1983

Relationships between a mountain lion population and hunting pressure in western Montana

Kerry M. Murphy
The University of Montana

RELATIONSHIPS BETWEEN A MOUNTAIN LION POPULATION AND HUNTING PRESSURE IN WESTERN MONTANA

By

Kerry M. Murphy

B.S., University of Montana, 1980

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1983

Approved by:

Bart W. O'Gara
Chairman, Board of Examiners

Dean, Graduate School

18 July 1983
Date

ABSTRACT

Murphy, K.M., M.S. 1983 Wildlife Biology

Relationships Between a Mountain Lion Population and Hunting Pressure in Western Montana (45 pp.)

Director: Bart W. O'Gara *Bart O*

Relationships between hunting pressure and a mountain lion (Felis concolor) population were studied during winters 1979 through 1982. Work was conducted in the Fish Creek drainage, western Montana, which contained easy road access and average winter densities of 7.1 lions/100km2. The spacial distribution of 8 radio-instrumented lions was established with 350 relocations. The amount, timing, and distribution of travel by houndsmen were determined by field observations and interviews.

Snow conditions largely determined magnitude and timing of harvest, and road access influenced its distribution. Houndsmen were 87% successful in treeing lions when they released dogs on tracks. Seven lions were killed by houndsmen during ideal snow conditions in the northern portion of the drainage, which contained the primary entrance. Houndsmen usually travelled only by automobile, checked main roads, and concentrated their activities in the northern portion.

This population resembled those that were hunted less, except no known transient lions moved through the area. Concentrated harvest did not deplete the number of adult lions present, although adult densities were slightly lower in the northern than the southern portion. Stability in the numbers of adults and sex ratios was maintained by young adults moving into the area or by local juveniles establishing residence.

Lions are easily treed by hounds when winter storms provide a continuous cover of fresh snow. When lion habitat is easily accessible by roads, kills of more than 50% of the resident adults are possible if ideal snow conditions prevail during much of the lion hunting season. However, frequent over-kill in drainages similar to Fish Creek at present is unlikely because periods of favorable snow conditions are usually brief, houndsmen do not thoroughly penetrate lion habitat, and agonistic behavior among houndsmen appears to limit simultaneous use by more that 1 party of hunters.

ACKNOWLEDGEMENTS

Financial and administrative assistance for this study was provided by the Montana Department of Fish, Wildlife, and Parks via Pittman-Robertson Project W-120-R, the Montana Cooperative Wildlife Research Unit, the National Rifle Association of America, and the USDA Forest Service, Forestry Sciences Laboratory, Missoula. The Ninemile Ranger District graciously provided winter housing.

I wish to thank the individuals who provided material support. The Askin and Kirchman families provided hot meals and needed distractions. Special thanks to Frank and Bob for their assistance in keeping our road passable during winter. Gary Power loaned us a fine hound.

I am indebted to my major advisor, Dr. B.W. O'Gara, for his encouragement, training, and help in administrative and financial matters. I benefited greatly from our discussions on predator ecology and management. Committee members, Drs. C.L. Marcum and P.L. Wright, provided guidance and edited the manuscript. Dr. L.J. Lyon and Daniel Edge advised me on statistical analyses and computer programs. Dr. I.J. Ball helped with administrative and logistical problems during crises. "Ginger" Schwarz was a tolerant secretary. Daniel Pond participated in early phases of the study and displayed mechanical wizardry when I was out of ideas. I am beholden to these individuals for their assistance.

I express my gratitude to Howard Hash for the many hours he donated to the study as a pilot, a consultant on mechanical matters, and a committee member. I enjoyed his company on the many safe flights for which he always made time among his other responsibilities.

I am grateful to the individuals who participated in the field work. Rebecca White and Robin Hompesch faithfully assisted me for 3 winters. They never complained of the long hours or hard work. They put up with my idiosyncrasies and maintained their enthusiasm through the entire project. This study can be considered a success largely because of their dedication to a difficult job. Bill Dishman and Bob and Diane Wiesner helped this study immeasurably. Bill willingly shared his knowledge concerning the interpretation of sign and animal behavior. He was a great companion. Bob and Diane initially trained me, other personnel, and later my first hound. Their guidance and efforts as houndsmen helped make the key first field season a success. I am indebted to these 5 individuals for their contributions, and will fondly remember the many good times and stories we shared.

Last but not least, I thank my mother and father for the moral and financial support they provided during my undergraduate and graduate studies. Their understanding and love helped me persevere.

TABLE OF CONTENTS

LIST OF TABLES

TABLE | Page

LIST OF FIGURES

FIGURE | Page

INTRODUCTION

The mountain lion (Felis concolor) received game animal status in most western states after its aesthetic and ecological values became apparent to the public. Faced with polarized views presented by preservation groups, sportsmen, and agricultural interests, states responded to needs for information by financing research concerning population characteristics and the extent of lion predation on game animals and livestock. Hornocker (1969, 1970) and Seidensticker et al. (1973) studied predator-prey relationships, social organization, and population dynamics of an unexploited lion population in the Idaho Primitive Area. Although their research is applicable, lions in Montana are managed under a full range of harvest intensity, often under conditions of easy road access. Population characteristics and spacial relationships may differ in exploited populations and dictate alternate approaches to management. Dixon and Boyd (1967), Donaldson (1975), and Currier (1976) inventoried populations. Shaw (1973, 1980), Donaldson (1975), Ashman (1976), Currier (1976), Sitton (1977), and Hemker (1982) documented spacial distributions and described populations. Dixon and Boyd (1967) , Shaw (1977, 1980), and Ackerman (1982) studied lion predation. These works increased the body of management information on lions, but they were conducted under habitat conditions different than those found in Montana. Seidensticker et al. (1973) cautioned that differences in topography or prey size may produce variable lion social systems.

After the lion was provided game and trophy status in 1971, game managers in western and central Montana were faced with similar information needs. The Department of Fish, Wildlife, and Parks (DFWP) and the Montana Cooperative Wildlife Research Unit initiated a mark-recapture study of lions, but the effort provided only limited data on dispersal and techniques for determining ages. To establish baseline information and examine possible effects of harvest on an exploited population, research was initiated to:

1. examine age structure, density, natality, and the distribution of mountain lions in hunted and unhunted drainages of a study area;
2. investigate hunting pressure and harvest of mountain lions in the study area, and relate those data to population characteristics;
3. determine timing and distance of dispersal by young animals and changes in movement patterns of male lions as they mature; and
4. identify and describe winter habitat requirements of mountain lions, specifically those relating to the aquisition of prey.

STUDY AREA

The Fish Creek study area is located 50 km west of Missoula, Montana, in the Bitterroot Mountains (Fig. 1). Terrain is steep, most slopes exceed 50%. Elevations range from 945 m at the mouth of Fish Creek to 2,164 m along the divide between the Clark Fork and Clearwater rivers. About 150 km2 (20%) of the drainage are used by wintering big game. This zone lies primarily below 1,520 m, although elk (Cervus elaphus) sometimes winter higher (Lyon 1979).

Temperature and precipitation patterns of Fish Creek are characteristic of the upper Transition, Canadian, and Hudsonian life zones (Merriam 1899). Most precipitation falls as snow or rain from early December through March, or rain in June (U.S. Climatological Bulletins). The depth of tracking snow at low elevations varies greatly during the winter. The longest periods of continuous snow cover occur in late December and January, although south slopes are often bare after 1 day of rain or sunshine. Snow commonly accumulates to over 1 m on shaded slopes and high ridges.

Habitat types of the Douglas-fir (Pseudotsuga menziesii) climax series (Pfister et al. 1977) comprise the principal vegetation on winter range slopes. However, the ponderosa pine (Pinus ponderosa)/bluebunch wheatgrass (Agropyron spicatum) type dominates the the most xeric south exposures at low elevations, and scree habitat types are common on steep slopes of southerly and westerly orientation. The Douglas-fir/ninebark

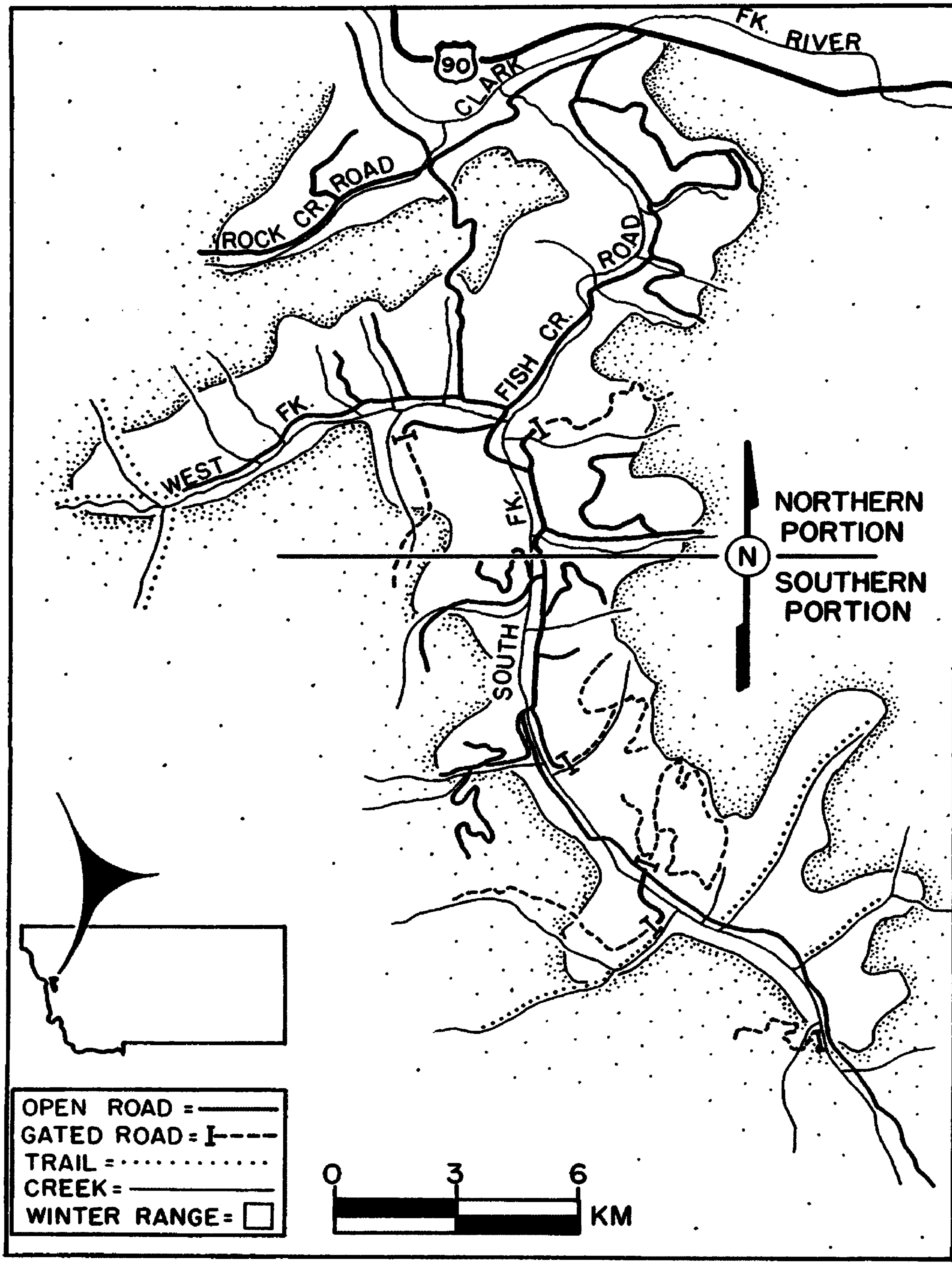

Fig. 1. The Fish Creek study area, showing access, major drainages, and ungulate winter range.

(*Physocarpus malvaceus*), Douglas-fir /bluebunch wheatgrass and Douglas-fir/beargrass (*Xerophyllum tenax*) habitat types cover most remaining winter range slopes. The western redcedar (*Thuja plicata*)/queencup beadlily (*Clintonia uniflora*) type predominates in drainage bottoms on the west side of Fish Creek. Seral black cottonwood (*Populus trichocarpa*)-ponderosa pine communities occur along the bottoms of the main and some major side drainages on the east side.

Annual harvests averaged 1.7 lions during the 9 winters from 1971-72 through 1979-80. People most frequently enter the drainage by the road up lower Fish Creek. After December, snow accumulations usually make 4-wheel drive truck access impossible via adjacent Rock Creek drainage or through the head of the Fish Creek watershed to the south (Fig. 1). Drainages accessible by motorized vehicles comprise 84% of the northern portion of the study area. The southern portion is only 40% accessible because of closed roads and unroaded side drainages. Travel by yearlong residents keep the West Fork road (length 11 km) and the upper South Fork road (35 km) to Wig Creek passable for vehicles the entire year. Normally, snowstorms close side drainage access to 4-wheel drive trucks by mid-January. Thereafter, they are accessible only on snowmobile or on foot until mid-March, unless mild weather or logging activities open them prematurely.

Largely migratory populations of white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), and elk (Bohne 1974, Zahn 1974, and Lemke 1975) are important prey of lions on the study area. A small population of moose (*Alces alces*) is present, but its importance as a food source is unknown. Small prey available during winter include snowshoe hares (Lepus americanus), pine squirrels (Tamiasciurus hudsonicus), porcupine (Erethizon dorsatum), beaver (Castor canadensis), and mountain grouse (Dendragapus obscurus, Canachites canadensis, and Bonasa umbellus).

METHODS

This study was conducted from December 1979 through June 1982. Seasons were W1 (winter 1979-80), W2 (winter 1980-81), SF1 (spring-summer-fall 1980), etc. Most fieldwork was conducted during the lion harvest (1 December through 15 February) and chase seasons (16 February through 30 April).

Characteristics of houndsmen (lion hunters) and hunting pressure were assessed by examining tire-track patterns made on snow-covered roads and interviewing houndsmen when encountered. Hunters reported by other persons in the area were interviewed later by telephone. Houndsmen were asked where they lived, whether the presence of collared lions and researchers would influence their future visits to the study area, the number of days they hunted in harvest and chase seasons, and the numbers and locations of lions they pursued and treed. Houndsmen who hunted in the study area more than 4.5 hours during a day were credited with 1 day of visitation; those that hunted less were credited with 0.5 day of visitation.

Main roads were defined as the upper and lower South Fork and the West Fork Fish Creek roads; all others were side roads. Mileage of "available" road used in analysis was passable in 4-wheel drive vehicles and usually included only access roads in the bottoms of the main or side drainages. Houndsmen could easily check all the 32 km of main road mileage usually available or at least 22 km of side roads during a 9 hour day. These values were used as the basis for measuring the extent hunters utilized road access. With respect to houndsmen, snow conditions were defined as ideal (continuous soft snow > 2 cm in depth) and poor (all other conditions). Houndsmen could best sight lion tracks and hounds could best follow them when snow had fallen within the last 24 hours and accumulated to greater than 5 cm in depth.

Lion activities and population characteristics were assessed using combined data provided by snow-tracking, captures, and radio-relocations. Murphy and 2 assistants travelled by truck, snowmobile, or foot. Typically, the Fish Creek road and main roads in side drainages were checked for lion tracks. This allowed us to monitor activities of hunters in vehicles and lions simultaneously. Unroaded drainages were small and unlikely to contain entire lion home ranges. No lions of unknown identity were detected during infrequent visits to unroaded drainages. Consequently, data for roaded and unroaded drainages were combined.

Whenever possible, lions of unknown identity were pursued and treed using trained hounds owned by the student and by houndsmen participating in the study. Capture techniques followed Hornocker and Wiles (1972). An average initial dosage of 1.0 mg of phencyclidine hydrochloride (Sernylan) per kilogram of lion body weight was administered remotely via commercial capture equipment. Usually, dogs were released to pursue a darted lion if it jumped from a tree, although some lions were approached on the ground with hounds on leashes. Lions that were immobilized in trees were lowered to the ground using ropes after hounds were withdrawn from the site. Three lions fell from trees before they could be secured, but none were injured seriously.

Drugged lions were measured (Hornocker 1967) and weighed, sexes were recorded, and ages were estimated to the nearest years (Greer 1976). All lions were tattooed in both ears and animals of sufficient size were fitted with a radio collar. Immobilized lions were observed directly until normality returned.

Transmitters were monitored from the air throughout the year and from the ground during winter. Accurate aerial locations and captures provided most of the data. The frequency of flights varied between years and was sufficient to establish at least gross home range sizes and spacial relationships. Aerial locations averaged 1.5 per lion month before February 1981 and 2.6 thereafter. Five aerial locations subsequently checked on the ground were accurate to within 100 m. Data from tracks, lions radio-tracked from the ground, or rough aerial locations, were used only to establish relative positions of lion home ranges.

Home range (Burt 1943) sizes were estimated by the minimum area method (Mohr 1947) via computer programs (Harstead 1981). Lions were designated as resident after tracking data indicated they had established a home range. Usually, data for 1 winter or longer was obtained before lions of unknown status were termed residents; exceptions are noted in the text. Outliers, locations of lions outside their presumed ranges, were excluded from the data base because they were believed to greatly inflate estimates of home range sizes. To qualify, proposed outliers must have been greater than 75% of the range length away from the closest location within the home range. This percentage was choosen arbitrarily, but it appeared to effectively separate areas used habitually from those used infrequently. Adults were defined as self-sufficient lions, including animals of young adult classes (generally 1-3 years of age), unless specified otherwise. Kittens were offspring entirely or partially dependent on their mothers. Lions were recorded as in association when different radio-signals appeared to be emitted from the same site. The Student's t distribution was used to test for possible differences in mean monthly elevations.

Winter habitat-use sites were visited during summer 1981 or spring 1982, habitat typed, and assigned a cover type category (Appendix A and B). Additionally, the locations of kills made by lions were noted and revisited during spring 1982 (Appendix C). Scientific nomenclature followed American Ornithologist's Union Checklist Committee (1957), Hitchcock and Cronquist (1978), and Jones et al. (1982).

RESULTS

We checked 3500 km of roads and trails during 133 days and were present in the study area on 83% of the 107 days when snow conditions were ideal for houndsmen. Effort, travel, and track counts are summarized in Appendix D. Sixteen lions were treed on 22 occasions and 8 individuals were instrumented with radio collars (Table 1). One adult lion died during capture because of stress and a bacterial infection. Physical characteristics of lions captured are provided in Appendix E. Instrumented lions were relocated on 365 occasions; 310 were obtained during 57 flights. No transmitters failed during the study.

Hunter Characteristics and Lion Mortality

Twenty-seven different houndsmen hunted 66 days and checked 1900 km of roads for lion tracks during 3 harvest seasons. Local hunters from Missoula, Mineral, and Ravalli counties comprised 64% of the visitors. Outfitters with clients comprised 30% of the visitors. Ninety-one percent of hunter visitation occurred during periods of ideal snow conditions. Reduced hunter visitation and travel in the study area during W2 probably resulted from reduced snowfall (Fig. 2). The presence of researchers and collared lions also discouraged visitation. Nine of 16 individuals interviewed during or after W1 indicated they were reluctant to hunt in the area and at least 2 houndsmen known to have visited the drainage regularly stopped hunting in the area. Six

Table 1. Characteristics and status of adult lions captured in the Fish Creek drainage.

Lion[a] No.	Date of Capture	Estimated Age at Capture (years)	Weight (kg)	Residential Status	Fate[b]
F5	12/79	5-9	41	Resident	S
F8	2/80	5-8	41	Resident	HM (2/82)
F9	3/80	3-4	43[c]	Resident	S
F10	12/80	3-4	30	Resident	S
F13	12/81	1-2	23[c]	Unknown[d]	HM (1/82)
F16	2/81	3	39	Resident	S
M1	1/80	1-2	48	Resident	HM (12/81)
M2	1/80	5-7	73	Resident	HM (2/80)
M14	2/81	3-5	71	Resident	S
M10	12/81	3-4	68	Unknown[d]	CM (12/81)

[a]F=Female; M=Male

[b]S=Survived for the duration of study; HM=Hunter mortality; CM=Capture mortality

[c]Estimated

[d]Status unknown, but probably resident

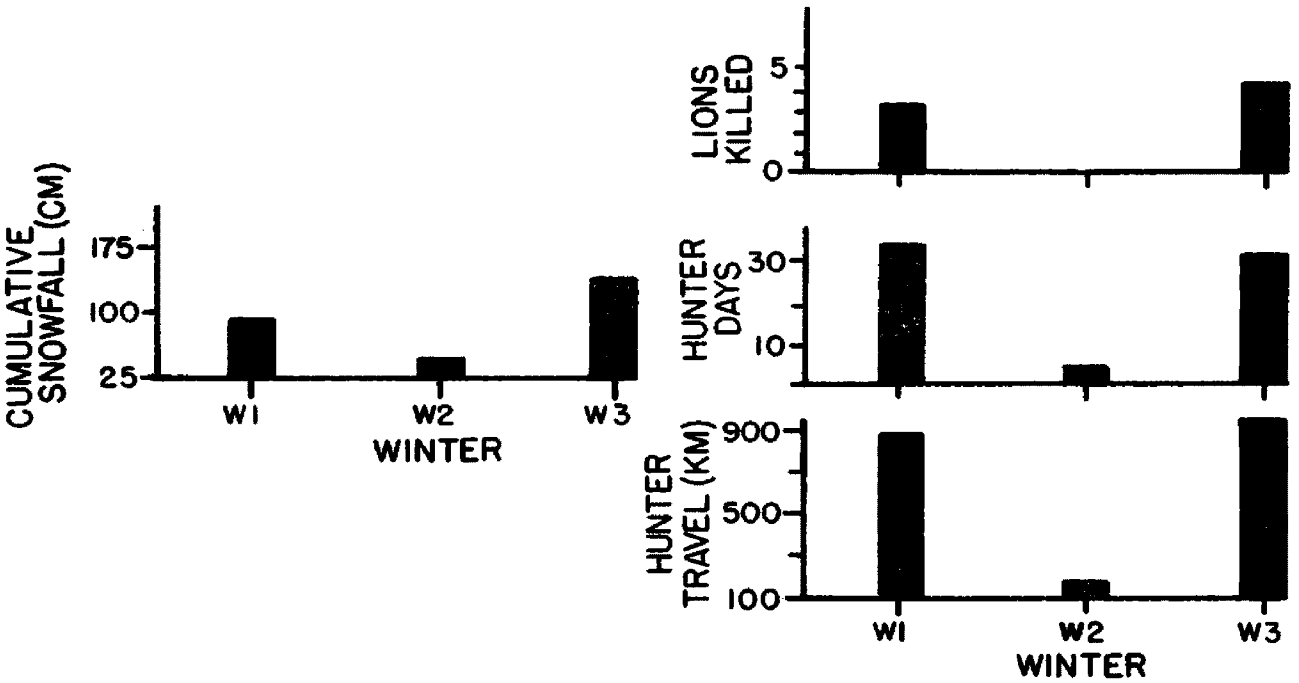

Fig. 2. Changes in cummulative snowfall (Dec. - Feb.), lion harvest, and hunting pressure. Average snowfall from 1969-70 through 1978-79 was 84 cm. Weather data were from Missoula County Airport, 44 km east of the study area.

different houndsmen hunted only 7.5 days during 3 chase seasons.

Houndsmen travelled about 69% of main road mileage and 20% of the side road mileage available each visit. Relative to main roads, side roads comprised 53% of the mileage available, yet side roads received only 19% of the total travel. Sixteen percent of the travel by houndsmen was in the southern portion of the drainage (Fig. 1), although it contained 38% of the road mileage. Six percent of the available mileage was checked via snowmobiles. Only 1 houndsmen reported that he occasionally searched for tracks when on foot. Travel per visit by non-local hunters on side roads averaged about half that of local hunters.

No natural mortality was documented among the 8 lions radio-tracked for up to 29 months (N = 135 lion months). Seven lions killed by houndsmen included 4 females (1 12-month old kitten; 2 young adults, <3 years; and 1 adult) and 3 males (1 young adult and 2 adults; Table 2). Only collared lions (N=4) were treed but not killed by houndsmen. Capture mortality M10 (Table 2) probably would have been a hunter mortality after our presence at the tracks discouraged pursuit by houndsmen on a particular occasion. Assuming that M10 would have been a hunter mortality, the rate of adult harvest was 1.0 female and 1.3 males per season. Annual harvest averaged 22% of the 4.5 adult females available and 48% of the 2.7 adult males available. At these turnover rates, all adult females would have been removed in 4.5 years and all adult males in about 2.1 years if no recruitment occurred.

Table 2. Characteristics and status of lions killed by houndsmen from 12/79 to 2/82 in the Fish Creek drainage.

Date Killed	Location Killed	Sex	Age at Death (years)	Weight (kg)	Residential Status	Status with Study[b]
1/80	Reubens Gu.	F	2	34[a]	Juvenile by Mother F10	KP
1/82	Cyr Flat	F	1-2	23[a]	Unknown	In (F13)
2/82	Deer Cr.	F	1-2	34[a]	Unknown	NKP
2/82	Deer Cr.	F	6-8	41[a]	Resident	In (F8)
1/80	Deer Cr.	M	2	54[a]	Unknown	NKP
2/80	Slaughter-house Gu.	M	5-9	73	Unknown	In (M2)
12/81	Whitehorse Gu.	M	3-4	68	Resident	In (M1)

[a]Estimated

[b]KP=Known Present; NKP=Not Known Present; In=Instrumented

Houndsmen treed lions on 11 of 13 (87%) occasions when they released nmpg +1 dogs on tracks. Ideal snow conditions prevailed when 10 individuals were treed. No lions were killed during W2 when snowfall was light and visitations by houndsmen were reduced (Fig. 2). All lions were killed in the northern portion (Fig. 3). Five tracks of lions subsequently killed were initially located from trucks; 2 were located from snowmobiles. Tracks of 4 lions were initially detected on main roads, and 3 tracks were detected on side roads. Outfitters with clients killed 4 lions.

Female lions appeared to cross roads as frequently, or more so than did males. Forty-five of 62 (72%) tracks of adult lions encountered by hunters and researchers were females, which comprised 62% of the adult population. Males crossed roads on 17 (27%) occasions, yet this sex comprised 38% of adults present. Side roads provided access to more lion tracks than did main roads. Hunters and researchers located 31 of 62 tracks (50%) on side roads, but travel on this type was only 19% of the total mileage. Main roads provided access to 50% of the tracks, although travel on main roads involved 81% of total.

Home Range Characteristics and Spacial Distribution

The sizes of female home ranges averaged 26 km2 in winter and 132 km2 during spring-fall, and males averaged 33 km2 and 290 km2 (Fig. 4; Appendix F). Both sexes used larger home ranges during W2 than W1 and W3. All adults on the area were apparently instrumented by March 1981; those encountered thereafter were new resident adults. Differences in home range sizes between sexes were more pronounced during spring-fall

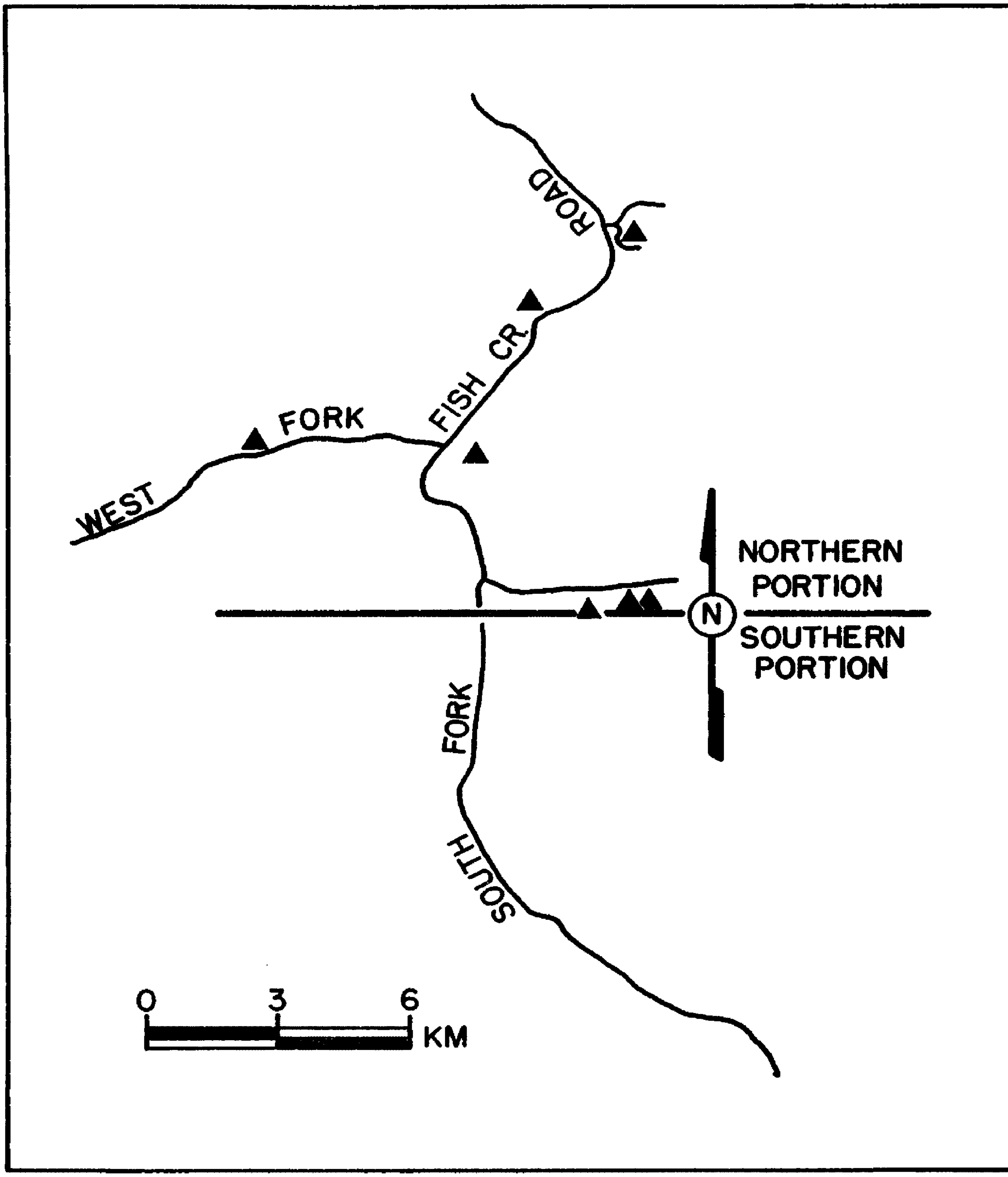

Fig. 3. Locations (▲) in the Fish Creek drainage where 7 lions were killed. Side roads are shown if they aided a houndsmen to find a lion's track.

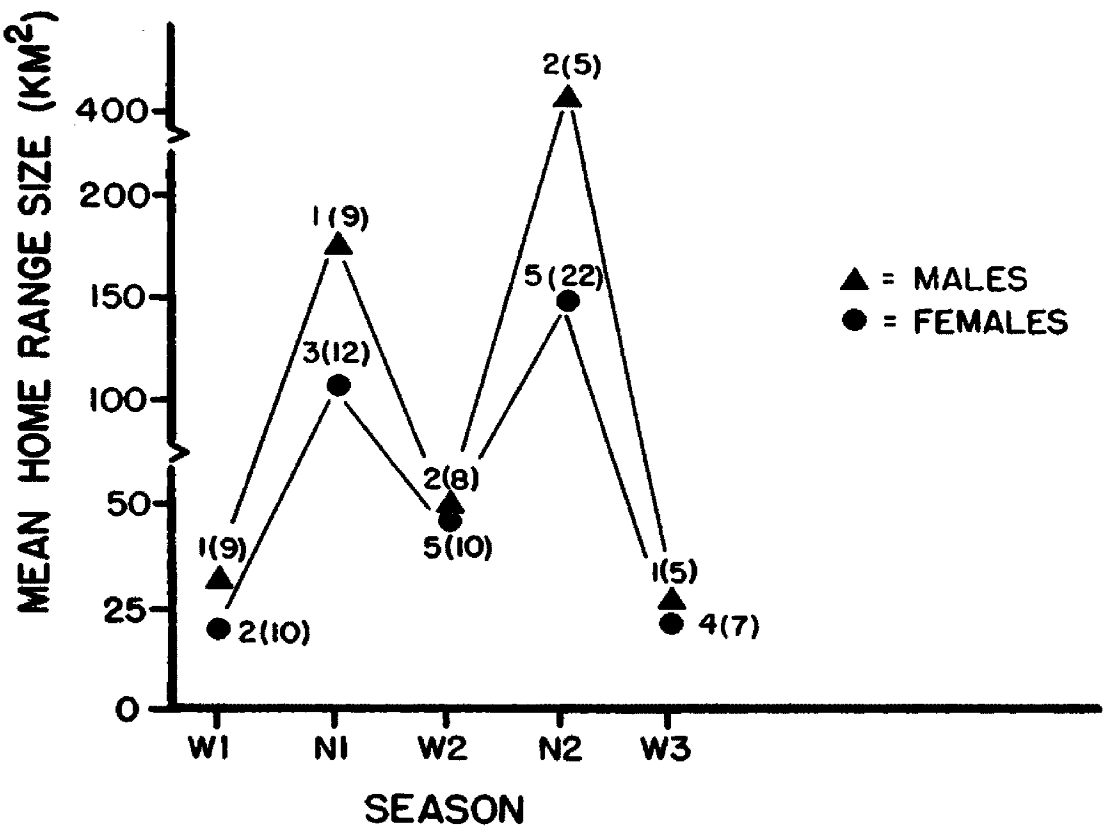

Fig. 4. Mean size of female and male home ranges by season. Note the breaks in vertical scaling. N = the number of home ranges/mean; (N) = the mean number of locations/home range.

than winter seasons. Overlap among female home ranges (67% unique; excluding W1 and N1) was greater than among males (98% unique; Fig. 5). Home ranges of males extensively overlapped those of females (all adults 51% unique). M1, age 1-2 years at capture, may have increased his winter home range size from 32km2 during W1 (weight 48 kg) to 61 km2 during W2 (weight 61 kg) related to maturation or diminished snowfall. His spring-fall range also increased markedly from N1 to N2, although an increase in the frequency of relocations also contributed to this change (Appendix F).

Individual lions maintained spring-fall ranges contiguous with, but at higher elevations than, their respective winter areas (Figs. 5 and 6). A gradual, but significant increase in elevation was evident from February through August. Mean elevation of lions declined significantly from August to September and increased from October to November. Lions returned to lower altitudes in December. No shifts in the relative position of home ranges occurred among different lions. All 8 lions followed for 1 to 29 months remained on or near the study area, indicating that none were transients (Hornocker 1967).

Radio-locations of outliers were associated with F8 during SF1, F5 during SF2, and M14 during W2 and W3 (Fig. 5); all were within the Fish Creek drainage. The average and maximum distances to home range perimeters were 12.8 km and 16 km. Location data suggest that M14 stayed in the West Fork Fish Creek drainage for more than 8 days; similar data were not available for the other outliers.

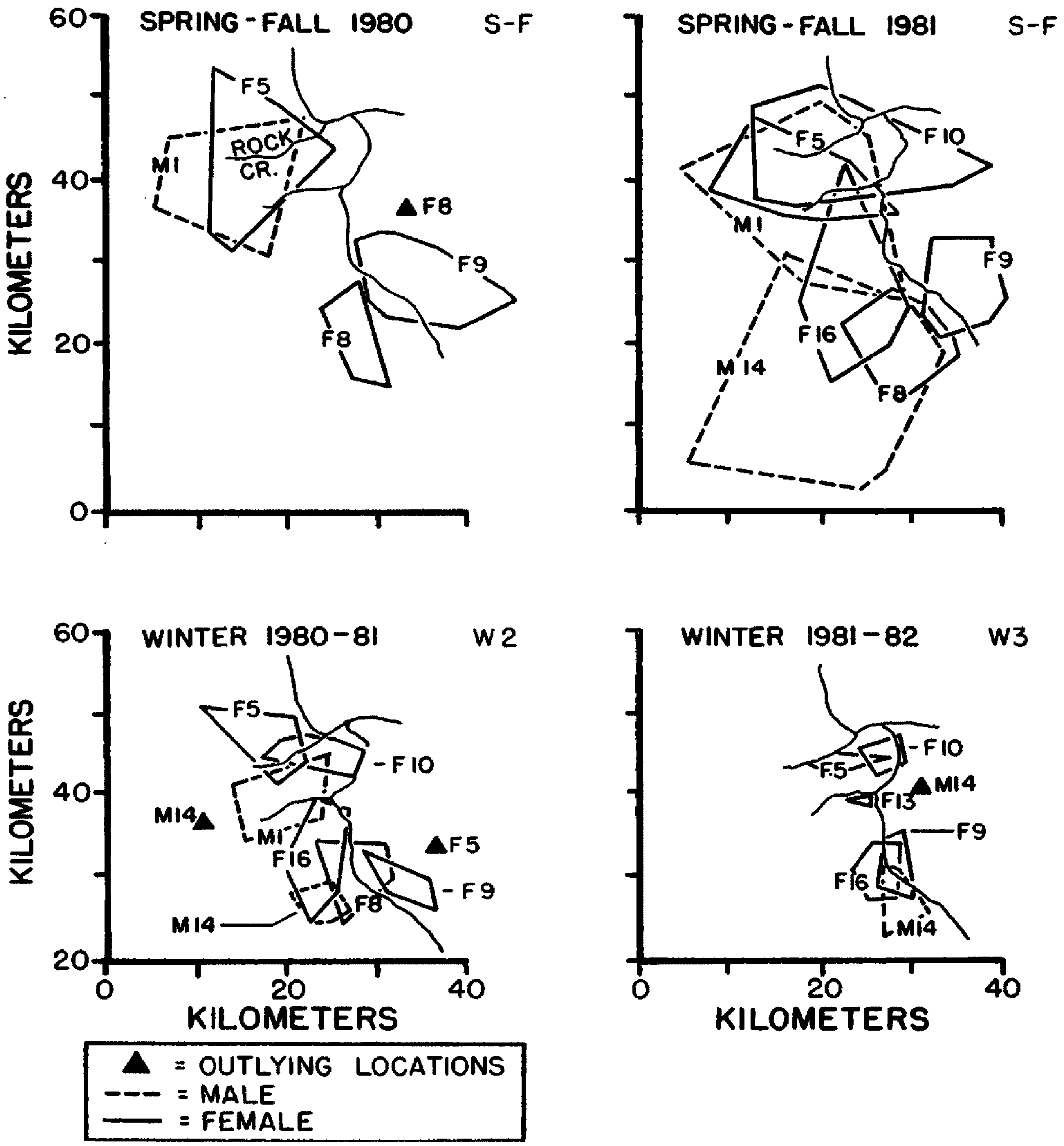

Fig. 5. The spacial distribution of lion home ranges.

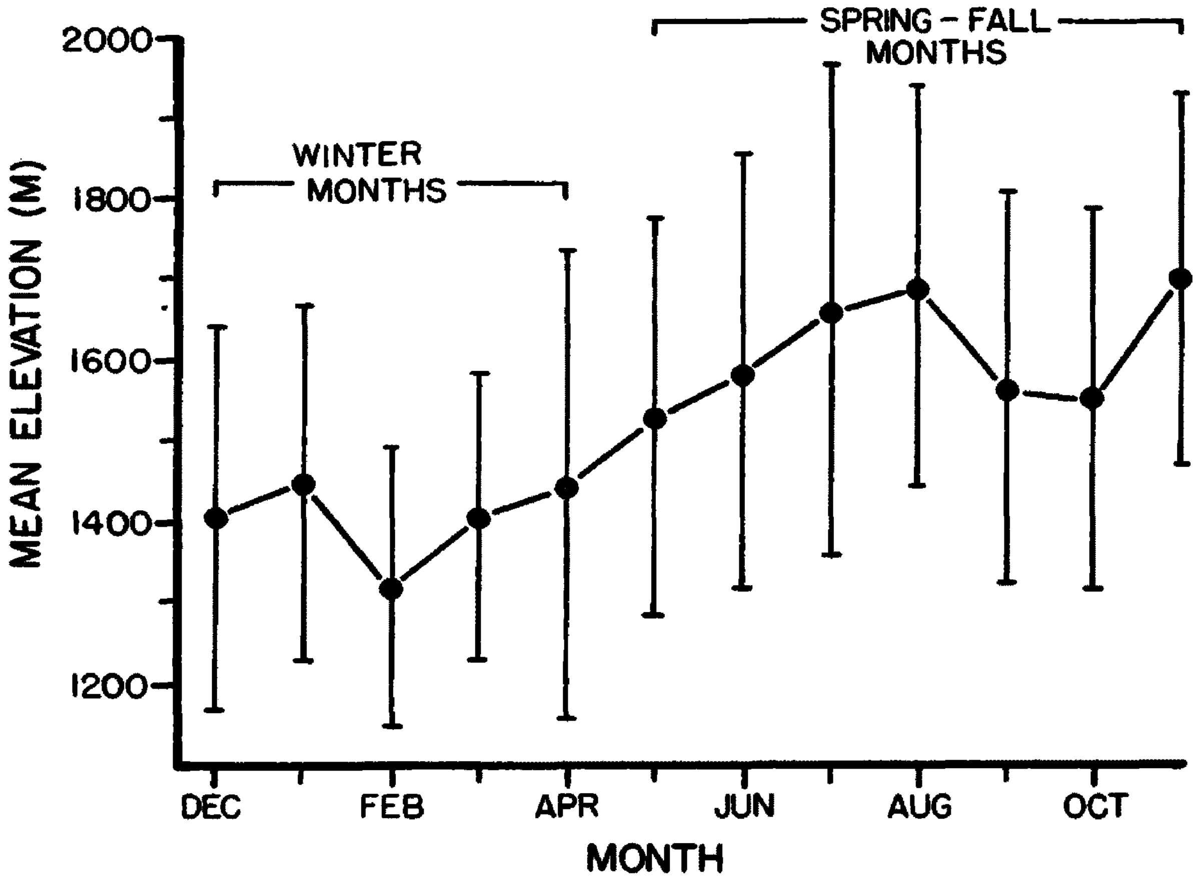

Fig. 6. Mean monthly elevations and standard deviations of lion radio-locations. Minimum and maximum study area elevation was about 975 m and 2100 m. P(Nov. mean = Feb., Feb. = May, May = Aug., or winter = spring-fall) $<$ 0.03. P(Aug. = Nov.) $<$ 0.96. P(Aug. = Sept., or Oct. = Nov.) $<$ 0.05.

Population Characteristics and Stability

The Fish Creek population was essentially stable during the study period (Fig. 7). An adult sex ratio of about 2 females per male and winter densities of about 4.3 adults per 100 km2, and 7.1 lions per 100 km2, were maintained throughout the study. The northern portion supported lower adult densities (2.4/100 km2 north versus 4.8 south), but it was not depleted of lions. Long time periods spent in adjacent, lightly hunted areas during winter may have extended the longevity of F5, F10, and M1 as partial residents in the southern portion of the study area. Key adult losses to the population, that occurred early during the study, included M2, F5 (which shifted her home range into the adjacent Rock Creek drainage during W2; Fig. 5), and an unknown male killed in the Deer Creek drainage during early W1 (Table 2). Losses were subsequently compensated within 2 years by the establishment of adults of similar sex. M14 was captured in W2 and established residence in the upper portion of the drainage. M10 was captured in W3 and showed attachment to the Deer-West Fork area during the 3 weeks of observations before his death, but his residency status remained questionable. Young F13 appeared in the West Fork area 1 year after the shift by F5. Six weeks of radio- and snowtracking data indicated that F13 would have established residence there if she had not been killed by houndsmen. Circumstances surrounding the presence of a different young female were unknown. She was killed in the Deer Creek drainage within the home range of F8 and F9 (Table 2).

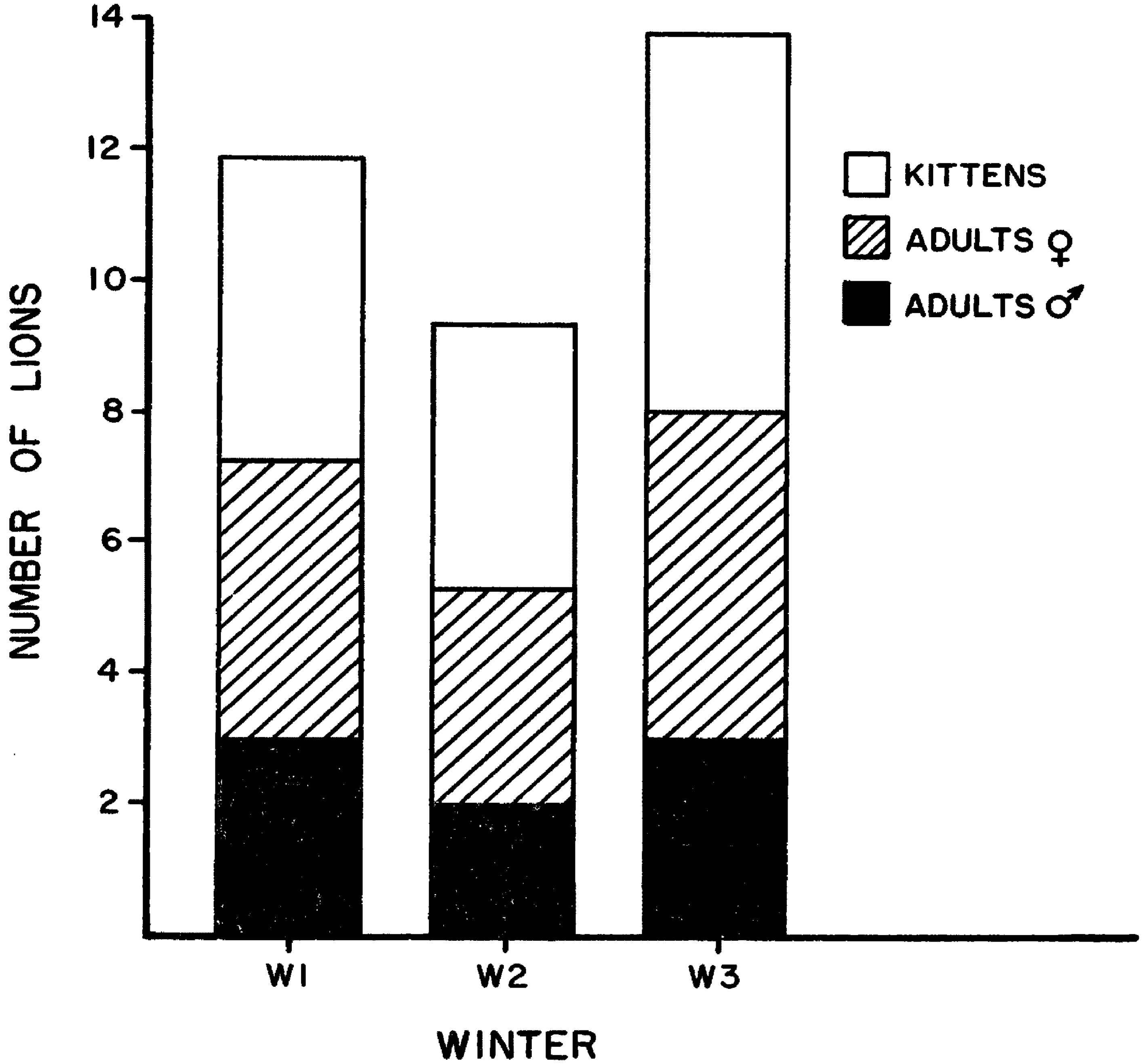

Fig. 7. Population composition in the Fish Creek drainage during 3 winters. Values include lions killed and those of unknown residency status. F16 was not captured but was presumed present during W1. Partial residents and their kittens were represented by their per cent of radio locations within the study area.

Seven litters were raised on the study area at approximately 2 year intervals per female (Fig. 8) and averaged 2.6 kittens (range 2-3). All females tracked for 1 winter or longer gave birth. Five litters were born during all seasons except spring. Capture of a lactating female indicated 1 birth date. An age-weight growth curve (Robinette et al. 1961) and scale weights (N=2) or weight estimates of kittens based on tracks (N=2), was used to infer the season of birth of the 4 other litters. Seasons of birth were unknown for 2 litters.

Data concerning the origin of new residents were provided by F16, who resided in the drainage as a kitten of F5 and remained there as an adult (Fig. 5). M14 and M10 probably were not born in the study area because they would have been first detected as young, rather than mature adults. The fates of ear-tattooed male kittens A96 and A92 are unknown.

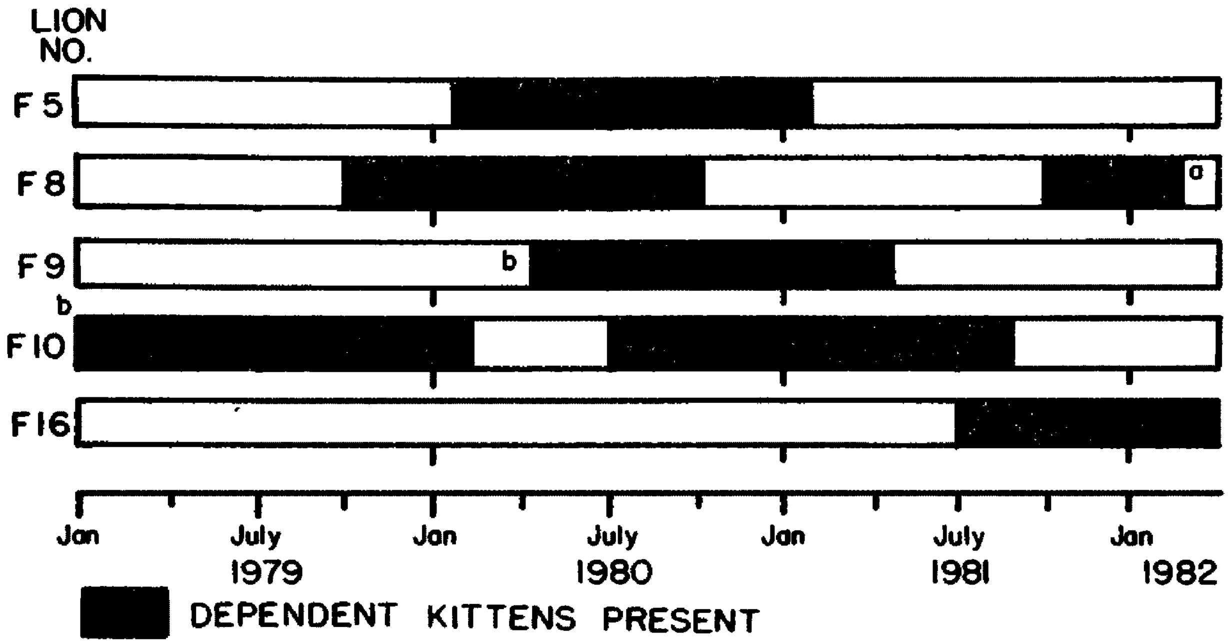

Fig. 8. Reproductive status of female lions, 1979-82. Kittens were presumed dead after their mother was killed at (a), and seasons of birth were not known at (b).

DISCUSSION

Snow conditions largely determined the magnitude of lion harvests by influencing visitation and the likelihood of houndsmen finding tracks and successfully pursuing lions. This was particularly evident during W2 when light snowfall discouraged participation by hunters and no lions were killed. Given ideal snow conditions, hounds treed 91% of the lions they pursued.

The study influenced visitation and the harvest because hunters viewed researchers as competitors, and often feared that hides of collared lions might show wear in the neck region. Two houndsmen who assisted the study would have otherwise hunted the drainage. The hunting effort documented was estimated at half of what would have occurred in the absence of the study. The normal hunting effort probably would not have resulted in twice the documented kill of lions, however, because the likelihood of finding tracks on roads probably diminished greatly once the most accessible lions were removed. Hunters did not concentrate their activity more in less accessible drainages as the season progressed, and probably were less successful in locating tracks as compared to earlier in the season.

Road access and the location of entrances were key factors influencing the distribution of hunting pressure and harvest in the drainage. However, houndsmen did not fully penetrate the available lion habitat even though road access was extensive. They travelled little via snowmobiles, utilized only about 65% and 15% of main and side road mileage available, and did not hunt on foot in unroaded drainages. Houndsmen did not usually travel beyond points where they located lion or bobcat (Lynx rufus) tracks, or sign of other houndsmen. Consequently, hunter activity concentrated on roads near the drainage entrances. Travel patterns of non-local hunters reflected their unfamiliarity with access. They often checked only main and obvious side roads in the northern portion.

Houndsmen probably would have been more successful if they had hunted side drainages more extensively. Disproportionately more lion tracks were located on side roads than on main roads. This trend was also evident in the circumstances surrounding lion harvests. Documented travel by houndsmen on side roads was only 23% of the total, yet tracks of 3 of the 7 (43%) lions harvested were found on side roads. Although only 6% of the total hunting mileage was by snowmobile, this method accounted for 2 of the 7 (28%) lions killed, both in side drainages.

Hunting mortality was the primary factor influencing the rate of turnover in adult lions during this study. No non-hunting mortalities of adults were documented, although Hemker (1982) reported 3 among 9 adult lions during 102 lion months, indicating that natural mortality can significantly influence adult longevity.

Disproportionately greater harvest of males (48%/year) versus females (22%/year) apparently did not lead to abnormally skewed sex ratios of resident adults; the 1 male/2 females found here was similar to results in other studies -- 3/6 (Seidensticker et al. 1973), 3/7

(Shaw 1982), and 1-2/5-6 (Hemker 1982). The reasons for the discrepancy in harvest of the sexes are unclear. Females appeared to cross roads at least as often as males, and no treed females were spared because they were accompanied by kittens, nor did houndsmen report avoiding pursuit of family groups. Two females were known to have been pursued but not treed, so chance escapes could partially account for the discrepancy. Most houndsmen concur with our impression that males are not more easily treed once pursuit begins. Avoidance of killing collared lions could have influenced sex ratios in the kill, but this factor is considered minor because 2 females and 2 males were spared. Usually, harvest pressure on females is lighter than on males. Houndsmen often select for males because females with kittens are granted legal protection and males are usually larger. During this study, houndsmen were not selective unless the lion they treed was collared. Seidensticker et al. (1973) reported that males reoccupied vacant habitat more quickly than did females. We did not have the opportunity to make these comparative observations, but faster replacement by males could maintain numbers and stability in sex ratios where males are removed more quickly than females.

Several factors explain why the study area probably receives greater lion hunting pressure than most other drainages in western Montana. The extensive road access is attractive to lion hunters. No human developments occur along the bottom of Fish Creek, so lost hounds may be recovered before conflict occurs with land owners or hounds encounter heavy and dangerous traffic on roads. Because the Fish Creek drainage contains a large area of winter range, houndsmen need not expend valuable daylight time travelling between small and isolated units of lion habitat, a condition necessary to hunt lions in many other areas.

Adult lions in the study area lived as solitary predators. Associations were brief in duration, and occurred mostly among adults of the opposite sex. Adult females associated occasionaly, although males did not. Low sample sizes did not permit statistical analysis of distances maintained between individuals. However, I observed that adult females rarely utilized the same side drainages concurrently, although these females showed extensive home range overlap. We observed scrapes made by 2 different males while snowtracking males 8 km and females 23 km. I did not make sufficient observations of scrapes and lion behavior to determine if scrapes were associated with territoriality (Hornocker 1969, 1970, Seidensticker et al. 1973), or temporal presence (Hemker 1982).

The amount of home range overlap among adults of the same sex differed little from that described by Hornocker (1969, 1970) and Seidensticker et al. (1973). In contrast, Sitton (1977), Shaw (1979), and Ashman (1981) found considerable overlap among adult males, and Sitton (1977) and Hopkins (1981) found that females were largely exclusive. The Fish Creek population was at lower winter density than populations in Idaho (Seidensticker et al. 1973 and Utah (Hemker 1982) which were believed stable and at carrying capacity (Table 3).

Table 3. Lion home range sizes and densities reported in the western states and provinces. Original values were converted to like units.

		Home Range Size in km^2 $\bar{x}$ (range)		Density		
Location	Season	F	M	Adults/100 km^2	Lions/100 km^2	Source
Montana	Winter	26 (13-62)	33 (17-73)	4.3[a]	7.1[a]	This study
	Spring-Fall	132 (49-245)	290 (176-484)			
	Yearlong	82 (106-278)	336 (271-588)			
Idaho	Winter-Spring	88 (31-142)	126 (41-220)	2.9		Hornocker (1970)
	Summer-Fall	125 (41-220)	293			Seidensticker et al. (1973)
	Yearlong	268 (173-373)	453			
Utah	Winter	236 (100-421)	508		0.6	Hemker (1982)
	Nonwinter	347 (232-556)	573		1.1	
	Yearlong	685 (396-1454)	826	0.15	0.45	
British Columbia	Winter	13				Dewar (1975)
	Summer	52				
	Yearlong		650			
Colorado	Yearlong				1.7-3.3	Currier (1976)
California	Yearlong	(47-65)	(65-91)		4.4	Sitton (1977)
	Yearlong	(62-71)	(82-355)		1.3	Hopkins (1981)
Arizona	Yearlong	(123-162)	(25-176)	2.2[b]		Shaw (1979,1982)
Nevada	Yearlong	161 (117-244)	616 (534-816)		1.4-1.6	Ashman (1976,1981)

[a] Estimates were based on 160 km^2 of ungulate winter range

[b] Resident adults only

Sizes of yearlong home ranges were also smaller in the Fish Creek drainage, suggesting that carrying capacity in this environment is greater than in the other areas. Presently, the ecological relationships that contribute to variability in home range sizes, spacial distributions, and densities are unclear, although prey density prey size, topography, and foraging efficiency probably account for the discrepancies observed among lion populations in the western states (Seidensticker et al. 1973, Hemker 1982). Wide riparian zones containing mixed stands of seral hardwoods and conifers support a good population of white-tailed deer in the Fish Creek drainage, apparently an important food source for lions (Appendix C). This may partly explain the high densities of lions in Fish Creek versus other study areas in the western states without whitetails.

Increases in mean elevation from winter through summer by radio-collared lions probably reflect similar movements of deer and elk away from winter ranges (Bohne 1974, Zahn 1974, Lemke 1975, Lyon 1979). A decline in elevation from August to September may have been in response to increased use of mesic creek bottoms by elk (Zahn 1974). Movements away from hunter concentrations along roads at low elevations did not appear to explain increases in elevation by lions from October to November, although this reaction by elk and lions might be in response to disturbance associated with fall hunting seasons.

Females in this study produced 2.6 kittens/mobile litter at 2 year intervals per female, and were as productive as females in other areas. Robinette et al. (1961) and Hemker (1982) reported 2.9/2 years and 2.8/unknown years in Utah. Hornocker (1970) found 2.5/2 years in Idaho. Litters were born in all seasons except spring during this study (N=5). Robinette et al. (1961) and Hemker (1982) found that births occurred mostly during summer-fall, whereas Seidensticker et al. (1973) reported that births were usually during spring.

Stable numbers and sex ratios were maintained after removal of 2 adult males during W1 by recruitment of M14 and apparently M10 within 2 winters. F13 reoccupied vacant habitat left open by the previous shift of F5 into adjacent Rock Creek drainage. We did not monitor population trends after W3, but 2 unmarked females and 1 unmarked male were identified in the drainage the following winter. These individuals were likely new recruits into the breeding population. New residents were probably dispersers from adjacent drainages that were lightly hunted, or from more distant habitats in western Montana or mountainous regions of Idaho. Hornocker (1967), Seidensticker et al. (1973), Dewar (1975), and Hemker (1982) found that young adults commonly dispersed more than 50 km from their juvenile home ranges. M14 and M10 appeared to be 1-3 years older than new resident M1, and may have been born to females in unexploited populations and unable to occupy home ranges near their birth places. Seidensticker et al. (1973) and Hemker (1982) concluded that dispersal was probably density independent in populations they studied. Behavior of F16, which resided as an adult adjacent to her juvenile range, suggested that kittens may not disperse if suitable habitat below carrying capacity was located nearby. Unexploited and recently unhunted populations studied by Hornocker (1967) and Hemker (1982) contained about 33% transient lions (my calculations). The absence of transient lions in the Fish Creek drainage suggests that vacant habitat triggered F16′s behavior. Proof that dispersal is density dependent, however, must await research evaluating the change, if any, in the behavior of dispersers when population numbers are manipulated.

Assuming the 12 kittens born to females survived to independence, total production during the period of study was double the 6 adult lions killed by houndsmen. Whether production usually equals or exceeds annual kill in the drainage is unknown, however, because the lion kill was light due to the study, and because mortality rates among young lions in coniferous forest habitats have not been documented. Although the study area appears to be heavily dependent upon production from other drainages, it probably provides transient lions to other habitats, but fewer than it recruits from surrounding areas. Regional exchange of young lions is promoted by the strong dispersal capabilities of this species, and ameliorates differences in density generated by concentrated lion harvests.

Lions made at least 4 excursions from their presumed home ranges during this study, and 1 was 8 days or more in duration. During September 1981, M14 was radio located 28 km from the study area in the Clearwater River drainage of Idaho. The location did not meet outlier criteria, but he did not subsequently venture into that portion of Idaho during the study. I believe these movements were not within his usual range. M2 (age 5-7 years) stayed 3 or more days in the home range of young M1 (age 1-2 years) which was becoming established in the West Fork drainage during W1. M2 was killed before his status could be determined, but his travel appeared unrestricted. He may have been a resident in either portion, or transient to the entire drainage. M14 and M10 entered M1′s home range after M1′s death during early W3. Seidensticker et al. (1973) and Hornocker (pers. comm.) reported that resident male lions entered home ranges of adjacent males, but only for periods of less than 24 hours. They described a reshuffling of space whereby a male was replaced by a different male in the absence of the first occupant′s sign. Exploratory behavior may be encouraged by the absence of sign and by social disruption accompanying harvest. This would be advantageous to the aquisition of a more desirable habitat, including breeding opportunities. Great mobility provides lone adults (Seidensticker et al. 1973, Hemker 1982) with the capacity to rapidly assess circumstances relating to vacant space.

Unequal distribution of harvest probably caused the lower densities of adult lions observed in the northern versus the southern portion of the study area. This was probably a local effect restricted to heavily hunted drainages. Lions were easily treed by good hounds when snow conditions were ideal. When these conditions persisted, a kill of more than 50% of the resident adults was possible in easily accessible habitats. However, several factors probably made this event uncommon.

Long periods of poor snow conditions, encountered between winter storms, worked against houndsmen and to the benefit of lions. Agonistic behavior among houndsmen when conditions were favorable for dogs seemed to limit the number of hunters using the drainage concurrently. More than 1 party seldom shared the drainage, although sufficient space was available for 2 aggressive hunters with snowmobiles in roaded areas alone. F13, M10, and M1 were quickly removed from areas frequented by houndsmen, but F9 and M14 were detected only occasionally because they rarely crossed the main road and only outside the concentrations of hunter activity. Houndsmen had to penetrate side drainages to reach the tracks of these lions. This was easily accomplished during early winter when roads are passable in 4-wheel drive vehicles. Later, logistical problems associated with moving equipment and hunters to lion tracks reduced the time and mileage available to houndsmen hunting in side drainages on snowmobiles. These factors, coupled with houndsmen travel patterns that were typically unaggressive, tended to reduce the likelihood of over-kill. However, the amounts and timing of snowfall during some winters dictated that the kill of lions would be excessive. In the Fish Creek drainage, recoveries after these events would likely be rapid because young adults would quickly replace those removed.

The level of harvest in the study area appeared to be compatible with recruitment of young lions. Sex ratios and numbers of lions in the study area remained stable during 3 years despite an average annual harvest of about 32% of the adult population. Young lions that rapidly established themselves as residents maintained that stability.

Increases in local big game populations during the last 3 years (Hartkorn, DFWP Region 2 Wildlife Biologist, pers. comm.) probably contributed to high natality and survival of kittens to breeding age. Regional trends in prey densities and lion harvest will probably continue to influence the number of young lions available to replace those killed by hunters. The number of potential recruits may decline if prey densities decline or the demand for lion hunting increases simultaneously with increases in road access to presently unroaded drainages near Fish Creek. These circumstances will diminish the allowable harvest of lions in the study area.

MANAGEMENT IMPLICATIONS and CONCLUSION

This investigation suggested that present lion hunting regulations in western Montana are adequate to protect the lion resource. Although drainages that are highly accessible and enjoy a reputation among houndsmen for providing good lion hunting will occasionaly be over-harvested, dispersal of young breeding recruits from lightly hunted drainages in Idaho and western Montana will probably compensate local over-kill. Regionally, biological surpluses probably still exceed the total kill of lions. However, the present policy allowing each hunter to kill 1 lion each year may have to be replaced by more restrictive regulations if deer and elk densities decline markedly, leading to lower production of kittens, or if large increases in road access to lion winter range accompany the current increases in demand to kill lions (K. Greer, DFWP Research Laboratory Supervisor, pers. comm.). The increases in road access, which usually accompany timber sales, and long-term effects of silvicultural treatments on deer and elk densities are important considerations in managing lion habitat. Closing new roads by installing gates and reducing adverse impacts of silvicultural treatments on prey animals can help maintain present lion populations and hunting seasons.

If large increases in road access and demand for lion hunting occur and danger of over-kill of lions is great, game managers in western Montana may elect to control the distribution of harvest by managing lions on a unit basis. Lion-environmental relationships may differ greatly among habitats of differing topography or prey densities. The population of lions in the Fish Creek drainage is characteristic of many large drainages in western Montana where extensive seral brush and riparian woodland communities support large populations of wintering ungulates. Habitats of different topography or lesser prey bases may require more conservative management than that appropriate in the Fish Creek drainage. Additional research is needed to more clearly illuminate the ecology of exploited lion populations in Montana.

REFERENCES CITED

American Ornithologist's Union Check List Committee. 1957. Checklist of North American birds, fifth ed. Amer. Ornithol. Union, Port City Press, Inc., Baltimore, MA. 691pp.

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

Ashman, D. 1976. Biology and life history. Pages 38-91 in G.C. Christensen and R.J. Fischer, eds. Transactions of the mountain lion workshop. U.S. Fish and Wildlife Serv., Portland, Ore.

_____. 1981. Mountain lion investigations. Nev. Dept. Fish and Game Rept., Proj. W-48-10, Job No. 5. Elko, Nev. 6pp.

Bohne, J.R. 1974. Food habits, seasonal distribution, and habitat utilization of elk in the South Fork of Fish Creek, Lolo National Forest, Montana. M.S. Thesis, Univ. Mont., Missoula. 187pp.

Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24:346-352.

Currier, M.J. 1976. Characteristics of the mountain lion population near Canon City, Colorado. M.S. Thesis. Colo. State Univ., Fort Collins. 81pp.

Dewar, P. 1975. Biology and life history. Pages 38-91 in G.C. Christensen and R.J. Fischer, eds. Transactions of the mountain lion workshop. U.S. Fish and Wildlife Serv., Portland, Or.

Dixon, K.R. and R.J. Boyd. 1967. Evaluation of the effects of mountain lion predation. Colo. Game, Fish, and Parks Dept., Job Comp. Rept., Proj. W-38-R-21, Job 4. Denver, Colo. 24pp.

Donaldson, B.R. 1975. Mountain lion research. N. M. Dept. of Game and Fish, Final Rept., Proj. W-93-R-17, Job 1. 18pp.

Greer, K. 1976. Age techniques. Pages 199-201 in G.C. Christensen and R.J. Fischer, eds. Transactions of the mountain lion workshop. U.S. Fish and Wildlife Serv., Portland, Ore.

Harstead, A.S. 1981. Computer analysis of home range data. Wildl. Res. and Tech. Ser. Sec., Fish and Wildl. Branch Bull., B-11. Ministry of Env. Victoria, B.C. 25pp.

Hemker, T.P. 1982. Population characteristics and movement patterns of cougars in southern Utah. M.S. Thesis. Ut. State Univ., Logan. 59pp.

Hitchcock, C.L. and A. Cronquist. 1978. Flora of the Pacific Northwest. Univ. Washington Press, Seattle. 730pp.

Hopkins, R.A. 1981. The density and home range characteristics of mountain lions in the Diablo Range of California. M.A. Thesis. San Jose State Univ., San Jose, Calif. 48pp.

Hornocker, M.G. 1967. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. PhD. Thesis. Univ. British Columbia, Vancouver. 112pp.

_____. 1969. Winter territoriality in mountain lions. J. Wildl. Manage. 33:457-464.

_____. 1967. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. PhD. Thesis. Univ. B.C., Vancouver., B.C. 112pp.

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

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

Jones, K.J., Jr., D.C. Carter, H.H. Genoways, R.S. Hoffmann, and D.W. Rice. 1982. Revised checklist of North American Mammals north of Mexico, 1982. Occasional Papers Museum Texas Tech University. No. 89. 22pp.

Lemke, T.O. 1975. Movement and seasonal ranges of the Burdette Creek elk herd, and an investigation of sport hunting. M.S. Thesis. Univ. Mont., Missoula. 127pp.

Lyon, J.L. 1979. Influences of logging and weather on elk distribution in western Montana. USDA For. Serv. Res. Paper INT-236. Intermountain For. and Range Exp. Stn., Ogden, Ut. 11pp.

Merriam, C.H. 1899. Life zones and crop zones of the United States. Bull. U.S. Biol. Surv. 10:1-79.

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

Pfister, R.D., B.L. Kovalchik, S.F. Arno, and R.C. Presby. 1977. Forest habitat types of Montana. USDA For. and Range Exp. Stn. Gen. Tech. Rep. INT-134. Ogden, Ut. 174pp.

Quimby, D.C., and J.E. Gabb. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. J. Wildl. Manage. 21:435-451.

Robinnette, W.L., J.S. Gashwiler, and O.W. Morris. 1961. Notes on cougar productivity and life history. J. Mammal. 42:204-217.

_____, G. Rogers, and J.S. Gashwiler. 1957. Notes on tooth development and wear for Rocky Mountain mule deer. J. Wildl. Manage. 21:134-153.

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

Shaw, H.G. 1973. Ecology of the mountain lion in Arizona. Ariz. Game and Fish Dept. Rept. Proj. W78-R-17, Job 13. Phoenix, Ariz. 31pp.

_____. 1977. Impact of mountain lions on mule deer and cattle. Pages 17-32 in R.L. Phillips and C.J. Jonkel, eds. Proc. 1975 Predator Symp. Montana For. and Cons. Exp. Stn., School of Forestry, Univ. Mont., Missoula.

_____. 1979. A mountain lion field guide. Ariz. Game and Fish Dept. Special Rept. 9. Phoenix, Ariz. 27pp.

_____. 1980. Ecology of the mountain lion in Arizona. Ariz. Game and Fish Dept. Rept., Proj. W-78-R, Job 13. Phoenix, Ariz. 14pp.

_____. 1982. Comparison of mountain lion predation on cattle on two study areas in Arizona. Pages 306-318 in J.M. Peek and P.D. Dalke, eds. Wildlife - Livestock Relationships Symp. For., Wildlife, and Range Exp. Stn. Univ. Id., Moscow.

Sitton, L.W. 1977. California mountain lion investigations with recommendations for management. Calif. Dept. Fish and Game, Proj. W-51-R. Sacramento, Calif. 35pp.

Zahn, H.M. 1974. Seasonal movements of the Burdette Creek elk herd. M.S. Thesis. Univ. Montana, Missoula. 71pp.

APPENDICES

Appendix A. Use of habitat types (Pfister et al. 1977) by lions during winter. The locations of all sites were accurately fixed from aircraft.

Habitat Type	Habitat Type Group[1]	No. Sites		% Sites	
		Type	Group	Type	Group
Scree (Pinus and Pseudotsuga Series)	NT	11	11	10.6	10.6
Pinus ponderosa/Agropyron spicatum	BG	10	14	9.6	13.5
Pseudotsuga menziesii/Agropyron spicatum	BG	2		1.9	
Pseudotsuga menziesii/Festuca idahoensis	BG	1		1.0	
Pseudotsuga menziesii/Festuca scabrella	BG	1		1.0	
Pseudotsuga menziesii/Physocarpus malvaceous	XDF	30	31	28.8	29.8
Pseudotsuga menziesii/Symphoricarpos albus	XDF	1		1.0	
Pseudotsuga menziesii/Xerophyllum tenax	MDF	5	25	4.8	24.0
Pseudotsuga menziesii/Vaccinium globulare	MDF	10		9.6	
Pseudotsuga menziesii/Calamagrostis rubescens	MDF	10		9.6	
Abies grandis/Clintonia uniflora	RP	2	13	1.9	12.5
Thuja plicata/Clintonia uniflora	RP	7		6.7	
Abies lasiocarpa/Clintonia uniflora	RP	4		3.8	
Abies lasiocarpa/Vaccinium caespitosum	HE	1	10	1.0	9.7
Abies lasiocarpa/Xerophyllum tenax	HE	9		8.7	

[1]NT = nontimber and grassy openings; BG = bunchgrass; XDF = xeric Douglas-fir types; MDF = mesic Douglas-fir types; RP = riparian types; HE = high elevation types.

Appendix B. Use of cover types by lions during winter. The locations of all sites were accurately fixed from aircraft.

No.	Type	Description/Criteria	No. Sites	% Sites
1	Pole stand	Largely uniform young or mid age conifer stands; trees broomed or unbroomed; and tree crown intercept >25%	44	42
2	Mature forest with ≥5% tree crown intercept	Mature, broomed stands of uniform age conifers	5	5
3	Mature forest with < 5% tree crown intercept	Ponderosa pine or occasional Douglas fir savannas on southerly aspects at low elevation	4	4
4	Selectively logged mature or pole stands	Cover types 1, 2, or 3 significantly changed by logging of a selective nature	31	30
5	Seral brush field	Usually fire-induced brush dominated sites on west, south, or southwest exposures; and conifers sparse	19	18
6	Riverine-Riparian	Seral hardwood and shrub stands in floodplains	1	1

Appendix C. Characteristics of prey at sites where lions made kills during winter.

Lion			Prey			Site								
No.[1]	Age	Status[2]	Species[3]	Age[4]	Sex[1]	Habitat Type Code[5]	Cover Type Code[6]	Elevation (m)	Aspect (°)	Slope (%)	Tree Canopy Coverage[7] (%)	Trees/ Acre[8]	Shrub Cover[7] (%)	Total Horizontal Cover[9] (%)
M 1	1-2	S	WD	P	F	260	4	1,158	340	65	20	23.5	30	92.5
F 5	5-9	A	E	O	F	260	1	1,150	50	80	24	60.0	70	67.5
F 5	5-9	NN	E	P	F	260	7	1,194	80	64	1	10.0	30	46.5
F 8	5-8	NN	SH			280	1	1,249	20	68	75	116.1	20	32.7
F 8	5-8	NN	WD	P		260	1	1,368	130	64	60	166.5	5	48.8
F 8	5-8	S	E	O	F	130	4	1,341	125	57	1	11.0	50	50.0
F 10	3-4	S	WD	Y	M	260	6	890	0[a]	3[a]	65	18.1	60	72.1
F 13	1-2	S	WD	Y	M	320	4	969	0[a]	3[a]	20	56.2	30	73.8
F 13	1-2	S	WD	P	M	320	4	969	0[a]	3[a]	20	86.2	10	81.2
M	1-2	S	MD	P	M	130	3	1,167	185	60	20	52.5	5	4.0
--	1-2	S	WD	F		320	4	923	0[a]	2	70	21.2	65	68.2

[1] M = male; F = female.

[2] S = solitary; A = accompanied by dependent offspring when kill was made; NN = not solitary but not accompanied when kill was made.

[3] WD = white-tailed deer; MD = mule deer; E = elk; SH = snowshoe hare.

[4] Based on tooth replacement and wear (Robinnette et al. 1957, Quimby and Gaab 1957). F = fawn; Y = yearling; P = prime (deer: 3.5-7.5 years; elk: 3.5-9.5 years); O = old.

[5] Codes follow Pfister et al. (1977). 130 = Pinus ponderosa/Agropyron spicatum; 260 = Pseudotsuga menziesii/Physocarpus malvaceous; 280 = P. m./Vaccinium globulare; 320 = P. m./Calamagrostis rubescens.

[6] See Appendix B.

[7] Estimated at the site, from aerial photographs, or topographic maps.

[8] Determined using an offset prism. Only trees with dbh ≥ 7.6 cm are included.

[9] Percent of a 27.4 cm diameter disc obscured by any matter. The disc was positioned 76 cm above ground and randomly directioned 18.3 m from the observer. Values provided represent averages of 4 readings per site.

[a] Kill made in a riparian zone.

Appendix D. Snow conditions, travel, and track counts.

Winter	No. Days: Ideal Snow Conditions Present	No. Days: Researchers Active[1]	Total km Searched[1]	Track Sets[2] Located	Tracks/100 km: All Tracks and Conditions	Tracks/100 km: Fresh Tracks and Ideal Conditions[3]
W 1 (1979-80)	36	65	1,502	20	2.0	2.4
W 2 (1980-81)	18	25	643	16	4.0	4.1
W 3 (1981-82)	53	43	1,372	27	3.2	1.3

[1] All snow conditions.

[2] Multiple lions travelling together were counted as 1 set.

[3] Tracks apparently <12 hours old.

Appendix E. Physical measurements of lions captured in western Montana during this study and other work, 1978-1982.

Lion No.	Weight (kg)	Age[1] (years)	Total Length (cm)	Tail Length (cm)	Neck Circumference (cm)	Chest Girth (cm)	Shoulder Height (cm)	Interocular Distance (cm)	Color
FA 90	36.3	1-2	198	71	37	70	61	7.0	Red
FA 91	38.6	1-2	206	76	36	69	61	7.6	Tawny
F 16	29.5	1-2	184	67	36	67			Tawny
--	33.2	1	182	60	38	69	70	6.3	Tawny
F 13	25.0	1-2			33				Red
F 16	38.6	3	189	65	34	70	61	6.4	Tawny
F 9	43.0	3-4	187	66	37	71	66	6.4	Tawny
F 10	30.7	3-4							Tawny
F 5	40.9	5-9	189	67	35	81	76	6.3	Tawny
F 8	40.9	3-4	183	69	36	67		6.7	Tawny
MA 96	10.0	2 months	114	38	25	46	41	3.8	Tawny
MA 92	50.0	1	203	76	39	80			Tawny
M 1	48.2	1-2	208	71	46	79	66	8.2	Tawny
M 10	68.2	3-4							Tawny
M 14	71.6	3-5	216	84	45				Tawny
M 2	72.7	5-7	229	81	48	89		7.6	Tawny

[1]Age follows descriptions in Greer (1976).

Appendix F. Individual home range sizes for 7 instrumented adult lions. (N) = number of locations used to estimate the home range size.

Lion No.	Year	Home Range Size (km^2) Winter	Spring-Fall	Yearlong
F 5	1980	13 (12)	169 (12)	194 (24)
	1981	53 (8)	142 (23)	279 (32)
	1982	12 (5)		
F 8	1980	18 (9)	49 (11)	132 (21)
	1981	50 (9)	99 (23)	188 (32)
F 9	1980		127 (12)	
	1981	24 (10)	92 (24)	106 (34)
	1982	20 (10)		
F 10	1981	36 (14)	246 (19)	246 (33)
	1982	18 (8)		
F 16	1981	62 (11)	165 (23)	193 (34)
	1982	29 (6)		
M 1	1980	32 (9)	176 (11)	271 (20)
	1981	73 (11)	326 (24)	335 (35)
M 14	1981	17 (6)	485 (23)	588 (29)
	1982	21 (5)		