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Vulnerability of Cougars to Hunting

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VULNERABILITY OF COUGARS TO HUNTING

by

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Dan Barnhurst

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ABSTRACT

Vulnerability of Cougars to Hunting
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Forty radio-collared cougars (Felis concolor) were monitored for 630 cougar months. Track searches were conducted and tracking information was gathered over a 20-month period. Vulnerability was estimated to be greatest for 0 to 6-month old kittens. This age class is the most susceptible to starvation after orphaning, or being killed by hounds when the hunter is unaware of their presence, since their tracks were found with their mother's tracks only 19 percent of the time. Tracks of 7 to 12-month old kittens were found with their mother's tracks 43 percent of the time. Relative road crossing frequencies of seven classes of transients and resident adults were derived from sequential, aerial telemetry locations. Significant differences ($P < 0.043$) in crossing frequencies were found among these classes. A relative vulnerability index, based on road crossing frequencies, was calculated for each class. Compared to an average vulnerability index of one for all classes, resident females without kittens, and those with 0 to 6-month, 7 to 12-month, and 13 to 18-month old kittens, had relative vulnerability indices of 0.6, 0.5, 0.83, and 0.78, respectively. Transient females, resident males and transient males had indices of 0.93, 0.95, and 1.35, respectively.

After two years of experimental hunts, where the average density of harvestable cougars (kittens and females accompanied by kittens excluded) was 0.71/100 km^2, hunters found an average of 1.3 tracks per day and started their hounds on 1 in 3.8 of these tracks. Treeing a cougar required an average of 8.7 hunting days and covering 559 km of road during track searches. The level of experience of the hunter and his hounds appeared to be very important in determining hunting success. How the differential vulnerability between cougar classes may affect the composition of the hunter harvest was also discussed.

(73 pages)

INTRODUCTION

Cougars have become the center of controversy in recent years. The conflicting views of livestock owners, sportsmen and conservation groups, as well as our lack of knowledge and understanding of their status and biology, have put wildlife agencies charged with the responsibility of managing them in an unenviable position.

Cougars once ranged coast to coast in North America and between British Columbia and southern Chile (Young and Goldman 1946). Because of habitat loss and persistent efforts to remove them, they are now found in significant numbers in the U. S. only in the western mountain states. Wildlife agencies have been slow to give them protection because of livestock depredation problems and competition with hunters for wild game. In the last two decades, however, these agencies have begun to recognize the value of the cougar as an integral part of the ecosystem and as a game animal. Thirteen of fourteen states with notable cougar populations have given them game status and now have regular hunting seasons. California recently lifted a moratorium on sporthunting, but cougars in Texas are still classed as predators and are offered no protection.

Several intensive studies have been conducted to gain a better understanding of cougar biology and ecology (Hornocker 1969 and 1970, Seidensticker et al. 1973, Shaw 1977 and 1980, Kutilek et al. 1980, Hemker 1982, Ackerman 1982). However, relatively little time has been devoted toward gaining an understanding of how sporthunting affects cougar populations. The most notable exception was a recent study in western Montana where Murphy (1983) monitored the response of a small population to heavy sporthunting pressure. He found that houndsmen treed cougars on 91 percent of the occasions when they were tracking under good snow conditions. He concluded that over 50 percent of the resident adults were harvested in an area with good access and suitable snow conditions, but that this concentrated harvest did not deplete the number of adult cougars present. Harvested adults were replaced by young adults raised in the area or transients immigrating from surrounding areas.

Cougar hunting is increasing in popularity. In most states allowing cougar hunting, the number of permits sold has risen steadily during the last decade. Permit sales have more than doubled in Utah during the past ten years with no corresponding increase in the harvest (Figures 1 and 2).

Wildlife managers are faced with the problem of providing hunting opportunities without knowing what level of harvest cougar populations can withstand. Ideally, harvest objectives should be based on detailed information about the size, sex, and age structure of the population. Unfortunately, these types of data are not readily available. Harvest reports, on the other hand, are one of the few sources of information a manager may have. However, the interpretation of these data is tenuous. Harvest data can be used to estimate the standing population composition

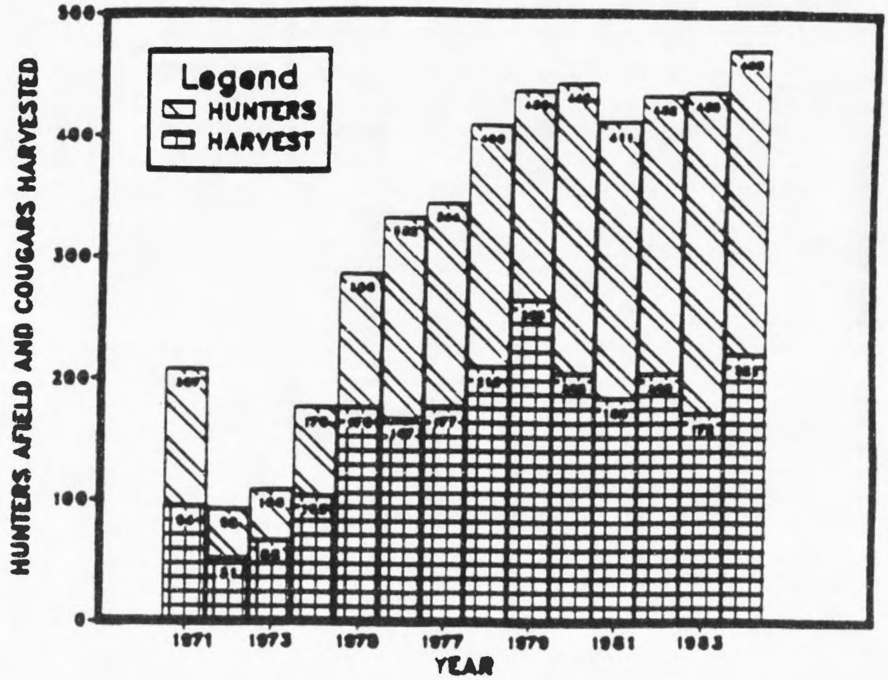

Figure 1. Hunters afield and cougars harvested in Utah between 1971 and 1984.

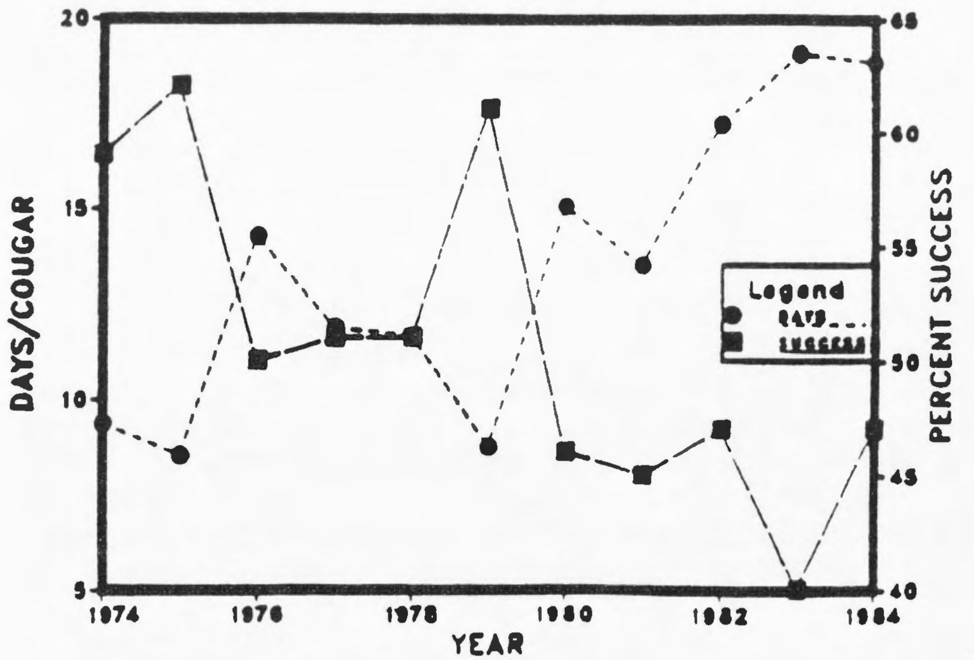

Figure 2. Days hunted per each cougar killed and percent hunter success in Utah between 1974 and 1984.

only if the biases associated with hunter selectivity and the differential vulnerability of cougar sex and age classes are understood. Investigating the vulnerability of cougars to sporthunting is a step towards understanding how to interpret harvest data.

This paper discusses the vulnerability of various sex and age classes of cougars to hunting, and how differential vulnerability among these classes may affect the composition of cougar harvests.

STUDY AREA

The study area encompasses 4500 km^2 of the Boulder, Escalante, and Canaan mountains in southern Utah. Research efforts were concentrated in a core area of approximately 1900 km^2. Elevation ranges from 1,350 m on the Escalante River to 3,355 m on Boulder Mountain. Precipitation comes mainly as snow in the winter and afternoon thunderstorms during August and September. Average annual precipitation ranges between 18 cm at Escalante and 60 cm at the higher elevations.

Most of Utah's major vegetation zones are represented on the study area. Below 1800 m, sparse pinyon pine (*Pinus edulis*) and juniper (*Juniperus osteosperma*) dominate the overstory; desert grass/desert shrub complexes dominate in the understory. Bare sandstone ridges in the rougher terrain, and dense pinyon-juniper woodland interspersed with big sagebrush (*Artemisia tridentata*) flats in the less rugged areas, occur between 1800 m to 2400 m. Ponderosa pine (*Pinus ponderosa*) and Gambel oak (*Quercus gambelii*) dominate the zone between 2400 m to 2700 m. Above 2700 m small mountain lakes and sub-alpine meadows are surrounded by Engelmann spruce (*Picea engelmannii*) and white fir (*Abies concolor*) forests and stands of quaking aspen (*Populus tremuloides*).

Mule deer (*Odocoileus hemionus*), the major component of the cougar's diet (Ackerman 1982), are the most abundant ungulate in the area. Approximately 700 elk (*Cervus elaphus*) inhabit the higher elevations on the study area. Four Leporids; blacktail jackrabbit (Lepus californicus), snowshoe hare (L. americanus), and both desert and mountain cottontails (Sylvilagus auduboni and S. nuttalli), are present. Sciurids are represented by yellowbelly marmots (Marmota flaviventris), golden-mantled ground squirrels (Spermophilus lateralis), whitetail antelope ground squirrels (Ammospermophilus leucurus) and chipmunks (Eutamias spp.). Smaller predators in the area include coyotes (Canis latrans), bobcats (Lynx rufus), grey fox (Urocyon cinereoargenteus), and badgers (Taxidea taxus). A population of black bears (Ursus americanus) is also present. About 6,000 cattle graze on public lands through summer and early fall, and year-round on private lands at lower elevations.

Approximately 850 people inhabit the area; most live in the towns of Boulder and Escalante. The area is used extensively for livestock grazing, timber harvesting, oil and mineral exploration, and recreation. Consequently, the area is well-roaded with few areas farther than 5 km from a road.

The area's cougar population has been subjected to both sport and commercial hunting in the past. As many as 18 cougars were taken annually in the late 1960s. Based on harvest records (Utah Division of Wildlife Resources 1980) and communications with local hunters, Hemker (1982) estimated the harvest to be between 5 and 10 annually during the 1970's. The area was closed to hunting at the beginning of this study in 1979. Experimental hunts were carried out in the winters of 1983-84 and 1984-85 as part of this study.

METHODS

Information was gained by tracking cougars with hounds, radio telemetry, snow-tracking and track searches. Cougars were trailed and treed by hounds, immobilized (1.0:0.15 mixture of ketamine hydrochloride and xylazine hydrochloride administered IM), and fitted with mortality-switch or motion-sensitive radio transmitter collars (Telonics Inc., Mesa, Arizona). Telemetry relocations were obtained from a Cessna 185 and by triangulation on the ground. Tracking in sand and snow was done on foot or horseback. A selected toe was surgically removed from each collared cougar to facilitate identification by tracks.

Vulnerability of Kittens

Kittens were classified into three age classes (Class 1: 0-6 mos., Class 2: 7-12 mos., Class 3: 13-18 mos.) and their relative vulnerability was estimated in two ways. The first estimate was based on the percentage of same-day telemetry locations when the female was found with her kittens. The second was based on the frequency that kitten tracks were found with their mother's tracks. These estimates are important in understanding the probability of a hunter chasing and killing a female without knowledge that she had kittens, or of the hounds following the female to her young kittens and killing them on the ground before the hunter arrives.

Vulnerability of Resident Adults and Transients

Since hunters typically drive roads in search of cougar tracks, an index to road crossing frequency was used to estimate the relative vulnerability of seven reproductive classes of resident-adult and transient cougars. These seven classes are:

1. Resident adult females - Class 0 : no kittens
2. Resident adult females - Class 1 : kittens 0-6 months old
3. Resident adult females - Class 2 : kittens 7-12 months old
4. Resident adult females - Class 3 : kittens 13-18 months old
5. Transient females
6. Resident adult males
7. Transient males.

Resident adults are defined as sexually mature cougars displaying site attachment for at least 6 months (Hemker 1982). Resident females were separated into one of four classes depending upon the presence and age of kittens. Most resident females were included in several or all four of these classes as they were monitored through time, and occasionally, one female provided additional data when she was monitored with a subsequent litter. Transients are defined as independent, non-breeding cougars not showing site attachment. Transients may or may not be sexually mature, but do not reproduce until they become resident (Hemker et al. 1982).

Since preliminary data analysis indicated a strong possibility of bias associated with telemetry locations obtained on the ground, only aerial relocations were used to estimate road crossing frequency. These relocations were obtained at approximately 7-day intervals. The locations were recorded to the nearest 0.10 km, in UTM (Universal Transverse Mercator) coordinate pairs. These data were then used to make a computer-generated plot of serially connected relocations

(Appendix, Figure 8). The number of times roads were crossed between relocations was counted and used as an index to crossing frequency. A relative vulnerability index was also calculated for each class of cougar by dividing the road crossing frequency index of each class by the average crossing frequency index of all classes. The density of roads (km roads/km^2) was calculated for the home-area used for each reproductive class of each cougar. Home-area sizes were based on modified minimum convex polygons formed by the outermost relocations for each cougar in each class. Program HOMER was used to identify and exclude extreme outlying relocations and calculate these home area sizes. The statistical package RUMMAGE (Statistics Department, Brigham Young University, Provo, Utah) was used to perform the covariance analysis and test for differences in the mean crossing frequencies between classes. The number of locations and road densities were used as covariates with the dependent variable (number of crossings) to assure valid comparisons between classes.

Road Density Comparisons

If any or all of the classes of cougars showed selection either for or against well-roaded areas it would affect their vulnerability to hunting. Road densities, expressed as km roads/km^2, were calculated for the area used by each cougar in each class and for the study area. A chi-square test was used to test for significant differences between mean home-area road densities for each class and the study-area road density. In a second comparison, paired-T tests were used to test for differences between classes.

Roads Type and Crossing Frequencies

Roads were separated into two subjective classes (high-use and low use) to test for differential crossing rates which might suggest avoidance based on the degree of human disturbance. High-use roads were defined as paved or graveled roads which I estimated to receive an average of one car per hour each day. Low-use roads were usually poorly maintained, dirt roads receiving less use than one car per hour. Analysis of variance was used to test for differences in road crossing rates for high-use and low-use roads.

Experimental Hunts

Experimental hunts were carried out in the winters of 1982-83 and 1983-84. Seven permits were issued by the Utah Division of Wildlife Resources the first year, ten the second. The permits were valid only for the study area the first year but hunters were allowed to hunt elsewhere the second year if they chose. Permittees were chosen at random after applying by mail. Hunters were required to check with study personnel before and after each hunting trip. They were also required to fill out a daily hunt record form (Appendix, Figure 9) summarizing their efforts and success in finding tracks and cougars.

Harvested cougars were weighed, measured and checked for ectoparasites. Adult females were checked for signs of recent lactation. Ages of all harvested cougars were determined based on dental characteristics (Ashman and Greer 1976); those with the cementum junction of the canines exposed beyond the gumline were judged to be over two years old. The density of cougars (expressed as cougars/km^2) within the study area core was extrapolated to an additional 350 km^2 of the adjacent study area buffer zone which was hunted during the experimental hunts. This allowed me to make comparisons between rates of hunter success per unit effort and estimated cougar densities.

Results of my hunting efforts during the study are included for comparison. My work routine involved both monitoring radio-collared cougars and searching for uncollared cougars that had immigrated into the area. During the winter months these searches involved driving roads in four-wheel drive vehicles, or using horses to find tracks in the snow; the same hunting methods as those used by permittees during the experimental hunts. To avoid unnecessary harassment of collared cougars, we initiated chases only when the tracks were fresh and thought to be made by uncollared cougars. Because I was unaided by telemetry, results of my hunting efforts should be similar and complementary to information from the experimental hunts.

RESULTS

All sex and age classes were represented in a sample of 40 radio-collared cougars. These animals were monitored for a total of 630 cougar months in which 4,400 telemetry relocations were obtained (Table 1 and Appendix, Figure 10). Intensive track searches were conducted and tracking

information was gathered over a 20-month period.

Vulnerability of Kittens

The vulnerability of kittens to hunting is directly related to the activity and movement patterns of their mothers, which are in part dictated by the age of the kittens (Hemker et al. 1982). With the exception of a few pre-dispersal excursions, kittens moved significant distances only when accompanying their mother. Travel is usually limited to movement between kill sites (location of carcass of a prey animal) when the kittens are young (Class 1), but they appear to accompany their mother more and more frequently as they grow older. Analysis of telemetry data from collared females and their collared kittens, however, failed to show significant differences in the amount of time the three age classes of kittens spent with their mother. Class 1 kittens were located with their mother 63 percent of the time. Class 2 and Class 3 kittens were located with their mother 69 percent and 65 percent of the time, respectively (Figure 3).

These percentages undoubtedly overestimate the actual percentage of time that females spend with kittens of different ages. All of the

Table 1. Sex, age, period monitored and comments relating to 73 cougars observed on the Boulder-Escalante Study Area between April 1979 and May 1985.

Number and sex[a]	Period monitored	Comment
F50	12/79-11/80	Transient, poached by trapper S.W. study area - 11/28/80
F70	1/80-2/80 and 2/81-3/81	First collar dropped off, second collar malfunctioned
F71 (79)	1/80-8/83	Died of natural causes
K711 (81)	Uncollared	Uncollared Kitten - fate unknown
F712 (82)	12/82-5/85	Currently being monitored
M713 (82)	12/82-11/84	Killed by hunter S.W. of study area - 12/84
K72 (79)	Uncollared	Found dead 2/80
K73 (79)	Uncollared	Found dead 6/81
K74 (79)	Uncollared	Last observed with F70 and F71 - 3/81
F80	Uncollared	F81s uncollared mother - fate unknown
F81 (78)	9/79-8/80	Collar malfunctioned - fate unknown
M82 (78)	Uncollared	F81s uncollared litter mate - fate unknown
F90	1/80-7/82	Died of natural causes
F91 (79)	2/80-9/82	Injury related death - crushed ribcage
F92 (79)[b]	2/80-4/81 and 11/82-12/84	First collar malfunctioned - moved to Henry Mtns. - 4/83
F921 (81)	1/83-5/85	Currently being monitored
K9211 (83)	Uncollared	Last observed with F921 - 3/84
K9212 (83)	Uncollared	Last observed with F921 - 3/84
K9213 (83)	Uncollared	Last observed with F921 - 3/84
F922 (81)	Uncollared	F921s uncollared litter mate - fate unknown

Table 1. Continued

Number and sex[a]	Period monitored	Comment
M93 (79)	2/80-5/81	Shot by a hunter, Salina Canyon - 11/81
F130	4/79-5/84	Died of natural causes
M131 (78)	4/79-9/79	Shot because of sheep depredation - 7/80
F132 (78)	Uncollared	Fate unknown
F133 (78)	Uncollared	Fate unknown
K134 (82)	Uncollared	Fate unknown
F150	4/79-4/81 and 4/84-12/84	Assumed poached 12/84, collar anonymously returned
F151 (78)	9/79-6/80	Shot by hunter - Old Woman Mountain - 2/82
F152 (78)	2/80-6/80	Possibly dispersed - ?
K153 (80)	2/81-5/81	Found dead and partially consumed
K154 (80)	Uncollared	Dead and partially consumed
K155 (83)	Uncollared	Last seen with F150 12/28/84 - fate unknown
K156 (83)	Uncollared	Last seen with F150 12/28/84 - fate unknown
K157 (83)	Uncollared	Last seen with F150 12/28/84 - fate unknown
M180	6/80-7/82	Died N.E. of study area - possible result of fight
M185	Uncollared	Track of large male observed after 180s departure
F190[c]	6/80-3/82	Poached by predator caller N.W. of study area - 3/83
F200	2/81-5/84	Collar malfunctioned
K201 (82)	Uncollared	Fate unknown - Possibly captured as F370
F202 (83)	9/83-5/85	Currently being monitored

Table 1. Continued

Number and sex[a]	Period monitored	Comment
M203 (83)	9/83-1/84	Found partially consumed
K204 (83)	Uncollared	Fate unknown
F210	Captured 3/81	Died from wounds inflicted by dogs during capture
F211 (80)	3/81-6/81	Poached by a fisherman
F212 (80)	5/81-8/81	Hung herself in the crotch of a tree
M213 (80)	5/81-10/83	Reported poached by deer hunter N.W. of study area - 10/83
F220[d]	5/81-12/82	Fate unknown
F260	2/82-2/85	Died from trap wounds
M261 (81)	3/82-9/82	Collared malfunctioned - fate unknown
M262 (81)	3/82-5/82	Found dead near highway
F263 (81)	4/82-2/83	Died from capture related injuries[e]
F264 (83)	1/84-5/85	Currently being monitored
F265 (83)	1/84-5/85	Currently being monitored
K266 (83)	Uncollared	Fate unknown
M001 (82)[f]	6/83-8/83	Died from injuries sustained in fall from tree
F002 (82)[f]	7/83-12/83	Hit by a car
M003 (82)[f]	7/83-5/84	Collar went dead - fate unknown
F370	12/83-3/84	Died of starvation
M380	12/83-5/85	Currently being monitored

Table 1. Continued

Number and sex[a]	Period monitored	Comment
M410	12/83-5/85	Currently being monitored north of area
M420	Uncollared	Tracks observed 11/84 and 12/84
F430	Uncollared	Tracks observed 11/84 and 12/84
C440	Uncollared	Tracks observed 11/84
C450	Uncollared	Tracks observed 11/84
M460	Uncollared	Shot 12/22/84 during experimental hunt
M470	Uncollared	Shot 12/17/84 during experimental hunt
F480	Uncollared	Shot in chicken coop 1/85
M490	Uncollared	Chased by a hunter - possibly F480s litter mate
F500[g]	Uncollared	Fate unknown - but probably poached 1/85
F501 (84)[g]	Uncollared	Orphaned - killed by hounds 2/85
F502 (84)[g]	Uncollared	Orphaned - assumed starved to death 2/85
M510	Uncollared	Tracks observed 1/85-5/85
M520	Uncollared	Tracks observed 2/85 and 4/85

[a]Generations indented, year of litter in parenthesis, F = Female, M = Male, K = Kitten of Unknown Sex, C = Adult of Unknown Sex.

[b]Was lactating at time of death but kittens could not be found.

[c]Caught by trapper S.E. Cedar City when about six months old, pen-raised and released.

[d]Lost middle toes of a front foot in a trap, recaptured in very poor condition, rehabilitated and released south of study area.

[e]Died from chase-inflicted damage to respiratory system. Passed many suitable trees during chase but treed only after lungs were badly damaged.

[f]Litter orphaned when a hunter killed their mother north of study area, pen-raised and released.

[g]Tracks of family group observed during 12/84. Kittens found traveling alone in very weakened condition at end of 1/85 and first week of 2/85.

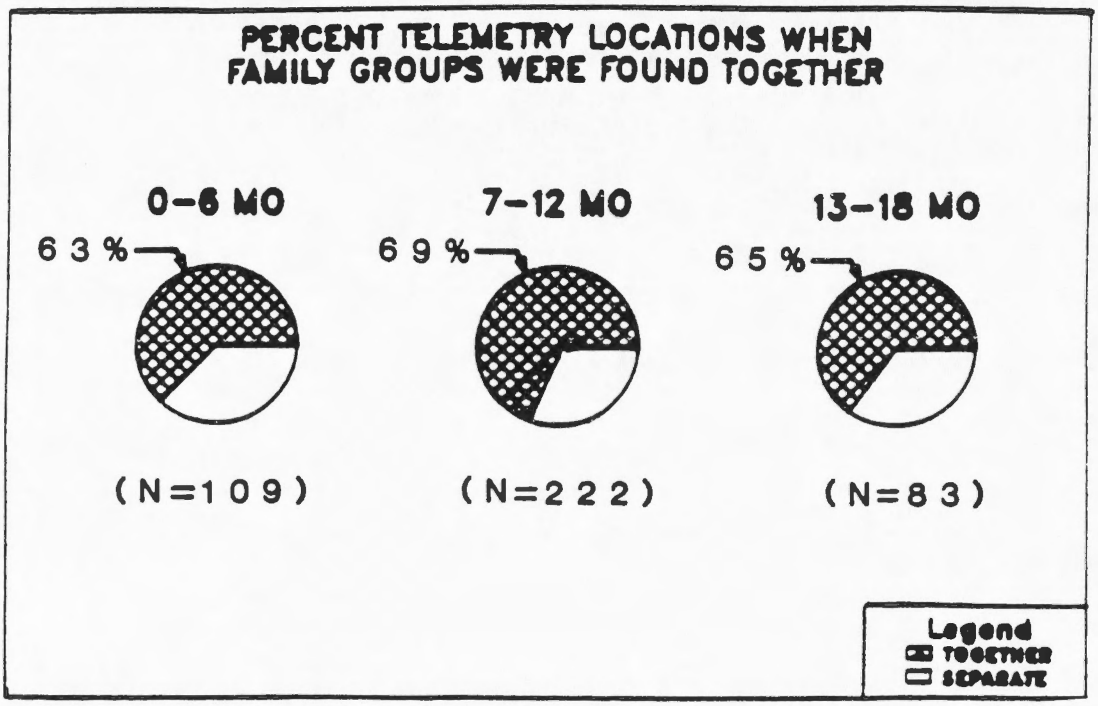

Figure 3. Percent of telemetry locations when females and their collared kittens (three age classes) were found together.

telemetry locations used in this analysis were obtained during daylight hours between mid-morning and early afternoon. As a consequence, they usually represented resting locations when the female is more likely to be with her kittens.

Results of track searches provided a direct measure of the amount of time kittens spent traveling with their mother (Figure 4). Of 75 tracks of Class 1 females, the kittens were present only 14 times (19 percent). Tracks of Class 2 kittens were found with their mother's tracks 12 of 28 times (43 percent). We were unable to obtain adequate data for Class 3 females and their kittens.

Two examples illustrate the difficulty of determining whether a particular female has kittens. Although we obtained telemetry locations and saw the tracks of Female #71 several times a month, we were unaware that she had kittens until they crossed a road with her in fresh snow on December 4, 1983, about 3-3.5 months after their birth. In the second instance, I found Female 260 with three kittens on May 19, 1983. The kittens were about two weeks old at the time and judged too small to carry a radio collar. For about one month, we were able to locate them by closely monitoring their mother's movement patterns. Despite intensive efforts to locate the kittens during June, July and August to put collars on them, we found no sign of them and assumed they had died. In late August, we once again found their tracks at a kill site. Despite several more attempts we were unable to find and catch these kittens until January 5 and 15, when two of the three kittens were collared at about nine months of age. This particular female frequently

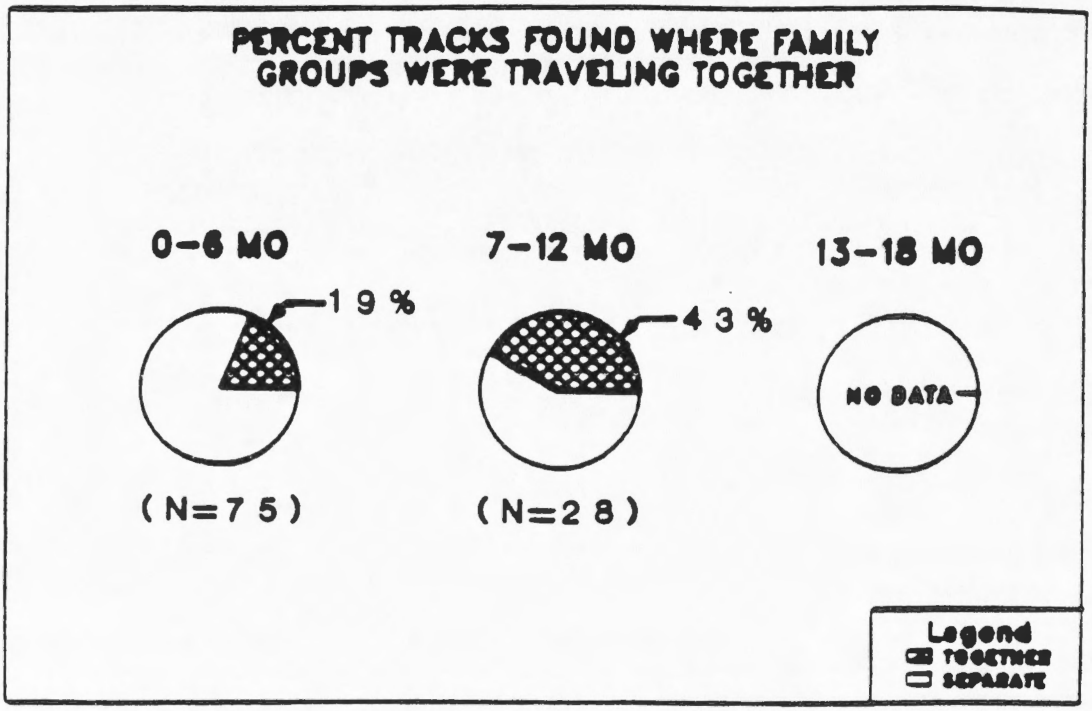

Figure 4. Percent of tracks found when the female was accompanied by her kittens (three age classes).

fed on kills at night or early morning and moved a mile or more away torest during the day, making it difficult to locate the kills where her kittens usually remained.

<u>Vulnerability of Resident Adults and Transients</u>

The mean road-crossing frequency indices of the seven classes of resident adult and transient cougars offered insight into their relative vulnerability because of the predominant hunting method. Crossing frequencies estimated from telemetry data were adjusted for the number of relocations involved and the road densities within individual areas (Figure 5). A summary of the data involved in estimating these road crossing indices for each class is found in Table 11 (Appendix).

The overall F-test values indicated statistically significant differences among the class means (P 0.043) and the LSD pairwise comparisons between classes located those differences (Figure 6). Transient males crossed roads significantly more frequently than all classes of resident females. Class 1 females (those with kittens 0-6 mo. old) crossed significantly less ($P=0.05$) than transient females and had the lowest overall road crossing frequency index of all classes of cougars. There were no significant differences between the mean crossing indices of resident males and resident females.

Road crossing frequency indices of each class, relative to the average for all classes, yield indices of relative vulnerability among classes. Because observed differences in road crossing frequency indices for the resident female classes were insignificant, a weighted

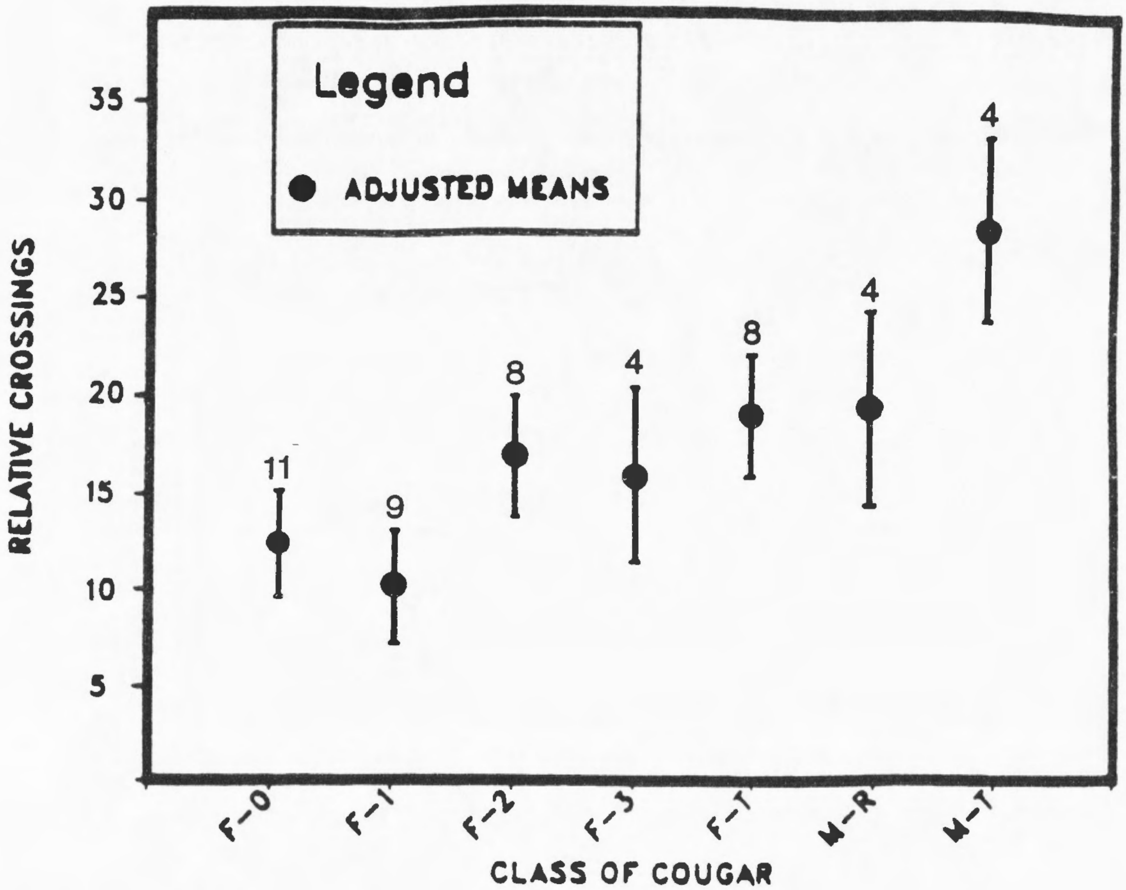

Figure 5. Relative road crossing indices of seven classes of cougars including: Class 0,1,2,3, and transient females; and resident and transient males. Adjusted means, standard deviations, and sample sizes are shown. Adjusted means are the observed means adjusted for the number of telemetry locations involved and the road density within individual areas.

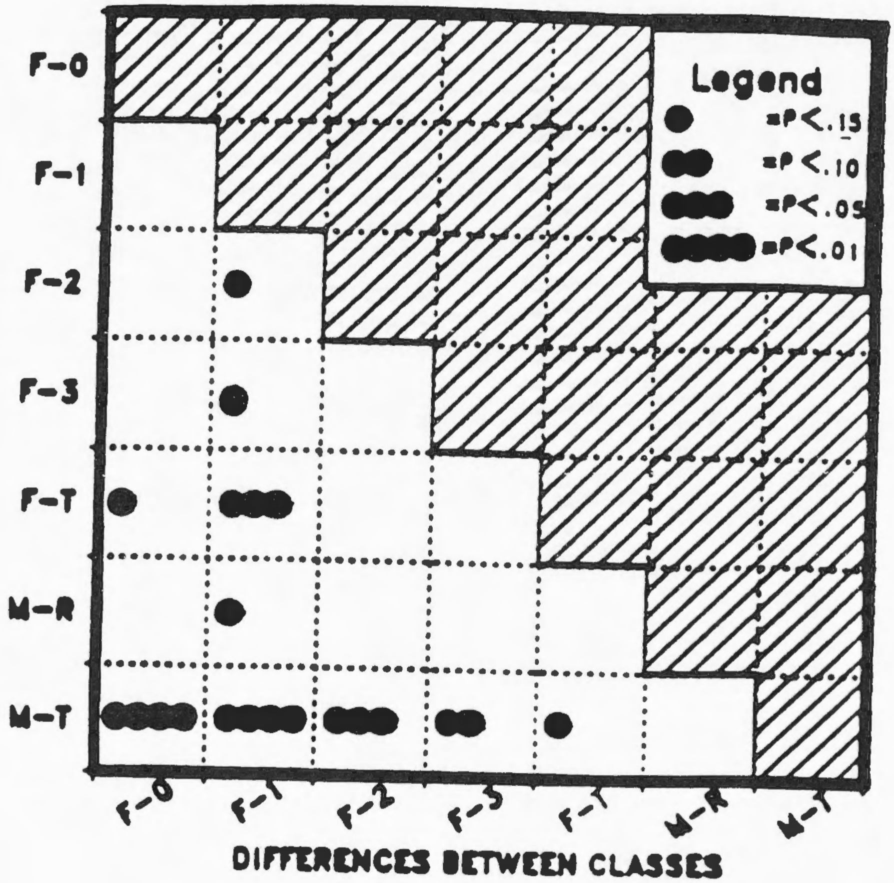

Figure 6. Statistically significant differences between the road crossing frequencies of seven classes of cougars including: Class 0,1,2,3, and transient females; and resident and transient males.

composite index of 0.74 was calculated for all resident females. Transient females had a relative vulnerability index of .93, and resident and transient males had indices of .95 and 1.35, respectively. The average index for all classes equals 1.

The analysis also revealed a high degree of variability in crossing frequency between individual cougars (P=.000).

Road Type and Crossing Frequencies

There was no significant difference in road-crossing frequency between high-use and low-use roads suggesting cougars do not avoid roads which received more vehicle use. Most roads in the area, including the highways, receive little use at night when cougars are most active (Ackerman 1982). Roads which are commonly used 24 hours a day (near mining operations, freeways, etc.) may, however, influence cougar movements.

Road Density Comparisons

One objective of the study was to determine whether cougars showed selectivity for or against well-roaded areas. The hypothesis that cougars chose home areas with road densities equal to the road density of the entire study area was tested for each of the seven classes of cougars. T tests revealed that only resident males had home areas with road densities significantly different ($\alpha = 0.05$) from the study area mean (Figure 7).

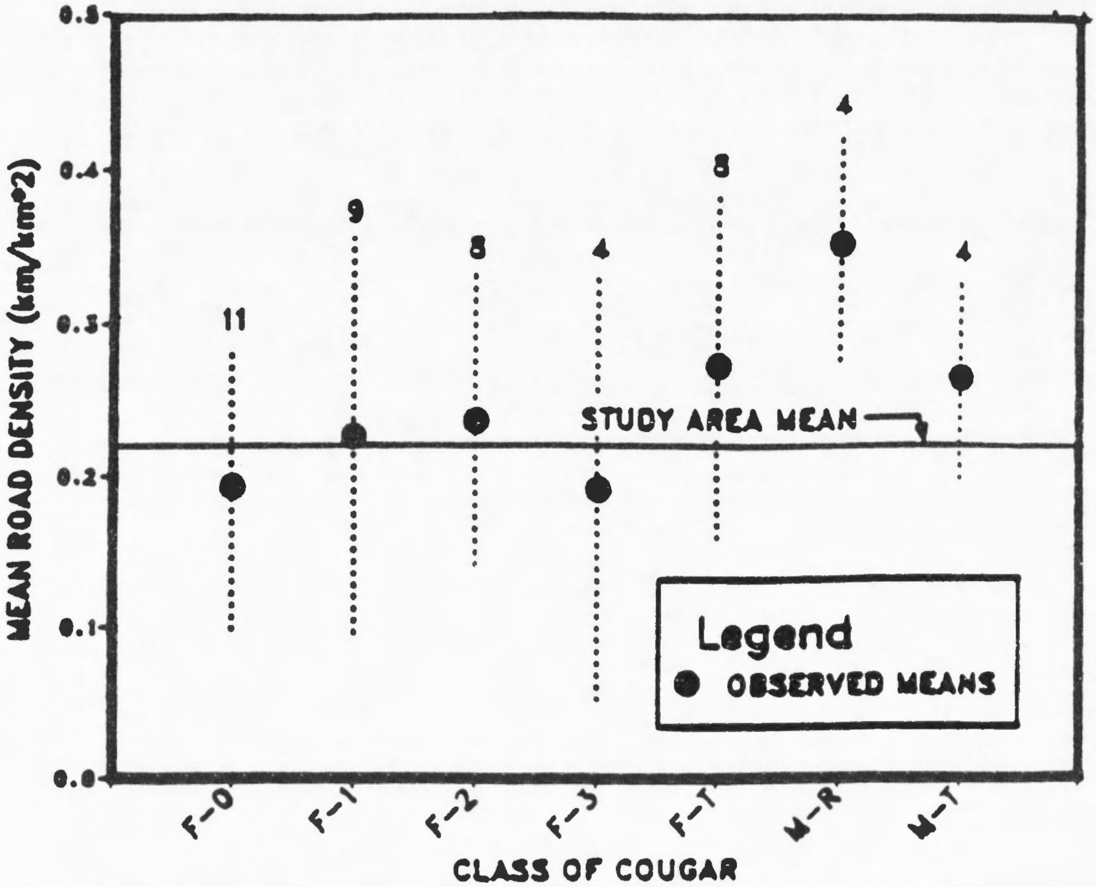

Figure 7. Road density within the home areas of seven classes of cougars compared to the study area mean. Road density is expressed as km road/km^2 area and the mean, standard deviation, and sample size is shown for each class.

A second hypothesis, that the reproductive classes used home areas of equal road density, was also tested. Of the 21 two-way comparisons, only one comparison, that between resident males and Class 0 resident females, indicated a significant difference ($\alpha = 0.07$). However, at $\alpha = 0.07$, random error alone will cause statistical significance in an average of one in fourteen comparisons.

Experimental Hunts

The first hunt was carried out between November 15, 1983, and January 31, 1984. Seven permit holders participated in the hunt. Five of the seven permittees had their own hounds; the other two hunted with friends or a relative who owned hounds. Hunters most often searched for fresh tracks from a four-wheel-drive vehicle but snowshoes, horses and snowmobiles were used occasionally.

Although high winds and drifting snow made hunting difficult for three days, hunting conditions were relatively good throughout the season. Snowfall was light enough to keep all major roads open to hunters, but frequent enough to create good tracking conditions. During the 1983-84 hunt, 9 of 18 cougars known to be present within the 1900 km^2 study area core were of a legally harvestable age (Table 2). This equates to a known density of 0.47 harvestable cougars/100 km^2. Tables 3 and 4 summarize the efforts and success of hunters during this hunt. Hunters spent 36 days afield and reported observing 44 sets of cougar tracks (1.2 tracks/day). They covered 2,435 km while hunting for an average of 1.80 tracks per 100 km traveled. Hunters occasionally reported observations of the same track on consecutive days, and at times, different hunters reported the same set of tracks.

Table 2. Number of cougars known to be present on the Boulder-Escalante Study Area during the 1983-84 and 1984-85 experimental hunts.

			1983-84	1984-85
INDEPENDENT COUGARS	Female	Class 0	1	2
		Class 1	2	1
		Class 2	1	0
		Class 3	0	1
		Transient	2	5
	Male	Resident	0	1
		Transient	3	6
		Unknown	0	2
KITTENS		Class 1	6	2
		Class 2	3	0
		Class 3	0	3
		TOTALS	18	23

Table 3. Effort expended by each hunter on the Boulder-Escalante experimental cougar hunt 1983-84).

Hunter	Hours hunted/day											Hunter days	Hunter hours	Mean hrs/day	km hunted
1	10	4	8	3.5	-	-	-	-	-	-	-	4	25.5	6.4	686
2	9[a]	6[a]	10[ac]	4[a]	-	-	-	-	-	-	-	4	29	7.3	236
3 & 4[a]	6[a]	6[a]	5[a]	10[a]	10[a]	-	-	-	-	-	-	5	39	7.8	179
5	8	6	8	8	6	9	-	-	-	-	-	6	45	7.5	190
6	8	9	5.5	8	10	5	5	9	8	8[c]	10[a]	11	85	7.8	946
7	5	8.5	7	8	8.5	6[a]	6[a]	10[a]	4[a]	8	9[a]	11	83	7.5	759
Totals												36[b]	298.5[b]	7.4	2435[b]

[a]Two permittees hunted together.

[b]Two permittees hunted together and were counted only once.

[c]Cougar treed but not taken.

Table 4. Hunter effort and success rates on the Boulder-Escalante experimental cougar hunt (1983-84).

	Tracks	Tracks started	Cougars treed	Cougars harvested
Total	44[a]	8	2[b]	0
Per day	1.2	.22	.06	0
Per 100 km	1.8	.29	.07	0

[a]Some were counted twice by the same hunter (consecutive days) or by different hunters.

[b]Cougar treed by two different hunters was likely the same animal on both occasions.

Hunters started their hounds on only eight sets of tracks. Of these attempts, four were discontinued when the dogs were unable to follow the trail any longer. Twice, hunters were unable to keep up with the hounds and the hounds were lost. The hunters treed a cougar on two occasions. In both instances, the animal was an unmarked transient male known to be in the area. Because of the locations of the captures and size of the cougar, it is likely that both hunters treed the same animal. Neither chose to kill the cougar.

Ten permits were issued for the second hunt which ran from November 17, 1984 to January 31, 1985. Four of the hunters owned their own hounds, three hunted with a professional hunter who was a close friend or relative, and three hired professional guides. Hunters used four-wheel-drive vehicles, horses, snowmobiles, and three-wheel all-terrain vehicles to search for tracks.

Intermittent snow storms provided excellent hunting conditions between the second week of December and the first week of January.

the first three weeks of the hunt lacked the good tracking snow that most hunter's hounds need, and the snow became so deep and crusted that many roads were closed and tracking conditions were poor during the last two weeks of the hunt.

Eighteen of twenty-three cougars known to be present during the 1984-85 hunt were of legally harvestable age and contributed to a density of 0.95 harvestable cougars/100 km^2 (Table 2). Hunter efforts and success are summarized in Tables 5 and 6. Hunters spent 34 days afield and located 47 sets of tracks for an average of 2.30 tracks per 100 km hunted and covered a total of 2,037 km during the hunt. They started their dogs on 16 of the 47 tracks found. The hunters were unable to keep up with their dogs and lost them on two occasions and the tracks were too old, melted out, or the hounds lost the track on eight other occasions. Five cougars were treed and killed and one kitten was treed and released. The five cougars harvested included: two adult females (one showing signs of recent lactation), one transient female, and two transient males.

Although conditions did not allow us to search for the kittens of the female showing signs of lactation, it is likely her kittens died. The hunter reported no sign of the presence of kittens either before or after the female was killed. The dogs of another hunter were chasing a female when they treed a small kitten. Again, this hunter had no prior knowledge that the female had kittens.

Table 5. Effort expended by each hunter on the Boulder-Escalante experimental cougar hunt (1983-84).

Hunter	Hours hunted/day											Hunter days	Hunter hours	Mean hrs/day	km hunted
1	8[c]	-	-	-	-	-	-	-	-	-	-	1	8	8	31
2	16[c]	-	-	-	-	-	-	-	-	-	-	1	16	16	73
3	10[c]	-	-	-	-	-	-	-	-	-	-	1	10	10	57
4	12	12[c]	-	-	-	-	-	-	-	-	-	2	24	12	203
5 & 6[a]	8[a]	4[ac]	-	-	-	-	-	-	-	-	-	2	12	6	57
7	13	7	6		-	-	-	-	-	-	-	3	26	8.7	132
8	5	5	6	6	5	6	6	-	-	-	-	7	39	5.6	106
9	3	8	7	7	6	9	8	9	-	-	-	8	57	7.1	1040
10	7	8	9	6	7	4	7	7	5[d]	-	-	9	60	6.7	338
Totals												34[b]	252[b]	8.9	2037

[a]Two permittees hunted together.

[b]Two permittees hunted together and were counted only once.

[c]Cougar taken.

[d]Cougar treed but not taken.

Table 6. Hunter effort and success rates on the Boulder-Escalante experimental cougar hunt (1984-85).

	Tracks	Tracks started	Cougars treed	Cougars harvested
Total	47[a]	16	6	5
Per day	1.38	.47	.18	.15
Per 100 km	2.31	.786	.2947	.24

[a]Some were counted twice by the same hunter (consecutive days) or by different hunters.

In summary of these two experimental hunts with an average known density of .71 legally harvestable cougars/100 km^2, hunters found an average of 1.3 tracks per day and started their hounds on only one out of 3.8 of these tracks. Treeing a cougar required 8.7 days of hunting and driving 559 km in track searches (Table 7).

Research Hunting

During the 1982-83 winter (December-April) we conducted track searches on 20 days and covered 733.4 km of road under good tracking conditions (Table 8). Thirteen sets of tracks were found (females accompanied by kittens were considered one set). Of the four chases initiated: two 3-month-old litter mates (F712 and M713) were captured and collared; F220, a Class 0 female suffering from a recent trap wound where two toes were amputated, was captured for rehabilitation; and a chase of an unknown cougar was halted after its tracks were covered by drifting snow (Table 8).

Table 7. Summary of success per unit effort, given a known cougar density, for two experimental hunts on the Boulder-Escalante Cougar Study.

	Known density of harvestable cougars	Number of hunters	Tracks found/ hunter days	Tracks found/ Tracks started	Hunter Days/ Cougars Treed	km Hunted/ Cougars Treed	Cougars Harvested
1983-84	.47/100 km^2	7 (2 Guided)	44/36 = 1.2	44/8 = 5.5	36/2 = 18	2435/2 = 1218	0
1984-85	.95/100 km^2	10 (6 Guided)	47/34 = 1.4	47/16 = 2.9	34/6 = 5.7	2037/6 = 340	5
Total & Means	.71/100 km^2	8.5	91/70 = 1.3	91/24 = 3.8	70/8 = 8.7	4472/8 = 559	2.5

Table 8. Results of track searches by study personnel under good snow conditions for three winters on the Boulder-Escalante Study Area.

		Tracks[a]	Tracks started	Cougars treed	Number of tracks by class[a]	Results
	Total	13	1.5	56.4	1 Class 0 Female	Recaptured F220-Fresh Trap Wound
1982-83	Per day	.65	.15	.15	2 Class 1 Female	Captured F712, M713 (F11s Uncollared Kittens)
(Dec-Apr)	Per 100 km	1.77	41	41		
					1 Class 2 Female	No Chase Initiated
					3 Transient Female	No Chase Initiated
					5 Female Status Unknown[b]	No Chase Initiated
					1 Sex and Age Unknown	Chase Aborted-Track Covered by Snow
1983-84	Total	2	1	1	1 Transient Female	Captured F370
(Nov-Dec)	Per day	.40	.20	.20	1 Transient Male	No Chase Initiated
	Per 100 km	1.45	.73	.73		
1984-85	Total	28	4	2	2 Class 0 Female	(Nov-Feb) No Chase Initiated
(Nov-Feb)	Per day	.82	.12	.06	6 Class 1 Female	Dogs Killed Kitten in Capture Attempt
	Per 100 km	3.28	.47	.23	2 Class 2 Female	No Chase Initiated
					4 Transient Female	Recaptured F265
					2 Female Status Unknown[c]	No Chase Initiated
					6 Transient Male	Two Unsuccessful Chases
					3 Sex and Age Unknown	No Chase Initiated

[a]Each track counted only on the first day observed.
[b]All five sets thought to be made by the same uncollected female.
[c]Both sets thought to be made by the same uncollared female.

Track searches were conducted during five days in November and December of 1983. Of 137 km of roads searched, two sets of tracks were found. One chase was initiated which resulted in the capture of F370, a transient female.

Track searches on 854.4 km of road during 34 days between November 1984 and February 1985, revealed 28 track sets. One 2- to 3-month-old kitten was killed on the ground by the hounds during a capture attempt. A radio-collared transient female (F265), was recaptured when the dogs struck her track on the road while returning to the track after chasing the kitten mentioned earlier. A transient male was chased twice but not captured.

Results of 40 capture attempts, by study personnel, between October 1982 and February 1985 are presented in Table 12 (Appendix).

DISCUSSION

Vulnerability by Class

Class 1 kittens appeared to be the most vulnerable segment of the cougar population. In most states, these spotted kittens and females accompanied by such kittens are protected, and while these laws certainly offer some protection, they undoubtedly do not eliminate hunting-related mortality of kittens. Class 1 kittens are almost totally dependent on their mother for food and protection. Their vulnerability to hunting at this time is largely a function of the temporal and spatial relationships between them and their mother. Although females were found with their Class 1 kittens 63 percent of the time during the day, when the females are traveling, usually in the evening, night, and morning hours (Ackerman 1982), they are only accompanied by their kittens 20 percent of the time. Thus, even if hunters wished to comply with the laws and refrain from killing spotted kittens or females known to have kittens, 80 percent of the time they would have no way of knowing the female has small kittens.

The minimum age at which kittens may be orphaned and still survive is probably 6 to 8 months (Shaw 1980, Hemker 1982). Those cubs orphaned between 6 months and the normal dispersal age of 12 to 18 months probably have a lower chance of survival than those accompanied by their mother. Logan (1983) reported that at least one and probably both of a pair of kittens abandoned at 11 months died of malnutrition.

Being orphaned is probably the main source of mortality of Class 1 kittens in heavily hunted cougar populations. Most researchers agree that the average birth interval in wild cougars is about 24 months. And, although cougars breed at all times of year, we observed a strong fall birth peak in Utah, with 16 of 17 litters born in the fall. Thus, approximately 50 percent of the resident females in these populations should have Class 1 cubs during the winter hunting season. Since 80 percent of the time that hunters encounter signs of a Class 1 female she will not be accompanied by her kittens, it is possible that as much as 40 percent of the adult females killed each winter had Class 1 kittens. Thirty-seven adult females were reported in the harvest in Utah during 1983-84 (Utah Division of Wildlife Resources 1985). Thus, with an average litter size of 2.8 (Hemker 1982), I estimate that killing these females may have resulted in the death of up to 40 Class 1 kittens.

Decreased survival rates of older kittens abandoned when their mother was killed, probably accounted for additional indirect hunting mortality. These figures may be somewhat high because some hunters may have avoided hunting areas where family groups were known to be present and some females may have already lost their kittens before the season began. Illegal actions of other hunters (killing a female they knew had kittens) would tend to inflate this figure.

A second, but largely unquantifiable source of hunting-related kitten mortality, is that of kittens being caught on the ground and killed by dogs. This potential is greatest when kittens are less than three months old, and the female must return frequently to nurse the kittens. Virtually all tracks of females with kittens less than three months old will eventually lead dogs to the kittens. Since kittens this young are generally unable to climb trees or run fast enough to escape the dogs, they may be caught on the ground and killed by the dogs before the hunter is aware of their presence. While houndsmen as a group are reluctant to admit that this happens, individuals acknowledge that it occurs.

Kittens were reported killed by dogs during five different research studies. One each was reported killed in Arizona (Shaw 1977), Colorado (Currier et al. 1977) and Wyoming (Logan 1983); a litter was killed in Idaho (Hornocker 1969); and 2 were killed in Utah (this study) for an average of 1 kitten killed for each 60 cougars captured. Because researchers are more likely to be aware of the presence of kittens and presumably more conservative and cautious than sport hunters, the ratio 1:60 is probably a conservative estimate for sporthunting.

During the 1983-84 hunting season in Utah, hunters reported treeing 579 cougars. Using the conservative ratio of 1:60, a minimum of ten kittens may have been killed by dogs during the season. This estimate does not include the 126 cougars treed during the 1983-84 pursuit season when cougars could be chased and treed but not killed. Presumably, kittens would be as vulnerable to mauling during pursuit seasons as during the sporthunting season.

Two instances during the 1984-85 experimental hunt illustrate the potential for both orphaning and mauling of kittens. One permittee killed a female with the hair worn from around her distended nipples indicating that she had young kittens. In the second example, two other hunters treed a Class 1 kitten while chasing what they thought to be a single adult female. The hounds were almost within reach of the kitten when the hunters arrived.

By 12 months of age, the spots on kittens are no longer obvious and male kittens may be as large or larger than their mother. At this age, kittens are also more likely to be found alone or when chased as a family group to split up, and are therefore more likely to be treed singly and killed by hunters than are younger kittens. Forty-eight subadult males and 43 subadult females were reported in the Utah sport harvest during the 1983-84 season (Utah Division of Wildlife Resources 1985). Because cougars whose canine teeth are not fully erupted (the cementum junction still unexposed below the gumline) are classed as subadults, some of the 91 subadults reported killed were probably Class 3 kittens.

Hemker (1982) reported that Class 1 females moved significantly less ($P < 0.10$) than all other classes at 2-and 7-day intervals. Since the telemetry locations used in my estimates were obtained at 7-day intervals, one would expect these lower road-crossing rates. However, Class 1 females are refuging predators, in that they return daily to their kittens after hunting. If they cross a road while hunting, they usually recross the same road to return. If the hunt was successful, they again must cross that road when they take the kittens to the new kill. I feel that the road crossing frequencies were probably under-estimated more for Class 1 females than for females with older kittens.

Females with older kittens do not need to cross the same road as often as Class 1 females. Class 2 kittens require less attention and the female is found with them less frequently than with younger kittens; they are most often found together when she is moving them from an old kill to a fresh one. As they grow older, they make short excursions with their mother, but gradually accompany her more frequently until, as Class 3 kittens, they spend a large percentage of time with her. These larger kittens require more food and the female must kill more often to support them. The greater mobility of older kittens enables the female to use a larger area, thus increasing her potential prey base, but at the same time, increasing the frequency with which she crosses roads. Although, the probability of recrossing the same road frequently is higher for Class 1 females than other resident females because of the smaller area used by them, their probability of crossing a number of different roads is lower than for females with older kittens and single cougars.

The refuging nature of Class 1 females may make them more vulnerable to hunting, however, since hunters are likely to concentrate hunting efforts where sign is most concentrated. When hunters find fresh tracks of a Class 1 female, she is more likely to still be in the area than are cougars of other classes and presumably would be more likely to be captured if the dogs are released. Seidensticker et al. (1973) also believed Class 1 females to be more vulnerable to hunting than Class 2 or Class 3 females. Van Dyke et al. (1983) concluded that Class 1 females were possibly the easiest class to detect in road searches.

Seventy-two percent of the tracks of adult cougars found by Murphy (1983) were made by females that comprised 62 percent of the population; 27 percent were made by males which constituted 38 percent of the population.

Both resident and transient males were estimated to cross roads more frequently than any of the female classes, possibly as a result of differing movement patterns and/or size of area used. Resident males are usually less abundant, use larger areas and cover them more quickly than do resident females. Also, transient males often move great distances in short time periods, crossing many roads in the process. This combination of factors may contribute to higher road-crossing frequencies for males, but may actually reduce the probability of hunters finding a fresh track.

Transient females also tend to travel more and have higher road-crossing frequencies than resident females. This makes them more detectable but also reduces the probability of a hunter searching the right road at the right time to get a fresh track.

The harvest composition during the second experimental hunt (two transient males, one transient female, one Class 1 female and another resident female) is interesting in that it closely approximates predictions I would have made based on my estimates of differential vulnerability.

Home-area size and road densities are important area-specific considerations in determining differential vulnerability between classes. In modeling the vulnerability of bears to hunting, Bunnell and Tait (1980) concluded that the probability of encountering randomly distributed bears by following a specific route, such as a road, river or trail, is roughly proportional to the square root of the bear's home range. It would seem that the larger home-area size alone would not increase an animal's vulnerability, but may increase the probability that the area is intersected by roads and that a hunter will enter its range. The probability of actually detecting a cougar's presence is probably influenced more by the density of roads within its home area than area size alone. For example, at low road densities it is conceivable that a female's range could be small enough to occupy an area between roads and be undetectable, while the larger home areas of males would encompass more roads and they would eventually be detected by hunters. Sitton and Weaver (1977) attributed the skewed sex ratio of cougars they captured (11 males to 6 females) to the smaller range and, thus, less road contact of the females. They felt that males made the most contact with ridgetop roads since they had the largest home areas.

Area-specific Considerations

The vulnerability of an individual or a population of cougars depends much on the site-specific characteristics of the area they inhabit. The remoteness, accessibility or road density, availability of escape terrain, the climate and even vegetation type will all affect the overall vulnerability of cougars to hound hunting.

The distance an area is from human population centers and the accessibility or density of roads through the area influence the probability that the area will be hunted and of finding a cougar's track. Road density, as previously discussed, will affect the relative vulnerability of different sex and age classes. Van Dyke et al. (1983) found that cougars on the Spider-Cross U study area in Arizona selected home areas with lower road density than the study area average. They did not find a similar pattern on the Kaibab study area and attributed this to a lower overall road density on the Spider-Cross U area which allowed some choice, whereas, roads were too dense on the Kaibab to avoid.

The ruggedness, availability of escape terrain (ledges, cliffs, deep ravines, etc.) and climate (which affects tracking conditions) probably all interact to determine the appeal of an area to hunters. Hunters will hunt the easiest areas first, but as hunting pressure increases, the more difficult areas will receive more pressure. While these variables may influence the probability of a hunter finding a track, they will probably have more impact on the ability of the dogs and hunter to catch and tree the cougar once a chase is initiated. Only a small percentage of the dogs in Utah are trained to trail and catch cougars on dry ground. Most hunters rely on fresh snow to make it easier to find a fresh track and enable their dogs to follow the trail.

Results of the experimental hunts illustrate the importance of road access and snow-tracking conditions. Each track located by hunters was found by driving roads after a fresh snow storm, and the eight cougars treed were caught under ideal snow conditions. Although hunting began before there was snow on the ground and continued after the snow became crusted both years, hunters were successful only when there was over one inch of fresh snow on the ground.

Hunter-specific Considerations

Selectivity by hunters may potentially bias the degree to which the harvest reflects the composition of the cougar population. Many sportsmen contend that they kill only mature and generally male cougars, but that guides, presumably because they wish only to fill their clients permit, appear less selective.

During the experimental hunts, the level of experience of the hunters and their dogs appeared to be a critical factor in determining success. During the first year with an estimated harvestable cougar density of 0.47 cougars/100 km^2, only two cougars were treed in 36 hunter-days. However, 60 percent of the hunter-days were accounted for by two hunters who considered themselves beginners. The average level of experience was greater during the second hunt, when the density of harvestable cougars was 0.9 (twice as high as during the first hunt), and the five cougars taken were caught in only seven (21%) of the total hunter-days. Four of these five cougars were treed by guides and their dogs and the fifth was treed by an experienced amateur. The four remaining hunters accounted for the other 79 percent of the total hunter days. Of these hunters: One, a beginning houndsman, accounted for nine days (24% of the total) and caught the only other cougar treed (a kitten discussed earlier); two were amateur houndsmen with moderate experience and accounted for seven and eight days, respectively; and the other hunted with an experienced guide for three days without success. In Murphy's (1983) study area in Montana, four of seven cougars taken were killed by guided hunters comprising only 30 percent of the total hunters.

The greater-than-expected percentage of mature males in the Utah harvest would suggest that some selection is occurring. Differential detectability alone, as indexed by road-crossing frequency, will not explain the difference between expected and observed harvest composition.

MANAGEMENT IMPLICATIONS

Interpreting Harvest Data

Management decisions ideally are based on a knowledge of the sex and age composition of the population as well as estimates of population size and trend. Harvest data are a potential source for some of this information, but managers have hesitated to base management decisions on these records in the past because interpretation of these data is clouded by several variables. Characteristics of the harvest are a function of the composition of the population and the probability of each class being captured, killed, and reported. Assuming that the harvest data are reported correctly, the relationship can be written as follows:

sex and age composition of reported harvest	=	sex and age composition of population	X	differential vulnerability	X	hunter selectivity

With sufficient knowledge about the variables which contribute to the sex and age composition of the harvest, harvest characteristics can be used to make inferences about the standing population. Understanding the differential vulnerability of different cougar classes to hunting is a first step toward interpreting harvest data.

Correcting the harvest for the relative vulnerability of each cougar class and then comparing that figure to estimates of the composition of cougar populations provides insight into the importance of the vulnerability of cougars and hunter selectivity in the harvest.

The formula,

$$\begin{array}{c} \text{estimated} \\ \text{population} \\ \text{composition} \end{array} = \begin{array}{c} \text{reported} \\ \text{harvest} \\ \text{(by class)} \end{array} \times \begin{array}{c} \text{relative} \\ \text{vulnerability} \\ \text{index (by class)} \end{array}$$

was used to compute the figures found in Table 9 for estimates of the standing population prior to Utah's 1983-84 hunt.

The reported harvest for Utah during the 1983-84 season was 37 adult females, 43 subadult females, 83 adult males and 48 subadult males. Although the distinction between adults and subadults in the harvest was based on physical characteristics, the study's residents and transients were classified according to behavioral differences. For purposes of comparison, I assumed that harvested adults were residents and that harvested subadults were transients and older kittens. Class 3 kittens often tree alone and spots are gone or difficult to see. Additionally, at this age, young males may weigh as much as and appear physically larger than their mother. For illustrative purposes, I assumed approximately 50 percent of all Class 3 kittens are not recognized as such and are treated the same as transients by hunters. I also assumed that hunters obeyed the law and did not kill females which were known to be accompanied by kittens. This included 30 percent of all resident females; 10 percent which had Class 1 kittens (50 percent of all females times 20 percent recognized as such); and 20 percent which had Class 3 (rarely Class 2) kittens (40 percent of all females, times 50 percent recognized as such).

The major differences between the reported harvest and the estimated population composition prior to the hunt was an 8 percent increase of the

Table 9. Example of correcting harvest data for differential vulnerability of four classes of cougars to get a better estimate of the pre-hunt composition.

Class	Reported harvest	Transient and class 3 kittens separated[a]	Relative vulnerability index[b]	Corrected relative number	Protected females added[d]	Estimated pre-hunt composition
Females						
Resident	37(18%)	37(18%)	.74[c]	37/.74=50	+15=65	65/253=26%
Transient	43(20%)	24(11%)	.93	24/.93=26	26	26/253=10%
Class 3 Kittens	--	19(9%)	.74	19/.74=26	26	26/253=10%
Males						
Resident	83(39%)	83(95%)	.95	83/.95=87	87	87/253=34%
Transient	48(23%)	26(12%)	1.39	26/1.39=19	19	19/253=8%
Class 3 Kittens	--	22(10%)	.74	22/.74=30	30	30/253=12%
TOTAL	211	211	218	253	253	100%

[a]Based on the average population composition of 4 intensive cougar studies (Table 3 in Hemker 1982 - my calculations). Based on an estimated survival rate of 67% from 3 mo to dispersal age (Hemker et al. 1982) I assumed 40% of the juveniles would be Class 3 Kittens during the winter hunting season and 50% of those would be considered fair game by hunters.

[b]This index was based on the relative road crossing frequencies of four classes of cougars divided by the average of those rates.

[c]For simplification, the four classes of resident females were combined into one class by using the average crossing frequency of Classes 0, 2 and 3. Class 1 females were given the same vulnerability rating for reasons discussed earlier.

[d]Assumed that 50% of the resident females have Class 1 kittens and are recognizable as such 20% of the time (N = 50 X .5 X .2 = 5), and that, 40% have Class 3 (rarely Class 2) kittens that are recognizable as such 50% of time (N = 50 X .4 X .5 = 10).

resident female component and a 5 percent decrease in resident males when differential vulnerability and legal constraints were considered (Table 9). These estimates still contain the bias associated with hunter selectivity.

Comparing the average population composition observed during four cougar studies (my calculations from Table 3 in Hemker 1982) to the population composition estimates corrected only for differential vulnerability (Table 9), indicates that differential vulnerability does not account for all of the difference between the observed and expected harvest composition (Table 10). Assuming that the relative vulnerability estimates are correct and Utah's 1983-84 cougar population was close to the composition observed in the intensive cougar studies, even after being corrected for differential vulnerability, proportions in the harvest would underestimate resident females by 23 percent and overestimate transient females, Class 3 female kittens, resident males, and Class 3 male kittens by 2 percent, 3 percent, 12 percent and 5 percent, respectively (Table 10). There was no difference between the estimated composition and harvest for transient males.

Assuming that, if given the opportunity, hunters would prefer to take resident adult males, typically identifiable because of their size, it is not surprising that adult males occur more commonly in the harvest than expected. That female residents were taken an estimated 23 percent less often than expected is less easily explained. Much of the difference could be explained, however, if in some cases hunters were able to distinguish breeding adult females from other cougars and were willing to release them once treed.

Table 10. Table showing the disparity between a pre-hunt population composition estimate based on harvest data corrected for differential vulnerability and the average population composition observed during four intensive cougar studies.

	Female			Male		
	Resident	Transient	Class 3 kitten	Resident	Transient	Class 3 kitten
[a]Observed Harvestable Population Composition	49%	8%	7%	22%	8%	7%
[b]Expected Harvestable Population Composition	26%	10%	10%	34%	8%	12%
Difference	-23%	+2%	+3%	+12%	0	+5%

[a]Average population composition of four intensive cougar studies. Taken from Table 3 in Hemker 1982 (my calculations).

[b]Population composition estimate based on Utah's 1983-84 harvest data corrected for differential vulnerability between classes (Table 9).

Correct reporting of the sex and age class of each harvested animal is also necessary for correct interpretation of harvest data. Currently each animal killed in Utah must be checked by a conservation officer or wildlife biologist. Since evidence of sex must remain on each cougar until checked, determining sex of harvested animals should be no problem. Each cougar is currently classed as either adult or subadult based on tooth eruption characteristics (Ashman and Greer 1976). Although the character used (descension of the cementum junctions of canine teeth below the gumline) will separate animals by age at roughly 24-36 months, it does not necessarily separate transients from residents. The age at which cougars become resident breeding adults is variable and may depend on how stable the population is (Seidensticker et al. 1973). In hunted populations where turnover is high, transients may fill vacant areas and become breeding adults earlier than in populations with lower turnover. Thus, using the cementum junction as an indication of breeding status may underestimate the true proportion of breeding animals in hunted populations.

Determining the breeding history of females is easier than determining that of males. Females that have nursed kittens may be distinguished by noticeably larger and darker nipples. Thirteen of thirty-seven cougars reported as adult females in the 1983-84 Utah harvest were also reported to have small nipples, and one, reported to be a subadult, had large nipples. Examination of the reproductive tracts for placental scars will identify those females which have given birth (Toweill et al. 1984). Males are much more difficult to separate according to breeding status.

Documentation of the age at which primary spermatocytes first mature in cougars is lacking (Anderson 1983). Also, results of examination of sperm counts in the epididymis have been quite variable (Seager 1977, Moore et al. 1981) and are not adequate. At present, tooth eruption characteristics may have to suffice, but research to find better methods for separating breeding males from non-breeding males would be useful in the future.

Once hunter selectivity is understood and harvest data reported correctly, managers can begin to understand how hunting is affecting a population and adjust management programs accordingly. For example, if the percentage of adult and transient males in the harvest had been relatively high and began to decline rapidly over a two- to three-year period, and the percentage of adult females in the harvest increased, this may signal that the more vulnerable and sought-after males had been overharvested, and that hunting was now reducing the resident population and lowering its reproductive potential. Conversely, lightly hunted areas would have a relatively large percentage of adult males in the harvest and should remain relatively stable through time.

Season Dates and Road Access

Since the two most important factors affecting a cougar population's vulnerability are road access and seasonal tracking conditions, varying season dates and controlling road access are two powerful options to consider when regulation of the level of harvest is desired.

Road closures would be very effective in limiting the harvest in specific areas. These road closures could be used for specific goals, such as discouraging hunting pressure in a drainage known to be occupied by a female and kittens, or to shift hunting pressure toward areas with livestock depredation problems.

Since increased road access increases cougar vulnerability, the potential impact on the cougar population should be considered in the environmental impact statement of any planned projects that include construction of new roads (i.e., for timber sales and fossil fuels or mineral exploration).

Most hunters rely on the excellent tracking conditions provided by snow which makes it easier for the dogs to find and follow tracks (Appendix, Figure 11). The birth peak of kittens in Utah is between September and November (Hemker 1982). Thus, hunting seasons that allow hunting during the winter months will have the highest rate of accidental kitten mortality as well as higher harvest overall.

Pursuit Permits

Permits to pursue (but not take) cougars for the purpose of training hounds are issued in Utah and other states. In theory, these permits allow nonconsumptive use of the resource. In reality, however, one should realize that accidental mauling of kittens, and even adults in some instances, could be significant in high-use areas. Repeatedly chasing the same animal could be injurious or fatal. A transient female (F263) died after failing to "tree" and running excessively while being chased by our study personnel and hounds. This female had ample opportunity to climb trees to avoid dogs but continued running to the point of exhaustion and was barely able to climb high and fast enough to avoid the hounds when she finally did. She had great difficulty breathing when observed in the tree and died during the night. Upon examination the next day, the lungs were grossly inflamed and lung damage was believed to be the cause of death. While pursuit hunts are a viable management option, managers should be aware that they are not necessarily nonconsumptive.

Sub-population Management

The cougar population in Utah is actually a complex of sub-populations located in islands of suitable habitat. These sub-populations are linked by immigration and emigration. Dispersal from the maternal area seems to be obligatory for males (Hornocker 1970, Hemker 1982), but females may establish a home area in or adjacent to their maternal home area (Ashman 1980, Murphy 1983, this study). Interchange between sub-populations is an important means of regulating density and sex ratios in an area and may also serve to minimize in-breeding.

Each mountain range which is suitable habitat has different qualities which render its cougars more or less vulnerable to hunting, thus making the area more or less appealing to hunters. Hunting pressure, if unregulated, will not be distributed equally over all cougar-inhabited areas. Habitat quality, prey densities, and qualities of the cougar population such as density, sex and age composition, and distribution, vary greatly between areas. Therefore, management programs should logically be based at the level of sub-populations with closely related sub-populations managed collectively.

Quota hunts are one sub-population-based management option. This system is based on a harvest objective set for each area. After the harvest objective is reached in an area, it is immediately closed to hunting. Nevada currently uses this system. Their harvest objectives are currently based on a percentage of their estimate of annual recruitment for each area (Ashman et al. 1983).

Another option which may merit consideration is a rest-rotation system; wherein, areas showing signs of excessive removal in harvest data might be rested and allowed to recover for several years while hunting is continued on adjacent areas. In this way, groups of related sub-populations could be managed collectively and one or two areas rested each year while the others are hunted.

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APPENDIX

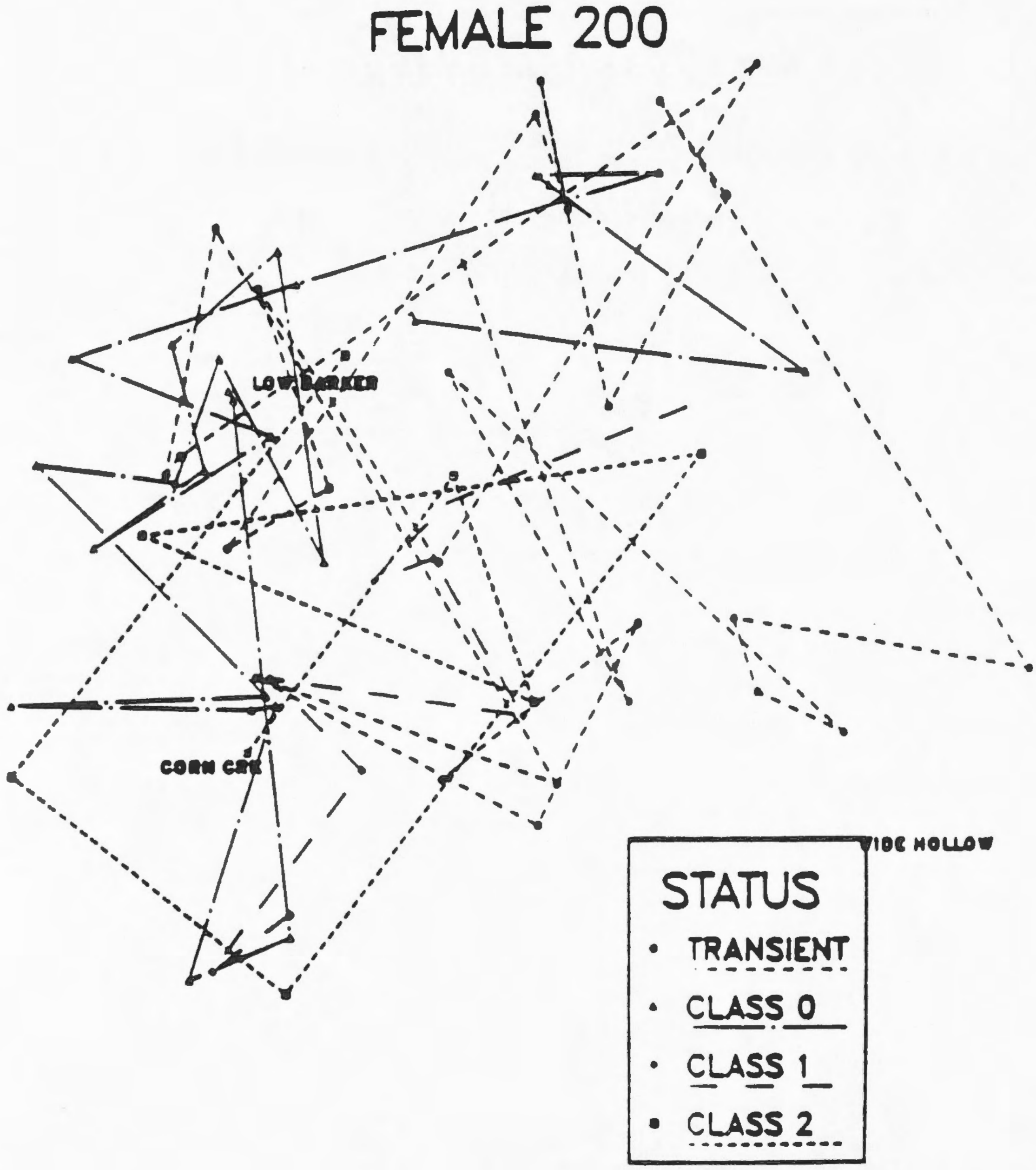

Figure 8. Example of serially connected telemetry locations used in a transparency overlay and placed over a map to count minimum road crossing frequencies.

Daily Hunt Record Form

1. Hunter's name ____________________
2. Date hunted ____________________
3. Time spent hunting (hours) ____________________
4. Method of hunting (truck, snowmobile, horse) ____________________

   ____
5. Miles driven while hunting ____________________
6. Sets of cougar tracks observed ____________________

   Approximate location of tracks ____________________

   ____
7. Number of tracks started ____________________

   Approximate location where track was started ____________________

   ____
8. Cougar(s) treed ____________________

   Approximate location of tree ____________________

   Estimated size and sex of cougar ____________________

   Collar or tags present ____________________
9. Cougar killed ____________________

   Approximate location ____________________
10. Number of dogs used ____________________
11. Additional comments ____________________

    ____

    ____

Figure 9. Daily hunt record form filled out by permittees during experimental cougar hunts on the Boulder-Escalante Study Area.

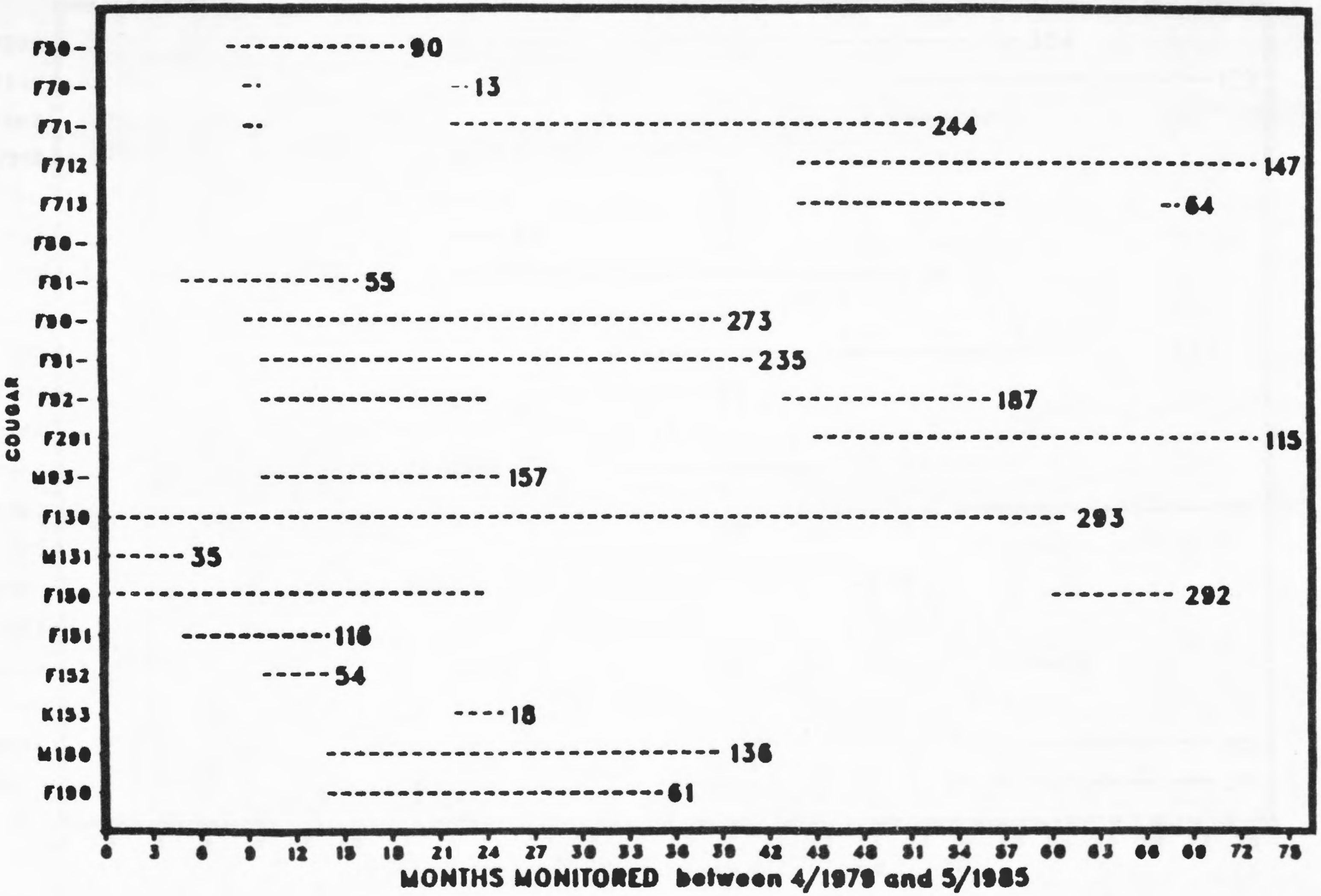

Figure 10. Time intervals during which 40 cougars were tracked using radio-telemetry and number of locations obtained for each.

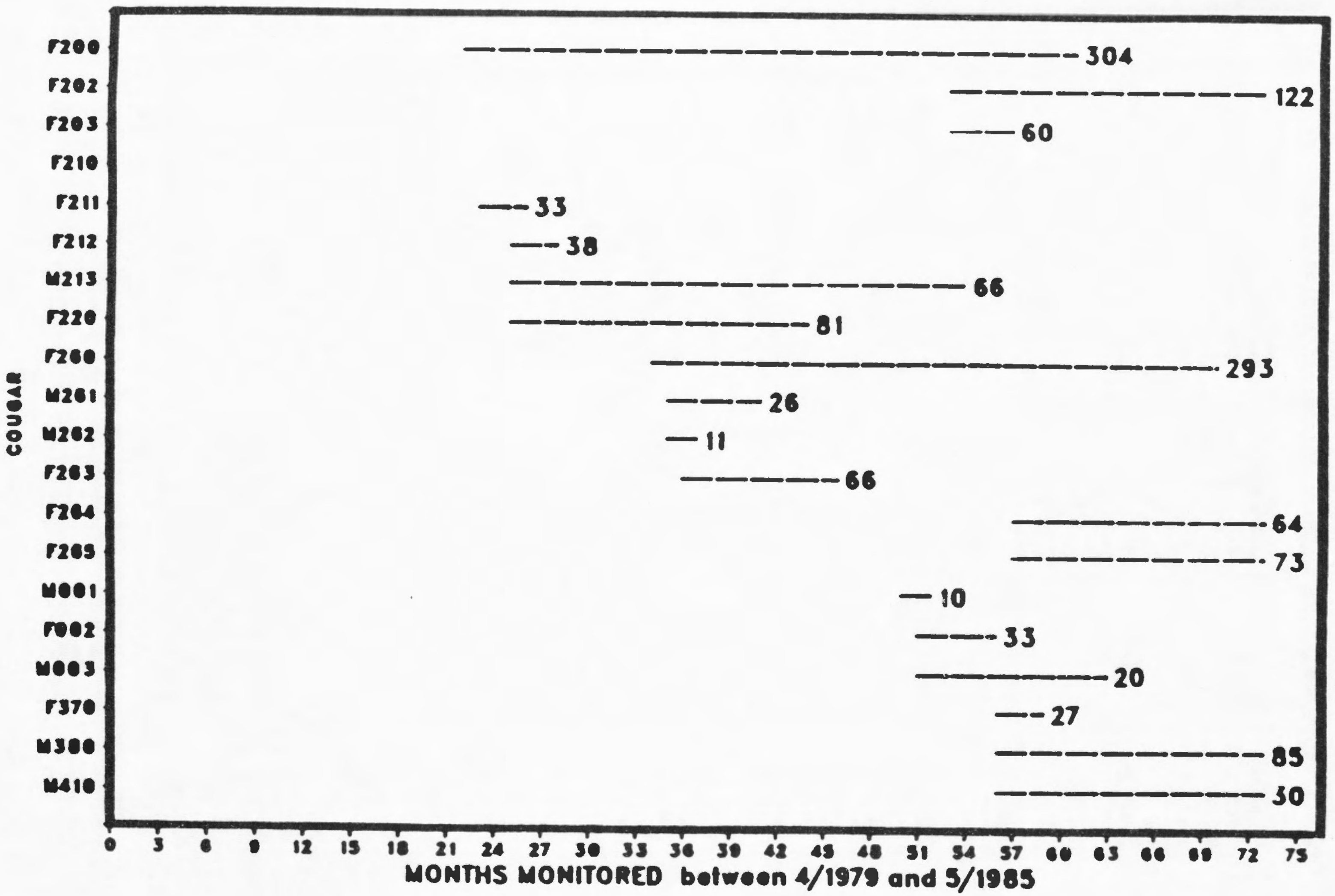

Figure 10. Continued

Table 11. Number of cougars, cougar months, number of relocations, number of road crossings, relocations per month, crossings per month and crossings per relocation for each of seven classes of cougars.

Class	Number of cougars	Cougar[a] months	Number of relocations[b]	Number of[c] crossings	Mean relocations/ month	Mean crossings/ month	Mean crossings/ relocation
Class 0 Females	9	116	252	172	2.17	1.48	.68
Class 1 Females	7	47.25	130	47	2.75	.99	.36
Class 2 Females	7	35.75	122	108	3.4	3.02	1.12
Class 3 Females	4	14.25	38	33	2.67	2.32	.86
Transient Females	8	64.75	156	184	2.4	2.84	1.18
Resident Males	4	57.25	125	163	2.18	2.85	1.3
Transient Males	4	11.5	28	61	2.4	5.30	2.18

[a]Number of months cougars were monitored by telemetry.

[b]Aerial relocations.

[c]Minimal estimates of road crossings between telemetry locations. Estimates are based on the number of times roads were intersected by a straight line between consecutive locations.

Table 12. Results of 40 capture attempts on the Boulder-Escalante Study Area between October 1982 and February 1985.

Date	Class of cougar[a]	Results	Weather conditions	Comments
November 1, 1982	F_1 (F130)	Recapture	Bare Ground	Changed collar
November 26, 1982	F_3 (F92)	Treed	Patchy Snow	Treed and released
December 5, 1982	K_1 (F712)	Capture	18" Snow	Easily captured and collared
December 5, 1982	K_1 (M713)	Capture	18" Snow	Easily captured and collared
December 12, 1982	F_3 (F92)	No Catch	4" Snow	Track 48 hrs. old, rough country
December 15, 1982	F_0 (F220)	Recapture	8" Snow	Short chase, previous trap injury
January 18, 1983	F_3 (F92)	Recapture	Patchy Snow	Changed collar, slick track
January 18, 1983	F_3 (F921)	Recapture	Patchy Snow	Changed collar
January 28, 1983	F? (Uncollared Female)	No Catch	4"-24" Snow	Snow drifted - track blown out
February 18, 1983	F_T (F263)	Recapture	10" Snow	Long chase-Died from lung damage
February 19, 1983	K_3 (F921)	Treed	Patchy Snow	Trying to catch 921s sibling
February 21, 1983	K_3 (F921)	Treed	Patchy Snow	Trying to catch F921s sibling
February 24, 1983	K_3 (F921)	Treed	Patchy Snow	Trying to catch F921s sibling
February 25, 1983	F_3, K_3 (F92) (F921)	Treed	4" and Snowing	Track snowed out
June 22, 1983	F_2, K_2 (F71) (F712) (M713)	No Catch	Bare Ground	Dogs out of shape
June 24, 1983	K_2, (F712)	Trees	Bare Ground	Treed F712 and released
June 24, 1983	F_2, (F71)	Recapture	Bare Ground	Recaptured F71 and changed collar
June 28, 1983	F_2, K_2 (F71) (F713)	No Catch	Bare Ground	Hot, Dogs overheated and gave out

Table 12. Continued

Date	Class of cougar[a]	Results	Weather conditions	Comments
July 6, 1983	F_0 (F200)	No Catch	Bare Ground	Hot, Circling track, Dogs gave out
August 17, 1983	F_1 (F260)	Treed	Bare Ground	Treed F260, Trying to catch kittens
August 26, 1983	F_1 (F260)	No Catch	Bare Ground	Hot, Dogs overheated
September 1, 1983	F_1 (F260)	No Catch	Bare Ground	Hot, Dogs overheated
September 21, 1983	F_3 (F130)	No Catch	Bare Ground	Too Many circling tracks
September 22, 1983	F_T (F712)	Recapture	Bare Ground	Cool, Changed collar
September 22, 1983	F_T (F002)	Recapture	Bare Ground	Cool, Changed collar
September 27, 1983	M_T (M713)	Recapture	Bare Ground	Cool, Foggy, Replaced collar
October 26, 1983	F_1 (F921) K_1	No Catch	Bare Ground	Tried to Catch F921s kittens, Pulled dogs off F921s track
November 16, 1983	F_1 (F921) K_1	No Catch	2" Snow	Tried to catch F921s Kittens, Dogs confused in circling tracks
November 20, 1983	F_1 (F921) K_1	Treed	Skiff of Snow	Treed F921 in attempt to catch Kittens
December 11, 1983	F_1 (F921) K_1	Treed	8" Snow	Treed F921 in attemp to catch Kittens
December 21, 1983	F_T (F370)	Capture	12" Snow	Long Chase, Collared F370
March 21, 1984	F_2 (F202)	Recapture	Bare Ground	Loosened collar
September 20, 1984	M_R (M380)	Treed	Bare Ground	Short chase, Treed and released
September 21, 1984	F_T (F265)	Recapture	Bare Ground	Long chase, Changed collar

Table 12. Continued

Date	Class of cougar[a]	Results	Weather conditions	Comments
January 22, 1985	F_T (F260)	Recapture	12" Snow	Short chase, Changed collar
January 26, 1985	M_T (M510)	No Catch	14" Snow	Long chase, Dogs out of shape
February 7, 1985	M_T (M510)	No Catch	12" Snow	Track at least 48 hrs. old
February 10, 1985	K_1 (K501, 502)	Capture[b]	12" Snow	Caught one of two orphaned Kittens
February 10, 1985	F_1 (F265)	Treed	12" Snow	Treed F265 after short chase

[a]F_0= Resident Female, no kittens; F_1-F_3= Resident Female with Class 1-3 age kittens, respectively; F_T= Transient Female, K_1-K_3= Kittens of age class 1-3, respectively; M_R= Resident Male; M_T= Transient Male.

[b]Orphaned K501 was caught on the ground and killed by the dogs during an attempt to capture and save her and K502 from starvation.

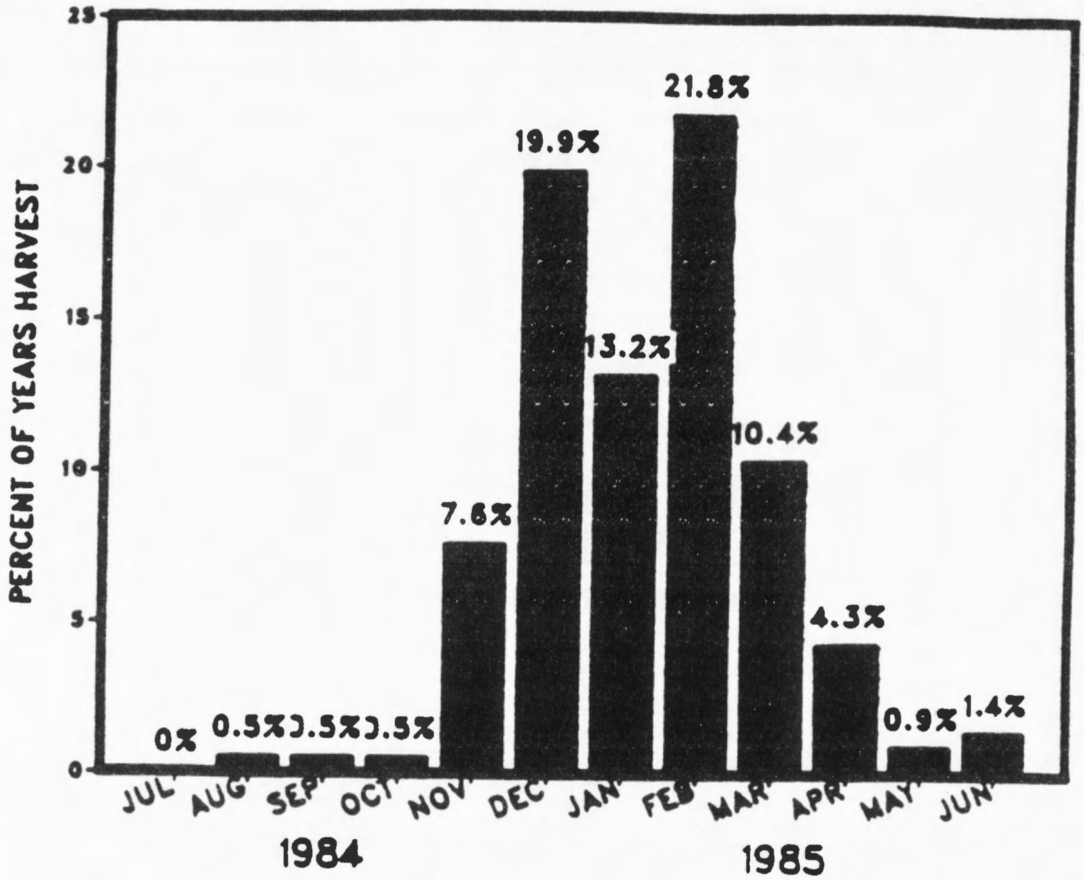

Figure 11. Percent cougar harvest by month in Utah during the 1984-85 season. Importance of snow to hunter success is suggested.