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.

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
Bozeman, Montana

November 1992

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.

11/30/92
Date

Chairperson, Graduate Committee

Approved for the Major Department

11/30/92
Date

Robert E Moore
Head, Major Department

Approved for the College of Graduate Studies

12/15/92
Date

R L Brown
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the library shall make it available to borrowers under rules of the library.

If I have indicated my intention to copyright this thesis by including a copyright notice page, copying is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U. S. Copyright Law. Requests for permission for extended quotation from or reproduction of this thesis in whole or parts may be granted only by the copyright holder.

Signature Jane S. Williams

Date 11/30/92

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

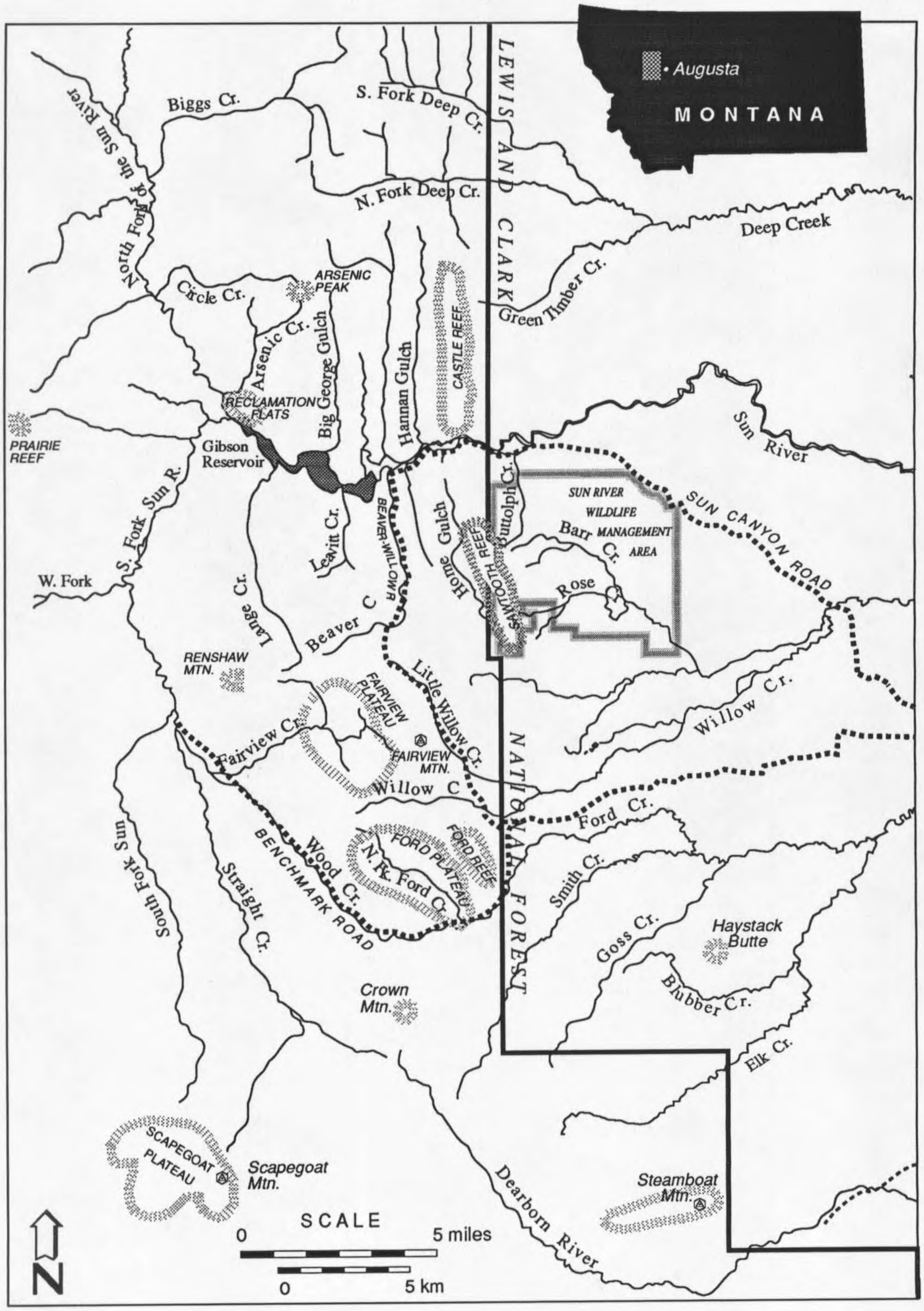


Figure 1. Map of the Sun River mountain lion study area in northern Montana.

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 $\geq$1 location per cell for statistical comparisons (Samuel et al. 1985). Mountain lion core areas were defined as the maximum area where the observed utilization distribution exceeded a uniform utilization distribution ($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) male	female	year	Reference	
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

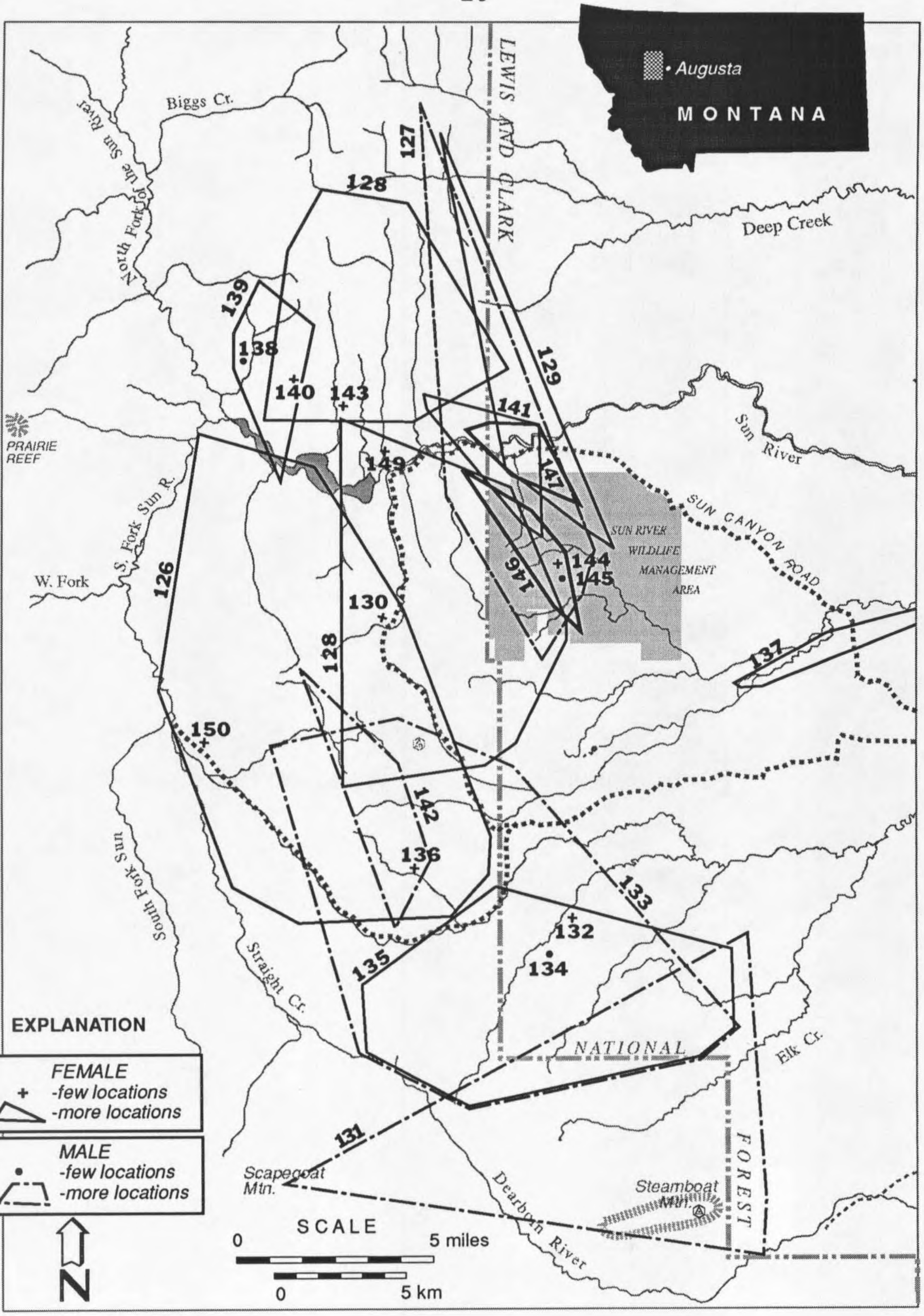


Figure 2. Minimum home area or general location of radio-collared mountain lions on the Sun River study area, 1991-1992.

(Figure 2). Both female 141 and 129 shared >50% of female 147's home area. While female 129 and female 141 shared 11% of their combined home areas, 33% of female 141's home area was shared by female 129. Interior female home areas did not overlap.

Core area analysis of 1 interior female mountain lion (128) home area and one prairie-front female (141) revealed disproportionate space use within their respective minimum convex polygons. Within the home area of female 141, 70% of the relocations (n=20) fell within 3 cells while one cell had no relocations present. Of the 9 cells available within the home area of female 141, 1 was used less than the expected availability (X^2 = 13.436, P = 0.0973). Within the home area of female 128, 60% of the relocations (n=20) fell within 5 cells while 7 cells had no relocations present. Of the 20 cells available within the home area of female 128, 7 were used less than the expected availability (X^2 = 22.053, P= 0.2814).

Habitat Use

Mountain Lion Habitat Selection Characteristics Considering All Presence Indicators

A total of 141 mountain lion telemetry relocations, 53 kill sites, 27 scat/scrape sites, and 27 track sites were assigned habitat cover types (Table 6). Chi-square analysis of mountain lion habitat selection patterns revealed some cover types were used out of proportion to availability

Table 6. Availability and description of 9 macrohabitat cover types on the Sun River mountain lion study area.

Type	Description	Avail. %
grassland	grassland/alpine meadows	42.7
shrubland	shrubfields, dry croplands	1.0
deciduous tree	aspen, cottonwood, riparian shrub	2.4
aspen + conifer	aspen + lodgepole pine and Douglas-fir	1.1
open conifer[a]	open canopy lodgepole pine, Douglas-fir, limber pine, spruce, subalpine fir, and whitebark pine	10.2
closed conifer[b]	closed canopy lodgepole pine, Douglas-fir, limber pine, spruce, subalpine fir, and whitebark pine	28.4
vegetated rock	rock, cliff, or slide areas with vegetation	8.8
bare rock	talus, scree, rock, and gravel bars with no vegetation	0.3
river-marsh	aquatic areas, fens, marshes, wet meadows, open and closed forest riparian areas	5.1

[a] open = <40% canopy closure, closed = >40% canopy closure.

[b] Closed conifer cover types included riparian areas concealed by a closed canopy.

(Table 7) when considered simultaneously (X^2 = 359.709, P < 0.001, 8 d.f.). Simultaneous confidence intervals, using the Bonferroni z statistic, indicated the closed conifer type, open conifer type, aspen plus conifer type, deciduous tree type, and shrubland type were used proportionately more than availability and the grassland-meadow type, vegetated rock type, and river-marsh type were used less than availability. The bare rock type was used in proportion to availability.

The gentle slope category (<20%) was used by mountain lions less than expected (X^2 = 9.192, P = 0.0264, 3 d.f.). All other slope categories were used in proportion to availability (Table 8). All LSRI categories were used in proportion to availability (X^2 = 3.424, P = 0.4916, 4 d.f.). Eastern aspects were used more than expected (X^2 = 32.924, P < 0.001, 8 d.f.). Western aspects were used less than expected (Table 8). All other aspects were used in proportion to availability. The 1219-1523 m and 1524-1828 m altitude ranges were used more than expected (X^2 = 90.743, P < 0.001, 4 d.f.). Elevations ranging from 1829-2437 m were used less than expected while elevations >2438 m were used in proportion to availability. There was a general increase in elevation use (telemetry locations) by mountain lions from June through September. Elevation of locations dropped in October and remained low through winter (Figure 3).

All distance from trail categories (Table 9) were used

Table 7. Percent availability and percent use[a] of cover types[b] based on summer, winter, and annual telemetry, kill locations, scat locations, and track locations of mountain lions on the Sun River study area, Montana, 1991-1992.

Cover type	% Avail	All data n=248	Telemetry Sum[c] n=55	Telemetry Win n=86	Telemetry Ann n=141	Kills n=53	Scats n=27	Tracks n=27
GRA	42.7	30.4-	30.5-	27.6-	29.4-	31.5-	36.1	35.6-
SHR	1.0	1.7+	1.0	2.3+	1.9+	2.1	0.4	2.2
DEC	2.4	5.3+	3.7	7.8+	6.1+	4.6	4.8	3.8
MIX	1.1	2.2+	1.4	2.3	2.0	3.3+	3.3	1.3
OPC	10.2	12.9+	12.8	12.6	12.4+	16.1+	14.8	6.9
CLC	28.4	37.3+	30.1+	40.6+	36.2+	37.7+	33.6	42.3+
VRO	8.8	6.7-	15.4+	5.2-	9.2	1.2-	2.5-	0.0-
BRO	0.3	0.2	0.6	0.0-	0.3	0.2	0.0-	0.0-
RIV	5.1	3.3-	4.5	1.6-	2.5-	3.3	4.5	7.9-

[a] + = Use > availability (P for simultaneous confidence intervals < 0.10); - = Use < availability (P for simultaneous confidence intervals < 0.10).

[b] GRA = grassland; SHR = shrubland; DEC = deciduous tree; MIX = aspen + conifer; OPC = open conifer; CLC = closed conifer; VRO = vegetated rock; BRO = bare rock; RIV = river-marsh.

[c] Sum = summer; Win = winter; Ann = annual.

Table 8. Percent availability[a] and percent use[b] of slope, aspect, elevation, and land surface ruggedness (LSRI) by mountain lions on the Sun River study area, Montana, 1991-1992.

Category	% Avail	All data n=248	Telemetry n=141	Kills n=53	Scats n=27	Tracks n=27
Slope						
<20%	21	15-	14-	13	19	26
20-49%	41	39	32-	53	59	37
50-69%	27	32	36+	23	18	30
>69%	11	14	18+	11	4	7
Aspect						
East	16	26+	28+	22	22	19
Northeast	14	10	14	6-	3-	0-
Southeast	9	6	6	6	7	7
West	18	12-	13	6-	15	18
Northwest	5	7	9	6	4	4
Southwest	9	6	6	2-	15	8
Level	7	8	7	13	4	15
North	12	14	12	14	15	18
South	10	11	5-	25	15	11
Elevation						
1219-1523m	10	19+	16	27+	18	26
1524-1828m	31	49+	44+	58+	20	63+
1829-2133m	37	25-	30	15-	30	7-
2134-2437m	20	6-	10-	0-	0-	0-
>2438m	2	1-	0-	0-	0-	4
LSRI						
0-10	11	11	9	11	11	11
11-20	35	35	35	32	35	41
21-30	37	37	33	46	37	41
31-40	15	15	21	11	15	3-
>40	2	2	2	0-	2	4

[a] % availability based on analysis of 281 random points.

[b] + = Use > availability (P for simultaneous confidence intervals < 0.10); - = Use < availability (P for simultaneous confidence intervals < 0.10).

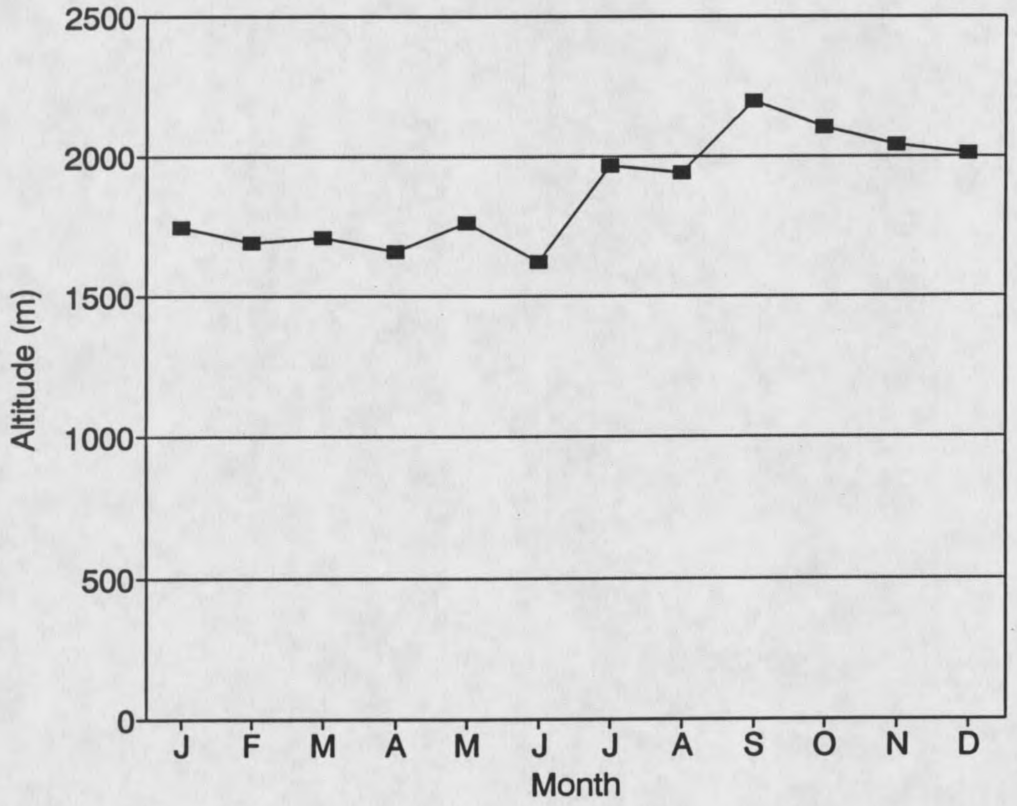


Figure 3. Mean altitude (m) of mountain lion telemetry locations by month on the Sun River study area, 1991-1992.

Table 9. A comparison of the use of areas[a] by mountain lions relative to the distance to water, trails, and roads on the Sun River study area, Montana, 1991-1992.

Category	% Avail	All data n=248	Telemetry n=141	Kills n=53	Scats n=27	Tracks n=27
Water Distance						
0-200m	36	60+[b]	52+	64+	74+	89+
201-500m	32	28	31	28	22	11-
>500m	32	12-	17-	8-	4-	0-
Trail Distance						
0-500m	27	33	25	45+	33	63+
501-1000m	21	17	18	15	22	15
1001-5000m	41	40	45	32	37	22-
>5000m	11	10	12	8	8	0-
Road Distance						
0-500m	14	22+	18	32+	19	29
501-1000m	9	17+	17+	13	26	11
1001-5000m	41	47	56+	34	37	33
>5000m	36	14-	9-	21-	18-	26

[a] % availability based on 281 random points.

[b] + = Use > availability (P for simultaneous confidence intervals < 0.10); - = Use < availability (P for simultaneous confidence intervals < 0.10).

by mountain lions in proportion to availability (X^2 = 5.993, P = 0.1104, 3 d.f.). The 0-500 m and 501-1000 m distance from road categories were used more than expected (X^2= 72.632, P < 0.001, 3 d.f.). Distances ranging from 1001-5000 m from a road were used in proportion to availability. Distances >5000 m from a road were used less than expected.

The 0-200 m distance to water category was used by mountain lions more than expected (X^2 = 80.804, P < 0.001, 2 d.f.). The 201-500 m category was used in proportion to availability whereas the >500 m category was used less than expected.

Diurnal Habitat Selection from Summer-Fall (May-Oct) Telemetry

Mountain lion use of habitats during summer-fall revealed some types were used out of proportion to availability when considered simultaneously (X^2 = 71.262, P < 0.001, 8 d.f.). The vegetated rock and closed conifer types were used more than expected. The grassland-meadow type was used less than expected. All other types were used in proportion to availability (Table 7).

Diurnal Habitat Selection from Winter-Spring (Nov-Apr) Telemetry

Mountain lion use of habitats during winter-spring revealed some types were used out of proportion to availability when considered simultaneously (X^2 = 327.169, P

< 0.001, 8 d.f.). The closed conifer type, deciduous tree type, and shrubland type were used more than expected. The grassland-meadow type, vegetated rock type, bare rock type, and river-marsh type were used less than expected. The open conifer type and aspen plus conifer type were used in proportion to availability (Table 7).

Annual Diurnal Habitat Selection Characteristics from Telemetry

Year-round mountain lion use of habitats revealed some types were used out of proportion to availability when considered simultaneously ($X^2 = 274.129$, $P < 0.001$, 8 d.f.). The closed conifer type, open conifer type, deciduous tree type, and shrubland type were used more than available. The grassland-meadow type and river marsh type were used less than available. All other types were used in proportion to availability.

Gentle and moderate slope categories were used by mountain lions less than expected ($X^2 = 20.973$, $P < 0.001$, 3 d.f.). Steep and rugged slope categories were used more than expected. All LSRI categories were used in proportion to availability ($X^2 = 5.374$, $P = 0.2499$, 4 d.f.). Eastern aspects were used more than expected ($X^2 = 29.478$, $P < 0.001$, 8 d.f.). Southern aspects were used less than expected. All other aspects were used in proportion to availability. The 1524-1828 m elevation category was used more than expected ($X^2 = 29.076$, $P < 0.001$, 4 d.f.).

Elevations greater than 2134 m were used less than expected. All other elevation categories were used in proportion to availability (Table 8).

All trail distance categories were used by mountain lions in proportion to availability ($X^2 = 1.985$, $P = 0.5792$, 3 d.f.). The 501-1000 m and the 1001-5000 m road distance categories were used more than expected ($X^2 = 58.523$, $P < 0.001$, 3 d.f.). The >5000 m category was used less than expected. The 0-500 m category was used in proportion to availability (Table 9).

The 0-200 m distance to water category was used by mountain lions more than expected ($X^2 = 24.923$, $P < 0.001$, 2 d.f.). The 201-500 m category was used in proportion to availability. The >500 m category was used less than expected.

Diurnal Use of Burned Regions

Both female 135 and male 131 utilized home areas within the region of the study area that was extensively burned in 1988. Sixty percent (12 of 20) of female 135's locations were in burned (vs forested or grassland) areas. All of female 135's locations in burned areas were associated with a rock-cliff component. Fifty-seven percent of male 131's locations were in burned areas. All of male 131's locations in burned areas were associated with a rock-cliff component.

Of the 42 (out of 56) kill locations where exact kill locations could be identified, 2 were located in burned areas. Both of these sites had an extensive understory (1.5 m high in the summer-fall period) of fireweed (Epilobium angustifolium) and were associated with female 135.

Habitat Characteristics at Kill Sites

The location of mountain lion kill sites (n= 56) revealed that kills were made in some habitats more than others when considered simultaneously (Table 7). (X^2 = 125.597, $P < 0.001$, 8 d.f.). The closed conifer type, open conifer type, and aspen plus conifer type were used more than expected. The grassland-meadow and vegetated rock types were used less than expected. All other types were used in proportion to availability.

All slope categories were used by mountain lions in proportion to availability (X^2 = 3.720, P = 0.2927, 3 d.f.). The extreme LSRI category was used less than expected (X^2 = 2.656, P = 0.6202, 4 d.f.). All other LSRI categories were used in proportion to availability. Northeastern, southwestern, and western aspects were used less than expected (X^2 = 26.036, P = 0.0013, 8 d.f.). All other aspects were used in proportion to availability. Elevation categories of 1219-1523 m and 1524-1828 m were used more than expected (X^2 = 45.735, $P < 0.001$, 4 d.f.). All other elevation categories were used less than expected.

The 0-500 m distance to trail category was used by mountain lions more than expected ($X^2 = 9.046$, $P = 0.0281$, 3 d.f.). All other distance categories were used in proportion to availability. The 0-500 m road distance category was used more than expected ($X^2 = 17.473$, $P < 0.001$, 3 d.f.). The >5000 m category was used less than expected. All other distance to road categories were used in proportion to availability (Table 9).

The 0-200 m distance to water category was used by mountain lions more than expected ($X^2 = 21.797$, $P < 0.001$, 2 d.f.). The 201-500 m category was used in proportion to availability and the >500 m category was used less than expected.

Habitat Characteristics at Scat/Scrape Sites

I determined habitat characteristics at mountain lion scat/scrape sites based on 27 scats collected (Murie 1954) during 1991-1992. Habitat use by mountain lions at scat/scrape sites differed when all types were considered simultaneously ($X^2 = 39.488$, $P < 0.001$, 8 d.f.). The bare rock and vegetated rock types were used less than expected. All other types were used in proportion to availability.

All slope categories were used by mountain lions in proportion to availability ($X^2 = 4.301$, $P = 0.2294$, 3 d.f.). All LSRI categories were used in proportion to availability ($X^2 = 3.424$, $P = 0.4916$, 4 d.f.). Northeastern aspects were used less than expected ($X^2 = 5.539$, $P = 0.7005$, 8 d.f.). All other aspects were used in proportion to availability.

The 1219-1523 m, 1524-1828 m, and 1829-2133 m elevation categories were used in proportion to availability (X^2 = 12.083, P = 0.0167, 4 d.f.). The 2134-2437 m and >2437 m categories were used less than expected.

All distance to trail categories were used by mountain lions in proportion to availability (X^2 = 0.841, P = 0.8413, 3 d.f.). The 0-500 m, 501-1000 m, and 1001-5000 m distance to road categories were used in proportion to availability (X^2 = 11.384, P = 0.0100, 3 d.f.). The >5000 m category was used less than expected.

The 0-200 m distance to water category was used by mountain lions more than expected (X^2 = 18.435, P < 0.001, 2 d.f.). The 201-500 m category was used in proportion to availability. The >500 m category was used by mountain lions less than expected.

Habitat Characteristics at Track Sites

The location of mountain lion travelling areas (track sites) revealed that some habitat types were used by mountain lions more than availability when considered simultaneously (X^2 = 68.624, P < 0.001, 8 d.f.). The closed conifer type was used more than expected. The grassland-meadow type, vegetated rock type, bare rock type, and river marsh type were used less than expected. All other types were used in proportion to availability.

All slope categories were used by mountain lions in proportion to availability (X^2 = 0.801, P = 0.8504, 3 d.f.). The rough LSRI category (>40) was used less than expected (X^2 = 3.045, P = 0.5527, 4 d.f.). All other LSRI categories were used in proportion to availability. Northeastern aspects were used less than expected (X^2 = 7.382, P= 0.4969, 8 d.f.). All other aspects were used in proportion to availability. The 1524-1828 m elevation category was used more than expected (X^2 = 27.928, P < 0.001, 4 d.f.). The 1829-2133 m and 2134-2437 m elevation categories were used less than expected. All other elevation categories were used in proportion to availability.

The 0-500 m distance to trail category was used by mountain lions more than expected (X^2 = 18.717, P < 0.001, 3 d.f.). The 501-1000 m category was used in proportion to availability. All other distance to trail categories were used less than expected. All distance to road categories were used in proportion to availability (X^2 = 5.993, P = 0.1105, 3 d.f.).

The 0-200 m distance to water category was used by mountain lions more than expected (X^2 = 33.301, P < 0.001, 2 d.f.). The 201-500 m and >500 m distance to water categories were used less than expected.

Foraging Habits

Analysis of Kills

A total of 56 mountain lion kills were examined between

February 1990 and June 1992. Nine prey species were represented in the kill sample (Table 10). Deer species (both white-tailed and mule deer) accounted for 41% of the kills examined, elk 27%, and bighorn sheep 18%. In addition, kills of 2 porcupine, 2 snowshoe hare, 1 raccoon, and 1 marmot were found.

Three instances of cannibalism were documented. One juvenile mountain lion was killed by an adult and partially consumed. A young adult mountain lion was killed by a blow to the head from a staff wielding hiker and scavenged by another young adult mountain lion within 24 hours. In another instance, a radio-collared adult male (127) was killed by another adult mountain lion and his internal organs were partially consumed and cached.

There were differences in percent prey species killed between winter-spring and summer-fall periods (Figure 4). Bighorn sheep (31%, n = 9), elk (31%, n = 9), and mule deer (21%, n = 6) were killed more in the winter-spring period than the summer-fall period. In contrast, white-tailed deer (26%, n = 7) and smaller mammals (15%, n = 4) were preyed upon more in the summer-fall period. There were 4 deer, all killed in the summer (15%, n = 4) that could not be identified to species in the field.

Of the kills examined (n = 56), 29 were recent enough to determine cause of death. A killing bite to the neck of the ungulates accounted for 66% of the kills while 24% was

Table 10. Composition of mountain lion diet based on kills located and scats analyzed for the Sun River study area, 1991-1992.

Prey	Kills (n=56) % of total	Scats (n=27) Freq. occur.
Elk	27.00	12.00
Mule deer	18.00	29.00
White-tailed deer	16.00	15.00
Unclassified deer	7.00	
Bighorn sheep	18.00	20.00
Snowshoe hare	3.50	8.00
Porcupine	3.50	2.00
Ground squirrel		8.00
Raccoon	1.75	
Marmot	1.75	
Pocket gopher		2.00
Vole		2.00
Mountain lion	3.50	
Domestic cat		2.00

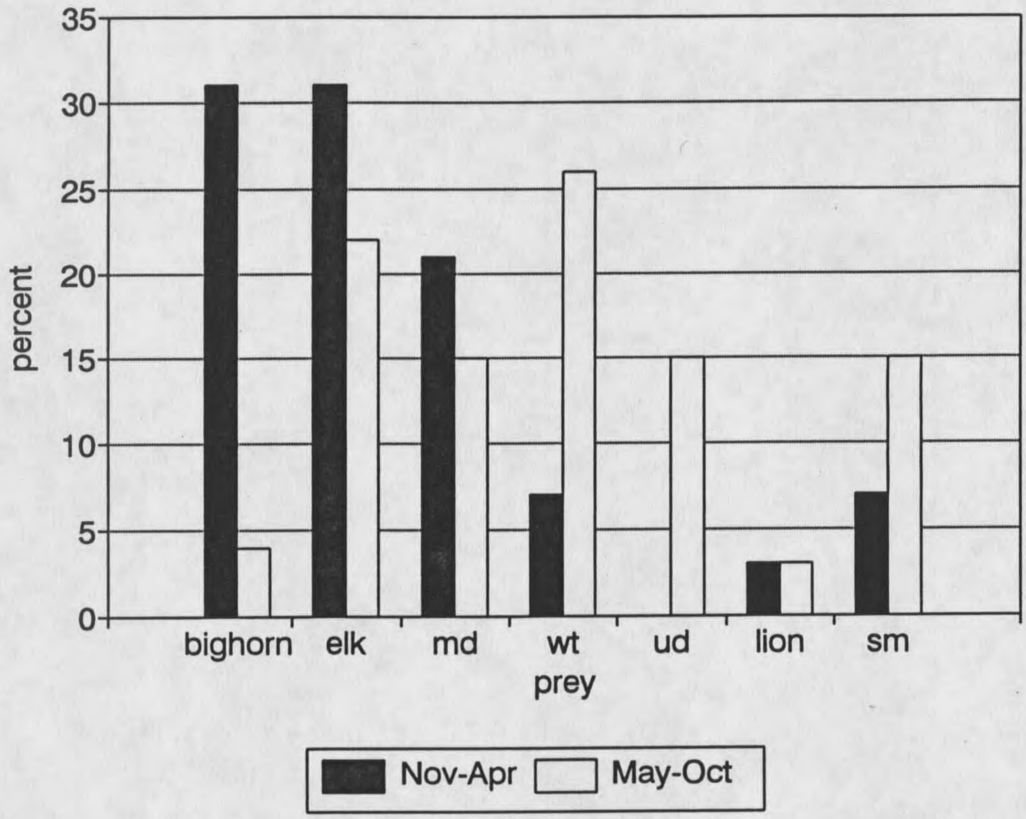


Figure 4. A comparison of the species composition (md = mule deer, wt = white-tailed deer, ud = unclassified deer, sm = small mammals) of kills made by mountain lions during the summer-fall period vs the winter-spring period on the Sun River study area, 1991-1992.

attributed to a facial bite (prey had nasal-jaw region removed), and 10% attributed to decapitation (small mammals).

Analysis of Scats

A total of 27 scats were examined revealing 34 prey items (Table 10). The same number of prey items were detected in scats as were detected in kills (10 taxa vs. 10). Deer species occurred in 44% of the scats, elk 12%, and bighorn sheep 20%. Two snowshoe hares and two ground squirrels comprised 16%. One pocket gopher, one vole, and one porcupine comprised 6%. One domestic cat comprised 2%.

Analysis of Prey Biomass

When the biomass of the prey consumed is estimated from the kill data collected, the importance of elk (59%, n = 15) in the diets of mountain lions (Figure 5) is emphasized. Deer (25%, n = 24) and bighorn sheep (14%, n = 10) also were important to the diet of mountain lions. When the biomass of prey species is broken down into sex and age classes (Table 11) the importance of both elk cows and bulls is evident. Bighorn sheep ewes (9%, n = 7), mule deer bucks (6%, n = 4), and white-tailed deer does (5%, n = 6) also contributed heavily to the diet of mountain lions.

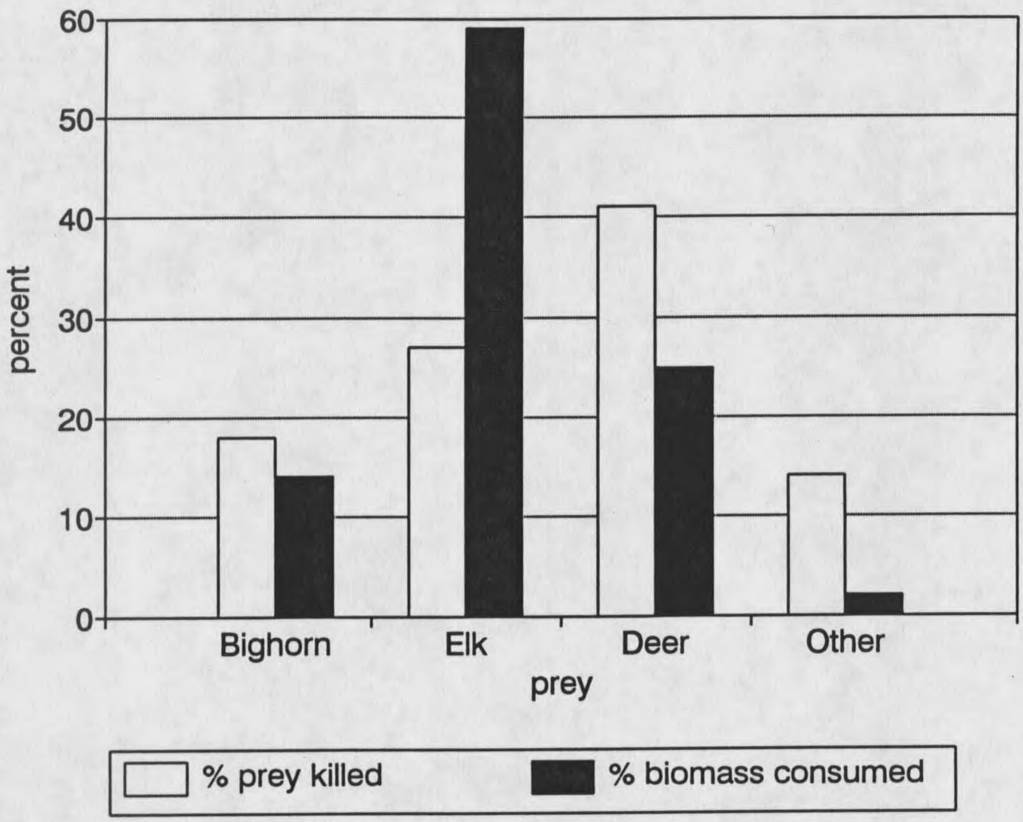


Figure 5. The contribution of prey species biomass to the diet of mountain lions as compared to the proportion of known kills on the Sun River study area, 1991-1992.

Table 11. Prey species age or sex specific contribution of biomass to the diet of mountain lions based on the number of kills found in the Sun River study area, Montana, 1991-1992.

Prey		No.	%	Biomass (kg)[a]	%
Bighorn sheep	male	3	5	213	5
	female	7	13	387	9
Elk	male	5	9	1185	28
	female	8	14	1264	30
	calf	2	3	79	2
Mule deer	male	4	7	234	6
	female	4	7	190	4
	yearling	2	3	79	2
White-tailed	male	1	2	54	1
	female	6	11	213	5
	yearling	2	3	63	2
Unclass deer[b]		4	7	194	5
Mountain lion	male	1	2	26	1
	juvenile	1	2	9	<1
Porcupine	adult	2	3	10	<1
Raccoon	adult	1	2	5	<1
Snowshoe hare	adult	2	4	3	<1
Marmot	adult	1	2	1	<1

[a] Ungulate utilization factor = 0.79; other mammals = 0.85.

[b] Unclassified (species) of adult deer

Blood Analyses

A total of 6 mountain lions, 1 male (142) and 5 females (141, 143, 144, 146, 150) were tested for brucellosis and 7 strains of Leptospira (L. pomona, L. hardjo, L. grippotyphosa, L. autumnalis, L. icterohemorrhagia, L. canicola, L. tarassovi). All mountain lions tested negative for brucellosis and all 7 strains of Leptospira.

DISCUSSION

Home Area and Movements

Home Area Size and AAR

Mean annual home area size for male (96.4 km^2) and female (58.1 km^2) mountain lions on the Montana Rocky Mountain Front were among the smallest recorded in the western United States. Hopkins et al. (1982) noted comparable mean annual home area sizes for 2 females (70.5 km^2) and 3 males (91.7 km^2) in an area with high prey densities in central California. Logan et al. (1985) noted similarly small mean annual home area sizes for 4 females (67 km^2) in the Bighorn mountains in Wyoming. Laundre et al. (1991) had 2 females with a mean annual home area size of 77 km^2 in fragmented habitat in southern Idaho. Other studies have noted considerably larger home area sizes for both male and female mountain lions (Seidensticker et al. 1973, Murphy 1983, Laing 1988, and Ross and Jalkotzy 1992). Home areas and movements of mountain lions in this study were likely influenced by prey populations, topography (appendix B), and cover, similar to the vegetation-terrain/prey abundance-vulnerability complex suggested by Hornocker (1970) and Siedensticker et al. (1973).

Smaller mean annual home area sizes for mountain lions that used a portion of the SRWMA compared to interior mountain lions may reflect smaller wintering prey populations in interior regions of the study area. Elk, mule deer, white-tailed deer, and bighorn sheep are present on the SRWMA as resident and migratory populations (Knight 1970, Kasworm 1981, Erickson 1972). The prey populations on the SRWMA fluctuate widely during the year, with ungulate populations at their highest on the SRWMA during winter (Knight 1970). The resident populations of ungulates on the SRWMA appeared much smaller than the migratory segment but nonetheless were available prey biomass during the summer-fall period. Male mountain lion mean annual home areas were larger than females for animals that seasonally used a portion of the SRWMA on the Rocky Mountain Front. On the SRWMA, where no hunting of mountain lions occurs and prey populations are seasonally more concentrated, the larger size of male home areas may be related to reproductive strategies (Hornocker 1970, Seidensticker et al. 1973).

Seidensticker et al. (1973) also noted that the relationship between home areas of mountain lions was likely influenced by elevation and snow depth. Mountain lions in this study with home areas encompassing interior drainages encountered more severe winter conditions (deeper snow) and more restricted but widely distributed prey patches (McCarthur and Pianka 1966, Charnov 1976) as compared to mountain lions inhabiting the prairie-front region of the study area. Foraging distances thus were greater for mountain lions that utilized multiple ungulate winter ranges in interior regions of the study area. Most ungulate populations in the study area winter on the prairie-front (SRWMA included) region, which is usually free of snow at times each winter (Knight 1970, Kasworm 1981, and Frisina 1974).

Similar to other studies (Maehr et al. 1989, Ross and Jalkotzy 1992), female mountain lions with kittens used smaller home areas compared to lone females inhabiting the same area. Female 135 and her 3 kittens resided in a burned region of the study area and had a larger home area than female 146 and her two kittens who resided on the SRWMA. Reduced cover and increased foraging distances may increase mean annual home area size for mountain lions inhabiting recently burned areas.

Movements

Rates of animal movement (RAM) were an index of mountain lion mobility in this study. If movements of mountain lions were inversely related to the quality of foraging areas, interior mountain lions should have exhibited higher RAM's than mountain lions that utilized the SRWMA which contained the highest densities of prey populations on the study area. However, RAM (km/day) did not differ significantly between sex or prairie-front and interior mountain lions (Table 5). Circuitous foraging routes that are possibly influenced by topography may have confounded movement analysis (Mack 1988). Also, the large variation in time intervals between successive mountain lion locations also confounded movement analysis (Seidensticker et al. 1973).

Home Area Overlap

Home area overlap for both male and female mountain lions occurred on the study area. The harvest of 6 adult males and 6 adult females from the study area during the mountain lion hunting season (winter 1990-1991) and 4 adult males and 3 adult females during the next year (winter 1991-1992) possibly influenced the extent of home area overlap displayed by radio-collared animals.

Female Home Area Overlap

Female home areas overlapped extensively on the SRWMA, sometimes completely. Interior female home areas (n = 3) did not overlap. Abundant and concentrated prey populations on the SRWMA may have affected the spacing of mountain lion home areas through intraspecific behaviors (Seidensticker et al. 1973, Hemker et al. 1984, Maehr et al. 1989). Overlapping female home areas have been documented in other areas (Hornocker 1970, Seidensticker et al. 1973, Murphy 1983, Laing 1988, Ross and Jalkotzy 1992).

Male Home Area Overlap

One interior male's home area (142) was completely within the home area of another male mountain lion (133). Overlapping home areas of male mountain lions is not common, but has occurred in other studies (Sitton 1977, Shaw 1979, Ashman 1981, and Hopkins et al. 1982). Male 142 may have been restricted somewhat to a smaller and more familiar foraging area because he only had one eye.

Male 133 was radio-collared as a juvenile on the study area and appeared to be establishing a home area adjacent to his natal area, possibly as a result of the legal harvest of 10 adult males during the study period resulting in unoccupied (male) habitat. Non-dispersing mountain lions have been observed in other studies (Murphy 1983, Maehr et al. 1989, Laing 1988, and Ross and Jalkotzy 1992). Hemker et al. (1984) observed 3 males that dispersed independent of density dependent factors. High concentrations of prey populations and vacated mountain lion home areas due to harvests in this study may make juvenile dispersal unnecessary for some mountain lions when unoccupied habitat is available. This differing from the strategy observed by Hemker et al. (1984) in a desert enviroment.

Temporal Home Area Overlap

Regions of home area overlap were not always avoided temporally. On one occasion, adult female 141 was located in a creek bottom 100 m from female 146 (with her 2 juvenile offspring). On another day in early-May, male 148, female 146 and her 2 kittens, female 141, female 147, and possibly female 129 (radio failure) were all on the SRWMA which encompasses an area of approximately 64 km^2. In June, male 148 was located approximately 200 m from male 142 on the same rocky reef. "Social gatherings" of up to 3 adult female mountain lions were noted by Laing (1988) in Utah.

Home Area Overlap vs Topography

The region of home area overlap between male 133, 142, and 148 corresponded with 1 of 2 major ungulate movement pathways (Ford-Fairview Plateau). The elk, bighorn sheep, and deer that move through Ford-Fairview plateau are limited topographically to 2 gorges (Knight 1970, Frisina 1974), Benchmark canyon and Willow Creek gorge. Mountain lions may seasonally focus their foraging efforts on these ungulate movement corridors.

Male 127's home area overlapped slightly with male 148. Male 127 was killed by a mountain lion before male 148 was radio-collared so temporally there may have been no overlap. The region of overlap was located on the SRWMA. Extensive female home area overlap was also common on the SRWMA. The northern end of the SRWMA is also a major elk and deer migratory corridor through limiting topographic features. The Sun River canyon, north of the SRWMA, and the Beaver-

Willow/Ford-Fairview plateau area to the South were used by ungulate species for travel into the interior regions of the study area and as movement corridors at other times of the year. Home areas of radio-collared mountain lions appeared to overlap most where these ungulate movement corridors were present.

Core Areas

Core areas were quantified for two adult females (128, 141). Although female 141's home area polygon included the talus-scree areas on Sawtooth mountain, she was never located above timberline in the rocky talus-scree. She restricted her movements to the timbered regions at lower elevations. Female 141 was consistently located only in 3 of 9 possible use cells within her home area. She selected covertypes where there was a combination of closed-conifer cover types and prey.

In the interior region of the study area, female 128 was consistently located in only 5 of 20 possible use cells. She appeared to concentrate her activities on 2 long (>8 km) rocky, timbered reefs. Her North-South movements between successive locations followed these topographic features. Although not quantified, other radio-collared mountain lions in my study appeared to concentrate activities to specific regions, influenced by topography, cover, and prey availability within their respective home area polygons

Habitat Use

All Presence Indicators

Considering all habitats available in this study, mountain lion presence indicators demonsrated the importance of cover. Hornocker (1970) noted the importance of cover for mountain lions to successfully stalk and attack prey. Cover also provides security for mountain lions during feeding periods (Logan and Irwin 1985). Other researchers also have noted the importance of cover for mountain lions (Seidensticker et al. 1973, Murphy 1983, and Laing 1988).

Combining all presence indicators for mountain lions (telemetry, kills, tracks, and scat-scrapes) in this study indicated that closed conifer, open conifer, aspen plus conifer, deciduous tree, and shrubland cover types were selected. These cover types provide both stalking and feeding security habitat (Hornocker 1970, Logan and Irwin 1985, Koehler and Hornocker 1991). The closed conifer type was preferred in all presence indicator classes except the scat/scrape type. The closed conifer type also included riparian areas concealed by a closed canopy (Table 7).

Although the grassland-meadow, vegetated rock, and river-marsh types were avoided, mountain lions were often located close to these types in areas with more cover. My results concur with Hornocker (1970) in that mountain lions used "edge" complexes while on hunting forays. The grassland-meadow habitats are important ungulate foraging areas on the Rocky Mountain Front in Montana (Picton 1960, Knight 1970, Frisina 1974, and Kasworm 1981).

Telemetry Data

Based on diurnal telemetry data, the vegetated rock type was selected by mountain lions during the summer-fall period, in part related to the use of this type by prey populations. Erickson (1972) and Andryk (1983) noted that bighorn sheep during the summer period used sparsely vegetated rock-scree habitats at high altitudes on the Rocky Mountain Front in Montana. Kasworm (1981) reported that mule deer residing east of the Continental Divide on the Montana Rocky Mountain Front also used vegetated scree habitats during the summer period. The use of the vegetated rock cover type during summer by mountain lions probably reflected similar use by prey populations.

Similar to the findings of Murphy (1983), mountain lions in this study showed an increased use of higher elevations in the summer-fall period as compared to the winter-spring period. Based on annual diurnal telemetry data, mountain lions used more open habitats during the summer-fall period than the winter-spring period. The spring dispersal of ungulates from the winter ranges on the Rocky Mountain Front to higher elevation summer ranges occurs from April to mid June (Knight 1970, Kasworm 1981). Increased use of more open cover types by mountain lions during the summer-fall period may have reflected an increase in search efforts for more widely distributed prey populations that were utilizing vegetated rock habitats.

Some mountain lions (131, 132, 133, 134, 135, and numerous unmarked animals) in this study were located in extensively burned areas. Most locations were associated with a rock-cliff component. Due to the absence of a canopy cover, mountain lions likely used the rocky areas within the burn for stalking and security cover. Extensive stands of fireweed within the burn during the summer-fall period also provided stalking cover. However, on one occasion, a family group of mountain lions was observed from the plane to be hunting or traveling through a burned region with no ground cover other than burned trees.

Kill Sites

Mountain lion kills in this study were located in closed conifer, open conifer, and mixed aspen-conifer types more than any other cover type. Mountain lion kills in an Idaho study were determined to be in rough bluff areas, heavily timbered northern exposures, and brushy bottoms of ravines and creeks (Hornocker 1970). Murphy (1983) reported that in winter, mountain lions in western Montana made most of the kills in Douglas fir habitats. Logan and Irwin (1985) found that nearly 58% of the kills made by mountain lions in northern Wyoming were in curlleaf mountain mahogany and mixed conifer habitats.

Although kill sites were not predominately located in the grassland cover type, there were occasions where mountain lions attacked bighorn sheep (Appendix A) away from the forest edge (>50 m) in a grassland cover type and then dragged the carcass into nearby cover. Most deer and elk kills however, were located in the timbered areas.

Mountain lion kills documented in this study occurred at lower elevations (< 1829 m) on northern, southern, and eastern aspects, where there was stalking cover and high use by ungulates (Knight 1970, Kasworm 1981, Erickson 1972). Kills were located in unbroken and flat topography as well as steep and complex topographical types.

Mountain lion kills in this study were mostly located close to water, USFS recreational trails, and roads, all of which are common in drainage bottoms. Consequently, most observations of prey killed by mountain lions were made in or near drainage bottoms. Other researchers have noted high use of drainage bottoms by mountain lions (Hornocker 1970, Murphy 1983, Laing 1988). Two of 56 mountain lion kills were made on roads. Mountain lion kills were often on or near USFS recreational trails. Thus human, horse, and automobile traffic did not appear to deter the foraging behavior of mountain lions. This implies a relatively fine grained habitat structure adapted to tolerance for people which provides the potential for mountain lions to live in close proximity to developments.

Scat-Scrape Sites

Seidensticker et al. 1973 suggested mountain lion urine, scats, and corresponding scrapes served to bring lions together or to maintain distance. They also noted that most scrapes and scats were associated with a large fir or pine tree. Hornocker (1970) found scats or scrapes on trails, high ridges, at lion crossings, and at some permanent mountain lion marking stations. The location of scrapes and scats in this study concurred with the conclusions of Hornocker (1970) and Seidensticker et al. (1973) in that they may have facilitated intraspecific communication.

No mountain lion scats or scrapes were found in the vegetated rock and bare rock cover types. Scats and scrapes were found in all other cover types. Scats were most often buried in scraped piles of pine duff with very few scats found unburied. In two scrapes that were independent of kill sites, there were scats of varying ages (<1 week, and >6 months) suggesting reuse of an old scrape or the use of the same scrape by two different animals (Seidensticker et al. 1973). Usually scrapes were associated with large or atypical trees in monotypic stands. Mountain lion scats not associated with detectable scrapes were located in limestone caves. Most caves (>1 m deep and 1 m high, 2 m wide) discovered on the study area contained mountain lion scat or kill remains.

Scats and scrapes made by mountain lions were located on slopes ranging from gentle to steep, found on all aspects, and found in all land surface ruggedness classes. High pass (<2133 m) scat and scrape sites also were common. Scrapes and scats were commonly located on sidehills above stream bottoms. Distances to USFS recreational trails and roads did not appear to influence the locations of scrapes and scats.

Track Sites

Several researchers have noted the tendency for mountain lions to travel along drainages or ridges (Hornocker 1970, Seidensticker et al. 1973, Shaw 1979, Murphy 1983, Hemker 1984, Logan and Irwin 1985, Laing 1988, and Van Sickle and Lindzey 1991). These researchers have also noted the strong relationship between travelling-hunting areas and cover. Location of track sites (independent of kills) were used as indicators of mountain lion travelling-hunting routes (Logan and Irwin 1985).

Mountain lions used the closed conifer cover type for travel more than any other. Open areas such as the grassland-meadow type were avoided. Snow-tracking revealed that mountain lions travelled from one patch of cover to another, using both vegetation and rocky overhangs for concealment. Travelling-hunting areas were generally below 1829 m and on all aspects, slopes, and land surface ruggedness types. Mountain lion tracks also were located near stream bottoms, trails, and roads on a regular basis demonstrating the adaptability of the mountain lion for foraging effectively in a wide variety of habitats.

Foraging Habits

Considerable variation in mountain lion food habits in North America has been documented (Young and Goldman 1946, Robinette et al. 1959, Hornocker 1970, Spalding and Lesowski 1971, Shaw 1979, Murphy 1983, Anderson 1983, Ackerman et al. 1984, Leopold and Krausman 1986, Logan and Irwin 1985, Murphy 1992, Ross and Jalkotzy 1992). The variation in prey species appears to be associated with latitude and climate at the continental level (Iriarte et al. 1990).

The Montana Rocky Mountain Front area is unique in that it contains all mammals historically present with the exception of bison. Large numbers and concentrations of both resident and migratory elk, mule deer, white-tailed deer, and bighorn sheep are limited both climatically and topographically to certain migratory pathways and winter ranges (Picton 1959, Knight 1970, Erickson 1972, Kasworm 1981). In this study, selection of prey by mountain lions coincided with seasonal availability and vulnerability of prey populations (Hornocker 1970), stalking cover present, and individual mountain lion reproductive status.

Analysis of Kills and Scats

Deer. With the exception of the tropics, deer or deer-sized ungulates are the most common mountain lion prey species (Iriarte et al. 1990). Cervids were the most common prey item of mountain lions in this study, with deer species making up 41% (n= 23) of the kill sample. This is similar to Ross and Jalkotzy's (1992) findings on a Rocky Mountain Front mountain lion study area in southern Alberta. Murphy (1983) noted that white-tailed deer were the most represented prey item in a sample of mountain lion kills in western Montana.

White-tailed deer were dominant in the mountain lion kills during the summer-fall period in this study. The summer-fall period may represent a difficult foraging period for mountain lions because elk, bighorn sheep, mule deer, and white-tailed deer are not concentrated on winter ranges (Knight 1970, Erickson 1972, Kasworm 1981). White-tailed deer were killed primarily in drainage bottoms (78%, n= 9) During summer, groups of white-tailed deer were observed most consistently in drainage bottoms and on closed canopy timbered sidehills. Observations of white-tailed deer were made as far back in the study area interior as the North Fork of the Sun River during summer. In winter, white-tailed deer appeared to use the Front and associated drainages extending out onto the short-grass prairie. White-tailed deer may provide a traditionally reliable and concentrated food resource for mountain lions during summer. During winter with some exceptions (Sun Canyon), the relatively open and low elevation winter ranges utilized by white-tailed deer may not provide desirable stalking cover. The ungulate species that utilize winter ranges closer to more timbered and rugged areas may be more vulnerable to mountain lion predation.

During winter, mule deer populations on the Montana Rocky Mountain Front use grassland areas intermixed with timbered patches (limber pine wind forest), moderate-steep slopes, and windward aspects low enough in elevation to be blown free of snow by chinook winds (Ishle 1982). During the summer period, Kasworm (1981) noted that mule deer used timbered and higher elevation habitats on the East Front. Mule deer were killed by mountain lions mostly during the winter and spring period. During winter-spring, Mule deer primarily occupied the moderately steep limber pine cover types interspersed with Douglas fir. This provided good stalking cover for mountain lions. Consequently, mule deer were generally more vulnerable to predation than white-tailed deer during the winter-spring period.

Mule deer bucks were killed by mountain lions more than does and fawns in this study. The solitary nature of mule deer bucks combined with their preference for rugged, dense habitat have been cited as behavioral factors that increase buck vulnerability to the stalk-ambush attack strategy of the mountain lion (Robinette et al. 1959, Hornocker 1970, Spalding and Lesowski 1971, Harrison and Hebert 1988). Female mule deer also were observed in the same vulnerable rugged, dense habitats as the bucks, although not as often. There was no evidence of selection by mountain lions for sick, young or old prey.

Elk. Elk were killed by mountain lions most often during winter and spring. During winter elk utilized the lowland open prairie, the limber pine wind forest, and higher elevation Douglas fir forest (Knight 1970). On the SRWMA, where all 3 of the preceding wintering habitats were available, elk were subject to mountain lion predation in the limber pine wind forest and the Douglas fir forest. No mountain lion kills were located on the open prairie. With the exception of riparian areas, there probably was not sufficient stalking or feeding security cover (Logan and Irwin 1985) on the open prairie for mountain lions to consistently prey on elk in this habitat.

Elk cows were killed by mountain lions in this study more frequently than bulls or calves. Only 2 cow elk kills were discovered on the Front (SRWMA); both were killed on the SRWMA in the closed canopy Douglas fir forest complex. All other cow elk kills were discovered on interior winter ranges which were associated with a Douglas fir forest. This closed conifer cover type may have provided more stalking cover for mountain lions. Large groups of cow and calf elk that winter on the open prairie likely were less vulnerable to mountain lion predation than elk that used smaller interior winter ranges surrounded with more potential stalking cover.

<u>Bighorn Sheep</u>. Compared to other studies of food habits of mountain lions in the Northwest U.S. (Hornocker 1970, Murphy 1983, Murphy 1992, and Ross and Jalkotzy 1992), bighorn sheep were preyed upon extensively in this study (10 kills, 20% frequency of occurrence in scats). Only Harrison and Hebert (1988) in British Columbia noted significant predation by mountain lions on bighorn sheep.

Bighorn sheep were killed by mountain lions in this study almost exclusively during the winter and spring. Most bighorn sheep appeared to have been killed by a mountain lion using a short stalk and ambush, near a forest-grassland edge. Erickson (1972) noted that most bighorn sheep in the same study area were on winter ranges by December. Bunchgrass, rocky reef, and old burned habitats were commonly used. Timbered habitats were seldom used by bighorn sheep during winter. Frisina (1974) noted that during fall and spring, 86% (n= 1,652) of the bighorn sheep observations in the same study area were within 100 m of escape cover, with only about 10% of the observations in forested habitats. Frisina (1974) further noted that forested habitats in the study area were used as escape terrain, only when bighorns were forced by severe weather to move away from rocky terrain in search of food. Bighorn sheep generally avoid timbered areas (Geist 1972).

Geist (1972) suggested that mountain lions occasionally take a healthy bighorn, but appear to play a very minor role in sheep mortality. Conversely, Kelly (1981) noted that the mountain lion is an important predator of the desert bighorn sheep. In a Desert Wildlife Refuge, mountain lions were noted to take bighorn sheep incidentally at or on the way to watering holes in high density mule deer areas (Kelly 1981). Mountain lions in this study were found to utilize segments of the Sun River bighorn sheep population as a seasonally important prey resource.

Both adult rams and ewes were killed by mountain lions in this study. Harrison and Hebert (1988) noted that more post-rut rams were killed by mountain lions than adult ewes and lambs. In this study more adult ewes were killed by mountain lions. The remains of one lamb were also found in one mountain lion scat. Perhaps the traditionally large winter aggregations of female bighorn sheep (Erickson 1972) on the study area provide a more dependable food resource for mountain lions; hence, they may be hunted more by mountain lions than smaller ram groups.

Small Mammals. Small mammals also were preyed upon by mountain lions in this study. Most of the small mammal kills occurred in the summer-fall period. Seidensticker et al. (1973) reported that small mammals were important alternative prey species of mountain lions during summer in Idaho. Leopold and Krausman (1986) also reported that mountain lions preyed on small mammals. Spalding and Lesowski (1971) found that snowshoe hares formed a significant part of the mountain lions diet in British Columbia. One adult female (146) with 2 kittens was observed feeding on a porcupine kill. Although it is doubtful that 1 porcupine could feed 3 animals, perhaps smaller mammals are more important prey items for females with kittens due to increased metabolic demands and the need for kitten predatory-play behavior (Leyhausen 1979).

Biomass

Estimated contribution of prey biomass has been calculated for mountain lions in several studies (Robinette et al. 1959, Hornocker 1970, Ackerman et al. 1982, Ross and Jalkotzy 1991). Although deer species made up the largest component of the kill sample, elk contributed most of the biomass to the diets of mountain lions. If prey species are separated into sex and age classes, bighorn sheep ewes contributed more biomass to the diets of mountain lions than all of the deer sex and age classes.

REFERENCES CITED

Ackerman, B. B. 1982. Cougar predation and ecological energetics in southern Utah. M.S. Thesis, Utah State Univ., Logan. 95pp.

______, F. G. Lindzey, and T.P. Hemker. 1984. Cougar food habits in southern Utah. J. Wildl. Manage. 48:147-155.

Anderson, A. E. 1983. A critical review of literature on Puma (Felis concolor). Colorado Div. Wildl. Spec. Rep. No. 54. 91pp.

Ashman, D.L., G. L. Christensen, M.L. Hess, G.K. Tsukamoto, and M.S. Wickersham. 1983. The mountain lion in Nevada. P-R Project W-48-15, Nevada Dep. Wildl. 75pp.

Aune, K., and P. Schladweiler. 1991. Wildlife laboratory report. job prog. re. W-120-R-15 Mont. Fish, Wildlife, and Parks, Helena. 52pp.

Beasom, S. L., E. P. Wiggers, and J. R. Giardino. 1983. A technique for assessing land surface ruggedness. J. Wildl. Manage. 47:1163-1166.

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

Charnov, E. L. 1976. Optimal Foraging, the marginal value theorem. Theor. Pop. Biol. 9:129-136.

Connolly, E. J., Jr. 1949. Food habits and life history of the mountain lion (Felis concolor hippolestis). M.S. Thesis, Univ. Utah, Salt Lake City. 176pp.

Conover, W. J. 1971. Practical nonparametric statistics. Wiley, New York. 462pp.

Coues, E. 1893. History of the expedition under the command of Lewis and Clark. Dover Publ. Co., N.Y. Vol. I:311-312.

Deiss, C. F. 1943. Structure of the central part of the Sawtooth Range, Montana. Bull. Geol. Soc. 54(3):1123-1168.

Erickson, G. L. 1972. The ecology of Rocky Mountain bighorn sheep in the Sun River area of Montana with special reference to summer food habits and range movements. M.S. Thesis, Mont. State Univ., Bozeman. 50pp.

Fitzpatrick, E. B. 1988. Mapping grizzly bear habitat with LANDSAT (MSS) data. USDA, Lewis and Clark National Forest manuscript. Great Falls, MT. 16pp.

Frisina, M. R. 1974. Ecology of bighorn sheep in the Sun River area of Montana during fall and spring. M.S. Thesis, Mont. State Univ., Bozeman. 68pp.

Gashwiler, J. S., and W. L. Robinnette. 1957. Accidental fatalities of the Utah cougar. J. Mammal. 38:123-126.

Geist, V. 1971. Mountain Sheep: a study in behavior and evolution. Univ. of Chicago Press, Chicago, IL. 383pp.

Hamilton, L. C. 1990. Statistics with STATA. (users manual) Brooks/Cole Publishing Co., Pacific Grove, CA. 171pp.

Harrison, S. and Hebert, D. 1988. Proceedings of the 6th Biennial Northern Wild Sheep and Goat Council. Banff, Alberta 6:292-306.

Hayne, D. W. 1949. Calculation of size of home range. J. Mammal. 39:190-206.

Hempker, T. P., F. G. Lindzey, and B. B. Ackerman. 1984. Population characteristics and movement patterns of cougars in southern Utah. J. Wildl. Manage. 48:1275-1284.

Holdorf, H. 1981. Soil resource inventory-interim in-service report now wilderness portions. USDA, Forest Service. Lewis and Clark Natl. For., Great Falls, MT. 70pp.

Hopkins, R. A., M. J. Kutilek, and J. Shreve. 1982. The density and home range characteristics of mountain lions in the Diablo Range of California. Proc. Int. Cat Symp. Caeser Kleberg Fed. Res. Inst., Kingsville, Tex., and Nat. Wildl. Fed. Inst. Wildl. Res., Washington, D. C.

Horner, M. A. and R. A. Powell. 1990. Internal structure of home ranges of black bears and analysis of home-range overlap. J. Mammal. 71(3):402-410.

Hornocker, M. G. 1969. Winter territorialityin mountain lions. J. Wildl. Manage. 33:457-464.

_____. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildl. Monogr. 21. 39pp.

_____. 1992. Mountain lions: The secret life of America's ghost cat. National Geographic. [(182)1:38-65.]

_____, and T. Bailey. 1982. Natural regulation in three species of felids. Proc. Int. Cat Symp. Caeser Kleberg Fed. Res. Inst., Kingsville, Tex., and Nat. Wildl. Fed. Inst. Wildl. Res., Washington, D. C.

_____, and W. V. Wiles. 1972. Immobilizing pumas (Felis concolor) with phencyclidine hydrochloride. Int. Zoo Yearbook. 12:220-223.

Ihsle, H. B. 1982. Population ecology of mule deer with emphasis on potential impacts of gas and oil development along the east slope of the Rocky Mountains, northcentral Montana. M.S. Thesis, Mont. State Univ., Bozeman. 85pp.

Iriarte, J. A., W. L. Franklin, W. E. Johnson, and K. H. Redford. 1990. Geographic variation of food habits and body size of the America puma. Oecologia. 85:185 190.

Jalkotzy, M. G., I. P. Ross, and J. R. Gunson. 1992. Management plan for cougar in Alberta. Wildlife Management Planning Series No. 5. Forestry, Lands, and Wildl., Fish and Wildl. Division. 91pp.

Joslin, G. 1988. Montana Mountain Lions. Montana Outdoors. 19(6):17-20.

_____, and G. Brown. 1978. Capture and reintroduction of a mountain lion kitten. Mont. Dep. Fish, Wildl. and Parks, Region one report. 7pp.

Kasworm, W. F. 1981. Distribution and population characteristics of mule deer along the East Front, Northcentral Montana. M.S. Thesis, Mont. State Univ., Bozeman. 73pp.

Kelly, W. E. 1980. Predator relationships. Pages 186-196 in G. Munson and L. Summer ed. The desert bighorn. Univ. of Ariz. Press, Tucson. 370pp.

Knight, R. R. 1970. The Sun River elk herd. Wildl. Monog. 23. 66pp.

Koehler, G. M. and M. G. Hornocker. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. J. Mammal. 72:391-396.

Laing, S. P. 1988. Cougar habitat selection and spatial use patterns in southern Utah. M.S. Thesis, Univ. of Wyoming, Laramie. 68pp.

Laundre', J. W., M. Sellers, T. Clark, and D. P. Streubel. 1991. Behavior, ecology, and conservation of mountain lions in fragmented habitat, a progress report. Idaho State Univ., Pocatello. 46pp.

Leopold, B. D. and P. R. Krausman. 1986. Diets of 3 predators in Big Bend National Park, Texas. J. Wildl. Manage. 50:290-295.

Leyhausen, P. 1979. Cat behavior: the predatory and social behavior of domestic and wild cats. Garland STM Press, New York. 340pp.

Lindzey, F. G. 1987. Mountain lion. Pages 657-658 in Novak, M., J. A. Baker, M. E. Obbard, and B. Malloch eds. Wild furbearer management and conservation in North America. Ontario Trappers Assoc., Toronto.

Logan, K. A. and L. L. Irwin, 1985. Mountain lion habitats in the Bighorn Mountains, Wyoming, Wildl. Soc. Bull. 13:257-262.

_____, L. L. Irwin and R. Skinner. 1986. Characteristics of a hunted mountain lion population in Wyoming. J. Wildl. Manage. 50:648-654.

Lonner, T. N. and D. E. Burkhalter. 1983. User's manual for the computer program TELDAY (TELemetry DAta analYis). 14pp.

Lund, R. E. 1987. Montana State University statistical package (MSUSTAT), microcomputer version 4.0, Mont. State Univ., Bozeman.

MacArthur, R. H. and E. R. Pianka. 1966. On optimal use of a patchy environment. Amer. Nat. 100:603-609.

Mack, J. A. 1988. Ecology of black bears on the Beartooth Face, south-central Montana. M.S. Thesis, Mont. State Univ., Bozeman. 119pp.

Mackie, R. J. 1982. Mule deer. Pages 862-877 in J. A. Chapman and G. A. Feldhamer ed. Wild mammals of North America. The Johns Hopkins Press, Baltimore.

Maehr, D. S., J. C. Roof, E. D. Land, and J. W. McCown.

1989. Early maternal behavior in the Florida panther (Felis concolor coryi). Am. Midl. Nat. 122:34-43.

Marcum, C. L. and K. O. Loftsgaarden. 1980. A non-mapping techniquefor studying habitat preferences. J. Wildl. Manage. 33:465-481.

McBride, R. T. 1976. The status and ecology of the mountain lion (Felis concolor stanleyana) of the Texas-Mexico border. M.S. Thesis, Sul Ross State Univ., Alpine. 160pp.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Moore, T. D., L. E. Spence, and C. E. Dugnolle. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wy. Fish and Game Bull. No. 14. Cheyenne. 177pp.

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

Murphy, K. A. 1983. Characteristics of a hunted population of mountain lions in western Montana. M.S. Thesis, Univ. of Montana, Missoula. 48pp.

_____, G. S. Felzien, S. E. Relyea, and M. G. Hornocker. 1992. The ecology of the mountain lion (Felis concolor missoulensis) in the northern Yellowstone ecosystem. Cumalitive Prog. Report No. 5. Wildlife Research Institute, Moscow, Idaho. 39pp.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availabilty data. J. Wildl. Manage. 38:541-545.

Peek, J. M. 1982. Elk. Pages 851-861 in J. A. Chapman and G. A. Feldhamer ed. Wild mammals of North America. The Johns Hopkins Univ. Press, Baltimore. 1147pp.

Peters, G. 1991. Vocal communication in cats. Pages 76-77 in J. C. Seidensticker and S. Lumpkin ed. Great Cats. Rodale Press, Emmaus, PA.

Pfister, R., B. Kovalchik, S. Arno, and R. Presby. 1977. Forest habitat types of Montana. U.S. For. Serv. Gen. Tech. Rep. INT-34. 174pp.

Picton, H. D. 1960. Migration patterns of the Sun River elk herd. J. Wildl. Manage. 24:279-290.

______, and I. E. Picton. 1975. Saga of the Sun. Mont. Dept. Fish and Game, Helena. 55pp.

Riley, S. 1992. Cougars in Montana: A review of biology and management and a plan for the future. Mont. Dept. of Fish, Wildl., and Parks, Helena. 65pp.

Robinette, W. L., J. S. Gashwiler, and O. W. Morris. 1959. Food habits of the cougar in Utah and Nevada. J. Wildl. Manage. 23:261-273.

Ross, I. P. and M. G. Jalkotzy. 1992. Characteristics of a hunted population of cougars in southwestern Alberta. J. Wildl. Manage. 56:417-426.

Samuel, M. D., D. J. Pierce, and E. O. Garton. 1985. Identifying areas of concentrated use within the home-range. J. Animal Ecol. 54:711-719.

Sauer, P. R. 1984. Physical characteristics. Pages 91-118 in L. K. Halls, ed. White-tailed deer ecology and management. Stackpole books, Harrisburg, PA.

Schaller, G. B. 1972. The Serengeti Lion. The Univ. of Chicago Press, Chicago. 480pp.

Seidensticker, J. C. IV., M. G. Hornocker, W. V. Wiles and J. P. Messick. 1973. Mountain lion social organization in the Idaho Primitive Area. Wildl. Monogr. 35. 60pp.

Shaw, H. G. 1979. A mountain lion field guide. Arizona Game and Fish Dept. Sp. Rep. No. 9. 27pp.

______. 1989. Soul among lions: The cougar as peaceful adversary. Johnson Publ. Co., Boulder, CO. 140pp.

Sitton, L. W. 1977. California mountain lion investigations with reccomendations for management. Final Rep. to the State Legislature, P-R Project W-51-R, Sacremento: California Fish and Game Dept. 35pp.

Spalding, D. J. and J. Lesowski. 1971. Winter food of the cougar in south-central British Columbia. J. Wildl. Manage. 35:378-381.

Van Sickle, W. D. and F. G. Lindzey. 1991. Evaluation of a cougar population estimator based on probability sampling. J. Wildl. Manage. 55:738-743.

Young, S. P. and E. A. Goldman. 1946. The puma, mysterious American cat. The Am. Widl. Inst., Washington, D.C. 358pp.

APPENDICES

APPENDIX A

CASE HISTORIES OF MOUNTAIN LION OBSERVATIONS

Case history 1

Reintroduction of juvenile female mountain lion

Mountain lion hunting regulations in Montana require that "females with kittens may not be taken" but if such a female is taken the kittens should be captured and turned over to Montana Department of Fish, Wildlife, and Parks (MDFWP) personnel (Joslin and Brown 1978). An orphaned mountain lion kitten was captured, raised, and released in northwest Montana previously (Joslin and Brown 1978).

A juvenile female (137) mountain lion was released on the Rocky Mountain Front study area in June of 1991. She had been raised at the MDFWP nature center in Helena, Montana after having been orphaned the previous winter. She was released in the limber pine wind forest on the SRWMA. Instead of using the SRWMA as was anticipated, female 137 moved east, on to the short-grass prairie, following Barr Creek into Willow Creek. She was subsequently located in Willow Creek. The reintroduction was biologically successful in that female 137 was able to kill both small and large mammals in the wild (Microtus spp., white-tailed deer).

Case history 2

Relocation of an adult male mountain lion

A young adult mountain lion (131) was captured in a farm shed containing domestic rabbits on a ranch 1.6 km east of Highway 287 between Augusta and Choteau. He was tranquilized, instrumented with a radiocollar, and released on the Ear Mountain Wildlife Management Area (state owned) west of Choteau, Montana. Following his relocation (within 2 weeks), male 131 moved approximately 53 km south into the Elk Creek drainage (Montana Rocky Mountain Front mountain lion project study area). Male 131's home area was subsequently determined to be in the southern 1/3 of the study area, >53 km south of his point of release.

Male 131 was legally harvested during the 1991-1992 mountain lion hunting season on the Dearborn River. The hunters located male 131 by following lion tracks with the use of trailing hounds from a recently killed mule deer buck (Jimmy Lee pers. comm. January, 1992). Male 131 weighed 52 kg at the time of his relocation in March, 1991 and 68 kg at the time of his harvest in January, 1992. His relocation was biologically successful in that he exhibited a substantial weight gain following relocation. From a game management standpoint, male 131's relocation was also a success in that a depredating adult mountain lion survived following relocation and was subsequently legally harvested providing a recreational opportunity for sportsmen.

Case history 3

Use of a prairie habitat by a mountain lion

Mountain lions historically have been regarded as forest dwelling animals (Young and Goldman 1946). Accounts exist, however, of mountain lions observed in more open habitats (Young and Goldman 1946). Female 137 used riparian areas within a short-grass prairie environment following reintroduction. She moved east to the prairie using riparian corridors. The presence of at least 6 adult mountain lions (radio-collared) on the SRWMA may have prompted her move east. Within the short-grass prairie habitat, she was mostly located in the Willow Creek riparian area. The creek bottom contained numerous stands of cottonwood (Populus trichocarpa) and willow (Salix spp) which served as potential stalking and feeding security cover. Female 137 was observed while aerial radio-tracking to be within 200 m of at least 5 (sometimes >20) white-tailed deer. Since most of the aerial radio-tracking was done when the deer were visible (6:00-10:00 a.m.), this may have biased the association between female 137 and the deer. She was also observed on 2 occasions to be travelling on the short-grass prairie with no apparent canopy cover for >300 m.

Case history 4

Mountain lion-human interaction

An introduced juvenile female mountain lion (137) was determined to be a threat to the safety of humans and consequently removed from the Sun River bottom, approximately 45 km east of the study area near the town of

Augusta, Montana. Female 137 inhabited riparian areas within the short-grass prairie habitat surrounding Willow Creek. Prior to the opening of bow hunting season, she moved further east into the Sun River bottom near the Young ranch north of Augusta, Montana. Two bowhunters were approached (possibly stalked) to within 3 m by female 137 on 2 occasions during the same day. She exhibited no fear of humans and was foraging close to local farmhouses and the town of Augusta. Female 137 was subsequently removed from the Sun River bottom by lethal management control action (Larry Davis pers. comm. September 1991). Female 137's reintroduction was a biological success in that she was able to kill prey in the wild but her lack of fear for humans was a management failure. Perhaps more emphasis should be placed on the negative conditioning (to the presence of humans) of mountain lion orphans being reared in captivity for release into the wild.

Case History 5

Mountain lion-human interaction

An unmarked (not radio-collared) young adult mountain lion was killed by a recreational backcountry horseman in the interior of the study area (North Fork of the Sun River) in March, 1992. The mountain lion reportedly approached a man repeatedly while he was off his horse and hiking near some timber in wet snow. Upon discovering the mountain lion, numerous attempts were made to discourage its approach (yelling, waving of arms, and throwing objects). The man then hoisted a dead lodgepole pine into the air and killed the approaching mountain lion by a blow to the head. Interestingly, within 24 hours of the incident, the dead mountain lion was cannibalized (scavenged) by another mountain lion approximately the same size (based on tracks present). Mountain lion litters have been noted to separate from their mother and travel together for a period of time (Kerry Murphy pers. comm. March, 1992). These mountain lions may have been a sibling pair travelling together.

Case History 6

Killing

The modus operanti of the mountain lions killing bite has been observed in captivity (Hornocker 1992) and rarely in the wild (Jim Mepham pers. comm. August, 1992). Most mountain lion kills in this study showed evidence of massive hemmorhaging in the neck area and punctured tracheas. Perhaps the killing bite of the mountain lion on either the dorsal or ventral region of an ungulates neck or the nasal area kills the prey by suffocation, massive blood loss, or lethal neurological damage (Schaller 1972). Ungulate prey species often had discernable claw marks on the rear limbs, possibly at the point of first contact with the lion.

In this study, when fresh small mammal kills could be located, decapitation appeared to occur prior to feeding on the rest of the carcass. In one instance, an adult female mountain lion was jumped from a fresh snowshoe hare kill in mid-summer. She had consumed only the head when she left the kill. It was difficult to judge the exact cause of death for small mammal kills due to their small size and tendency to be consumed rapidly

Case History 7

Cannibalism

Cannibalism has been observed in mountain lion populations in other regions (Connolly 1949, Hornocker 1970, Hemker 1984, Ross and Jalkotzy 1992). All three of the cannibalized mountain lions in this study showed partial consumption from the ventral abdominal area. Two of the cannibalized mountain lions were older juveniles or young adults killed by larger adult mountain lions. The third cannibalized mountain lion was a resident adult on the study area that moved northwest of his home area on the SRWMA into Deep Creek and was killed by an adult mountain lion within 2 weeks of his move north. Perhaps the seasonal change of mountain lion land tenure (Hornocker 1970) in the study area due to the legal harvest of mountain lions results in more intraspecific conflicts. Thus it appears possible that legal harvest could either increase or decrease intraspecific conflicts. This will have to be resolved by future research.

Case history 8

A mountain lion stalks and kills a bighorn sheep

A mountain lion attack on a bighorn sheep ewe was evaluated by observing recently made tracks in the snow. The bighorn sheep ewe was apparently travelling through a snow-covered grassland plateau approximately 5 m from a large stand of Douglas fir. A large (52 kg) radio-collared adult female (136) mountain lion stalked the ewe to the edge of the Douglas fir stand, then crouched low and waited. When the bighorn ewe approached to within some unknown critical distance to the still concealed female 136, the attack ensued. There was very little struggle in terms of distance moved by the ewe after point of first contact with female 136. The ewe had claw marks on the right shoulder and the ventral region of her neck ripped open.

Case history 9

Mountain lion family communication during the hunt

A mountain lion attack on an adult female mule deer was evaluated by snow-tracking female 146 and her 2 juvenile kittens (143,144) on the SRWMA. The family group apparently was travelling over a small, snow-covered grassy knoll in the limber pine wind forest when they discovered a bedded mule deer doe in a draw approximately 10 m below them. At that point, the two juveniles circled down the grassy knoll to the south and waited in the draw approximately 50 m below the bedded mule deer doe. They presumeably watched the attack take place as their tracks were oriented towards the incident. The adult female, waited (crouched in the snow) for an unknown time period then pounced onto the back of the bedded mule deer. Female 146 covered the 10 m distance between her and the deer in 2 pounces. The juveniles, after an unknown time period, rejoined their mother at the kill site. Very little is known about communication between mountain lion females and their kittens (Peters 1991), especially while on hunting forays. Perhaps females communicate with body movement or posture instead of acoustically with their kittens while hunting to minimize detection by prey species.

Case history 10

Opportunistic feeding

On one occasion, an adult male mountain lion killed a snowshoe hare just prior to killing a mule deer, possibly indicating opportunistic feeding behaviour. An adult female with 2 week old kittens consumed a domestic cat near a housing development in Mortimer Gulch which may have been opportunistic feeding as domestic cats are not common in the study area.

Case history 11

Caching of kills

Similar to Hornocker (1970), almost all mountain lion kills located in this study were cached or covered in some manner. Vegetation usually was used to cover freshly killed prey species. Pine duff, when available, was used to cover most kills. If sufficient vegetation was not available (i.e. grassland habitats), the prey item was usually dragged into covered areas or moved into a ravine bottom for concealment. Snow was used at times to cover prey species during winter, especially bighorn sheep which were usually killed in grassland areas where prey caching materials are less common.

Case history 12

Use of caves

Mountain lions have historically been noted to use caves (Connolly 1949). Five caves were examined on the study area and all were found to contain mountain lion scats. Two of the 5 caves contained the remains of a kill. One cave contained multiple kills (1 bigorn sheep ewe, 2 unclassified deer, and 1 marmot). A small felid anterior jaw fragment was also discovered in this cave. All of these caves were >1 m deep and high, and >2 m wide and were located in limestone formations, on southern exposures.

Case history 13

Evidence of intraspecific strife

Numerous scars, presumably from intraspecific strife, were present on both adult male (127, 131, 142) and adult female (147, 150) mountain lions. Male 142 was missing his left eye, and had scratch marks on his right shoulder along with a kinked tail at the time of his capture. Male 131 had numerous cuts on his face and scratches on his left rear flank at the time of his harvest. Male 127 had numerous cuts, tooth marks (neck area), and scratches present following a lethal battle with another unmarked (not radio-collared) adult mountain lion. Female 147 had a scarred face, ears, and tail at the time of her capture. Female 150 had some scars on her body and a possible broken tail.

Mountain lions have been noted to incur injuries while attacking prey (Gashwiler 1957, Hornocker 1970). However, the presence of claw marks (scratches) and a mortality (male 127) due to fighting suggests that intraspecific strife may be common on the study area. Hornocker and Bailey (1982) noted that exploited mountain lion populations may be in a state of flux and that intraspecific fighting may occur when home areas are being established. Intraspecific fighting has been reported in other studies of exploited mountain lion populations (McBride 1976, Logan et al. 1986). The mountain lion land tenure system described by Seidensticker et al. (1973) appears to be operating in the Montana Rocky

Mountain Front mountain lion population, and the occurrence of intraspecific strife was probably a result of land tenure battles.

Case history 14

Swimming

Mountain lions have been noted to cross large rivers during the high water season (Hornocker 1970). An adult female (141) mountain lion in this study was observed swimming across a large body of water. While radio-tracking during summer, after noting 2 female white-tailed deer running from an island into the Sun River and three Canada geese (*Branta canadensis*) taking flight, I heard a splash in the direction of female 141's radio-signal. I observed female 141 moments later crawling out of the river, shaking water off, and running south towards Home Gulch. The river in this area is about 50 m wide and >3 m deep. This incident may have been induced by the investigator as mountain lions observed in this study usually flee when approached closely.

Case history 15

Agricultural depredations

In some areas of the western United States mountain lion depredations are a serious problem (Shaw 1989). Only one domestic sheep depredation was attributed to a mountain lion attack during the study. This attack occurred at a private residence, not on the Lewis and Clark National Forest. One cattle depredation was rumored to have occured, but was not verified. Perhaps the availability of native ungulates is above some critical threshold which reduces predation on domestic ungulates. However, if cattle ranches are increasingly used as winter range by native ungulates, mountain lions on hunting forays might come into contact with domestic ungulates more often and depredation incidents may increase.

Case history 16

Home area replacement

An unmarked (not radio-collared) adult female mountain lion was harvested on the east side Mortimer reef on January 18, 1992. On March 8, 1992 female 143 was captured on the west side of Mortimer reef. Female 143, at the time of her capture, had 2, approximately 1-week-old kittens (1 male, 1 female). The location of female 143's capture was approximately 0.8 km west of the unmarked adult females harvest location. If the unmarked adult female that was harvested was a resident mountain lion on the study area with a home area encompassing Mortimer Reef, the presumably available habitat was only vacated for approximately 40 days.

Laing (1988) found that female home area replacement occurred rapidly and that home area size did not increase following the first year of establishment. He further noted that daughters of resident mountain lions were often the individuals which established in vacant areas following the demise of their mothers or adjacent resident females. In the Sun River study area, which has high ungulate diversity, density, and variable vulnerability, mountain lion home area replacement following harvest probably occurs rapidly.

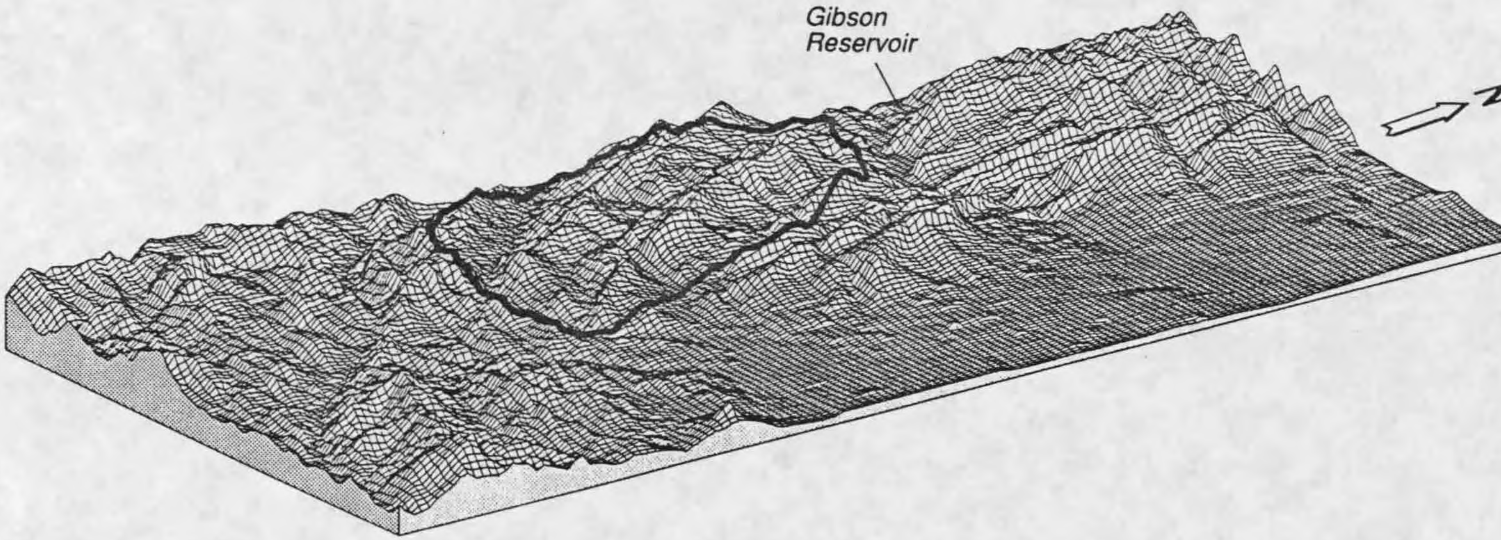
Case history 17

Mountain lion-wolf interactions

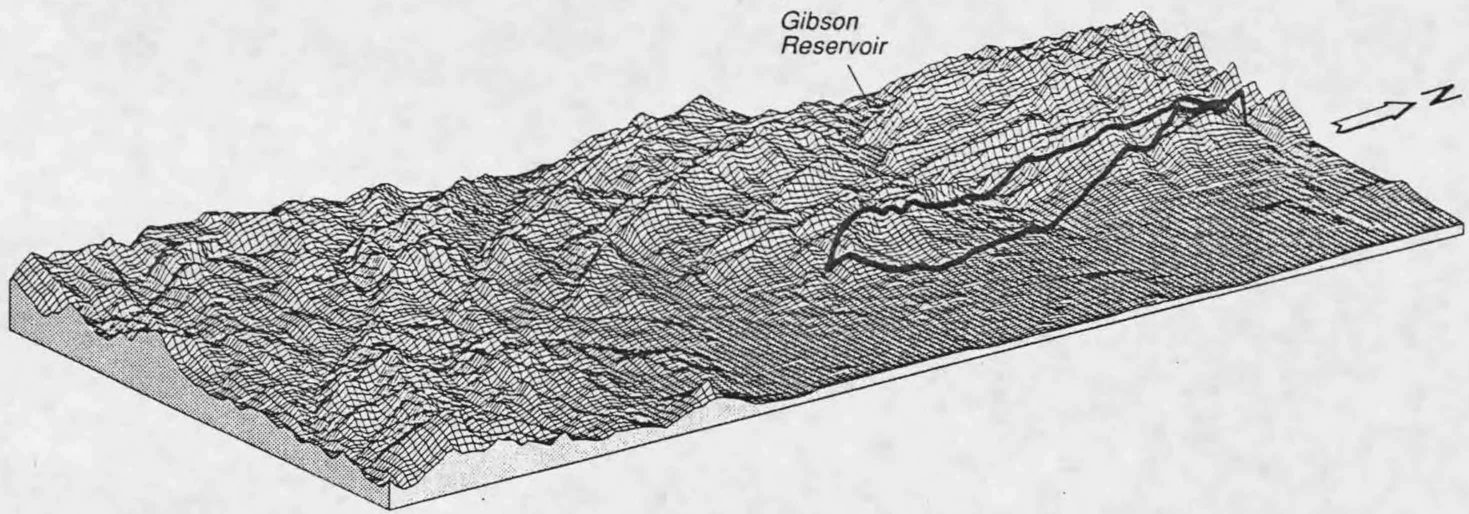
The gray wolf and mountain lion are sympatric on the Sun River study area. Tracks made by a lone adult gray wolf were observed regularly during the winter period. During winter, there was evidence of scavenging by a wolf on mountain lion kills (Pat Finnegan, USFS, pers. comm., March, 1992). There were five documented instances of a wolf approaching mountain lion kills. The kills consisted of 4 cow elk, and 1 spike bull elk. In 3 of the cases, the wolf approached the kills, apparently inspected the kill, and then moved on. In another case, a wolf had fed on the carcass, urinated on some of the ribs, and had dragged some bones away from the kill site. There was evidence of interspecific competition (Pat Finnegan, USFS, pers. comm., January, 1992). Based on recently made tracks in the snow, an adult gray wolf displaced an adult mountain lion from its kill (cow elk). The wolf had apparently chased the mountain lion approximately 20 m away from the kill site and then returned to feed. Interspecific competition between wolves and mountain lions may increase as wolves become more numerous in the study area.

APPENDIX B

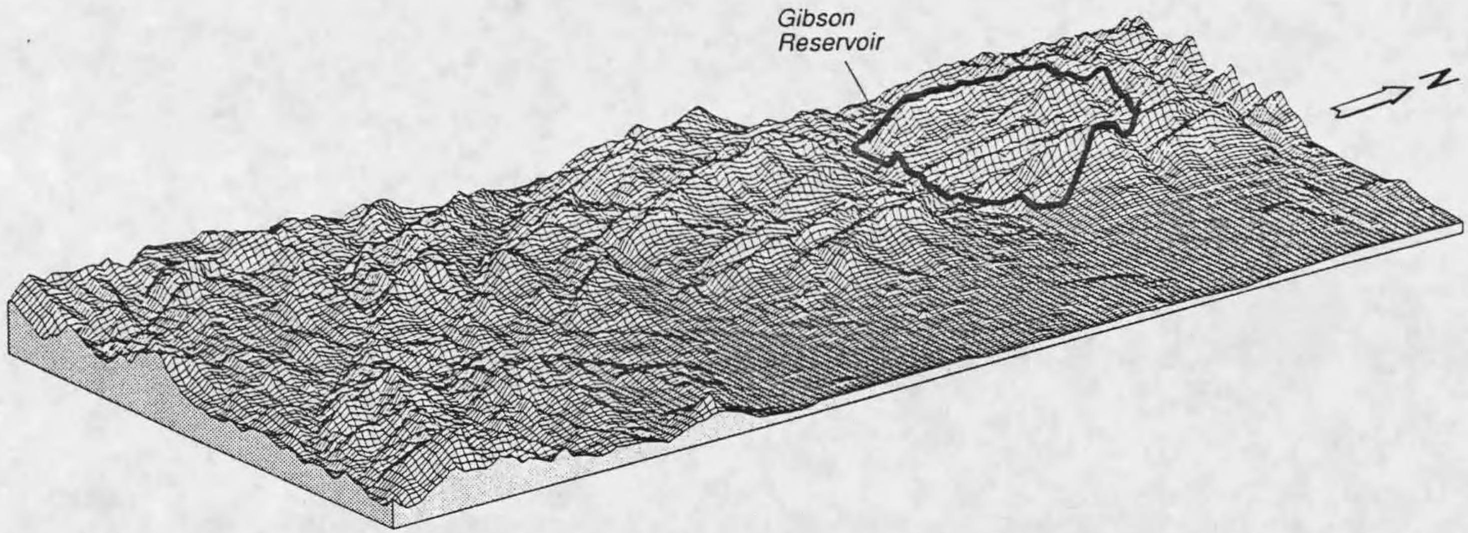
MOUNTAIN LION HOME AREAS RELATIVE TO TOPOGRAPHY ON THE SUN RIVER STUDY AREA



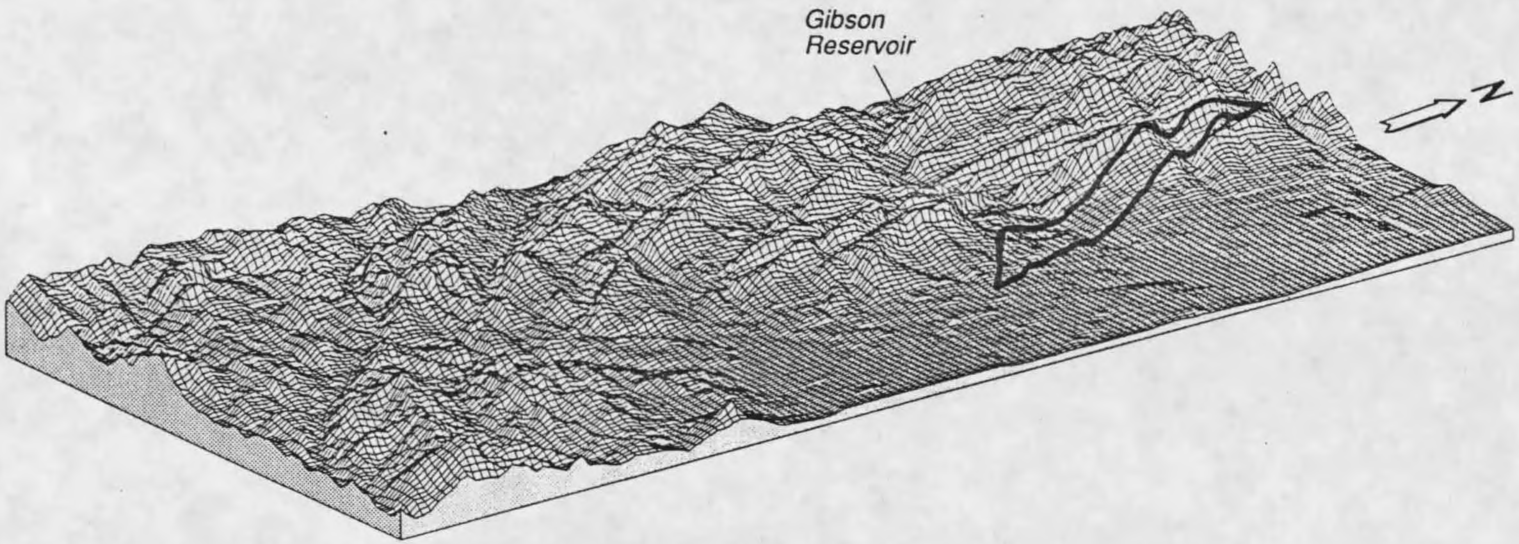
Appendix B (continued). Minimum home area of female 126.



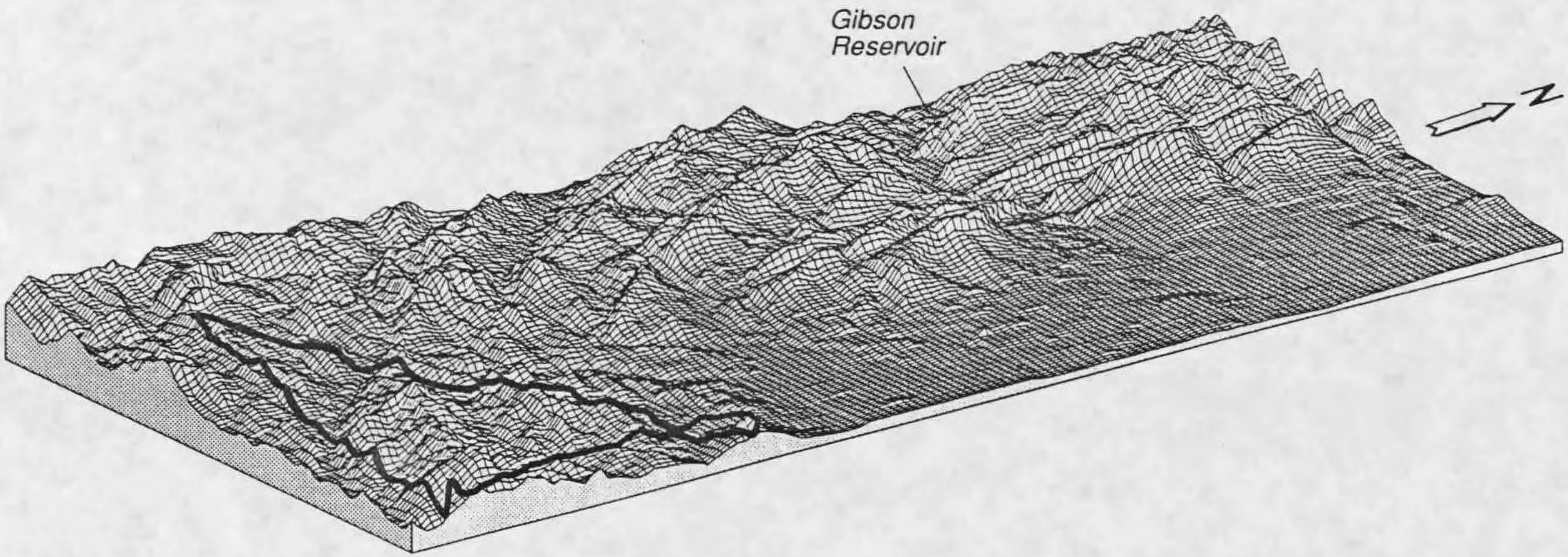
Appendix B (continued). Minimum home area of male 127.



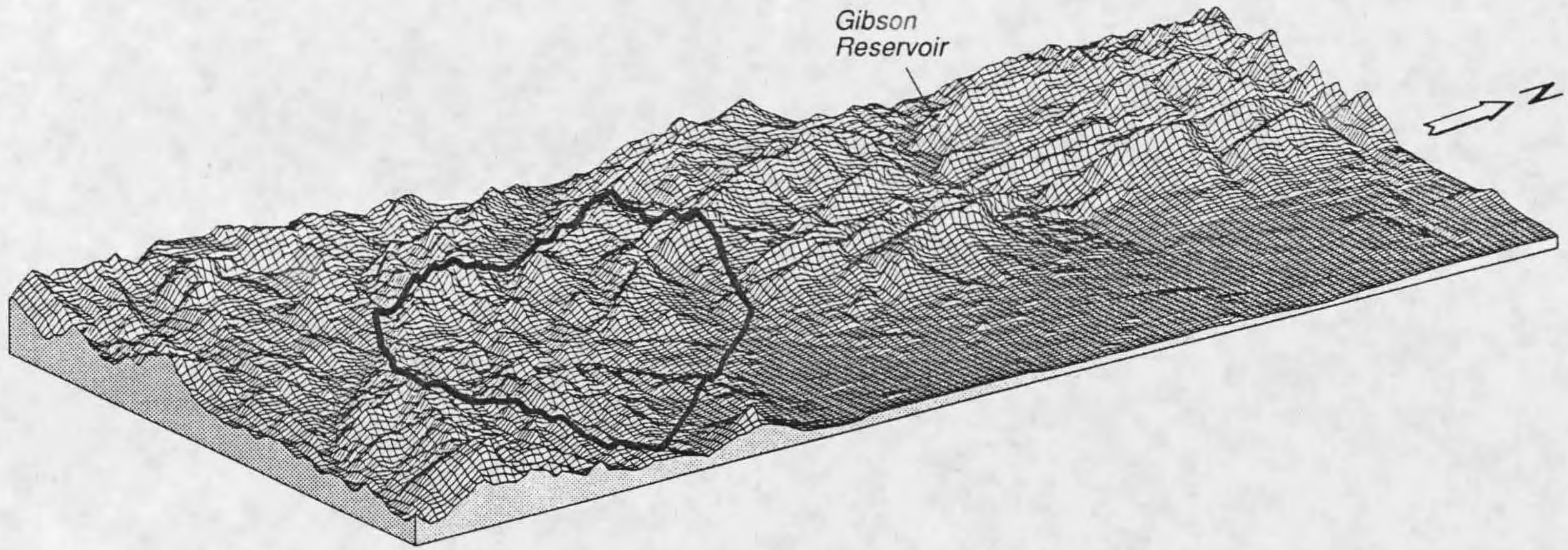
Appendix B (continued). Minimum home area of female 128.



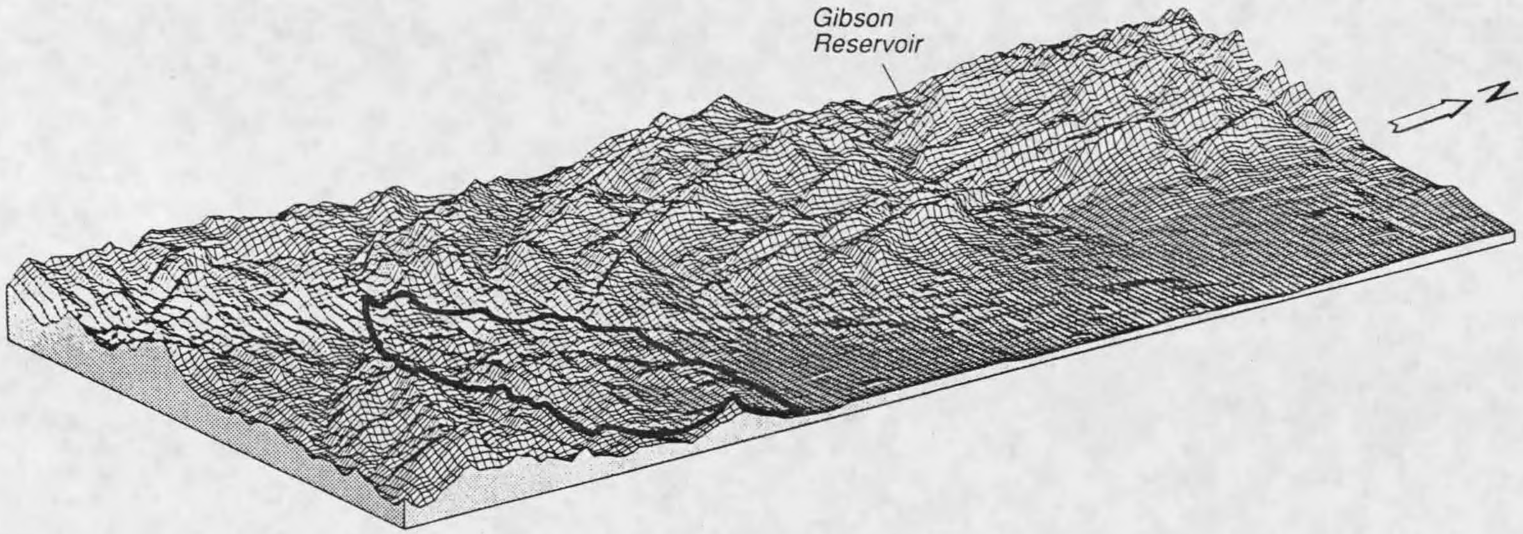
Appendix B (continued). Minimum home area of female 129.



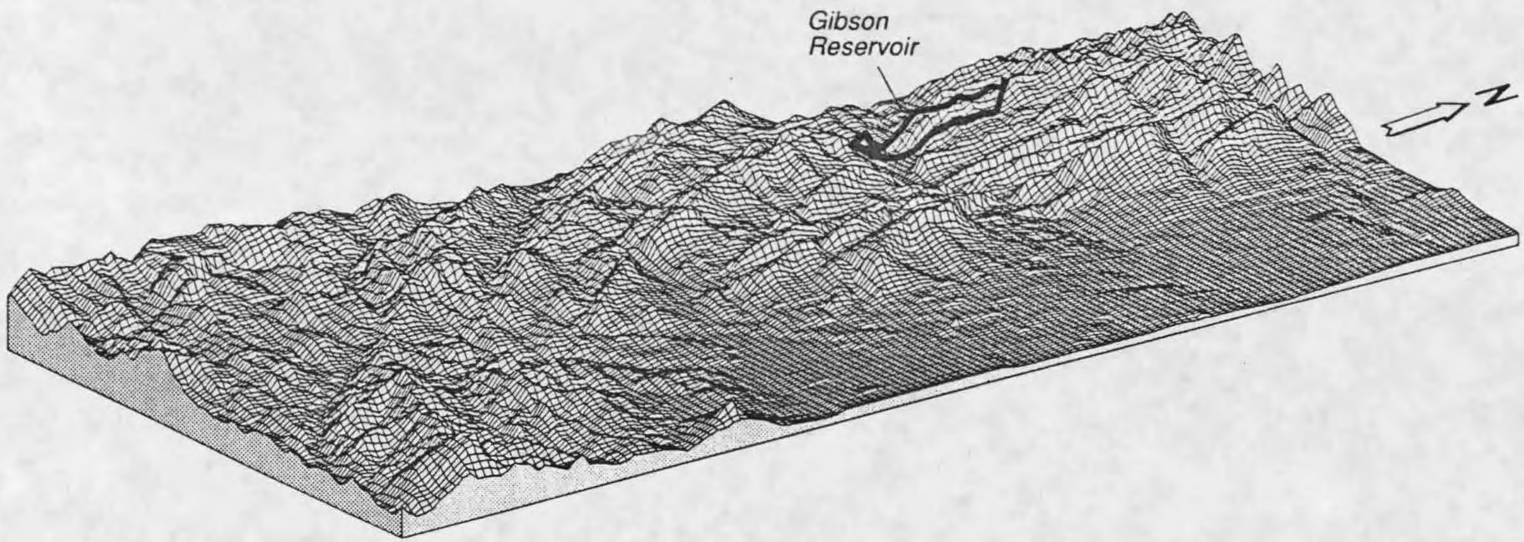
Appendix B (continued). Minimum home area of male 131.



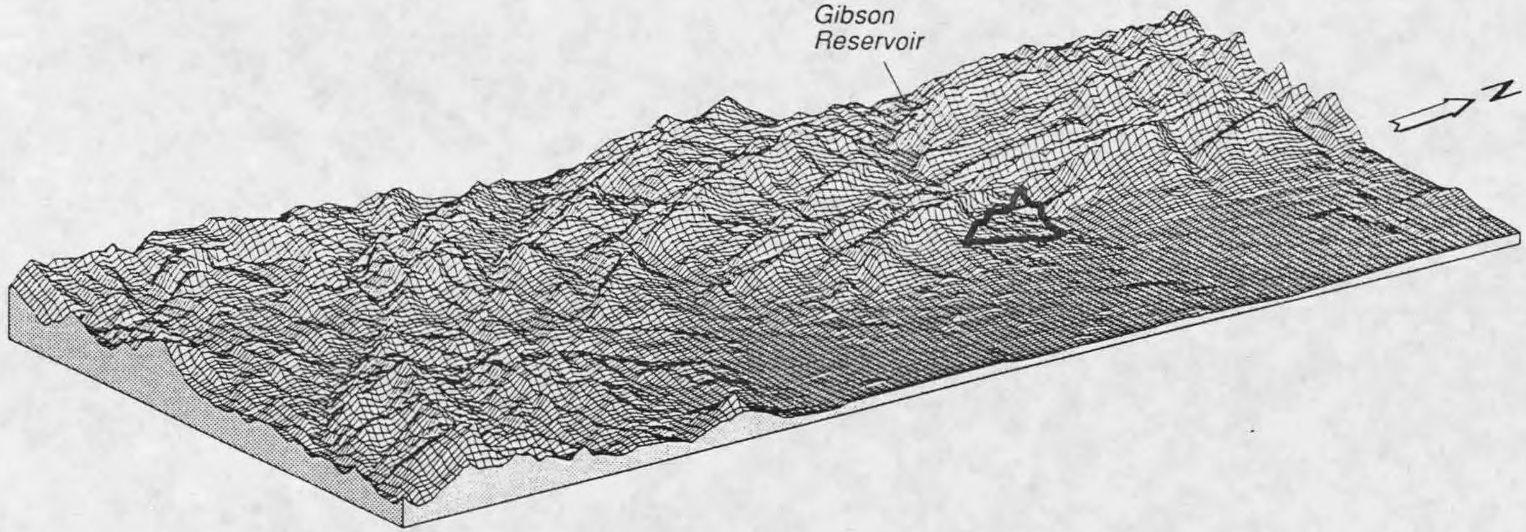
Appendix B (continued). Minimum home area of male 133.



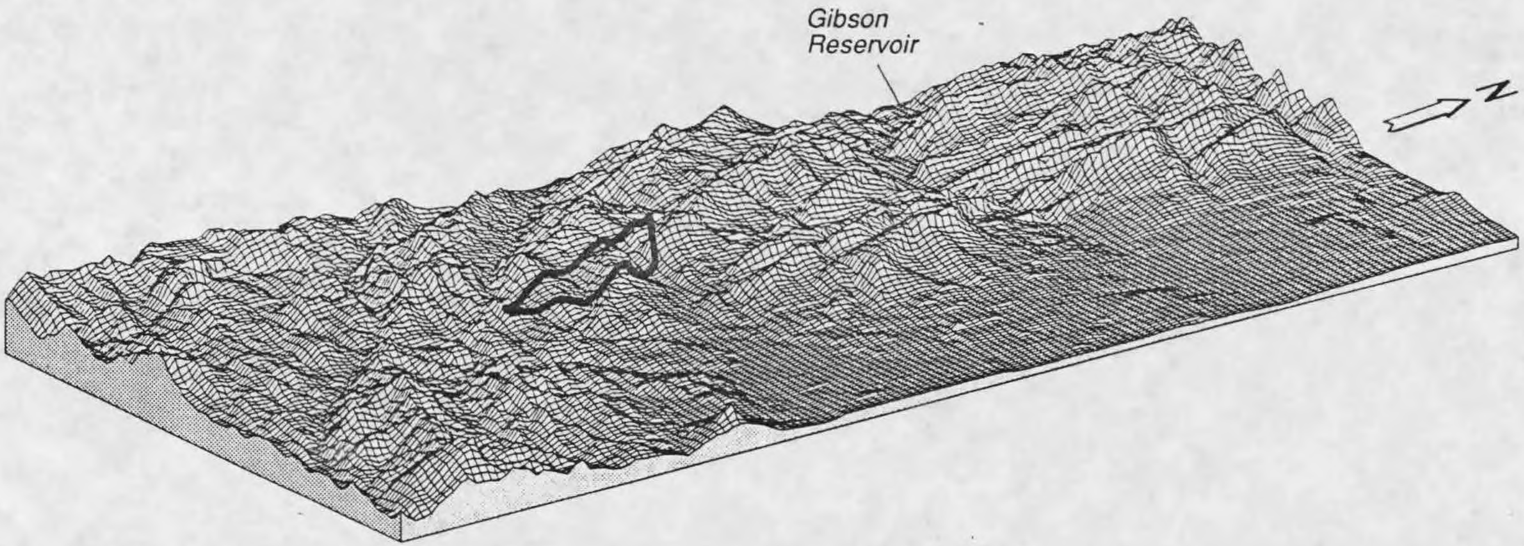
Appendix B (continued). Minimum home area of female 135.



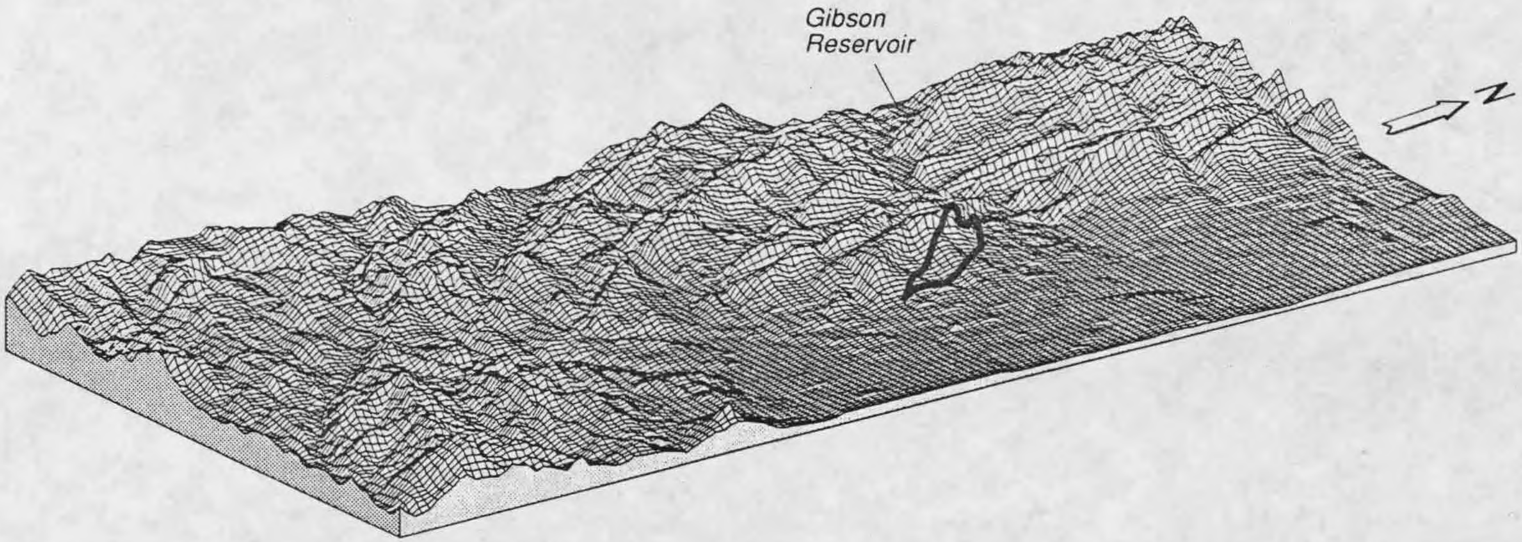
Appendix B (continued). Minimum home area of male 139.



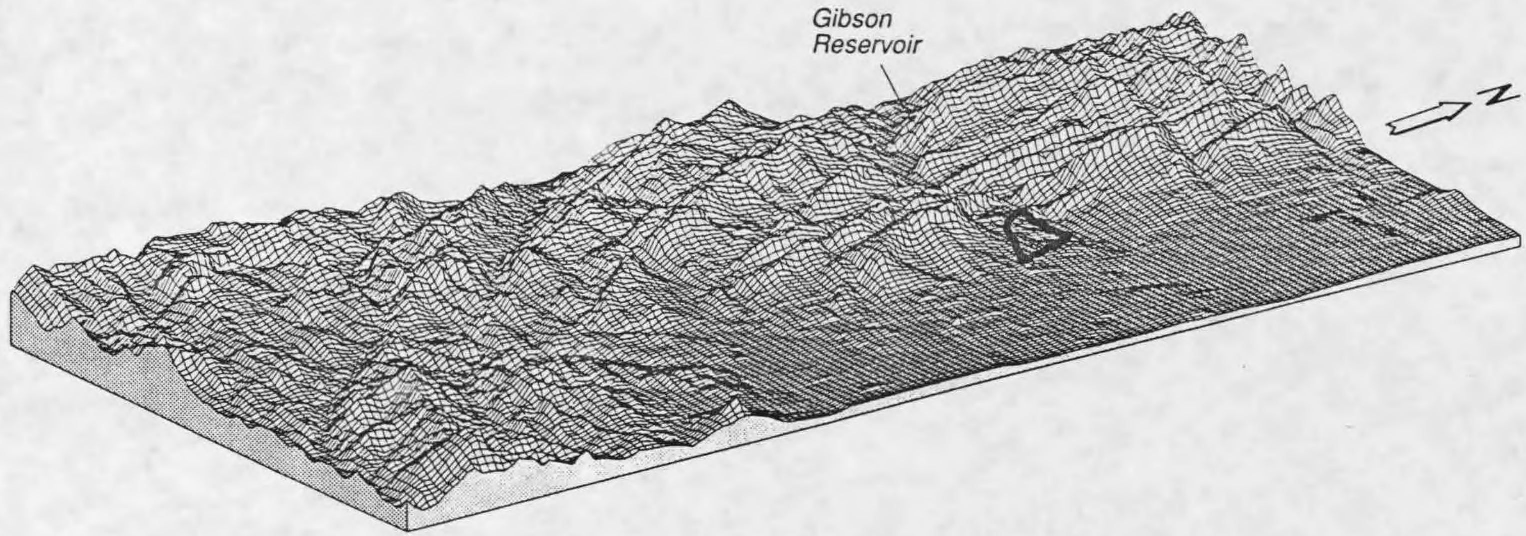
Appendix B (continued). Minimum home area of female 141.



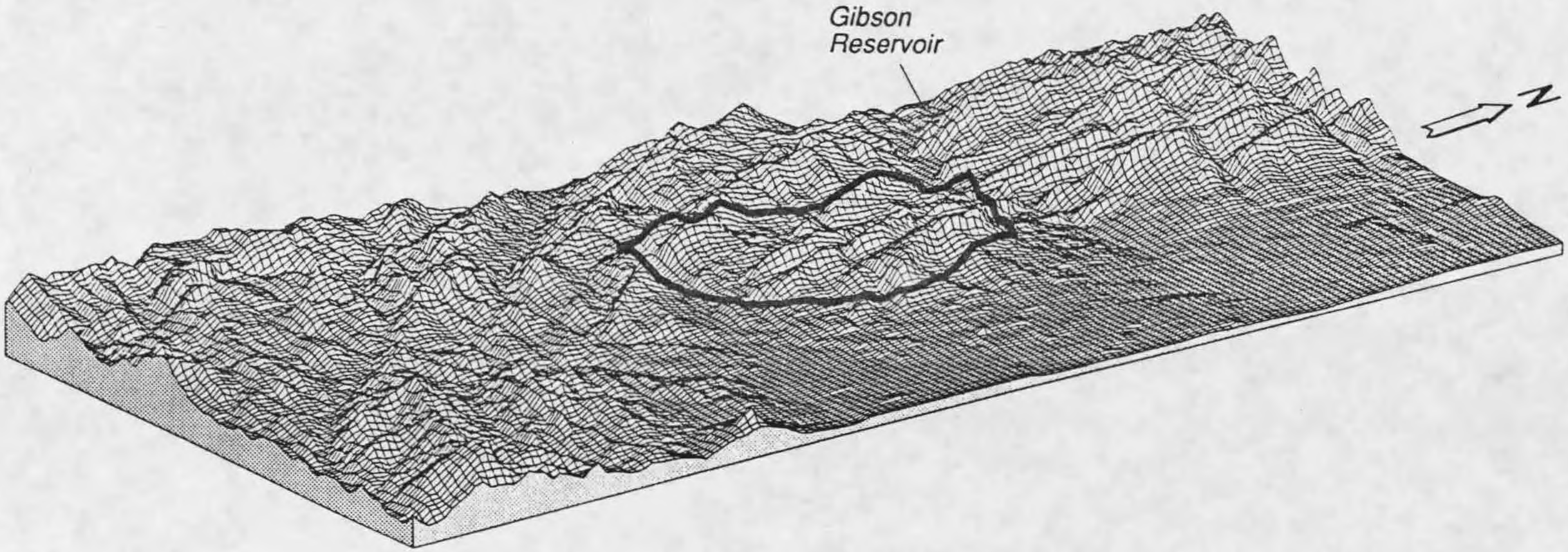
Appendix B (continued). Minimum home area of male 142.



Appendix B (continued). Minimum home area of female 146.



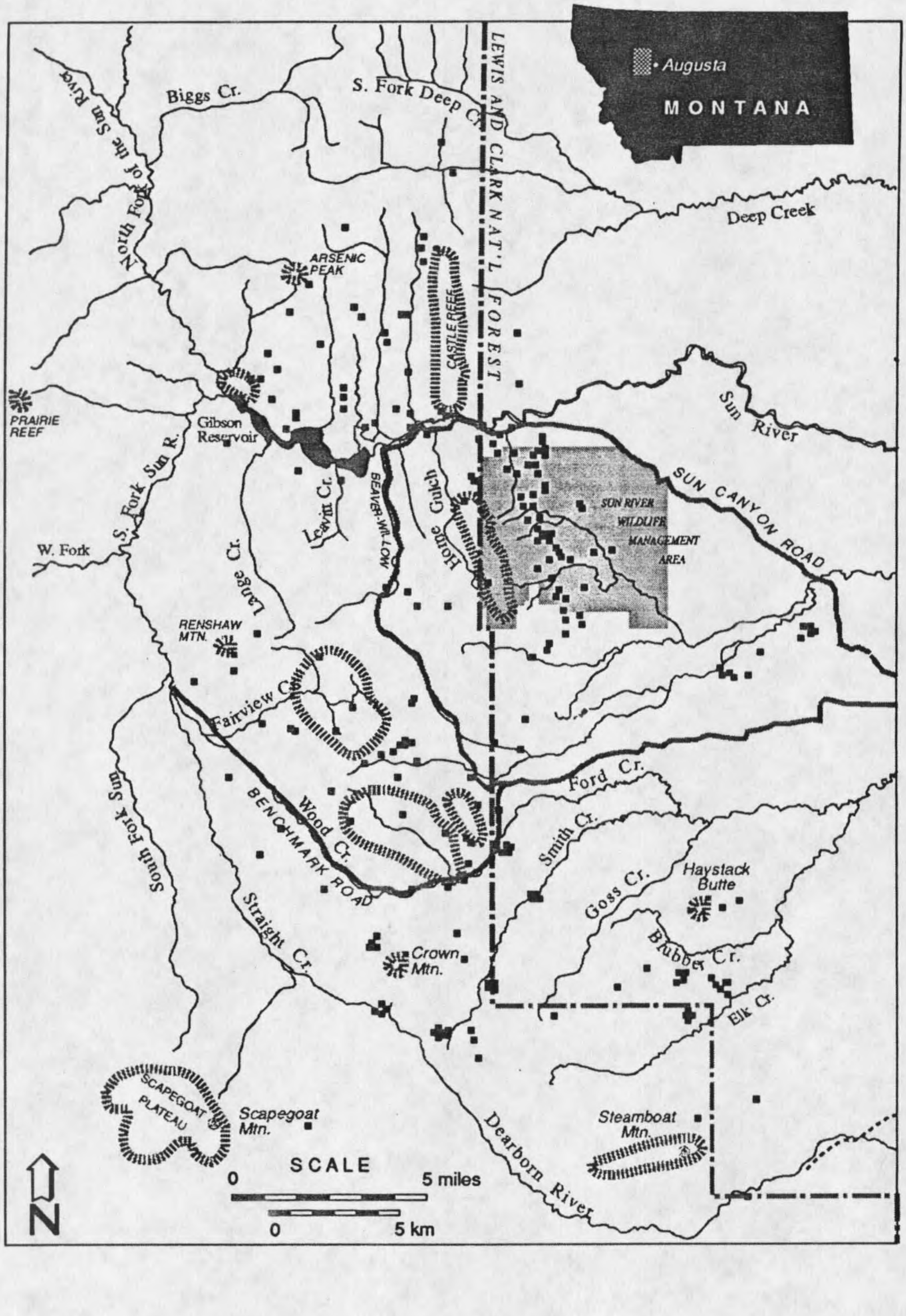
Appendix B (continued). Minimum home area of female 147.



Appendix B (continued). Minimum home area of male 148.

APPENDIX C

DISTRIBUTION OF MOUNTAIN LION TELEMETRY LOCATIONS



Appendix C (continued). Distribution of 245 mountain lion telemetry locations, 1991-1992, on the Sun River study area, Montana.