lonner and Burkhalter (1983) was used to make calculations and plots of individual bobcat home range sizes and movements. This program employs the convex polygon method (Hayne 1949) for determining home range size and calculates movements as the straight-line distance between locations. Seasonal home range sizes and movement patterns were also generated. Seasons were designated as winter (December-February), spring (March-May), summer (June-August), and

fall (September-November) following Smith (1984). In addition, I investigated an alternate seasonal division, breeding (February-April) and non-breeding (May-January) periods. Seasons and seasonal periods were delineated and compared for differences in home range size and movement patterns. Movements were determined by comparing distances between consecutive locations falling within a 14-day period similar to Smith (1984) for comparison with bobcat movements in western Montana. Differences in seasonal movements were also calculated. Differences in total and seasonal home range sizes and movement patterns were tested using the Chi-square distribution.

A second program, HOME (Harestad 1981) was used to analyze the bobcat location data in a slightly different manner. This program identifies and illustrates areas of intensive use in addition to eliminating extreme locations. HOME uses the modified minimum area method to calculate home range size, incorporating a modification which allows for deletion of extreme locations by using the sum of distances from a location to all other locations. Once such a location is eliminated the next extreme location is identified on the basis of the remaining locations. Use of specific areas within individual home ranges was examined by selecting subsets of relocations via sequential elimination of extremes or outliers. According to Harestad (1981), home ranges

defined by 100% of the locations represent a "total use" area which is likely to be inflated by extreme locations. Ninety percent of the locations would indicate an area "frequently used", and 50% of the locations would indicate the area of "intensive use". Using this approach, I compared the size and array of habitat features in each subset within each individual home range.

In this study, habitat was defined as a combination of vegetation and terrain complexity (roughness). Vegetation was classified by cover type. Four cover types were delineated: open sagebrush/grassland, badlands, creek bottom, and stock reservoir. Cover type descriptions were based on sampling 20 sites representative of each type. Percent plot coverage values for total shrub cover and for each shrub species present were estimated in a Pfister plot (Pfister et al. 1977) at each site. Within each Pfister plot, twelve 0.1 m^2 Daubenmire (1959) plots were sampled. Percent plot coverage values were estimated for total plant coverage, shrubs, grasses, forbs coverage by individual plant species, soft and hard litter, bare ground, rock, and lichens.

Cover type availability was determined using a nonmapping technique developed by Marcum and Loftsgaarden (1980). Using this method, a number of random points were scattered throughout an individual bobcat home range and

then each point was assigned to the habitat category or cover type in which it fell. USGS topographic maps, aerial photos and ground checks were used to assure accurate designations. Random points were generated on the Scientific Subsystem (SSS), transferred to the Honeywell (CP6), converted into TELDAY format, and plotted on acetate overlays. The number of random points found to be sufficient to accurately represent the available cover types was determined by adding new points (generally in increments of 50) to the analysis until the percent composition of the cover types represented did not change with the addition of more points. Availability was determined within individual home ranges defined by three subsets of locations (100%, 90%, 50%) and between individual total (100%) home ranges. Habitat use was determined by recording the cover type classification at each bobcat location.

Habitat use was evaluated using the Montana State University Statistics Package (MSUSTAT) (Lund 1983). A technique described by Neu et al. (1974) was used to compare use with availability. Chi-square analysis was used to identify differences between subsets and between home ranges used by different bobcats.

A roughness index (Beasom et al. 1983) was developed to measure quantitatively the availability and use of terrain roughness within individual home ranges. A circle

representing approximately 10 ha² on a USGS topographic map was outlined on a clear plastic sheet and marked with 21 evenly spaced dots. The center dot was placed on individual random points within home ranges to determine availability and on bobcat relocations to determine use. A roughness value (0-21) was assigned to each random point, the value depending on how many dots intersected contour lines on a USGS topographic contour map. An area assigned a high value was considered to have much more broken or steep terrain than one with a low value.

Differences in terrain roughness between random points and bobcat relocations were tested using a Student's t-test. Analysis of variance (AOV) was used in comparisons of home ranges defined by subsets (100%, 90%, 50%) for each individual bobcat and for comparisons among individual home ranges.

A secondary objective of this study was to develop a bobcat population trend index. Three scent-post transect lines, each line containing 20 scent-post stations spaced at 0.5-km intervals, were established and monitored on a regular basis on the Hook Ranch study area. Several commercial lures (Bobcat urine, Cat pack, Pacific call, Catnip, Bobcat gland) were tested to determine which lures had the best potential for attracting bobcats.

Headlight surveys of lagomorphs, the preferred prey of bobcats (Young 1958, Hash 1981), were conducted

throughout the field period on regularly traveled routes. Data reported in this thesis for both the scent-post and headlight surveys represents the first year of a 4-year trial of both techniques.

State bobcat harvest records were examined for the period 1977-85 to estimate the number of bobcats taken in Region 7, hunting district (H-D) 713, the entire Hook Ranch, and the immediate study area. During the fall of 1983, form letters requesting ear tag numbers and the return of radio collars from trapped study animals were sent to all trappers known to be trapping in or adjacent to the study area.

RESULTS

Trapping and Density Estimates

Eight bobcats were captured and fitted with radio transmitters during spring 1983 (Table 1). All bobcats were trapped after 500 trap-nights of effort (62.5 trap-nights per capture). The physical characteristics of captured bobcats are provided in Appendix Table 15. Individual bobcats were followed over periods ranging from 2 weeks to 19 months and a total of 172 radio locations were recorded. By the end of the study period, one radio transmitter was detached from the collar, five collars apparently had ceased functioning, and two animals had operational radio collars.

Although a minimum density estimate was calculated for the study area, an investigation of population parameters was not an objective of this study, and, therefore, it should be considered an extremely rough estimate. Based on the number of bobcats captured, home range size information, harvest data, and additional unidentified bobcat activity in the area, I would estimate a population of 11-14 bobcats occupying the study area. These numbers translate into a density of 1 bobcat/16-22 km².

Home Range Size and Movements

Of the eight adult bobcats monitored on the Hook Ranch, 154 radio-locations from five individuals (4

Table 1. Physical characteristics, number of locations, and fate of bobcats captured on the Hook Ranch study area.

Bobcat Number ^{1,2}	Date Captured	Age ³	Weight (kg)	Number of Locations	Last Contact	Fate
M 1488	9 Mar 83	A	8.4	2	24 Mar 83	Unknown
*F 1637	18 Mar 83	A	8.2	45	2 Sept 84	Trapped 8 Dec 85
F 0083	26 Mar 83	A	7.3	2	15 Aug 83	Unknown
*M 0141	2 Apr 83	A	9.5	15	6 Oct 83	Trapped 10 Feb 86
*F 0122	2 Apr 83	A	10.9	15	7 Feb 84	Trapped 1 Jan 85
*F 0102	5 Apr 83	A	8.6	45	2 Sept 84	Trapped 2 Jan 85
M 0063	6 Apr 83	A	11.4	2	23 Jul 83	Unknown
*F 1212	9 Apr 83	A	7.3	34	26 Jun 84	Unknown

¹F = Female, M = Male

²N = Radio Frequency

³J = Juvenile, A = Adult

* Bobcats used in this study

females, 1 male) produced estimates of home range size (Table 2). The spatial distribution of home ranges in the Hook Ranch is illustrated in Figure 3. Home range size estimates for the four females, based on 7 to 19 months per individual, ranged from 20.1 - 33.5 km² with a mean home range size of 27.6 km². The single male occupied an area of 4.3 km² during the 6-month period in which he was monitored. Overall mean home range size was 22.9 km².

Individual bobcat home ranges decreased in size ($\bar{x}$ = 51%, range 26-72%) after extreme locations were eliminated (Table 3). The calculated size of "core" areas within each bobcat home range was between 0.5 km² and 1.0 km². An example of this analysis is given in Figure 4.

Home range overlap was evident between male and female and between female bobcats. Portions of two female home ranges overlapped the male home range. One female home range, overlapped those of two other females.

Seasonal home ranges of females were smaller in spring, summer and fall ($\bar{x}$ = 2.7, range = 0.0-5.8 km²) and larger in winter ($\bar{x}$ = 15.5, range = 5.4-32.2 km²). The male could not be located in winter and spring, but summer and fall estimates were 2.7 km² and 0.8 km², respectively.

Table 2. Individual home range sizes (km^2) of instrumented bobcats. (N) = number of radio locations used to estimate home range size.

Bobcat Number	Year	Winter	Spring	Summer	Fall	Total
F 0102	1983			5.8(8)	1.0(6)	
	1984	8.7(14)	1.4(4)	1.8(7)	5.1(5)	20.1(45)
F 0122	1983			5.6(3)	3.8(7)	
	1984					26.7(15)
F 1212	1983			0.1(3)	1.1(9)	
	1984	32.2(17)	4.2(3)			33.5(34)
F 1637	1983			3.2(8)	3.5(9)	
	1984	5.4(15)	0.0(3)	1.9(4)	2.2(4)	30.1(45)
Female Mean		15.4(46)	1.9(10)	3.1(33)	2.8(40)	27.6(139)
M 0141	1983			2.7(8)	0.8(6)	
	1984					4.3(15)
Male Mean				2.7(8)	0.8(6)	4.3(15)
Overall Mean		15.4(46)	1.9(10)	3.0(41)	2.5(46)	22.9(154)

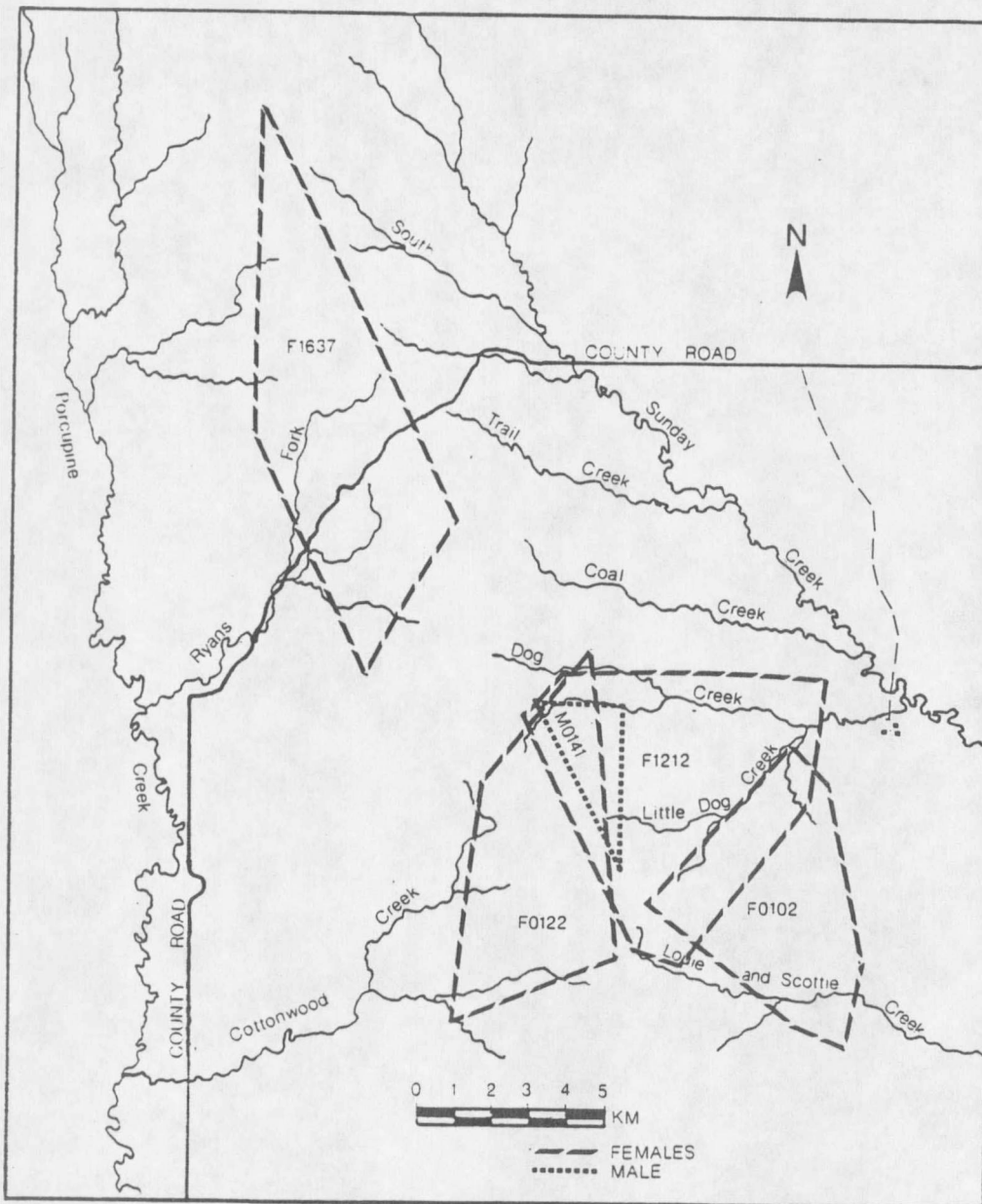


Figure 3. Home ranges of study animals in the Hook Ranch study area between March 1983 and January 1985.

Table 3. Estimated bobcat home range sizes (km²)
based on the number of animal locations (N).

Bobcat Number	Percentage of total bobcat locations		
	100%	90%	50%
F 0102	20.1 (45)	10.8 (40)	1.0 (22)
F 0122	26.7 (12)	7.5 (10)	.2 (6)
F 1212	33.5 (34)	24.8 (32)	.9 (17)
F 1637	30.1 (45)	10.7 (40)	.9 (22)
Female Mean	27.6 (136)	13.5 (122)	.7 (67)
M 0141	4.3 (15)	2.8 (13)	.5 (7)
Overall Mean	22.9 (151)	11.3 (135)	.7 (74)

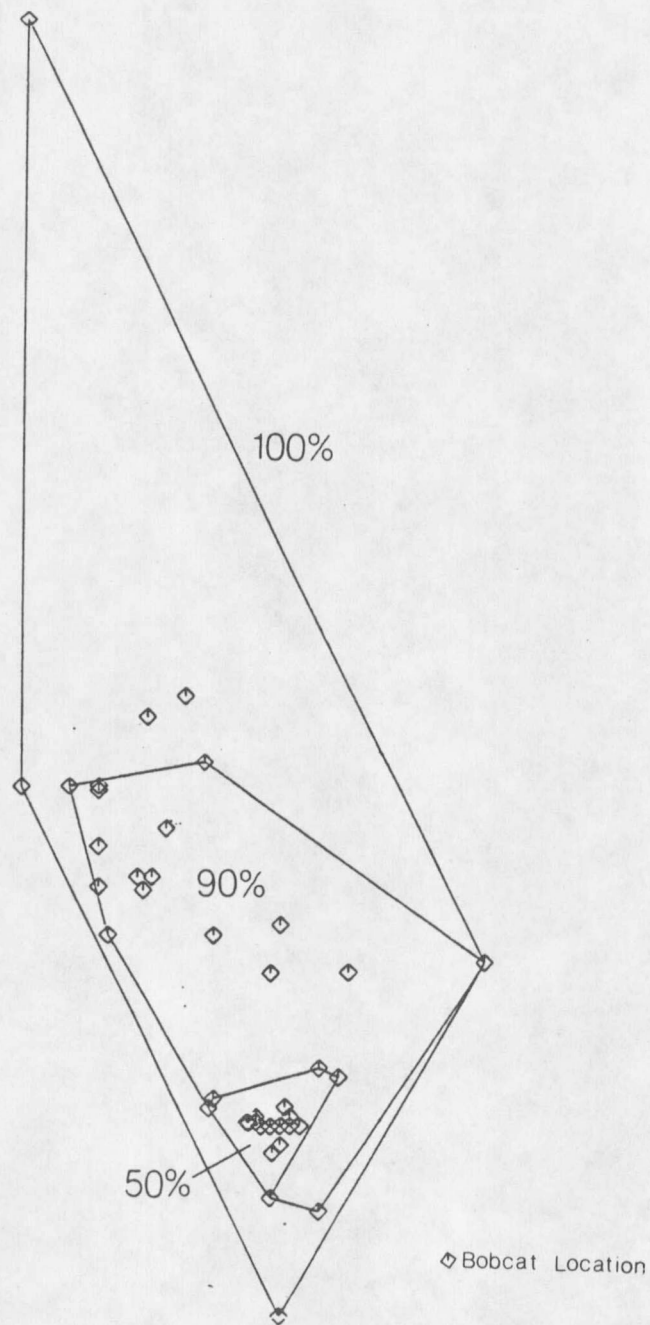


Figure 4. Bobcat F1637 home range illustrating areas of intensive use based on the percentage (100%, 90%, 50%) of locations used (Harestad, 1981).

Seasonal period (non-breeding vs. breeding) home range sizes of females (Table 4) were smaller during the non-breeding period ($\bar{x} = 8.7$, range = 1.6 - 14.7 km²) and larger during the breeding period ($\bar{x} = 12.3$, range = 2.0 - 30.4 km²). Too few relocations were available for the single male to determine differences.

The distribution of distances between consecutive radio locations of 14 days or less was compared for females by season and between females and the single male bobcat for summer and fall (Table 5). Distances averaged 1.6 km and > 90% of distances were < 6 km in all seasons. Seasonally, females traveled greater distances in winter and spring and shorter distances in the fall. The distribution of distances during the summer appeared similar for females and the male. During fall, the male evidently traveled more than the females.

The distribution of distances between consecutive radio locations of 14 days or less was compared for the breeding and non-breeding periods (Table 6). Females appeared to move more, as indicated by frequency of movements > 3 km and mean distance, during the breeding season than during the non-breeding period.

Habitat Use

Based on 154 radio locations from the Hook Ranch, bobcats did not use cover types in proportion to availability. The open sagebrush/grassland type

Table 4. Individual bobcat home range sizes (km²) by seasonal period (breeding/non-breeding). (N) = number of locations.

Bobcat Number	Year	Non-breeding	Breeding	Non-Breeding	Total
F 0102	1983-84 1984-85	10.9(20)	2.0(11)	14.7(13)	20.1(45)
F 0122	1983-84 1984-85	13.4(10)			26.7(15)
F 1212	1983-84 1984-85	1.6(19)	30.4(13)		33.5(34)
F 1637	1983-84 1984-85	4.4(25)	4.6(10)	5.1(8)	30.1(45)
Female Mean		7.6(74)	12.3(34)	9.9(21)	27.6(139)
M 0141	1983-84 1984-85	3.7(14)			
Overall Mean		6.8(88)	12.3(34)	9.9(21)	22.9(154)

Table 5. Distribution of distances between consecutive radio locations of 14 days or less and average distance traveled by adult bobcats by sex and season.

	Number of Locations					Total	Average (km)
	0-1 (km)	1-3 (km)	3-6 (km)	6-9 (km)	>9 (km)		
Females							
Winter	19	18	5	1		43	1.6
Spring	2	3	1		1	7	3.4
Summer	7	11	1			19	1.3
Fall	19	8	3			30	1.3
	—	—	—	—	—	—	—
Total	47	40	10	1	1	99	1.6
Male							
Winter							
Spring							
Summer	2	4				6	1.0
Fall	1	4				5	1.2
	—	—	—	—	—	—	—
Total	3	8				11	1.1
Grand Total	50	48	10	1	1	110	1.5

Table 6. Distribution of distances between consecutive radio locations of 14 days or less and average distance traveled by adult bobcats by sex and seasonal period.

	Number of Locations						
	0-1 (km)	1-3 (km)	3-6 (km)	6-9 (km)	>9 (km)	Total	Average (km)
Females							
Non-breeding	35	25	5			65	1.3
Breeding	12	15	5	1	1	34	2.2
Total	47	40	10	1	1	99	1.6
Male							
Non-breeding	3	8				11	1.1
Grand Total	50	48	10	1	1	110	1.5

represented the most common type available (64% of the pooled home ranges) but on an annual basis, only 29% of the bobcat locations were recorded in this type (Table 7). The badlands type represented 28% of the five home ranges yet, on an annual basis, 53% of the bobcat locations fell into this category. Creeks and reservoirs represented a small portion of the cover types available to the bobcats but were used more than twice as much as expected. Higher than expected use of draws or broken terrain and rock outcrops within the open sagebrush/grassland types was also documented (Table 7).

Vegetation characteristics and species composition of delineated cover types from Pfister and Daubenmire plots are shown in Appendix Table 16 and 17, respectively. A species list and species composition data from the study area from Daubenmire plots are presented in Appendix Table 18.

Seasonal comparisons based on pooled home ranges indicated use of the open sagebrush/grassland was less than expected and use of the badlands was greater than expected in all seasons. The highest use of the open sagebrush/grassland occurred during the spring (37%) and the lowest in the fall (17%). Use of the badlands was greatest during winter (56%) and lowest during summer (48%). Locations in creek bottoms were most frequent in fall (29%). None were recorded during the spring.

Table 7. Cover type categories, percent availability, and percentage of bobcat locations falling within the cover types for all bobcats. (N) = total sample size.

Cover type	% Availability (1134)	% Bobcat Use (154)				
		Winter	Spring	Summer	Fall	Annual
Open sagebrush/grassland	63.7	29.2	37.5	36.6	17.8	28.7
draws/broken	10.3	42.8		13.3	25.0	23.2
rock outcrops	0.3	28.6	16.6	20.0		18.6
Badlands	28.1	56.2	50.0	48.8	53.3	52.6
draws	7.9	18.5	12.5	15.0	8.3	14.0
rock outcrops	0.6			5.0		1.3
Creeks	7.1	14.6		14.6	28.9	17.3
Reservoirs	0.5		12.5			1.3

Reservoirs appeared to be used primarily during the spring. Draws and broken terrain and rock outcrops in the open sagebrush/grassland and badlands were used to a greater extent during winter and summer.

Habitat availability and use in home ranges defined by subsets of locations showed some marked differences for pooled home ranges (Table 8). Changes in habitat availability and composition were evident between the 100% home range and the smaller areas assumed to represent intensive use areas (90%, 50%). Open sagebrush/grassland, creek bottoms and reservoirs decreased in availability while the badlands increased. The distribution of locations among types other than creek bottoms became more similar to availability of types as home range size was decreased. Although distribution of types varied markedly among individual home ranges, a similar trend (decreases in deviations from expected use) is evident as smaller subsets were used to define home range.

The percent of broken terrain, as indicated by the index of roughness was significantly greater ($P < 0.05$) in the 50% home range than in the 100% home range for all bobcat home ranges (Table 9). The mean roughness at bobcat locations also increased from the 100% to the 50% level for each bobcat with the exception of the male. It appears that, in general, availability and use of rough

Table 8. Analysis of all bobcat home ranges comparing habitat availability and use based on 100%, 90%, and 50% of relocations. (N) = sample size.

Cover type	% habitat availability (N = 1134)			% habitat use (N = 154)		
	100%	90%	50%	100%	90%	50%
Open sage/grass	61.6	57.4	34.2	26.8	26.2	22.4
draws/broken	12.6	12.6	13.4	29.8	0.3	35.0
rock outcrops	0.8	1.2	2.2	6.6	6.6	4.6
Badlands	29.6	33.8	60.2	51.0	55.2	53.4
draws	9.4	11.6	17.6	13.2	14.6	7.0
rock outcrops	0.8	0.6				
Creeks	8.0	7.6	5.4	20.2	18.0	24.2
Reservoirs	0.4	0.1		1.8	0.6	

Table 9. Comparisons between roughness availability and use within individual bobcat home ranges within areas of increasing use. (N) = sample size.

Bobcat Number	Roughness Index					
	Availability (N = 1134)			Use (N = 134)		
	100%	90%	50%	100%	90%	50%
F 0102	11.5	12.8	14.4	16.1	16.5	17.1
F 0122	16.8	17.4	20.6	19.5	19.9	20.3
F 1212	12.7	17.7	19.8	17.3	17.8	19.4
F 1637	15.6	16.5	17.6	19.2	19.2	19.7
M 0141	15.6	16.4	16.2	17.1	17.5	16.7
Means	14.4	16.2	17.7	17.8	18.2	18.6

areas coincided at the 50% use level but not at the 100% use level.

Population Trend Analysis

The three scent-post survey lines run during August 1984 produced 34 bobcat visitations in 54 replicated runs (1080 scent-post days). This resulted in a visitation rate of 3.1%. Bobcat gland lure and bobcat urine appeared to attract the highest number of bobcat visits (Table 10).

Headlight surveys on 189.7 km of primitive roads yielded a count of 891 lagomorphs for an average of 2.9 lagomorphs/km during the study period. Lagomorph densities appeared to decrease during this period, from 10.4/km in June of 1983 to 1.4/km in August of 1984 (Table 11).

Trapping records indicate an increase in numbers of bobcats taken in Region 7. H.D. 713, and the Hook Ranch between 1977 and 1985 (Table 12). In two trapping seasons during the study period, no study animals were known to be taken although one female was caught and released by a local trapper. Post study trapping records indicate three study animals were taken, one male and two females. A total of four bobcats were or could have been taken out of the eight originally tagged study animals. Calculating a mortality rate for the study animals of 50% over 3 years translates into a 17% mortality rate per year due to trapping.

Table 10. Productivity of bobcat lures used in scent-post survey with visitation rate/lure type.

<u>Bobcat gland</u>		<u>Bobcat urine</u>		<u>Pacific Call</u>		<u>Catnip</u>		<u>Cat Pack</u>		<u>No lure</u>	
#	scent-posts	visits	#	scent-posts	visits	#	scent-posts	visits	#	scent-posts	visits
60		6	60		3	60		3	60		1
60		7	60		1	60		2	60		0
60		0	60		2	60		0	60		1
Total											
180		13	180		6	180		5	180		4
Visitation Rate											
7.2 %			3.3 %			2.7 %			2.2 %		0.5 %

Table 11. Monthly lagomorph densities estimated from head light surveys.

Month	Jun 83	Jul 83	Aug 83	Oct 83	Nov 83	Jan 84	Feb 84	Jun 84	Jul 84	Aug 84
km traveled	7.4	45.7	8.0	14.4	10.4	25.6	45.6	11.4	57.6	77.4
# of lagomorph/km	10.4	4.0	6.6	4.0	9.9	2.3	1.7	4.5	2.1	1.4

Table 12. Bobcat harvest numbers by region, hunting district, Hook Ranch, and study area for the period 1977-1985.

Trapping Season	Region 7	H.D. 713	Hook Ranch	Study area ¹
1977-78	132	3	1	0
1978-79	159	6	2	2
1979-80	362	16	9	0
1980-81	178	8	4	0
1981-82	219	23	17	4
1982-83	306	37	25	10
1983-84	403	71	50	3
1984-85	693	76	52	1

¹ Minimum estimates from tagging records.

DISCUSSION

Population Density

A number of investigators suggest capture rates can give a relative indication of bobcat densities in a given locale (McCord and Cardoza 1982, Zezulak and Schwab 1980, Lembeck and Gould, Jr. 1979, Sweeney 1978, Crowe 1974, Jones 1977). High trapping success for study animals (62.5 trap nights per capture) suggests a high bobcat density on the Hook Ranch study area during 1983.

Lembeck (1978) concluded that a strong inverse relationship existed between home range size and density during a bobcat study in southern California. The average sized home ranges from radio collared bobcats in this study during 1983-84 compared to the home range sizes reported in Table 13 would indicate a moderate population density on the study area.

General comparisons of trapping success, visual sightings, track observations, and home range sizes for other studies of bobcats in Montana (Smith 1984, Knowles 1981) indicate that the bobcat population density on the Hook Ranch study area was probably higher than densities reported for other areas in Montana.

During the summer of 1984, I had a visual observation of an uncollared adult female, accompanied by a kitten, within the center of a home range occupied by a radio collared female and only 0.5 km from the marked female.

Table 13. Home range size estimates for bobcats from several regions of the United States.

Region	Home Range Estimate ¹ (km ²)	Sex (N)	Reference
Northwest Montana	88 (50-147) 63 (55-70)	F(6) M(2)	Smith (1984)
Northeastern California	43(26-59) 73(39-95)	F(4) M(3)	Zezulak (1981)
Minnesota	38(15-92) 62(13-201)	F(6) M(16)	Berg (1981)
Eastern Montana	27 (20-33) 4	F(4) M(1)	This study
Idaho	19 (9-45) 42 (6-107)	F(8) M(4)	Bailey (1972, 1974)
Northcentral Montana	17 83	F(1) M(1)	Knowles (1981)
Oklahoma	16 43	F(4) M(7)	Rolley (1985)
Utah	16 (9-26) 22 (13-35)	F(3) M(3)	Karpowicz (1981)
Southern California	2 (0-4) 3 (0-6)	F(3) M(9)	Lembeck (1978)
Alabama	1 3	F(6) M(6)	Miller (1980)
Louisiana	1 (0-1) 4 (3-7)	F(3) M(3)	Hall and Newsom (1976)

¹ Responded ranges in parenthesis.

This observation is contrary to what Bailey (1972) reported on the social organization of bobcats in Idaho and may indicate increased tolerance of home range overlap by bobcats of the same sex in moderate to high density populations in eastern Montana.

Home Range Size

Home range size estimates in this study fall well within limits reported elsewhere (Table 13). Female total home range sizes were larger than that of the male, presumably because information collected on the male was limited (April - October 1983) and there was evidence that this individual had an injured front foot (trapped foot) which may have restricted his movements during this period. In the northern states, male home range sizes reported are considerably larger than female ranges (Table 13). The mean female total home range size was one-third of that reported in the mountainous, coniferous forest environment of western Montana (Smith 1984) but was one and a half times the size reported in the Missouri River breaks of northcentral Montana (Knowles 1981).

Although most bobcat studies use all observed animal locations to estimate home range size, this approach could lead to inflated estimates (Harestad 1981). Disturbance due to trapping and handling could be a major home range inflation factor. Bobcat F1637 was trapped and fitted with a radio collar on March 18, 1983. The first

radio fix was recorded on March 24, 1983, almost 14 km directly north of the trap site. By the next location on June 6, 1983, she had moved 11.5 km directly south. For the remainder of the study period (15 months), this individual was located consistently at least 10 km south of the March 24 site. The trauma from being trapped and handled may have accounted for this extensive movement yet this single location from March 24, increased this individual's calculated total home range size by over 50%.

Breeding behavior is another home range inflation factor. Bobcat home ranges appear to expand during the breeding period, especially in the case of males in Montana (H. Hash, pers. comm., A. Brown, pers. comm.). In southern California, four males increased their home range size during the breeding season (Lembeck 1978). My results indicate that females may also greatly increase movements during breeding season. F1212 occupied a home range of 1.6 km^2 during the non-breeding period of 1983-1984 but increased it to 30.4 km^2 during the 1984 breeding period. Locations recorded during the breeding period and incorporated into the total home range size may have important implications in determining the degree of home range overlap, habitat preference, home range size, and density estimates.

Home range sizes may change over time due to changing prey densities. Prey densities (lagomorphs) were high at

the onset of this study and declined toward the end of the study period. Bobcat home range sizes in this study may, therefore, represent an average of small home ranges during the 1983 relocation period when prey densities were high and increasing home range size during the later relocation period when prey densities were low. Bailey (1972) also noted an alteration in home range size with changing prey densities.

To compensate for these various possible inflation factors, I used 90% of each individual bobcats locations as an mechanism for eliminating outliers (Harestad 1981). Due to the small number of locations on some bobcats, 6-17% of the locations were actually eliminated while the home range areas decreased in size from 26-72%. I felt elimination of outliers at this level may provide for a better understanding of home range parameters.

Using only 50% of each individual bobcats locations, home range sizes decreased for females from 20.2 - 33.5 km² to 0.2 - 1.0 km². This indicates to me that the requirements essential to the survival of the bobcats are available in these "core areas". McCord and Cordoza (1982) indicated that bobcats do utilize what they perceived as the "best" bobcat habitat within their home range disproportionately. The total home range (100%) may then actually represent the area required to meet changes in environmental conditions such as changing prey

densities or to optimize breeding opportunities.

Seasonal home range estimates were largest during winter months for the female bobcats during this study. In other Montana studies, Smith (1984) reported that largest seasonal home ranges were during spring and fall, and Knowles (1980) reported the largest home range estimates in fall and winter. Buie (1980) reported no significant changes in seasonal home range size for bobcats in South Carolina.

During this study, female bobcats had smaller seasonal home ranges during spring, summer and fall. Other Montana studies (Smith 1984, Knowles 1980) reported summer home ranges to be the smallest. In contrast, Zezulak (1981) reported a 70% smaller home range size in winter than summer.

My deliniation of breeding and non-breeding seasonal periods allowed for an examination of home range size differences based on bobcat behavior. In Montana, the bobcat breeding season overlaps both winter and spring months (H. Hash, pers. comm.). Calculating breeding home range size may provide insight into home range overlap. One female bobcat during this study (F1212) increased her home range size from 1.6 km^2 in the non-breeding period to 30.4 km^2 during the breeding season, and this size increase produced almost all the overlap with other female bobcat home ranges recorded.

Movements

Females and the male had a similar distribution of distances between locations during summer and fall, but the male traveled greater distances more often than females in the fall. Smith (1984) found no marked difference between males and females. McCord and Cardoza (1982) indicated that males generally travelled greater distances than females.

Females in this study traveled greater distances in winter than in summer and fall. Smith (1984) reported the shortest movements during summer for females and attributed this to the restraints of kitten rearing. Buie (1980) also reported that females traveled greater distances during winter and the least during summer.

Habitat Use

The badlands habitat type had the greatest percentage of use on an annual and seasonal basis, with the highest use during winter months. Characteristics of this type indicate it provides security shelter. During a study in similar terrain to that on the Hook Ranch, Bailey (1981) reported a high utilization of caves and rocky areas during winter and felt that this protective cover was especially important to bobcats during severe winter weather. Smith (1984) found that bobcats preferred habitat types with dense understory layers of either shrubs, grasses, forbs, or with rocky features. Knowles

(1981) reported bobcats selected habitat with dense vegetation. She attributed this selection to bobcat hunting behavior.

On an annual basis, the open sagebrush/grassland type, the most abundant type on the study area, ranked second in use. However, the percentage of use was significantly lower than the percentage available. This type appeared to provide a minimum amount of security cover and was inhabited mainly by jackrabbits. Cottontails, the preferred prey species of bobcats (Hash 1980) were observed more often in broken terrain such as the badlands and creek bottom types. Coyotes, considered potential competitors of bobcats (Lembeck 1978), also were observed to frequent the open sagebrush/grassland type.

The creek bottom type was used by study animals to a much greater extent than expected on an annual basis. My observations indicate that creeks were probably used primarily as travel corridors through the open sagebrush/grassland type, as they were usually deeply eroded and provided some concealment. High fall use of creek bottoms may have been a direct result of increased human disturbance associated with bird and ungulate hunting. The complete absence of bobcats along creek bottoms in the spring may have been a result of high

water. Spring is the only season when most creeks carried running water.

Areas adjacent to reservoirs were used more than expected on an annual basis. Use was greatest in spring when reservoir margins supported early spring growth of vegetation. This condition may attract various prey species which could attract bobcats.

To determine the biological validity of the reductions in area associated with the home range "core area" concept (home ranges defined by the interior 50% of relocations), habitat availability and use were compared between the 100% and 50% home range areas. Habitat availability was dramatically different between 100% and 50% levels, however use was similar. For example, the mean percentage of the badlands type increased from 24.6% to 60.0% although mean use of this type remained about the same, 51.0% versus 53.4% at the 100% and 50% levels, respectively. Preferred habitat types, specifically badlands and creek bottoms, almost exclusively composed the core areas of the home ranges. These types provide security for bobcats and moderate prey densities.

The results of the "roughness" analysis suggested that terrain complexity was more important than vegetation density to bobcats. Since the highest observed use was in rough areas with sparse vegetative cover (badlands type), there does appear to be a strong preference for areas

based on terrain complexity (McCord and Cardoza 1982).

Population Trend Analysis

The low harvest of marked animals indicated a low percentage of bobcats on the study area were trapped in 1983-84. Although 10 bobcats were trapped in the study area prior to the beginning of this study, the population density during the study appeared moderate to high. However, the high harvest from the Hook Ranch as a whole may indicate other areas of the ranch are being over-harvested and attention should be given to 1985-88 harvests to delineate these areas. Population trend information may be best utilized if it is gathered in areas from which the bobcat population is not heavily exploited.

The bobcat scent-post survey did demonstrate that bobcats were attracted to scent stations. During its first field season in operation, the visitation rate was similar to rates reported from other studies (Conner et al. 1983, Torland 1980, Rust 1980). In this study, a commercial bobcat gland lure produced the highest visitation rate with bobcat urine producing the second highest visitation rate. Conner et al. (1983), Torland (1980) and Rust (1980) all used bobcat urine as their primary scent attractant.

The efficiency of this technique as an indicator of

bobcat trends has not been conclusively determined. Conner et al. (1983) felt that the scent-station indices did reflect trends in the bobcat population. However, Rust (1980) felt this technique was an unreliable means of indexing bobcat population trends. Conner et al. (1983) indicated a relationship between population abundance and scent-station indices must be established and offers guidelines for standardizing the scent-station technique.

Lagomorph population surveys would appear to be an essential component of any bobcat population assessment program in that changes in prey densities should induce corresponding changes in bobcat populations, at least in eastern Montana where suitable alternate prey species are often scarce. The lagomorph survey during this study was sensitive enough to detect a drop in rabbit numbers during the study period.

Management Considerations

Complete information on the age structure of the population is essential to bobcat management. As part of the mandatory tagging program, trappers should be required to provide a jaw or tooth from each bobcat carcass for accurate age determination (McCord and Cardoza 1982). Changes in the age distribution over time can be a precise indicator of changes in habitat conditions, prey densities, and trapping pressure that will influence population density (Bailey 1981). Although McCord and

Cardoza (1982) indicate there is no age selectivity or differences in age structure due to sex caused by trapping, under the present quota system trappers may be selective in which animals they keep therefore, age structure in a trapped sample should be regarded as a relative rather than absolute value.

The sex of each carcass must be recorded in all instances. Sex determination should be made by experienced personnel. McCord and Cardoza (1982) noted that misidentification can contribute to significant errors in estimated sex ratios. They found the error made most often was identifying males as females.

Location of kills should be recorded (at least to the township level and more precisely if possible) to help identify subsegments of the population that are heavily trapped and important areas for bobcat production. The distribution of the harvest can provide essential clues to opportunities for increasing harvest levels and can be used to identify local over-exploitation that may not be reflected in numbers.

Continued testing of the scent-post trend index on a statewide basis would aid in determining its efficiency for detecting changes in bobcat numbers in different habitats. If used on an annual basis, population trends could be evaluated and trapper limits or season quotas adjusted to compensate for changes in bobcat numbers.

Lagomorph surveys should be run concurrently with the scent-post index.

The bobcat carcass collection program should be continued (at least one collection every 3 to 5 years) to provide an index to reproductive status and physical condition of Montana's bobcat population. In addition, sex determination by internal examination would provide periodic, accurate sex ratios.

An annual harvest survey is essential to assess trapping pressure and distribution of trapping effort. This survey should emphasize information on the total harvest (bobcats harvested and released) and the distribution of the harvest (kill locations). The method of taking bobcats should also be recorded. McCord and Cardoza (1982) indicate that hunting may select for the 0-1 age class.

Current management strategies such as a regulated harvest, a mandatory pelt tagging program, and an annual harvest level assessment should be continued.

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APPENDIX

Table 14. Mammal species present on the Hook Ranch study areas (Burt and Grossenheider 1976, Hoffman and Pattie 1968).

Badger (<u>Taxidea taxus</u>)
Beaver (<u>Castor canaclensis</u>)
Big brown bat (<u>Eptesicus fuscus</u>)
Black-tailed prairie dog (<u>Cynomys ludovicianus</u>)
Bobcat (<u>Felis rotus</u>)
Bushy-tailed wood rat (<u>Neotoma cinerea</u>)
Common shrew (<u>Sorex cinereus</u>)
Coyote (<u>Canis latrons</u>)
Deer mouse (<u>Peromyscus maniculatus</u>)
Desert cottontail (<u>Sylvilagus audubonii</u>)
Eastern fox squirrel (<u>Sciurus niger</u>)
Hoosy bat (<u>Lasiurus cinereus</u>)
Least chipmunk (<u>Eutamias minimus</u>)
Little brown bat (<u>Myotis lucifugus</u>)
Long-eared bat (<u>Myotis evotis</u>)
Long-tailed vole (<u>Microtus longicaudus</u>)
Long-tailed weasel (<u>Mustela franata</u>)
Lynx (<u>Felis lynx</u>)
Masked bat (<u>Myotis leibii</u>)
Meadow vole (<u>Microtus pennisylvanicus</u>)
Merriam's shrew (<u>Sorex merriami</u>)
Mink (<u>Mustela vison</u>)
Mountain cottontail (<u>Sylvilagus nuttallii</u>)
Mountain lion (<u>Felis cancolor</u>)
Mule deer (<u>Odocoileus hemionus</u>)
Muskrat (<u>Ondatra zibethicus</u>)
Northern grasshopper mouse (<u>Onychomys leucogaster</u>)
Northern pocket gopher (<u>Thomomys talpoides</u>)
Ord's kangaroo rat (<u>Dipodomys ordii</u>)
Porcupine (<u>Erethizon dorsatum</u>)
Prairie vole (<u>Microtus ochrogaster</u>)
Preble's shrew (<u>Sorex preblei</u>)
Pronghorn (<u>Antilocapra americana</u>)
Raccoon (<u>Procyon lotor</u>)
Red fox (<u>Vulpes vulpes</u>)
Red-backed vole
Richardson's ground squirrel (<u>Citellus richardsonii</u>)
Sagebrush vole (<u>Lagurus curtatus</u>)
Silver haired bat (<u>Lasionycteris noctiuagans</u>)
Stripped skunk (<u>Mephitis mephitis</u>)
Swift fox (<u>Vulpes velix</u>)
Thirteen-lined ground squirrel (<u>Citellus tridacemlineatus</u>)
Western harvest mouse (<u>Reith rodontomys megalotis</u>)
White-tailed deer (<u>Odocoileus virginianus</u>)
White-tailed deer mouse (<u>Peromyscus leucopus</u>)
White-tailed jack rabbit (<u>Lepus townsendii</u>)
Wyoming pocket mouse (<u>Perognathus fasciatus</u>)
Yellow bellied marmot (<u>Marmota flaviventris</u>)

Table 15. Physical measurements of bobcats captured in eastern Montana, Hook Ranch, Montana, 1983.

Bobcat number	Age (yrs)	Weight (Kg)	Total length (cm)	Neck size (cm)	Tail length (cm)	Hindfoot length (cm)	Shoulder height (cm)	Heart girth (cm)	Mammae condition	Coat color
M1488	2+	8.4	96.0	22.0	18.0	19.0	45.0	41.0	-	Light
F1637	2+	8.2	98.0	24.0	15.0	-	43.0	43.0	slight swollen	Reddish gray
F0083	2	7.3	85.0	20.0	16.0	17.5	29.0	36.0	not swollen	well spotted back, light color
M0141	3+	9.5	98.0	23.0	15.0	18.0	45.0	42.0	-	light, well spotted back & belly
F0122	3+	10.9	94.0	23.5	15.7	18.8	42.0	45.0	very swollen	brownish, plain back with little markings
F0102	-	8.6	91.0	21.0	17.0	18.0	41.0	41.5	not swollen	red
M0063	Adult	11.4	111.0	29.2	16.5	20.5	47.0	47.0	-	gray
F1212	1-2	7.3	95.0	24.0	17.5	18.0	43.0	40.0	not swollen	well spotted back reddish

Table 16. Vegetational characteristics and species composition of delineated cover types from Pfister plots, shown in % ^a, ^b.

Cover Type	Total shrub cover	Artemisia tridentata	Artemisia cana	Sarcobatus vermiculatus	Chrysothamnus spp.	Atriplex spp.	Rosa spp.	Ribes spp.	Salix spp.	Rhus spp.	Water ^c
<u>open sagebrush/grassland complex</u> (40)	16.9	15.7	0.76	T ^d							
open sagebrush/grassland-flats(20)	19.4	17.6	1.5	T							
open sagebrush/grass-hills(20)	14.5	13.9	T	T							
<u>badlands complex</u> (60)	6.5	5.3	T	T	T	T		T			
badlands-gumbo(20)	3.0	1.0	T	T	T						
badlands-scorio(20)	3.3	3.0		T	T	T					
badlands-brush draws(20)	13.3	11.9		T	T	T		T			
<u>Creek bottom complex</u> (20)	12.6	1.7	11.9	T	T		T				
<u>Reservoir complex</u> (20)	4.1	2.1	2.3	T		T			6.8		17.8
Rocky outcrops ^e (20)	6.2	1.5	T	T	T	T		1-2		T	

^a Delineated cover types may be composed of two or more subtypes which when combined represent a total habitat complex.

^b Percentage figures are based on averaging midpoints of seven coverage classes (Daubenmire 1959).

^c Plot centers along reservoirs were 10 meters from water but plot may have included water.

^d T = Trace amount, less than 1.0 %.

^e Represents plots taken in open sagebrush/grassland complex and badlands complex but considered as a separate entity.

Table 17. Vegetational characteristics of delineated cover types from Daubenmire plots, (percent canopy coverage)^{a,b}.

Cover types	Total plant cover	Total shrubs	Total grass	Total forbs	Litter-soft	Litter-hard	Bare ground	Rock	Lichens	Feces ^c
<u>open sagebrush/grassland complex</u> (20)	34.5	3.6	28.0	3.6	16.3	3.6	28.5	3.6	4.2	1.5
open sagebrush/grassland-flats(60)	35.1	4.8	26.0	2.8	22.3	5.0	26.1	T ^d	2.6	1.8
open sagebrush/grassland-hills(60)	34.0	2.4	30.0	4.4	10.4	2.4	30.9	6.9	5.9	1.2
<u>badlands complex</u> (180)	11.1	5.0	2.7	3.6	2.1	2.4	35.1	46.9	T	T
badlands-gumbo(60)	5.4	1.9	T	2.9	T	T	58.6	38.0		T
badlands-scorio(60)	10.7	2.4	4.1	4.2	1.0	1.4	9.5	73.2	T	1.0
badlands-brushy draws(60)	17.2	10.8	3.7	3.6	4.8	4.7	37.2	29.6	T	1.4
<u>Creek bottom complex</u> (60)	26.5	6.8	18.0	2.5	6.4	1.5	51.6	10.6	T	T
<u>Reservoir complex</u> (60)	32.2	1.9	25.3	7.5	16.2	1.8	43.1	2.9		1.7
Rocky outcrops(60)	10.3	5.1	2.9	2.3	3.3	1.1	26.4	53.9	T	T

^a Delineated cover types may be composed of two or more subtypes which when combined represent a total habitat complex.

^b Percentage figures are based on averaging midpoints of seven coverage classes (Daubenmire 1959).

^c Composed of lagomorph pellets, cattle or horse.

^d T = Trace amount less than 1.0 %.

Table 18. Species list and species composition of plants identified in 0.1 m² Daubenmire plots per cover type on the Hook Ranch Study Area, Montana.

Plant Species	Cover Type									
	Open sagebrush grassland complex	Open sagebrush grassland flats	Open sagebrush grassland hills	Badlands complex	Badlands gumbo	Badlands scorio	Badlands brushy draws	Creek bottom complex	Reservoir complex	Rocky outcrops
<i>Artemisia cana</i>	T	T	T					6.5	1.3	T
<i>Artemisia frigida</i>	T		T	T		T	T			T
<i>Artemisia tridentata</i>	3.5	4.8	2.1	3.7	1.3	1.1	8.5	T ²	T	2.5
<i>Artiplex</i> spp.				T		T	T			T
<i>Chrysothamnus</i> spp.				T	T	T	1.5			T
<i>Rhus</i> spp.										1.7
<i>Ribes</i> spp.										T
<i>Rosa</i> spp.				T			T			T
<i>Sarcobatus vermiculatus</i>	T		T	T	1.0	T				
<i>Agropyron smithii</i>	T	T	T							
<i>Agropyron</i> spp.	2.2	1.3	3.2	1.7	T	2.4	2.6	2.3	5.4	1.8
<i>Agropyron cristatum</i>									T	
<i>Agropyron spicatum</i>	T	T	T	T	T					
<i>Boutelous gracilis</i>	13.7	10.6	16.7	T	T	1.3	T	3.3	T	T
<i>Bromus tectorum</i>	1.5	2.4	T	T	T	T	T	T	T	T
<i>Bromus japonicus</i>	T	T	T	T		T	T	1.3	2.9	T
<i>Calamagrostis</i> spp.								3.3	1.3	T
<i>Carex</i> spp.	2.0	1.2	2.9	T		T	T	T	T	T
<i>Danthonia</i> spp.								T	T	
<i>Eleocharis</i> spp.									1.1	
<i>Festuca octaflora</i>	T	T	T					T	T	T
<i>Hordeum jubatum</i>	T	T		T	T	T	T			T
<i>Hordeum murinum</i>								T	10.0	
<i>Hordeum pusillum</i>									T	
<i>Koeleria cristata</i>	T	T	T	T		T	T	T		T
<i>Oryopsis hymenoides</i>				T		T			T	T
<i>Poa</i> spp.	T	T	T	T	T	T	T	T	T	T
<i>Schedonnardus</i> spp.	T	T								T
<i>Stipa</i> spp.	2.2	1.9	2.5	T		T	T	1.5	T	T
Unknown grasses	T		1.0	T			T	T	T	T
<i>Achilles millefolium</i>	T	T		T			T		T	
<i>Antennaria</i> spp.				T	T	1.1	T			T
<i>Amaranthus</i> spp.				T	T					
<i>Aster/Erigeron</i>	T	T								
<i>Astragalus</i> spp.	T	T						T		
<i>Artiplex nuttallii</i>	T		T	1.8	2.4	T	2.3			
<i>Carduus</i> spp.				T			T		2.4	
<i>Cerastium</i> spp.	T	T	T					T	T	T
Cruciferae family	T	T						T		T
<i>Echinacea pallida</i>									T	
<i>Eremocarpus setigerus</i>								T		
<i>Erigeron</i> spp.	T	T								
<i>Euphorbia</i> spp.	T	T						T		
<i>Grindelia</i> spp.								T	T	
<i>Hymenoxys</i> spp.										T
<i>Gutierrezia sarothrae</i>	T	T	T	T	T	T			T	T
Leguminosae family								T	T	T
<i>Lepidium</i> spp.	T	T		T		T	T		T	
<i>Meibomia officinalis</i>								T		
<i>Oenothera</i> spp.	T	T								
<i>Opuntia polyacantha</i>	T	1.0	T	T		T		T		
<i>Phlox</i> spp.	T	T	T	T	T	T	T			T
<i>Plantago purshii</i>	T	T	T	T	T	T	T	T	T	
<i>Psoralea</i> spp.								T		
<i>Selaginella</i> spp.	3.5	3.8	3.2							
<i>Sphaeralcea coccinea</i>	T	T	T	T	T	T	T	T	T	
<i>Taraxacum officinale</i>	T	T	T	T			T	T	1.5	T
<i>Thermopsis</i> spp.								T	T	
<i>Tragopogon</i> spp.								T	T	
Unknown compositae	T		T	T		T		T		T
Unknown forbs	T	T	T	T	T	T	T	T	1.3	T
<i>Vicia</i> spp.	T	T	T	T			T	T		T

^a T = Trace amount, less than 1.0 %.

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