Ecology of mountain lions in the Sun River area of northern Montana
by James Scott Williams

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:
Mountain lion (Felis concolor missoulensis) habitat use, foraging habits, and home area characteristics were investigated in the Sun River area of northern Montana. Twenty-five mountain lions were monitored in 1991-1992. Mountain lions selected closed-conifer, open-conifer, aspen-conifer, deciduous tree, and shrubland cover types.

Mountain lions avoided grassland and vegetated rock cover types. Mountain lions preferred areas near a stream course (0-200 m). They did not avoid roads or USFS recreational trails. They were found on slopes ranging from gentle (<20%) to steep (>69%). Mountain lions preferred eastern aspects, elevations ranging from 1219 m to 1828 m, and were located in both broken and unbroken topography. Mean annual home area size was among the smallest reported in the literature. Mean annual home area size for prairie-front mountain lions was smaller than mountain lions that utilized interior areas. Home area size for prairie-front males was larger than for prairie-front females. Interior male home area size did not significantly differ from interior females. There was considerable overlap in female home areas. Mountain lions used core areas within their individual home areas. Mountain lions primarily killed deer, bighorn sheep, and elk. Bighorn sheep, elk, and mule deer were killed more often during winter (Nov-Apr). Whitetailed deer, and smaller mammals were killed more often during summer (May-Oct). Overall, elk contributed more biomass to the diet of mountain lions than deer and bighorn sheep. Specifically, elk bulls, cows, bighorn sheep ewes, and mule deer bucks contributed the most biomass to mountain lion diets. Three instances of cannibalism by mountain lions were documented.

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Master of Science

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Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

November 1992

N378
W6728

APPROVAL

of a thesis submitted by

James Scott Williams

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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ACKNOWLEDGMENTS

I'd like to thank my major professor Dr. Harold Picton for giving me the opportunity to participate in this project, for guidance in manuscript preparation, for encouragement, and for sharing his knowledge of science. I would also like to thank committee members Robert Moore, Lynn Irby, Robert White, and John McCarthy for reviewing the manuscript. I am indebted to biologist John McCarthy (Montana Dept. of Fish, Wildlife, and Parks) for project development, logistics, friendship, and advice. I thank John for his enthusiasm and support for the project. The skill and dedication of both Rocky Heckman and Kelly Hirsch in the use of trailing hounds and mountain lion capture techniques is greatly appreciated. Their knowledge of the wilderness, hard work, and sense of humor made this project a success. I also extend thanks to Seth Diamond, Brad McBrattney, Pat Finnegan, Ray Mills, and Don Goedtl of the Rocky Mountain Ranger District of the Lewis and Clark National Forest. The skill of pilots Jim Heppner, Jim Lowe, and Chuck Redd in flying and the use of aerial radio-telemetry is greatly appreciated. The hard work and dedication of volunteers Jay Kolbe, Mike Kuleza, Gary Kiester, and Mark Walters is also appreciated. My fellow graduate students, especially Thomas Baumeister, Bill

Thompson, and Matt Reid, gave helpful suggestions and provided interesting debate. I extend thanks to John Morgan for encouragement and GIS assistance and analysis. I also wish to thank Dr. Dan Gustafson (Montana State University) for statistical consultation and assistance in data analysis. I thank Kevin Frey, Phil Schladweiler, and Keith Aune at the MDFWP Wildlife Laboratory for assistance with scat analysis and project support. I thank Kerry Murphy for sharing advice concerning mountain lion ecology and research techniques. Finally, I extend my deepest appreciation to my families, both of them, for their undying support throughout my education.

This project was funded by the Montana Department of Fish, Wildlife, and Parks, The Rocky Mountain District of the Lewis and Clark National Forest, The Allen Foundation, The Teller Foundation, The Peter Busch Family Foundation, and the Montana Houndsmen Association.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Mountain lion (Felis concolor missoulensis) habitat use, foraging habits, and home area characteristics were investigated in the Sun River area of northern Montana. Twenty-five mountain lions were monitored in 1991-1992. Mountain lions selected closed-conifer, open-conifer, aspen-conifer, deciduous tree, and shrubland cover types. Mountain lions avoided grassland and vegetated rock cover types. Mountain lions preferred areas near a stream course (0-200 m). They did not avoid roads or USFS recreational trails. They were found on slopes ranging from gentle (<20%) to steep (>69%). Mountain lions preferred eastern aspects, elevations ranging from 1219 m to 1828 m, and were located in both broken and unbroken topography. Mean annual home area size was among the smallest reported in the literature. Mean annual home area size for prairie-front mountain lions was smaller than mountain lions that utilized interior areas. Home area size for prairie-front males was larger than for prairie-front females. Interior male home area size did not significantly differ from interior females. There was considerable overlap in female home areas. Mountain lions used core areas within their individual home areas. Mountain lions primarily killed deer, bighorn sheep, and elk. Bighorn sheep, elk, and mule deer were killed more often during winter (Nov-Apr). White-tailed deer, and smaller mammals were killed more often during summer (May-Oct). Overall, elk contributed more biomass to the diet of mountain lions than deer and bighorn sheep. Specifically, elk bulls, cows, bighorn sheep ewes, and mule deer bucks contributed the most biomass to mountain lion diets. Three instances of cannibalism by mountain lions were documented.

INTRODUCTION

The mountain lion (Felis concolor) is the most widely distributed large carnivore in North and South America (Young and Goldman 1946, Anderson 1983). In Montana, mountain lions are found in 42 of 56 counties and in all habitats except the open plains and prairies (Riley 1992). Historically mountain lions have been reported to follow water courses into the more open prairie country of eastern Montana (Young and Goldman 1946). In May of 1805, a "panther" was observed by the Lewis and Clark expedition "feasting" on a freshly killed deer approximately 300 km east of the Montana Rocky Mountain Front near the Missouri Breaks (Coues 1893).

The mountain lion was historically classified as a predator in Montana. Under this clssification, bounties were paid until 1962 because of the perception that mountain lions significantly influenced livestock, big game, and wildlife populations. Public interest and accumulated field evidence resulted in its reclassification as a game animal in 1971. Mountain lion populations in Montana have expanded in the last 30 years, since classification as a game animal (Riley 1992). Consequently, mountain lions now occupy much of their former range in Montana and are probably colonizing new habitats (Riley 1992). Mountain lion-human interactions in Montana have also increased in the last 20 years (Aune and Schladweiler 1991).

There has been an increasing interest in the sport hunting and management of mountain lions since 1971 (Joslin 1988). Mountain lion hunting provides over 11,600 hunter days of recreation annually in Montana. While mountain lions are neither threatened or endangered in Montana, they are quite secretive. Each sighting of a mountain lion by anyone, hunter or viewer, is usually regarded as an exciting and unique experience by the observer.

Mountain lions have been studied in Montana near Fish Creek by Murphy (1983) and in Yellowstone National Park by Murphy et al. (1992). However, a paucity of information exists concerning mountain lion ecology in the Montana Northern Continental Divide Ecosystem which includes the Scapegoat, Bob Marshall, and Great Bear Wilderness areas as well as the eastern front of the Rocky Mountains and Glacier National Park.

The Sun River area of the Montana Rocky Mountain Front is inhabited by a unique species array, made up in part by large numbers of both resident and migratory ungulates as well as sympatric large carnivores. The relationships of mountain lion predation to ungulate abundance and niche breadthe, and the factors affecting mountain lion predation are not well understood in Montana (Riley 1992).

The human impacts on the study area have fluctuated widely in the last 100 years (Picton and Picton 1975). Climatic and topographic factors on the East Front of the

Rocky Mountains that may influence mountain lion ecological relationships are more variable than other regions where mountain lions have been studied. Despite the proliferation in mountain lion research, few studies have quantified habitat use by mountain lions (Logan and Irwin 1985, Laing 1988, Koehler and Hornocker 1991). Data concerning mountain lion number, density, reproductive rates, survivorship, recruitment of young, population trends, and the impacts of harvest were also collected. Specific project objectives were as follows:

1. To describe and quantify habitat used by mountain lions.

2. To describe foraging habits of mountain lions on the Montana Rocky Mountain Front.

3. To explore mountain lion population characteristics on the Montana Rocky Mountain Front including: distribution, home area size and overlap, movements, and density.

4. To explore mountain lion-human interactions.

STUDY AREA

The 2127 km^2 study area was located on the east slopes of the Rocky Mountains 24 km West of Augusta, in Lewis and Clark County, Montana (Fig. 1). The study area was bounded on the north by Deep Creek, on the west by the Sun River and the Continental Divide, on the south by the Dearborn River, and on the east by U.S. Highway 287.

Physiography

The study area was located in a geologically and topographically complex transition zone between the relatively level, low elevation (approximately 1300 m) Great Plains to the east and the high elevation (approximately 2500 m) ranges of the Rocky Mountain Front to the west. Elevations generally increased moving from the eastern to the western portion of the study area and ranged from 1,311 m on the prairie to 2,805 m on Scapegoat mountain. The East Front of the Rocky Mountains is composed of a series of parallel north-south trending ridges and peaks, characterized by moderate west facing slopes and abruptly sloped east faces, separated by narrow stream bottoms and canyons. Pleistocene and recent streams and Pleistocene glaciers carved the existing peaks and valleys and are responsible for the present topography of the Sawtooth Range (Deiss 1943).

The foothill-prairie ecotone is composed primarily of

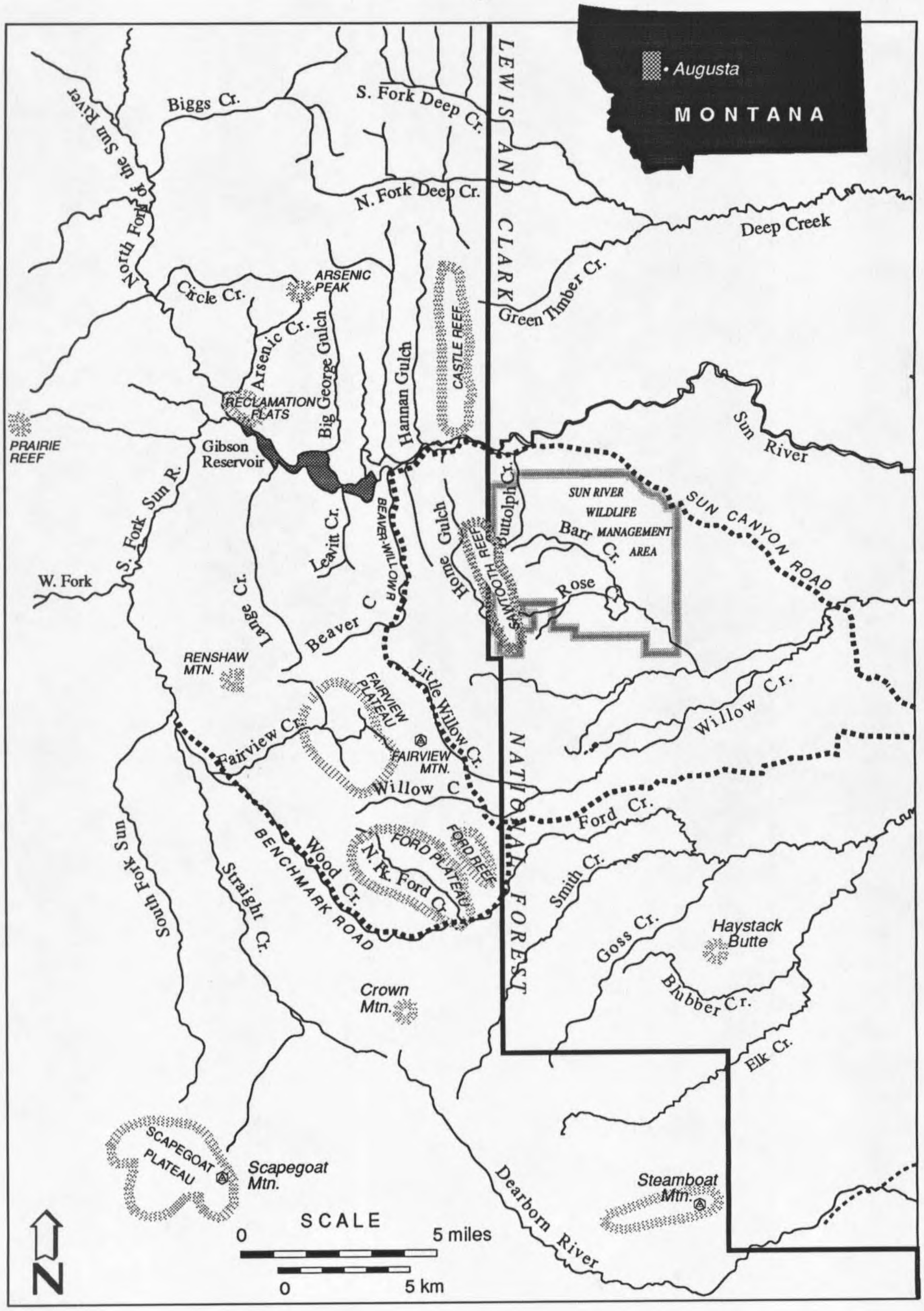

Figure 1. Map of the Sun River mountain lion study area in northern Montana.

rolling hillsides and relatively level grasslands. Timbered drainages, limestone reefs, sparsely vegetated ridges and hillsides, and prairie characterize the area. Open grassy meadows are scattered throughout the area in drainage bottoms or on benches and plateaus.

Geological features of the study area have been described in detail by Deiss (1943), and Holdorf (1981). The mountainous portion of the study area was created when the Lewis overthrust forced Paleozoic limestones and shales over more recent Mesozoic sediments Deiss (1943). The prairie-foothill ecotone topography is typical of glacial deposition with low rolling hills mantled with a thin layer of glacial drift separated by coulees and numerous potholes (Knight 1970). Rocks exposed today are typically from the Middle and Upper Cambrian, Upper Devonian, Mississippian, Upper Jurassic, and Cretaceous periods (Deiss 1943).

Climate

Climatic conditions are subject to extreme variation given the wide range of elevations and topographic features present within the study area. Prevailing weather patterns typically move in from the West, giving rise to general downslope wind conditions (Knight 1970). During the winter, these warming downslope winds limit snow cover on southern and western aspects within the prairie-front portion of the study area. In contrast, the northern and eastern aspects of the prairie-front ecotone, as well as most of the interior study area, are snow covered. Upslope conditions sometimes develop from the east resulting in large amounts of precipitation (i.e. > 1 m snow) in the study area. Generally, temperatures were above normal and precipitation was below normal throughout the study period. Climatalogical data for 2 weather stations are presented in Table 1. The Gibson Dam weather station (elevation 1400 m) was centrally located in the mountainous region of the study area. The Augusta weather station (elevation 1240 m) was located 24 km east of the study area on the prairie.

Flora

Vegetation on the East Front has been discussed in detail by Picton (1960), Knight (1970), Kasworm (1981), and others. Lower elevations are characterized by shortgrass prairie and shrublands interspersed with buttes and ridges covered by limber pine (_Pinus flexilis_) savannahs and wind forests (Ihsle 1982). Bluebunch wheatgrass (_Agropyron spicatum_) and Idaho fescue (_Festuca idahoensis_) comprise the major understory component of the limber pine savannah and wind forest. Aspen (_Populus tremuloides_) and cottonwood (_Populus trichocarpa_) stands are scattered throughout drainages and foothills. At higher elevations, Douglas fir (_Pseudotsuega menziesii_), lodgepole pine (_Pinus contorta_), spruce (_Picea engelmannii_), and subalpine fir (_Abies

Table 1. Mean monthly temperature (C), precipitation (cm), and departure from normal for the period January, 1991 through February, 1992 at Augusta and Gibson Dam Weather Stations (National Oceanic and Atmospheric Association).

	Augusta				Gibson Dam			
Month	Temp.	dep.	Ppt.	dep.	Temp.	dep.	Ppt.	dep.
Jan	-5.7	1.0	1.3	-0.00	-6.2	-0.4	2.8	-0.10
Feb	4.3	11.4	0.3	-0.38	3.5	10.7	1.5	-0.19
Mar	-0.7	1.5	2.0	-0.18	-0.5	1.3	3.8	0.53
Apr	5.8	0.6	3.2	-0.02	4.6	1.4	5.9	0.58
May	10.0	-1.5	9.8	1.54	8.4	-0.6	14.5	2.60
Jun	14.3	-2.2	16.0	3.38	12.0	-1.4	12.1	1.42
Jul	19.0	0.1	0.9	-1.04	17.3	1.1	0.5	-1.21
Aug	20.0	3.4	2.7	-0.27	18.6	4.8	3.4	-0.26
Sep	14.1	1.5	1.	-0.24	13.0	2.7	2.2	-0.41
Oct	7.2	-2.3	19	0.13	5.7	-2.6	1.3	-0.47
Nov	0.4	-1.2	1.9	0.20	-0.4	-1.6	3.3	0.17
Dec	1.7	6.8	1.0	0.14	-0.1	5.4	2.8	0.07
Jan	1.7	14.5	1.1	0.15	0.2	11.2	1.5	-0.56
Feb	2.8	8.8	0.1	0.46	1.7	7.4	0.5	-0.56

lasiocarpa) dominate the forest canopy. Habitat types generally fit those described by Pfister (1977). Pinegrass (Calamagrostis rubescens) is the major understory species associated with Douglas fir. Heartleaf arnica (Arnica cordifolia), gooseberry (Ribes inerne), and smooth menziesia (Menziesia glabella) comprise the major understory component of the closed canopy-subalpine forest. At higher elevations sagebrush (Artemesia tridentata) or shrubby cinque-foil (Potentilla fruticosa) and grassland habitats are also common. Extensive willow (Salix spp.) stands characterize the vegetation in lowland riparian areas. Extensive regions of seral grassland and shrubland were found on burned sites, especially in the southern portion of the study area.

Fauna

The Montana Rocky Moutain Front has a high diversity of mammalian species with only the bison being absent from the historical array. Potential large mammalian prey species included elk (Cervus elaphus nelsoni), mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), bighorn sheep (Ovis canadensis), and in smaller numbers, moose (Alces alces), pronghorn (Antilocapra americana), and mountain goat (Oreamnos americanus). Potential small mammalian prey species included snowshoe hare (Lepus americanus), Nuttall's cottontail rabbit (Sylvilagus nuttalii), porcupine (Erethizon dorsatum), yellow-bellied marmot (Marmota flaviventris), raccoon (Procyon lotor), and many other smaller mammals.

The Lynx (Lynx canadensis), bobcat (Lynx rufus), gray wolf (Canis lupus), coyote (Canis latrans), red fox (Vulpes vulpes), wolverine (Gulo gulo), badger (Taxidea taxus), black bear (Ursus americanus), and grizzly bear (Ursus arctos horriblis) were potential competitors.

Administration and Land Use

The study area is located in both Teton and Lewis and Clark Counties, Montana. Research was centered on the Lewis and Clark National Forest, the Sun River Wildlife Management Area (state owned), and adjacent private and public lands. Livestock grazing is the major agricultural activity in the study area. The Lewis and Clark National Forest administers 10 cattle and horse grazing allottments totalling 1,273 animals and 5 Packer allotments totalling 124 animals (Brad McBrattney USFS pers. comm. June 1992). Hunting, fishing, hiking, and camping comprise the majority of public activity as most of the area is under designated Recreation and Wilderness management. The extreme western edge of the study area lies within the Sun River Game Preserve.

METHODS

Mountain Lion Capture and Monitoring

Capture operations extended from January 15, 1991 to March 31, 1991 and from December 2, 1991 to April 6, 1992. Mountain lions were captured by pursuing with trained hounds until treed (Hornocker and Wiles 1972). Local houndsmen were contracted for the chase-capture season due to familiarity with the study area and to encourage public support. Once treed, mountain lions were tranquilized using a Palmer capture gun (Palmer Chemical, Douglasville, GA). Approximately 7 mg/kg of Ketamine hydrochloride (Parke-Davis, Morris Plains, NJ) was administered initially to allow approach and handling of the treed mountain lion. Immobilized mountain lions were lowered from the tree with the use of a rope to prevent injury to the animals.

After immobilization, mountain lions were weighed and opthalmic ointment was applied to the eyes. The age of captured animals was estimated by using dental characteristics, and overall health and appearance was noted (Shaw 1979, Lindzey 1987). Mountain lions were placed in one of three age classes as follows: kitten (0-6 months, spotted), juvenile (6 months-independence), adult (independence and greater).

Each mountain lion was tattooed in an ear with an identification number, numbered ear tags were attached, and the animal was instrumented with a mortality sensing radio-collar (AVM Inc., Telonics Inc.). Juveniles (<18 months) were fitted with a special expandable mortality sensing radio-collar (AVM Inc.).

When possible, blood samples were drawn from the femoral vein of mountain lions. A blood sample utilizing a 10 ml vacutainer tube containing the anticoagulant (Ethylenedinitrilo)tetraacetic acid (EDTA) was collected. Another blood sample utilizing a 15 ml vacutainer tube was collected for Brucellosis and Leptospirosis testing. Both samples were frozen upon collection. The 10 ml EDTA preserved sample was stored for future DNA analysis. The 15 ml blood sample was tested for diseases by the Montana Department of Livestock Diagnostic Laboratory Division.

After completion of data gathering and depending on ambient temperature, mountain lions were placed in the shade or on snow, on their chest with legs splayed outward. Pine bows were placed over the head to shade the animal and minimize visual contact. When possible, the animals were observed until drug recovery was complete and the animal regained mobility.

Most radiocollared mountain lions were relocated at least 2 times per month primarily via fixed-winged aircraft (Piper Supercub). Due to the extreme topographic relief of the study area, relocations obtained from ground radiotracking with a hand-held H antenna (Telonics Inc.) were only used if the animal was observed, fresh sign such as a track or kill site was encountered, or the animal was pinpointed by circling at least 270 degrees around the transmitter. One mortality, and three shed radio-collars offered a field test of the relocation accuracy from a fixed-winged aircraft.

Home Area and Movements

Hornocker (1969) noticed that resident adult mountain lions reused areas previously visited, although there were seasonal patterns, changes over time, and individual patterns. Home area (Seidensticker et al. 1973) size, using the convex polygon method (Mohr 1947), average activity radii (AAR), and rates of animal movement (RAM) in km/day, were calculated using the computer program TELDAY (Lonner and Burkhalter 1983). Average activity radii (AAR) based upon the geographic activity center (GAC) was used as an index of mobility for comparisons between mountain lion sex and reproductive groups and to compare prairie-front with interior mountain lions (Hayne 1949). Rates of animal movement (RAM) in km/day were used in the analysis of mountain lion movements rather than the distance between successive location points because of the variation in time between successive mountain lion locations (Mack 1988). Only mountain lions having a minimum of 7 telemetry locations were used in the home area analysis.

Mountain lion home areas that did not encompass a portion of the Sun River Wildlife Management Area (SRWMA) were considered to be "interior". These home areas utilized mountainous interior drainages. In contrast, mountain lion home areas that encompassed a portion of the SRWMA were termed "prairie-front". These home areas utilized the transitional zone between the prairie and the Rocky Mountain Front. The area within the minimum convex polygon of each mountain lion home area was used for mathematical comparisons of home area overlap.

To examine the intensity of utilization of various home areas the distribution of relocations for home areas were analyzed for core areas (Horner and Powell 1990). Core areas were determined by superimposing a 2 km grid (Telday scale = 0.3) over the home area and plotting the frequency of locations within each cell (Samuel et al. 1985). The grid cell size was selected to encompass telemetry error and to achieve a probability of ≥ 1 location per cell for statistical comparisons (Samuel et al. 1985). Mountain lion core areas were defined as the maximum area where the observed utilization distribution exceeded a uniform utilization distribution ($P < 0.10$). Overlays of mountain lion home areas on topographic features (appendix B) were produced by a computer program developed by Dan Gustafson (Biology Dept., Montana State University).

Habitat Use

Previous studies have demonstrated the importance of vegetation cover to mountain lions (Laing 1988, Logan and L. Irwin 1985, Murphy 1983, Seidensticker et al. 1973, Hornocker 1970, and others). A vegetative cover map of the study area was developed utilizing information derived from Landsat multispectral scanner(MSS) digital data (Fitzpatrick 1988). The study area map utilizes three overlapping Landsat(MSS) scenes, two taken on the same pass of July 3, 1981 and one on a previous pass of July 2, 1981. The Landsat(MSS) data and Defense Mapping Agency digital terrain data were acquired by the United States Forest Service in computer compatible format from the Earth Resource Observation and U.S. Geological Survey.

Image processing and spatial data analysis were accomplished through a working agreement between the Lewis and Clark National Forest and the Digital Image Analysis Laboratory (DIAL) at Washington State University Computing Service Center (WSUCSC) in Pullman, Washington. The final product was a rasterized (organized by cells) vegetative cover map derived from Landsat imagery utilizing 244 spectral classes representing various vegetation types. The southern one-third of the study area burned in 1988, resulting in large scale cover type changes for the burned area. Consequently, only mountain lion data for the unburned region of the study area were used for macrohabitat analysis utilizing the LANDSAT technology.

For this study, data were entered in a format that was compatible with the GIS computer program EPPL7 (Minnesota State Planning Agency, 1990). Following the aggregation of numerous pixel spectral classes, a map of 15 macrohabitat cover types was produced (Don Goedtel pers. comm. March, 1992). Of these 15 cover types, an aggregation of 9 pixel classes was used for habitat analysis. Quantitative calculations involving mountain lion use of the macrohabitat classes utilized EPPL7.

The 50 by 50 m habitat pixels were smaller than the 150-200 m telemetry error. For this reason, the buffer option in EPPL7 for single pixels was employed. This option adds 2 pixels at 4 compass bearings around the actual pixel cell and 1 pixel at 4 points at the pixel cell corners for a final cluster of 13 pixels for a sampling unit. This option samples an area of roughly 200 by 200 m, reducing the telemetry error problems in choosing exact mountain lion use pixels.

For the burned region of the study area (southern 1/3), I recorded formation (burn, forest, or grassland) for each mountain lion location. The presence or absence of a rock-cliff component was also noted. These observations were made during radio-tracking flights.

Telemetry data, kill sites, scat-scrape sites, and track sites represented the 4 classes of mountain lion point data for habitat use analysis. For each mountain lion location, slope, aspect, elevation, and distance to water were recorded using USGS 7.5-minute topographical maps. Use of categorical variables (excluding cover types) relative to availability was determined as described by Marcum and Loftsgaarden (1980). The distance to the nearest road and USFS recreational trail was recorded for each mountain lion location to detect any avoidance of roads or recreational trails.

Land surface ruggedness is a vital component of habitat for many wildlife species (Beasom 1983). A land surface ruggedness index (LSRI) was developed following Beasom (1983). The basic assumption of this quantitative index is that ruggedness is a function of the total length of all contour lines traversing a given area. A clear mylar overlay was chosen to match a 0.5 by 0.5 km square on a USGS 7.5-minute topographical map. There were 49 randomly spaced dots on this overlay. The LSRI was calculated for a given cell by recording the number of dot-contour intercepts. LSRIs were calculated for both mountain lion use cells and random cells. The LSRI classes represented smooth (0-10), moderate (11-20), rugged (21-30), rough (31-40), and extreme (>40).

Foraging Habits

Mountain lion food habits were based on prey species present at kill sites and scat analysis. Mountain lion kill sites were analyzed for food habits data. Following Murphy (pers. comm. December 1991), location, prey species, prey species age (yearling or adult), prey species sex, presence or absence of a rock component, marrow condition of prey species (Hornocker 1970), kill confirmation, incident description, feeding description, and associated radiocollared mountain lion information was recorded for most kill sites.

Criteria for mountain lion kill determination was as follows: 1) kill was associated with a radiotelemetry relocation, 2) mountain lion tracks were present at the kill, 3) cause of death was typical of a mountain lion attack (Hornocker 1970), 4) carcass was fed upon in a characteristic manner typical of mountan lions (Shaw 1979), 5) caching of the prey species was typical of mountain lions (Hornocker 1970), and 6) corresponding mountain lion scrapes or scats were present.

Mountain lion scats were collected (Murie 1954) for food habits analysis. Following Murphy (pers. comm. December 1991), location, association with kill site, urine presence, scat caching, scrapes, and substrate characteristics were recorded for scat sites. Scats were collected upon discovery, usually while trailing individual mountain lions. Searching in areas around atypical trees or rocks in a monoytpic stand associated with a telemetry relocation was also employed for scat collection.

Mountain lion scats were analyzed at the Montana Department of Fish, Wildlife, and Parks Laboratory in Bozeman, Montana. Scats were air dried in paper bags and stored until analyzed. Scats were soaked in hot water to make the contents pliable prior to analysis. Scats were washed in stacked 3.96 mm and 1.18 mm mesh sieves to separate contents for identification. Scats were identified macroscopically or with a dissecting and compound microscope by comparing them to a reference collection. Animal hair was identified macroscopically or by scale pattern (Moore et al. 1974). Frequency of occurrence for species identified in scats was estimated. Frequency of occurrence provides a better indication of the relative frequency with which each item is consumed because it accounts for more than one of a given item being found in a scat (Ackerman et al. 1984).

Biomass calculations of prey consumed by mountain lions followed Ackerman et al. (1982) and Ross and Jalkotzy (1992). Assumed live weights for prey consumed were taken from the literature (Table 2). Estimated prey biomass consumed was determined by multipling the live weights by a utilization factor of 0.79 for all ungulates and 0.85 for smaller prey species.

Statistical Analysis

For most of the home area and movement comparisons, a nonparametric hypothesis test (Mann-Whitney U) for ordinal

Table 2. Estimated live weight of mammals killed by mountain lions used for calculation of biomass importance.

Prey species	Weight (kg)			Reference	
	male	female	year		
Elk	300.0	200.0	125.0	Peek	1982
Bighorn sheep	90.0	70.0		Geist	1972
Mule deer	74.0	59.0	50.0	Mackie	1982
White-tailed deer	68.0	45.0	40.0	Sauer	1984
Unclassified deer	45.0	68.0	45.0	[a]	
Porcupine	6.0			Jalkotzy	1992
Raccoon	6.0			Jalkotzy	1992
Snowshoe hare	1.5			Jalkotzy	1992
Marmot	1.5			Jalkotzy	1992
Mountain lion	52.0		23.0	This Study	

[a] Live weight of unclassified deer was calculated by averaging the weights of mule and white-tailed deer.

data was used (Conover 1980). Spearman's rank correlation was used to compare the number of relocations with mountain lion home area sizes and the duration of observation with mountain lion home area sizes. Chi-squared goodness-of-fit tests were used to determine if significant differences ($P < 0.1$) existed between the expected utilization of habitats based on their availability and the observed frequency of their selection. If significant differences existed, Bonferroni simultaneous confidence intervals were calculated to determine habitat type selection patterns (Neu et al. 1974, Byers et al. 1984). Statistical tests were performed with STATA (Computing Resource Center, Los Angeles, CA) and MSUSTAT (Lund 1987).

RESULTS

Capture Success

Twenty three mountain lions were instrumented with radio-collars during capture efforts (Table 3). Two mountain lions, one juvenile (female 137) and one adult (male 131) were introduced into the study area. Capture success was largely dictated by recent snowfall which facilitated detection of mountain lion tracks.

Adult male:female ratio of first-time captures was 3:13. Total male:female ratio of first time captures (juveniles included) was 8:15. One adult male (131) which was captured on a ranch 24 km east of the study area on the prairie may have been a resident adult on the study area but was excluded from the capture sex ratio due to a capture location that was outside of the study area.

Known weights of adult mountain lions (Table 4) in this study area were positively correlated with girth ($P < 0.001$, $r = 0.9309$, $n = 22$), canine length ($P < 0.001$, $r = 0.9609$, $n = 19$), neck circumference ($P < 0.001$, $r = 0.9541$, $n = 11$), nose to base of tail length ($P < 0.001$, $r = 0.8234$, $n = 22$), and total body length ($P < 0.001$, $r = 0.7973$).

Home Area and Movements

Annual home area characteristics were determined from 183 locations of 11 adult and 3 independent juvenile mountain lions, one of which was introduced onto the study

Table 3. Capture dates and current status information for mountain lions captured on the Sun River study area, Montana, 1991-1992.

I.D. #	Sex	Age	Wt kg	Capture date	Status (June 1992)
126	F	A	36	01/30/91	active
127	M	A	64	02/23/91	dead
128	F	A	39	02/25/91	shed radio-collar
129	F	A	39	02/26/91	radio failure
130	F	A	36	03/08/91	radio failure
131	M	A	52	03/09/91	harvested
132	F	J	17	03/15/91	shed radio-collar
133	M	J	17	03/15/91	active
134	M	J	18	03/15/91	shed radio-collar
135	F	A	48	03/18/91	active
136	F	A	52	03/21/91	radio failure
137	F	J	27	05/24/91	management removal
138	M	J	22	12/11/91	radio failure
139	M	J	23	12/16/92	active
140	F	A	59	01/08/92	harvested
141	F	A	43	02/11/92	active
142	M	A	54	02/24/92	active
143	F	A	36	03/08/92	active
144	F	J	9	03/09/92	shed radio-collar
145	M	J	11	03/09/92	active
146	F	A	36	03/17/92	active
147	F	A	41	04/10/92	active
148	M	A	68	04/11/92	active
149	F	A	41	04/12/92	active
150	F	A	41	04/13/92	active

Table 4. Body measurements of captured mountain lions showing sex, capture age class, body length, total length, weight, girth, neck circumference, and canine length on the Sun River study area, Montana, 1991-1992.

I.D.#	Sex	Age	Body (cm)	Total (cm)	Wt (kg)	Girth (cm)	Neck (cm)	Canine (cm)
126	F	A	122	191	36	69		
127	M	A	147	224	64	97		3.2
128	F	A		173	39	74		
129	F	A	122	157	39	76		2.8
130	F	A	122	185	36	74		2.5
131	M	A	132	198	52	79		2.8
132	F	J	102	155	17	56		1.3
133	M	J	102	163	17	56		1.4
134	M	J	102	160	18	56		1.3
135	F	A	124	198	48	81		3.2
136	F	A	127	203	52			
137	F	J	107	170	27	61		
138	M	J		138	22	58	30	1.4
139	M	J		150	23	60	34	1.5
140	F	A	123	202	59		44	3.5
141	F	A	129	200	43		43	3.0
142	M	A	126	181	55	82	43	
143	F	A	118	184	36	66	40	3.0
144	F	J	84	116	9	48	28	1.2
145	M	J	88	127	11	52	30	1.6
146	F	A	131	187	36	68	39	2.8
147	F	A	112	163	41	66		
148	M	A	128	186	68	83		3.5
149	F	A	118	186	41	73	41	3.0
150	F	A	124	191	41	68	36	3.0

area (Table 5). The radio-telemetry location error from aerial surveys was estimated to be 150-200 meters. Results of a Spearman's rank correlation revealed the number of observations per animal (Table 5) was not correlated with home area size ($r = 0.3707$, $P = 0.1919$). However, monitoring period (number of months per animal) was correlated with home area size ($r = 0.7331$, $P = 0.0024$).

The mean annual home area size for male mountain lions was 96.4 km^2 (range = 12.0-205.3 km^2) compared to the 58.0 km^2 (range = 7.1-204.5 km^2) for females. Results of a Mann-Whitney U-test showed that mean annual home area sizes for both sexes did not significantly differ ($U = 1.35$, $p = 0.245$). Prairie-front mountain lion annual home areas (mean = 36.3 km^2, range = 7.1-116.8 km^2) were significantly smaller than interior mountain lion annual home areas (mean = 110.9 km^2, range = 12-205.3 km^2) throughout the study period ($U = 4.44$, $p = 0.035$).

Mean annual home area sizes for 5 prairie-front females was 13.2 km^2 (range = 7.1-28.3 km^2) which was significantly smaller ($U = 3.75$, $P = 0.053$) than the 94.3 km^2 mean (range = 71.9-116.8 km^2) for the 2 prairie-front males. Mean annual home area sizes for 3 interior females was 133 km^2 (range = 76.9-204.5 km^2) which did not significantly differ ($U = .13$, $P = 0.724$) from the 97.4 km^2 mean (range = 12.00-205.3 km^2) of 4 interior males.

The home area size for one interior adult female (135)

Table 5. The home area size, average activity radii (AAR), rate of animal movement (RAM) and number of locations (N) of mountain lions classified by the location of their home areas on the Sun River study area, Montana, 1991-1992.

I.D.	Sex	Location	N	Home Area (km2)	AAR	RAM
147	F	front	7	7.1	1.5	0.2
137	F	front	12	8.4	2.6	0.2
146	F	front	11	9.3	1.9	0.3
141	F	front	20	12.6	2.1	0.3
129	F	front	7	28.2	5.3	0.2
127	M	front	8	71.9	6.5	0.4
148	M	front	10	116.7	5.3	0.1
139	M	interior	9	12.0	2.1	0.0
142	M	interior	9	20.8	2.8	0.3
128	F	interior	19	76.9	3.8	0.2
131	M	interior	7	151.5	7.1	0.1
126	F	interior	24	204.5	6.7	0.3
133	M	interior	20	205.3	6.5	0.2
135	F	interior	20	117.4	5.6	0.2

with 3 dependent juveniles was compared with other interior female (126, 128) home areas. Mean annual home area size for female 135 was 117.9 km^2 which was smaller than the 140.7 km^2 (range = 76.9-204.5 km^2) mean annual home area size for other interior mountain lions. Mean annual home area size for prairie-front female 146 with 2 dependent juveniles was 9.3 km^2 which was smaller than the 14.1 km^2 (range = 7.1-28.2 km^2) mean annual home area size for other prairie-front females.

Study long estimates of average activity radii (Hayne 1949) varied among sex and geographic classes. The mean study-long AARs for 7 interior mountain lions was 5.0 km (range = 2.13-7.19 km) which was larger (U = 2.16, P = 0.142) than the 3.7 km (range = 1.55-6.59 km) for 7 prairie-front mountain lions. Mean study-long AARs for 6 males was 5.1 km (range = 2.13-7.19) which did not significantly differ (U = 1.35, P = 0.245) from the 3.7 km (range = 1.55-6.74) for 8 females. However, mean study-long AARs for 2 prairie-front males was 6.0 km (range = 5.3-6.6) which was larger (U = 2.4, P = 0.121) than the 2.7 km mean (range = 1.5-5.3 km) for 5 prairie-front females. In contrast, mean study-long AARs for 3 interior females was 5.4 km (range = 3.8-6.7), which did not significantly differ (U = 0.13, P = 0.724) from the 4.7 km (range = 2.1-7.2 km) for 4 interior males.

Study-long estimates of movement rates (RAM) did not vary among sex and geographic groups. Mean study-long RAMs for 7 interior mountain lions was 0.2 km/day (range = 0.04-0.4 km/day) which did not differ significantly (U = 0.00, P = 0.949) from the 0.3 km/day (range = 0.2-0.4 km/day) for 7 prairie-front mountain lions. Mean study-long RAMs for 6 males was 0.2 km/day (range = 0.04-0.4 km/day) which did not differ significantly (U = 0.42, P = 0.516) from the 0.3 km/day (range = 0.2-0.4 km/day) for 8 females.

Mean study-long RAMs for 2 prairie-front males was 0.3 km/day (range = 0.2-0.4 km/day) which did not significantly differ (U = 4.00, P = 1.000) from the 0.3 km/day (range = 0.2-0.3 km/day) for 5 prairie-front females. Mean study-long RAMs for 3 interior females was 0.3 km/day (range = 0.2-0.4 km) was not significantly larger (U = .50, P = 0.479) than the .207 km/day (range = .041-.306 km/day) for 4 interior males.

There was considerable overlap in male home areas (Figure 2). Male 133's home area encompassed male 142's home area. Although male 148 and male 142 shared 2% of their combined home areas, 21% of male 142's home area was shared with male 148. While male 148 and male 127 shared 9% of their combined home areas, 30% of male 127's home area was shared by male 148. While male 133 and male 131 shared 9% of their combined home areas, 20% of male 131's home area was shared with male 133.

There was overlap in prairie-front female home areas