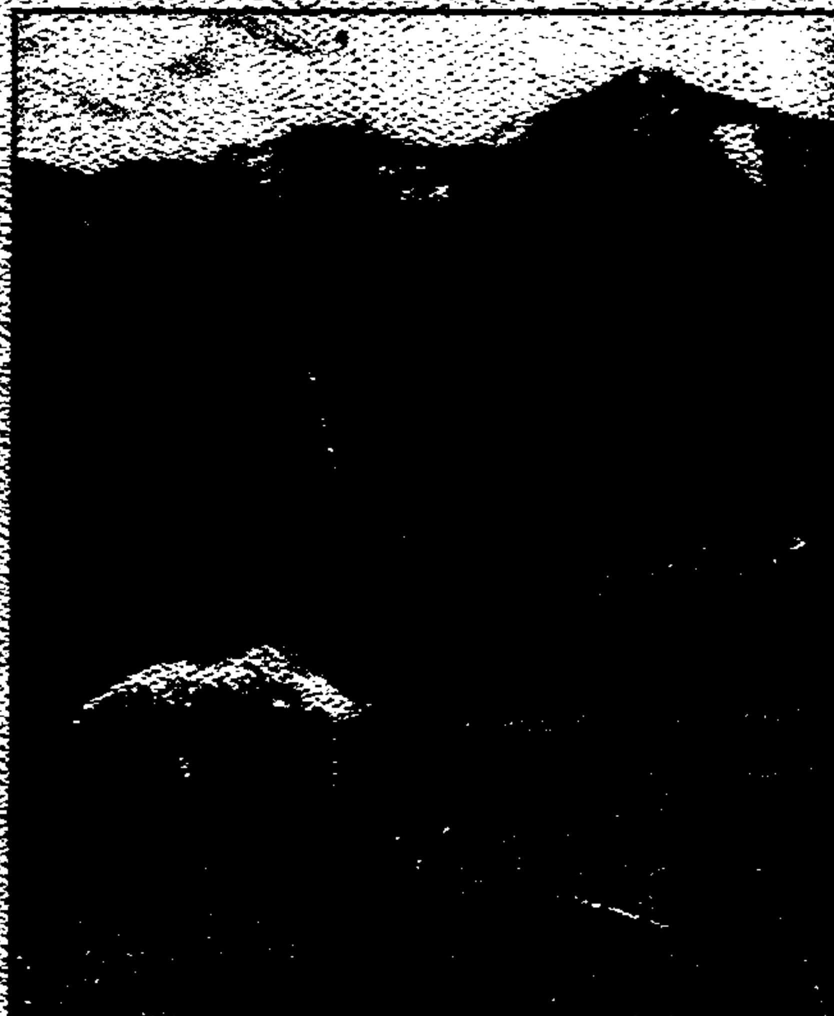
SOUTH FORK FLATHEAD RIVER GRIZZLY BEAR PROJECT



COOPERATORS:

Montana Department of Fish, Wildlife, & Parks
USDA Forest Service, Intermountain Research Station
USDI Fish and Wildlife Service
National Fish and Wildlife Foundation

April 1993

SOUTH FORK FLATHEAD RIVER GRIZZLY BEAR PROJECT: PROGRESS REPORT FOR 1992

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This research has been funded by the Montana Department of Fish, Wildlife and Parks, USDA Forest Service, USDI Fish and Wildlife Service, and National Fish and Wildlife Foundation

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INTRODUCTION

The Montana Department of Fish, Wildlife and Parks initiated a long-term research project on grizzly bear population ecology and habitat selection in 1988. In coordination with the USDA Forest Service and the USDI Fish and Wildlife Service, the South Fork Grizzly Project has recently completed the fifth field season of an anticipated 10-year program.

Preliminary research findings have been documented annually. Furthermore, we have prepared and submitted several documents for publication that are intended to form the technical foundation for further population and habitat studies (Appendix A). We believe that this early "check-and-balance" procedure in refereed journals is necessary for long-term research continuity.

To date, most of our preliminary analyses have been tailored to the habitat studies. However, for this annual report we believed it was timely to provide managers with preliminary information on population status in the study area.

GOALS AND OBJECTIVES

The goal of the South Fork Grizzly Study is to identify factors limiting grizzly bears and develop reliable and practical methods to determine status and trend and predict response to habitat change by obtaining quantitative information from the South Fork Flathead River grizzly bear population.

Research objectives for the population and habitat studies are closely intertwined. To investigate limiting factors suggests reproductive, survival, and movement parameters be coupled with measures of habitat condition. Furthermore, to assess the population response to habitat change requires a relatively large sample of bears with each sample living under incremental differences of habitat alteration.

Specific objectives are as follows:

Population Objectives

1. develop annual estimates of population size/density with measures of statistical precision which will result in a nine-year measure of population trend

2. determine population parameters including
    a. age and sex ratios
    b. litter sizes
    c. age of first reproduction
    d. age distribution
    e. cause-specific mortality rates, and

f. age/gender specific mortality rates

3. test several long-term trend monitoring techniques

4. compare population parameters and survival rates among several land management designations including wilderness, multiple use, private, and corporate

5. correlate survival rates to road and trail densities

6. investigate if demographic thresholds exist and if they affect subadult dispersal

7. investigate the effects of female population density on litter size

8. determine if a relationship exists between habitat quality parameters and reproductive rates of individual females, and

9. determine if habitat features can be used to predict bear density.

Habitat Objectives

1. collect grizzly bear telemetric locations to increase sample sizes of all age/gender classes to accurately assess habitat selection and disturbance parameters

2. quantify and compare grizzly bear habitat selection parameters in multiple use habitats and designated wilderness/roadless lands

3. quantify habitat quality values of habitats preferred by grizzly bears which will result in a hierarchial habitat classification

4. develop satellite Thematic Mapper (TM) habitat maps for the South Fork Study Area

5. develop the habitat parameters and spacial limitations for extrapolating TM habitat maps to other portions of the Northern Continental Divide Ecosystem

6. quantify habitat quality values occurring in several classes of road density zones

7. quantify grizzly bear spacial and temporal use of open and closed roads for travel routes and foraging areas

8. document the short-term (3-4 year) response of grizzly bears to road closures, and

9. document nocturnal habitat selection/activity patterns and bear response to roads from selected areas.

STUDY AREA

The study area, in the Swan Mountain Range in western Montana, extended from Highway 2 on the north to the Bob Marshall Wilderness boundary on the south (Fig. 1). This 563-mi^2 area is administered under a multiple-use management strategy.

The study area is characterized by heavily forested, rugged mountain topography; elevations vary from 2997 ft.-8974 ft. Over 50% of the area is closed-canopy coniferous forest with the remainder broadly classified as rock lands, avalanche chutes, shrub lands, and timber harvest units.

Depending on study objective, we delineated two subdivisions within the study area (Fig. 1). For some habitat selection analyses, we have used an area termed the "Core Area" (268 mi^2). For several population analyses, we used a 365 mi^2 "Buffered Core Area." This was constructed by placing a 0.6 mi buffer around the core area which represented the average daily movement distance of radioed bears.

METHODS

Population Studies

<u>Capture</u>

Grizzly bears were generally captured during May and June of 1988-1992. Several short-term snaring sessions were conducted at other times to recapture bears that lost radio collars.

Capture sessions were designed to mark as many bears as possible within and surrounding the Core Area by modifying snaring methods and placement (White et al. 1982). At least two Aldrich foot snares were placed at each site and checked daily. About 50 lb. of bait was maintained at all sites. We used different combinations of wooden cubbies (Jonkel and Cowan 1971) and trail sets each year. Each bear was marked with a Nasco button tag and a 16.5 cm x 5 cm Armortite ear streamer with a unique symbol in each ear. Ear streamers were color coded for gender. A premolar tooth was extracted for age determination (Stoneberg and Jonkel 1966), and individuals $\geq$5 years old were classified as adults. Grizzly bears $\geq$2 years old were fitted with radio collars with the exception of five yearlings.

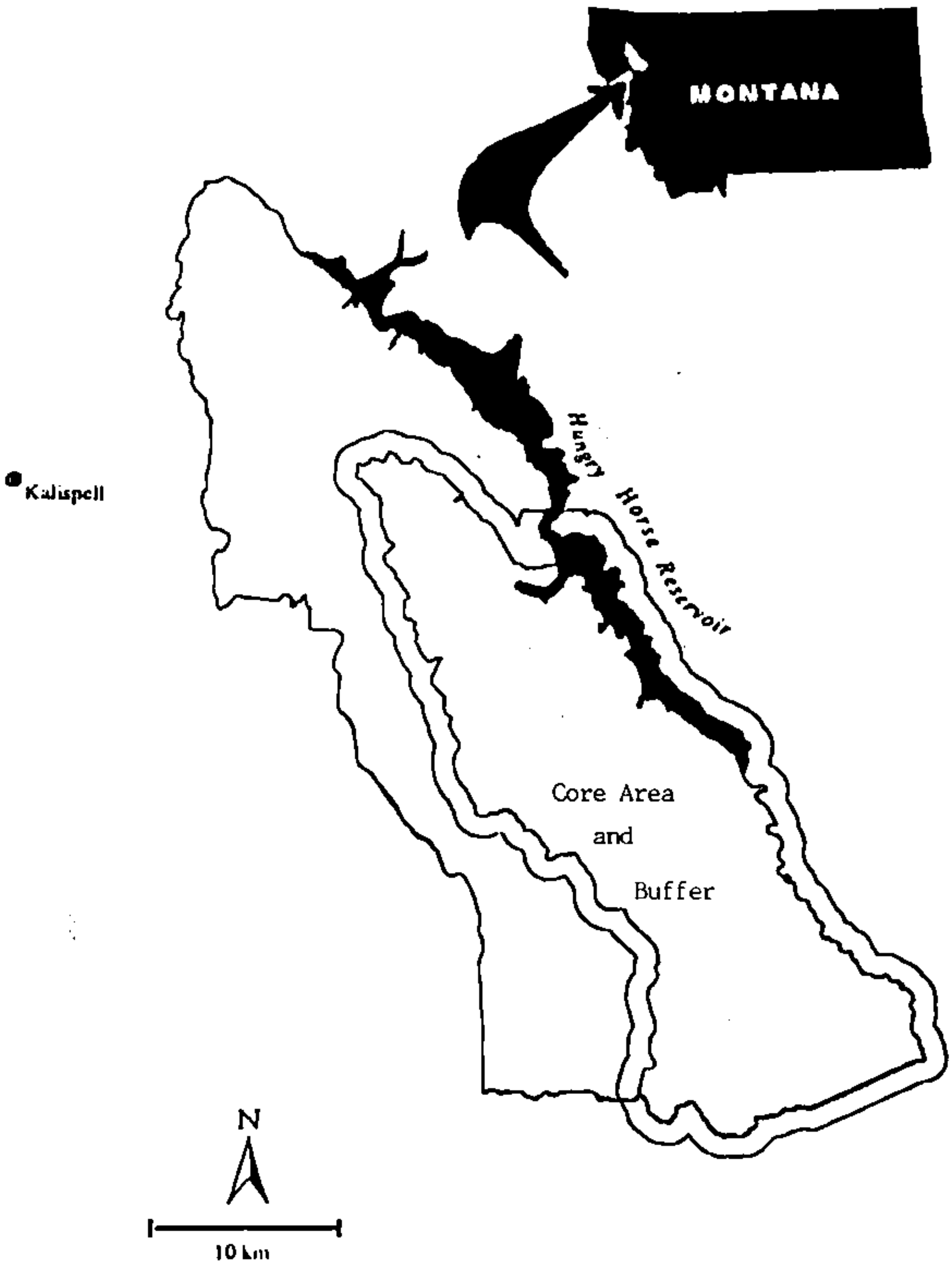


Figure 1. Location of the study area showing the core area and the buffered core area, Swan Mountains, Montana.

Telemetry

Radio-instrumented grizzly bears were monitored weekly from fixed-wing aircraft (Cessna 180 and 182) during 1988 and 1989.

During 1990-1992, bears were located twice a week from fixed-wing aircraft. A color Polaroid photograph was taken of each aerial location. After the photograph developed, the location was marked on the photograph while the airplane was still over the location. Information such as drainage, time, activity, visual, other bears, cover type, special feature, and canopy coverage were recorded on the bottom of the photograph.

After the flight, locations from the photographs were transferred to 1:24,000 black and white orthophotoquads. Slope, elevation, aspect, and Universal Trans Mercator (UTM) coordinates were recorded to tenths of meters for each location. All grizzly bear locations that were within UTM zone 11 were converted to UTM zone 12. The data were entered into a computer database created and managed using Foxbase+ (Fox Software 1988).

Ground locations were obtained as possible using triangulation. Past efforts at ground tracking had revealed significant telemetric error in mountainous terrain. Error polygons were computed and plotted for each ground location, and the UTM coordinates were recorded for the center of each polygon.

Each grizzly bear location was grouped into one of eight classes:

1. Aerial locations that were specific and had the least observer bias (the best locations for habitat analysis).

2. Ground telemetry locations that were specific but locations biased toward observer access (useful for some habitat analysis).

3. Capture or baited camera site locations that were specific but bears were attracted to the site by bait (not used for habitat analysis).

4. Aerial locations that were general (not used for habitat analysis).

5. Ground locations that were general (not used for habitat analysis).

6. Aerial or ground locations that were very general (not used for habitat analysis).

7. Location were a bear was killed (not used for habitat analysis).

8. Camera locations where bears were photographed along roads (no attractants were involved).

For this report only, the class 1 locations were used.

Population Size

Our field and analysis techniques to estimate the population size of grizzly bears are described in Mace et al. (in press). We used leg-hold snares for initial capture and marking, and self-activating cameras for the second (recapture) sample. Using Monte Carlo simulation methods (Minta and Mangel 1989), we developed point estimates and 95% likelihood intervals for closed populations. We conducted three photographic recapture sessions in 1989 and 1990, and one spring session in 1991 and 1992. We selected the spring session each year for our annual population estimate.

We compared and contrasted the Monte Carlo technique with two other techniques: 1) absolute minimum count and 2) count of core bears. The three techniques are derived differently and carry some unique sets of assumptions. Only the Monte Carlo estimator provided a measure of statistical precision, although it is sensitive to photographic detection rates.

The absolute minimum count refers to a simple count of all known bears in the buffered core area during spring photo sampling. The number of marked and unmarked bears are summed to derive a minimum count of bears. Methods used to differentiate unmarked individuals follows those described by Mace et al. (in press). This absolute minimum method applies to the study area only during the 2-3 week period that cameras were deployed.

The "core bear" technique involves determining the percentage of aerial telemetry locations for each radio-collared individual within the 365 mi^2 buffered core area. All marked bears with more than 50% of locations in the buffered core area were summed whether or not they lived the entire year. Additionally, unmarked grizzly bears observed or photographed were included. Unmarked bears were each assumed to be in the buffered core area 50% of the time. A specific set of criteria were developed to standardize the method of including or excluding radioed bears that had either died or lost collars during the year. These criteria were:

1. All bears captured in the spring snaring grid were assumed to be in the study area between 12 March and their individual capture date.

2. Marked grizzly bears without active radio collars were included in each years' estimate if they were known to be alive and present within the buffered core area. For example, M146 was marked but not radioed in 1991. However, he was

observed or photographed numerous times during the year. For 1991 then, we used his percentage of time from the previous year (61%).

Population Density

Population density estimates were developed for the buffered core area for 1989-1992. We converted the population size estimate derived from the absolute minimum method to the number of bears/100 km^2. Two density estimates were calculated using all bears (including cubs and yearlings) and bears independent of their mother.

Population Age/Gender Structure

The annual age/gender structure of the population was determined from the percentage of time data. Marked bears and their attendant young were categorized by age/gender and age class. Unmarked bears observed or photographed were labeled as unknown.

Recruitment of Young

Records were kept of all reproduction in the study area for marked and unmarked females. Telemetry was used to monitor size and survival of marked litters. Visual observations and cameras were used to document unmarked females and attendant young and used "best judgement" to reduce duplicated sightings of unmarked females. We determined the year of birth for all new bears captured as subadults.

Home Range Size Estimates

We selected the adaptive kernel home range estimator as described by Worton (1987) and estimated 95% utilization isopleths. Annual estimates of home range size for each radioed bear were derived and averaged for all years they were monitored. We used the software program CALHOME (USDA Forest Service Pacific Southwest Res. Stn, California Dept. Fish and Game) for analyses using one location per week for each bear.

Habitat Studies

Habitat Mapping Procedures

Relationships between grizzly bears and multiple-use habitat were investigated using several computer-generated maps in a Geographical Information System (GIS) (Eppl7, Minnesota State Planning Office, 1990) software system (Manley and Mace in press). Descriptions of the maps are given in Table 1. We defined our habitat terms as follows:

1. low elevation habitats: all habitats between the elevation of 3281 and 5249 ft.

2. high elevation habitats: all habitats higher than 5249 ft.

3. silviculturally treated habitats: areas with a history of timber management activity, and

4. untreated habitats: areas that have no known history of timber management activity.

Table 1. GIS map layers used to investigate habitat use of grizzly bears, Swan Mountains, Montana.

Map Name	Description
Grizl	1697 telemetry locations from 31 grizzly bears from 1987 to 1992.
Treated	a map of the core area only showing each treated (harvested) stand, removal method, and age of stand. This map has only 2 habitats: treated or untreated. Obtained from USDA Forest Service.
Elevation	the study area was divided into two elevation zones. High elevation included all areas higher than 5249 ft. Low elevations were those areas <5249 ft.
Lowtype	this map was built to evaluate three habitats at low elevation only. The entire core less than 5249 ft. was classified as either treated, close canopy forest, or other. Generally, "other" refers to low elevation natural openings.
Total Road Density	this map was created using methods of Manley and Mace (1992). It displays exact road densities at a 30m resolution. We included all roads in this map, not just open roads. The entire analysis area was classified into four road density classes ranging from 0 mi/mi^2 to 2+ mi/mi^2.
Open Road Density	this map used only permanently open or seasonally open roads within the analysis area. Four open road density classes were used ranging from 0 miles of open road/mi^2 to 2+ miles of open road/mi^2.

We used a GIS modeling routine to more precisely map road densities within the entire analysis area (Manley and Mace 1992). We converted the map of linear roads to a map of road densities (miles of roads/mi^2) (Manley and Mace 1992). The core area was divided into 770,133 cells (pixels), each 30 m x 30 m in size. Each cell was then classified as belonging one of four road density classes varying from 0 miles of road/mi^2

to 2+ miles of roads/mi^2. We built two road density maps. A total road density map was built using all but revegetated roads. We defined a revegetated road as a road where vegetation succession had progressed to the point where motorized vehicle or unincumbered foot travel was deterred. The open road density map used only permanently open and seasonally open roads.

Grizzly bear selection for (or against) specific habitats and road densities was analyzed using the concept of habitat availability and use (Neu et al. 1974). We determined the percentage of each habitat feature (as described in Table 1) present in the core area. This constituted "habitat availability." By overlaying telemetry locations on each map, the proportion of use (P) for each age and sex class was determined. Significant deviations from availability were used to describe the level of grizzly bear selection for each habitat. Habitat selection was classified into three groups based on 95% simultaneous confidence intervals (Byers et al. 1984). These levels of selection were:

- - : habitats used significantly less than available,
- = : habitats used by bears in proportion to the amount of that habitat in the analysis area, and
- + : habitats used in a significantly greater proportion than available in the analysis area.

<u>Use of Self-Activating Cameras to Monitor Road Traffic and Grizzly Bears</u>

Self-activating cameras were use to document bear use of roads and to assess the types and levels of human use of roads. We wanted to document seasonal and temporal use of roads by grizzly bears because there was concern of possible telemetry bias during diurnal aerial flights.

Twenty-three remote cameras were placed on 12 different roads in 1992. Ten sites were on roads with unrestricted public access. Two sites were on seasonally restricted roads, and the remaining 11 sites were on permanently closed roads. We restricted our research vehicle traffic at two of the permanently closed sites. Cameras were placed perpendicular to the roads and oriented toward the north as possible. These cameras were passive as baits and/or attractants were not used.

RESULTS

Population Studies

<u>Grizzly Bear Captures</u>

We captured 39 individual grizzly bears in 85 capture episodes between 1987 and 1992. Twenty-three (59%) individuals were female, and 16 (41%) were male.

Population Size and Density

The number of independent grizzly bears in the buffered core area was calculated using three techniques: absolute minimum, core bears, and Monte Carlo simulation.

Population size estimates were very similar for the three techniques (Table 2). We are confident that the population of independent bears has varied between 15-20 bears each year. The high point estimate of 31 bears in 1991, using the Monte Carlo procedure, is an artifact of a poor photographic detection rate for that year. We do not believe that the upper 95% likelihood intervals calculated from the Monte Carlo procedure accurately reflect true population size. Given the intensity of our field activities, it is not probable that 36-80 independent bears were present in the buffered core area without our knowledge.

Table 2. Comparison of three population estimates for the buffered core area for independent bears only 1989-1992, Swan Mountains, Montana.

	Population Size Estimator		
Year	Absolute Minimum	Core Bear Count	Monte Carlo Estimate[a]
1989	15	16	15-15-20
1990	20	20	18-21-36
1991	15	16	17-31-80
1992	16	20	14-21-42

[a] lower 95% point estimate, upper 95% likihood interval

Densities of grizzly bears in the buffered core area were calculated using the absolute minimum method (Table 3). Total bear density (includes cubs and yearlings) varied from 5.47-7.67 bears/100 mi^2. Considering only independent bears, estimates varied from 4.10-5.47 bears/100 mi^2. Population trend should not be inferred from these annual density statistics. We do not believe long-term trend can be assessed from four years of data.

Age Structure of Core Population

The buffered core area was predominated by adult female grizzly bears for all four years (Table 4). Cubs-of-year showed the seconded highest percentage. Adult males averaged 10% of total. Subadult males were the least common age/gender class.

Table 3. Numbers and absolute minimum density (bears/100 mi^2) of marked and unmarked grizzly bears in the buffered core area (366 mi^2) during the spring population sampling period, 1989-1992, Swan Mountains, Montana.

Year	Number and density of marked and unmarked independent grizzly bears				
	Number Marked Bears	Total Bears[a]	Density of Total Bears	Total Independent Bears	Density of independent bears
1989	17	20	5.47	15	4.10
1990	23	28	7.67	20	5.47
1991	23	26	7.12	15	4.10
1992	17	23	6.30	16	4.38

[a] marked plus unmarked bears

Table 4. Standing age structure of the grizzly bear population in the buffered core area, 1989-1992, using marked and unmarked individuals. Percentage of time in buffered core for marked bears and 50% for unmarked bears, Swan Mountains, Montana.

Year	Percentage of Population by Age and Gender						
	Cub	Yrling	Sub F	Sub M	Ad F	Ad M	Ukn.
1989	24.7	2.2	14.4	0.8	38.6	14.6	4.5
1990	12.6	12.6	11.5	7.1	36.8	10.8	8.4
1991	26.8	14.0	7.2	7.4	35.3	7.1	2.0
1992	8.1	26.6	7.0	3.3	37.2	9.4	8.2
Av.	18	14	10	5	37	10	6

The population was comprised mostly of adult grizzly bears, averaging 49% of total over four years (Table 5). Yearlings and subadults comprised an average of 14% and 15% of the population.

Grizzly Bear Mortalities

We have captured and radioed 38 grizzly bears since 1987. Fourteen of those 38 individuals (37%) have died. Twenty-one grizzly bears (including unmarked cubs and yearlings) have died since 1988. Not all individuals that died were members of the core population. Specific details of each mortality are given in Appendix B.

Table 5. Percentage of the grizzly bear population in each age class in the buffered core area, 1989-1992, using marked and unmarked individuals. Percent of time in buffered core for marked bears, and an assumed 50% of time for unmarked bears, Swan Mountains, Montana.

Year	Percentage of Population by Age Class				
	Cub	Yrling	Subadult	Adult	Ukn.
1989	24.7	2.2	15.1	53.3	4.5
1990	12.6	11.5	18.7	47.7	8.4
1991	26.8	14.0	14.7	42.5	2.0
1992	8.1	26.6	12.4	51.0	2.0
Av.	18	14	15	49	4

Three or four core bears died each year (Table 6). The percentage of independent bears dying each year varied from 6.6% to 20.0%, and averaged 16.0% over the 4-year period. Four cub deaths, all natural, were recorded for the period. Between 0 and 25% of the cubs died annually.

Recruitment of Young

For this analysis, recruitment was defined as survival of young through 2.5 years of age. Therefore, an individual bear was not considered to be recruited if it died at age 0.5, 1.5, or during the year of family breakup at 2.5 years of age. A minimum of 19 cubs were believed produced in the study area from 1986 through 1990 (Table 7). Twelve (75%) of the 16 bears for which we knew gender were females.

Table 6. Preliminary survival mortality statistics for the buffered core area using core bears only 1989-1992, Swan Mountains. Percentages do not represent mortality rates.

Year	Number bears before mortality[a]	Number indep. bears before mortality[b]	Number cub/ yrlings before mortality	Total number deaths	Number indep. bear deaths	% mortality: indep. bears (cubs/yrling)
1989	20	16	4	4	3	18.8 (25.0)
1990	26[c]	20	6	4	4	20.0 (0)
1991	29	16	13	4	1	6.6 (23.0)
1992	29[d]	20	9	3	3	17.6 (0)

[a] Includes unmarked cubs and yearlings of marked females and previously marked bears that were recognized by natural markings.

[b] bears independent of their mothers.

[c] Excludes bear #M43, classified as research mortality after being killed by an adult male following release. Includes suspected mortality of bear #M150.

[d] 1992 data do not include a subadult female illegally shot in snare.

Table 7. Minimum number of cubs produced in study area 1986-1992, Swan Mountains, Montana, using marked and unmarked bears.

Year Born	Mother Tag Numbers	Number of Cubs	Tag Numbers for Known Bears Birth Year
86	1	2	F3, F147
87	96, ukn#17[a]	4	M98, F137, F18
88	ukn#2	2	F26, M71, F47
89	143, 5, 94, uk#12, ukn#10	7	M42, M43, 5A, 94A, F69, F-ukn#42[b]
90	14, 147	4	F34, F35, F32, M33
91	139, 96, 48, 5, 45, 143	10	
92	94	2	

[a] unmarked female/young observations in core area. Each observation is given a unique number.
[b] F-ukn#42 was 3-yr-old illegally shot in snare in 1992.

We were able to ascertain the fate for 18 of the 19 cubs produced. Thirteen of 18 (72.2%) bears survived to recruitment. Ten (76.9%) of the 13 recruited were females. One bear (M98) was illegally killed in the Flathead Valley, one (M43) was categorized as a research mortality, one death (5a) was attributed to natural causes, and two siblings died from management removals (F32,M33).

Home Range Size

Home-range size estimates from our study area are not comparable to other published findings because of differences in the estimator used. Most studies have used the convex polygon procedure, and we selected the adaptive kernel estimator because of its well-known statistical properties. We developed 66 annual home range estimates. The general trends in home-range size among age/gender classes observed in this study are similar to those given by Aune and Kasworm (1989) for the East Front, and from Servheen (1981) for the Mission Mountains.

Adult male grizzly bears in this study exhibited the largest home ranges (Table 8) of all age/gender classes, averaging 291 mi^2. The largest average home range, using the 95% isopleths, was for M149 (430 mi^2). Subadult males exhibited the second largest home range size ($x=143$ mi^2). Adult females had relatively small home ranges, averaging 48 mi^2.

Table 8. Home range estimates (mi^2) for grizzly bears using the adaptive kernel estimator, 1988-1992, Swan Mountains, Montana.

Age/Gender Class	n	Average	SE	Range
Adult Female	10	48	9	18-105
Adult Male	8	291	37	162-430
Subadult Female	9	83	20	14-176
Subadult Male	4	143	74	18-308

Movements of peripheral grizzly bears

While a majority of the grizzly bears remained within the study area, there were several that spent a large portion of their time outside the area. A general summary of their movements is as follows.

Adult male #56 was captured in the Spotted Bear River drainage in May. He moved northwest along Hungry Horse Reservoir, then northeast over the Middle Fork of the Flathead River divide where he was observed with an unmarked female near Mt. Bradley. Over the next two weeks, he was observed twice, alone, along the ridges near Horseshoe Peak. In late June, he had moved east to Calbick Creek where he was observed alone. By 2 July, he had moved north into Puzzle Creek where he dropped his collar in a lush riparian/snow chute complex.

Subadult male #36 was captured near Meadow Creek in spring 1991, and he spent most of his time in the Bob Marshall Wilderness, primarily in the vicinity of the Chinese Wall. On 11 April 1992, he was still at his den in Rock Creek, east of the Chinese Wall. Three days later, he had moved south into Moose Creek, on 20 April farther south into the West Fork of the Sun River, and by 23 April to Benchmark. During May, he moved north into the North Fork of the Sun River where he was observed with a female grizzly. The last location we had on him was on 1 June where he was observed alone just below the Chinese Wall in Pine Creek.

The radio collar on adult male #149 failed while he was in the den in 1991. He was observed with adult female #147 in the upper Bunker Creek drainage and was captured and fitted with a new radio collar two days later. Bear #149 continued to use the Bunker Creek area and was observed with an unmarked female grizzly and again with female #147. By mid-June he moved south into the Bob Marshall for about two weeks. On 1 July, he was observed in the Sullivan Creek drainage about 100 yards below an unmarked female grizzly bear and two cubs of the year (possibly #94). The next day, he was observed about 150 yards below an unmarked blonde female grizzly bear and one yearling (possibly #139). Both of those family groups were photographed later in the year, and all offspring were still present. On 17 July, #149 was in the north end of the Bob Marshall again, but by 27 July he was back in the Sullivan drainage where he was observed feeding on *Vaccinium* spp. He remained in that general area until mid-September. On 28 September, he was in Little Salmon Creek in the Bob Marshall Wilderness. He was last located in the Big Salmon drainage on 1 October.

Adult male #22 was originally radio-collared in 1989 and spent that summer at the grain spill along The Burlington Northern railroad tracks in the Middle Fork of the Flathead River. Since then, he has essentially stayed in the study area. On 21 September 1992, he moved west across the Swan River to the Swan Hill area just east of the town of Bigfork where he was feeding on apples. By 27 September, he had crossed the Swan River and headed south paralleling Flathead Lake. He was located near Woods Bay, and by 6 October 1992 he was just northeast of Yellow Bay. A week later, he was back on Swan Hill and remained there until mid-November when he was captured and moved to Challenge Creek in the Middle Fork of the Flathead River. After he was released, he moved east to the edge of the plains near the site of Palookaville (23 November). On 27 November, he moved southwest to Lodgepole Creek, north of Schafer, and on 13 December he was on the east side of Hungry Horse Reservoir. He denned three days later about 1.5 miles south his 1988 den.

Habitat Studies

<u>Telemetry Data Set</u>

Since fall 1987, 38 of the 39 individual grizzly bears captured were radio-collared (Appendix B). A total of 3,417 grizzly bear locations have been recorded for the entire South Fork Grizzly Bear Project: 2,641 (77%) were class 1, 104 (3%) class 2, 207 (6%) class 3, 129 (4%) class 4, 198 (6%) class 5, 101 (3%) class 6, 7 (0.2%) class 7, and 30 (1%) class 8.

Radio locations accounted for 3,188 of the locations: 2,804 (88%) aerial and 384 (12%) ground. Ninety-seven percent of the radio locations were on National Forest lands. The majority (54%) were on the Spotted Bear Ranger District, 30% on Hungry Horse, and 14% on Swan Lake. Less than 4% were on State Forest and private lands combined. Approximately 10% of the locations were within designated wilderness areas.

Class 1 locations totaled 2,641: 16 (1%) from 1987, 233 (9%) from 1988, 356 (13%) from 1989, 663 (25%) from 1990, 734 (28%) from 1991, and 639 (24%) during 1992. Denning (winter) locations totaled 112 (4%), 244 (9%) were in early spring, 866 (33%) in spring, 932 (35%) in summer, and 486 (18%) in autumn.

Aerial locations were biased toward daytime locations. Seventy-five percent of the locations were obtained between 0500 and 1200 MST. The earliest location was 0515 MST, and the latest was 2100 MST.

Seven hundred thirty-eight of 2,641 (28%) locations were visual observations of the bears from the plane. Visual observations ranged from 6% in 1987 to 42% in 1992.

Relationship of Grizzly Bears to Elevation

Grizzly bears used both low and high elevation habitats. Adult females were more selective than other age/sex classes, using high elevation habitats in greater than expected frequency and low elevation habitats less than expected (Table 9). Other age/gender classes used both elevation classes in proportion to availability.

Table 9. A comparison of high and low elevation habitats using classes of availability-use (-, =, +), proportion of radio locations (P), and number of radio locations (n) of grizzly bears in the Swan Mountains, Montana, 1987-1992.

Age/gender	Low Elevation			High Elevation		
	Bear Use	P	n	Bear Use	P	n
Ad Fem	-	0.30	285	+	0.70	652
Sub Fem	=	0.37	123	=	0.63	211
Ad Male	=	0.39	95	=	0.61	151
Sub Male	=	0.39	70	=	0.61	110

Percentage of Area: Low elevation = 41%, High elevation = 59%

Relationship of Grizzly Bears to Treated Habitats

Sixteen percent of the core area was treated silviculturally and 84% was untreated. Eighty-three percent of the treated stands were at low elevation. Thirty-one percent of the low elevation area had a history of treatment. Ten percent of 1,697 grizzly bear locations occurred in treated stands.

Adult females used high elevation untreated habitats more than expected (Table 10). Both adult and subadult females used low elevation treated stands less than available. Males used treated and untreated stands at both elevations as available.

When grizzly bears used treated stands, they did not appear to "prefer" a specific silvicultural prescription. Removal methods (e.g. clear-cutting, shelter wood) were used as available (Fig. 2). Age of harvest was important to grizzly bears. Treated stands less than 12 years old were used significantly less then expected by bears relative to older treated stands.

Table 10. Grizzly bear use of silviculturally treated and untreated stands at low and high elevation using classes of availability-use (-,=,+), proportion of radio locations (P), and number of radio locations (n) in the Swan Mountains, Montana, 1987-1992.

	Low Elevation						High Elevation					
	Untreated			Treated			Untreated			Treated		
	Use	P	n	Use	P	n	Use	P	n	Use	P	n
Ad Fem	-	0.24	222	-	0.07	63	+	0.67	628	=	0.03	24
Sub Fem	=	0.32	105	-	0.05	18	=	0.62	205	=	0.01	4
Ad Male	=	0.27	66	=	0.12	29	=	0.58	143	=	0.03	8
Sub Male	=	0.28	51	=	0.11	19	=	0.59	106	=	0.02	4

Percent of Area:
Low elevation untreated Stands =28%
Low elevation treated stands =13%
high elevation untreated stands =57%
high elevation treated stands = 3%

Relationship Between Grizzly Bears and Low Elevation Treated, Forested, and Open Habitats

We classified low-elevation habitat into three broad categories: 1) areas that have been silviculturally treated, 2) closed-canopy coniferous forest, and 3) all other habitats (generally natural openings in the overstory). Treated, forested, and other habitats represented 31, 43, and 26% of the total low-elevation area, respectively.

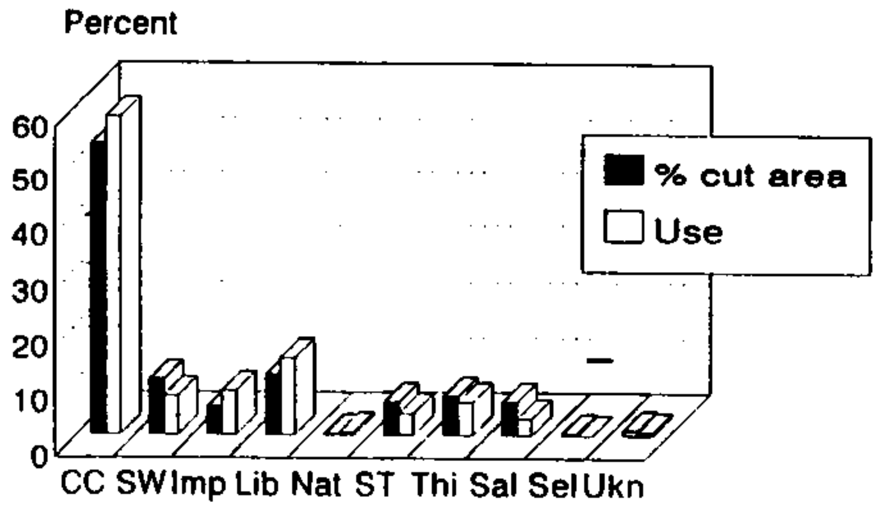
All age/gender classes used untreated open habitats greater than they were available while at low elevation (Table 11). Females used low elevation treated habitats less than available. Males used untreated forested stands less than available and treated stands as available.

Relationships Between Grizzly Bears and Roaded or Unroaded Habitats

We classified habitats within the core area as either roaded (< 0.5 miles from any road) or unroaded (> 0.5 miles from any road). Forty-two percent of the core area was unroaded. Sixty-five percent of the roaded area was at low elevations.

Females used high elevation unroaded habitat greater available whether roaded or not (Table 12). Males used low and high elevation habitats as available, regardless of road densities.

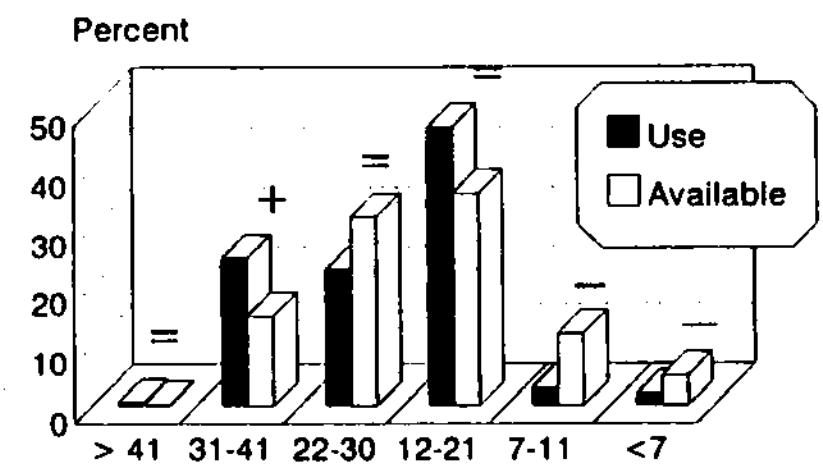
A



% cut area	53	10	5	11	0.3	6	7	6	0.4	1
Use	58	7	8	14	0.6	4	6	3	0	0.6

% of locations in harvest stand only, not % total Locations

B



Use	0.6	25	23	47	3	2
Available	0.3	15	32	36	12	5

Age (Since 1992)

Uses only locations in harvested unit (exclude Wheeler Cr. Burn)

Figure 2. Grizzly bear use of harvested stands, A) use of different removal methods, B) use of different stand ages, Swan Mountains, Montana.

Table 11. Grizzly bear use of three low elevation habitats using classes of availability-use (-, =, +), proportion of radio locations (P), and number of radio locations (n) in the Swan Mountains, Montana, 1987-1992.

Age/gender	Silviculturally Treated Stands			Untreated Forested Stands			Untreated Open Habitats		
	Use	P	n	Use	P	n	Use	P	n
Ad Fem	-	0.22	63	=	0.38	108	+	0.4	114
Sub Fem	-	0.15	18	=	0.44	49	+	0.46	56
Ad Male	=	0.31	29	-	0.27	26	+	0.42	40
Sub Male	=	0.27	19	-	0.23	16	+	0.5	35

Percent of low elevation area:
Treated stand = 31%
Untreated forested stand = 43%
Untreated Open habitats = 26%

Relationships Between Grizzly Bears and Road Densities

Total Road Densities:

Female grizzly bears used unroaded habitats greater than this class was available while males used unroaded habitats as available (Table 13). Generally, grizzly bears used habitats having a total road density of 0.1 to 2.0 mi/mi^2 as available. Twenty-two percent (59 mi^2) of the core area had a precise total road density of >2.0 mi/mi^2. These areas were used less than available by all age/sex classes.

Open Road Densities:

Preference, as exhibited by use-availability comparisons, indicated a shift in use of an area when precise open road densities approached 1.0 mi/mi2 (Table 14). Adult bears used areas with >1.0 mi/mi^2 less than available. Adult females used areas with an open road density of 0 mi/mi^2 greater than expected.

Road Densities within Adult Female Home Ranges

We determined the distribution of road density classes within adult female home ranges. We pooled 19 annual home ranges (95% isopleths) from 9 adults for this analysis. Comparisons were then made to road density percentages outside of the cumulative home range.

Table 12. Grizzly bear use of roaded and unroaded habitats at low and high elevations using classes of availability-use (-, =, +), proportion of radio locations (P), and number of radio locations (n) in the Swan Mountains, Montana, 1987-1992. (All roads included (open and closed)).

Age/ gender	Low Elevation						High Elevation					
	Unroaded			Roaded			Unroaded			Roaded		
	Use	P	n	Use	P	n	Use	P	n	Use	P	n
Ad Fem	=	0.03	27	-	0.28	258	+	0.44	412	+	0.26	240
Sub Fem	=	0.03	9	=	0.34	114	+	0.47	156	=	0.17	55
Ad Male	=	0.05	13	=	0.33	82	=	0.41	100	=	0.21	51
Sub Male	=	0.02	4	=	0.37	66	=	0.38	68	=	0.23	42

Percentage of Area:
low unroaded = 3%
low roaded = 38%
high unroaded = 39%
high roaded = 20%

Table 13. Grizzly bear use of four classes of total road density using classes of availability-use (-, =, +), proportion of radio locations (P), and number of radio locations (n) in the Swan Mountains, Montana, 1987-1992 (all but revegetated roads included).

Age/ gender	Precise Total Road Density											
	Unroaded			0.1-1 mi/mi^2			1-2 mi/mi^2			> 2 mi/mi^2		
	Use	P	n	Use	P	n	Use	P	n	Use	P	n
Ad Fem	+	0.47	439	+	0.26	241	=	0.16	150	-	0.11	107
Sub Fem	+	0.49	165	=	0.25	83	=	0.19	64	-	0.07	22
Ad Male	=	0.46	113	+	0.28	68	=	0.14	34	-	0.13	31
Sub Male	=	0.4	72	+	0.28	50	=	0.18	32	-	0.14	26

Percentage of Area:
Unroaded = 42%, 0.1-2.0 = 17%, 0.1-1.0 = 19%, >2.0 = 22%

Table 14. Grizzly bear use of four classes of open road density using classes of availability-use (-, =, +), proportion of radio locations (P), and number of radio locations (n) in the Swan Mountains, Montana, 1987-1992 (permanently open and seasonally open roads only).

Age/ gender	Precise Open Road Density											
	0 mi/mi²			0.1-1 mi/mi²			1-2 mi/mi²			> 2 mi/mi²		
	Use	P	n	Use	P	n	Use	P	n	Use	P	n
Ad Fem	+	0.69	650	=	0.15	137	-	0.1	89	-	0.07	61
Sub Fem	=	0.62	208	+	0.21	70	=	0.13	42	-	0.04	14
Ad Male	=	0.66	162	+	0.22	54	-	0.05	13	-	0.07	17
Sub Male	=	0.63	113	=	0.16	28	=	0.14	25	=	0.08	14

Percentage of Area:
0 = 61%, 0.1-1.0 = 13%, 1.0-2.0 = 13%, >2.0 = 13%

Forty-six percent of the cumulative female home range was unroaded: 21% had no roads or trails, and 25% had trails but no roads (Fig. 3). This 46% unroaded habitat within the home range compared to 26% unroaded habitat outside the range. The percentages of habitat in the >0 - <2 mi/mi² within and outside the cumulative home range were similar (Fig. 3), but the distribution of permanently open, seasonally closed, and permanently closed road categories differed. Females were selecting habitats with more permanently closed habitats. Eighteen percent of the habitat in the cumulative adult female home range was at total road densities >2 mi/mi². This compares to 39% outside of the home range.

Comparison of grizzly bear use of road density classes between South Fork and North Fork Studies

Results of this study regarding grizzly bear response to roads are often compared and contrasted to those found by McLellan and Shackleton (1988) for the North Fork of the Flathead River, Canada. In the Canadian study, the authors expressed bear response relative to four distance classes: 0-100m, 101-250m, 251-500m, and 501-1000m. All locations more than 1000m from a road were excluded from analyses by the authors, thus bear habitat selection more than 1000m from a road was assumed to be unaffected by roads. To provide a preliminary comparison, we built a GIS road file with the above categories and overlayed our aerial telemetry points from 1988-1992. Over 1,000 of our locations were excluded because they were >1000m from a road. We used the same analysis procedures as McLellan and Shackleton (1988) with alpha set at 0.95.

When telemetry points were pooled from all bears and all years, grizzly bear response to road distance classes was quite similar between to two studies. Table 15 shows this comparison using data in Fig. 1 (p. 454) from McLellan and Shackleton (1988). Bears in both areas used the 0-100m distance significantly less than expected. In both areas, bears used the category 101-250m as expected. North Fork bears used the

251-500m category significantly greater than expected while South Fork bears used this category as expected. Bears in both areas used the 501-1000m category significantly greater than expected.

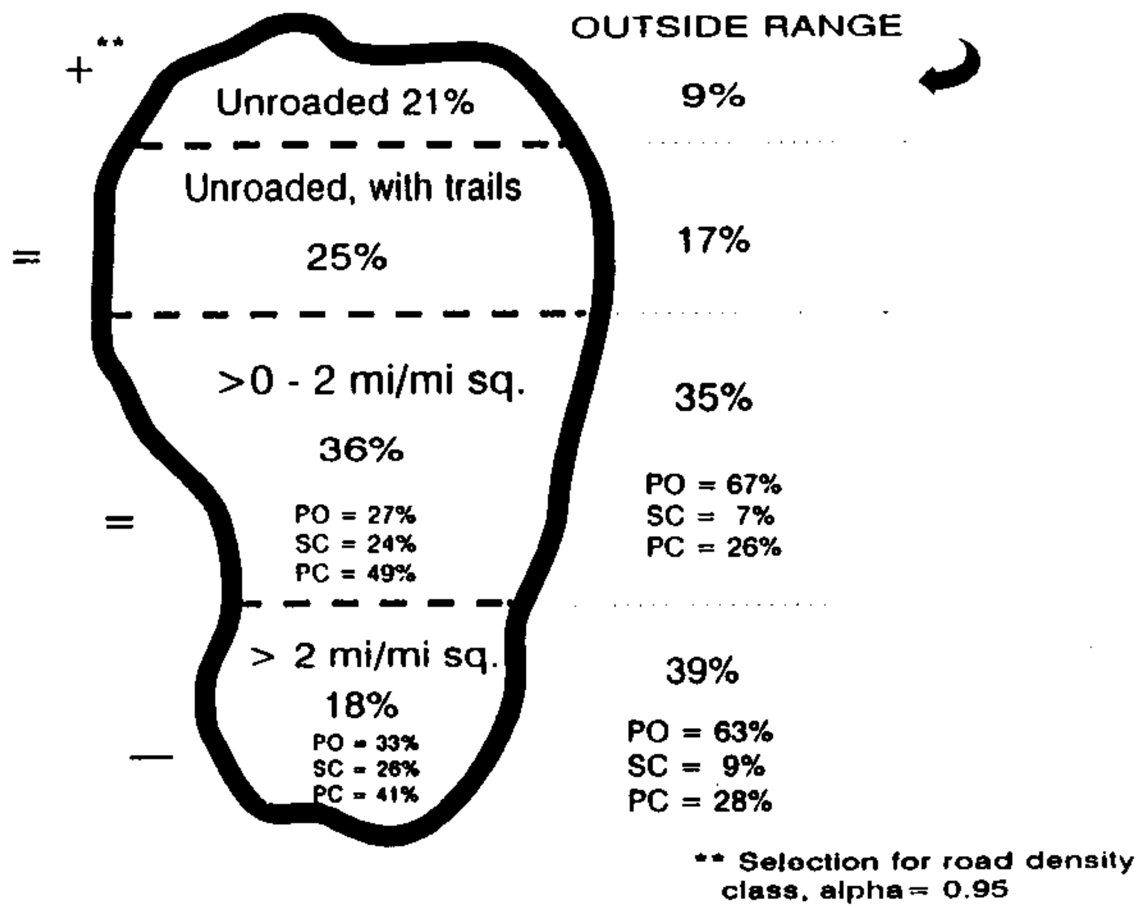


Figure 3. Distribution of road density classes within and outside of cumulative adult female home ranges using 19 annual home ranges from 9 adult females, Swan Mountains, Montana. (PO=permanently open, SC=seasonally closed, PC=permanently closed).

Table 15. Grizzly bear use of four distance to road categories in the South Fork (this study) and North Fork (from McLellan and Shackleton 1988).

Distance to road category	South Fork			North Fork[a]		
	observed	expected	selection	observed	expected	selection
0-100m	0.18	0.24	-	0.09	0.18	-
101-250m	0.18	0.21	=	0.20	0.23	=
251-500m	0.22	0.24	=	0.35	0.28	+
501-1000m	0.42	0.31	+	0.37	0.31	+

[a] proportions for North Fork are approximate

<u>Use of self-activating cameras to monitor traffic volumes and grizzly bears</u>

The cameras were deployed 3,229 camera days in 1992 and were operational 2,366 of those days for an operational efficiency of 73%. A total of 10,734 photographs were taken resulting in 45 (0.42%) photographs of grizzly bears. On 10 of those occasions, the grizzly bear was photographed more than once. The 35 individual grizzly bear records represented one grizzly photo event in 67.6 camera days. Nine of 35 events (26%) were diurnal and 74% were nocturnal.

Fifteen photographs were of eight marked grizzly bears (FY#5, F#18, M#22, F#26, FY#48, M#71, F#147, M#149). Ten photographs were identified as M#146 (lost collar and tags but unique markings). The remaining ten photographs involved unidentified grizzly bears. An unmarked female (possibly #94) and her two cubs were photographed once. Bear (#48) and her two yearlings, and bear #5 and her yearling were also photographed. All of the remaining identifiable grizzly bears were males.

Eight photographs of marked grizzly bears were during September, and seven occurred from May through June. No grizzly bears were photographed during October. April had the highest photographic rate at 0.037 grizzly bears per camera day and October the lowest at zero.

Thirteen (37%) of the grizzly bear photographs were on open roads, 19 (54%) on permanently closed roads, and 3 (9%) on seasonally closed roads. A total of 978 vehicle trips (51% general public, 43% research, 4% Forest Service) were recorded. Approximately 98% of the vehicle traffic occurred during daylight. September had the most traffic recorded and the highest ratio of 0.63 vehicle trips per camera day. July had the lowest at 0.25 vehicle trips per camera day.

By placing several cameras in the same drainage during 1991 and 1992, we were to compare vehicle traffic in that drainage. During 1991 and 1992, there were four and five cameras, respectively, along a permanently-open road that bisected the study area. During 1991, the four cameras were operational 592 camera days and recorded 568 vehicle trips for an average 0.95 vehicle trips/day. For 1992, there were 576 camera days, and 545 vehicle trips were recorded for an average of 0.94 vehicle trips/day. About one third of the vehicle trips (34%) were due to research traffic during both years.

Micro-habitat Studies

A total of 357 habitat plots have been inventoried at grizzly bear use sites since 1987. A majority of the plots (68%) were examined during June, July, and August. A total of 107 plots were inventoried in 1992. The plot data have been entered and edited, and analyses will begin for the next report period.

DISCUSSION

Population Studies

Our population studies are not completed. With four years of investigation completed, data are as yet insufficient to document population trend. We also believe that survival rate estimates are inappropriate at this time.

Habitat Studies

Ten percent (n=169) of 1697 telemetry locations from 31 individual grizzly bears over five years occurred in silviculturally treated stands. No age/sex class selected specifically for treated stands. While at low elevations, grizzly bears in the analysis area used treated stands less than available. Although not detailed here, Waller (1992) determined that individual grizzly bears varied considerably in their use of treated stands. From our data, we know that several treated stands in the analysis area were very important to bears while foraging on huckleberries. However, the vast majority of treated stands in the analysis area were never used by bears.

Grizzly bears require habitats found at both low and high elevations and move between these zones during each season and for variable periods of time. Adult females are especially tied to high elevation areas. Because grizzly bears can not be restricted to high elevations only, we believe land management alternatives should be evaluated and displayed relative to both low and high elevation "impacts."

Our data imply that human use of the low elevation roaded environment negates bear use of treated stands. The management concept of "habitat improvement" through silvicultural treatment may only apply where grizzly bear security is maximized.

Grizzly bears can live and reproduce in multiple-use habitats. Preliminary data analyses strongly suggest that grizzly bears are not able to fully exploit habitats, especially those at low to mid-elevation, because of human activity associated with roads.

Techniques for calculating road densities that average over large blocks of land (e.g. a BMA), inclusive of both high and low elevations, result in inadequate assessments of grizzly bear response to road densities. Using an average road density figure, derived from a large area, will not detail the precise road densities within smaller areas. The current method employed to calculate road densities, using an average open road density only, has a tremendous effect on how road density standards are interpreted and applied to grizzly bear habitat. When only open roads are used in density calculations, the influence of closed roads is removed. For example, an area may have an open road density of 1.0 mi/mi^2; thus, there is one mile of open road for each square mile of habitat. However, this same area could also have two miles of closed roads per square mile, an actual total road density of 3 mi/mi^2. This area would still meet the 1 mi/mi^2 open road density standards, but according to our data areas where the total road density exceeded 2mi/mi^2 would receive use less than expected. For example, our entire analysis area has an average open road density of 0.63 mi/mi^2 and meets current road density standards. Our precise open road density technique produces the same average open road density. However, from our method we know that 26% of the analysis area (70 mi^2 of habitat) exceeds the 1.0 mi/mi^2 standard. When all roads are included in calculations for our analysis area, the average total road density is 1.13 mi/mi^2 with 22% (58 mi^2) of the area having >2 mi/mi^2. This 58 mi^2 of habitat was used less than expected by radio-instrumented grizzly bears.

The amount of area with a total road density of >2 mi/mi^2 in our analysis area is considerable. Juxtaposition of this 58 mi^2 to other lands with other classes of road densities and associated cover types is critical for determining the overall quality of the habitat.

Apparently, grizzly bears adjust their habitat use patterns in part to both precise open road densities and precise total road densities. Unless a road has completely revegetated, managers should assume that some level of human use is occurring along closed roads, and grizzly bears will respond to that use.

Our data suggest that once a decision is made to road and silviculturally treat stands in a previously unroaded area, that area will subsequently be used less by female grizzly bears. This response by female bears is predicted to occur regardless of what silvicultural treatment is chosen. Once precise total road densities reach 2 mi/mi^2, use by all bears is predicted to significantly decline. Closing roads has a positive effect on use of an area by grizzly bears when precise open road densities are reduced below 1.0 mi/mi^2.

Females in our study do not all use the same unroaded habitats. Females show a strong geographical fidelity to specific areas. Observed patterns of home range overlap among individuals suggest that only limited temporal overlap occurs (Mace unpublished data). To date, most of the man-caused mortality of the marked population is not occurring directly within the study area; mortality is occurring when bears move to peripheral areas.

The ultimate question is: what is the desired population size of this and other related grizzly bear populations over the long-term? Suitable and available habitat must exist to accommodate young bears upon dispersal for a population to grow. Adult females in our study tend to use unroaded habitats; use of such habitats contribute to recruitment into older age classes. The preponderance of adult females in the population suggests that survival of individual bears is directly related to their selection for unroaded areas. To date, the data suggest that if unroaded habitats are reduced in quantity or size, the number of adult females will eventually decline. To increase bear numbers and survival, adequate secure habitat should be maintained at all elevations to benefit all segments of the population.

RECOMMENDATIONS

We have completed four years of a 10-year assessment of the grizzly population and their habitat requirements in the Swan Mountains of South Fork of the Flathead River. Subsequently, all data, analyses, and discussions are preliminary in nature. We recommend that managers and other interests recognize this, and that continued field observations and data analyses will occur during the remainder of this investigation.

The chief value of our information is that preliminary results will allow managers to formulate initial guidelines for managing habitats to benefit grizzly bears in this and similar areas. These initial guidelines should remain flexible as we learn more about grizzly bears in this environment. We recommend that several preliminary guidelines be formulated, reviewed, and adopted by the involved resource management agencies, specifically the MDFWP, the USDA Forest Service, and the USDI Fish and Wildlife Service in the near future. These guidelines should include specific recommendations for population and habitat management at each scale of analysis (e.g. site-specific project area, Bear Management Area, Bear Management Unit, etc.). Such guidelines will require that inter-agency habitat and population thresholds be established.

We have designed this project to test specific hypotheses, most of which can not be evaluated yet. These include:

Population

1. grizzly bear survival rates are equal in multiple use lands and designated wilderness

2. grizzly bear survival rates in open road drainages equal rates in habitats where roads have been closed

3. grizzly bear man-caused survival rates are correlated to open road densities

4. the female/young population segment is an accurate predictor of population size and trend

5. subadult female dispersal distances remain the same as the population of adult females increases

6. habitat features can be used to predict bear density

7. grizzly bear breeding areas can be accurately identified and described

8. litter sizes will not decrease as the density of adult females increases

9. the number of productive pair bonds will remain the same regardless of male density, and

10. adequate space exists to increase the population of bears beyond current levels.

Habitat

1. grizzly bear habitat use patterns (by age/gender) are similar in multiple use lands and designated wilderness

2. grizzly bears exhibit measurable changes in habitat and topographic (including elevation) use when roads are closed

3. adult female home range areas can be predicted by TM habitat maps

4. the density of major grizzly bear foods in roaded drainage bottoms is similar to those habitats selected by bears

5. grizzly bears walk/forage along closed roads more frequently than open roads

6. major patterns of seasonal habitat selection can be predicted by bear food density indices

7. subadult grizzly bears occupy home ranges with a detectable difference in habitat quality as measured by food density indices and TM habitat maps relative to adult bears

8. preferred grizzly bear seasonal habitats are limited within the evaluation area

9. grizzly bears (all age/gender) have not been displaced from habitats of variable road density zones, and

10. security areas can be accurately mapped using habitat variables.

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APPENDIX B
SUMMARY OF ALL MARKED GRIZZLY MORTALITIES

Tag	Sex-age	Date	Cause
97	F-15	9/88	Natural, possibly killed by M144
1	F-12	5/88	Mistaken Id, in Swan Valley
363	F-14	10/88	Legal harvest, in core area
12	F-2	9/89	Mistaken Id, in Bob Marshall
98	M-2	9/89	Unreported, illegal, in Flathead Valley
13	M-7	9/89	Defense of Life, elk hunter, Bob Marshall
148	M-9	10/89	Defense of Life, elk hunter, Bob Marshall
5a	Ukn-cub	89	Natural, in core area
144	M-13	4/90	Defense of life, entered dog kennels, in Flathead Valley
43	M-2	6/90	killed by M149 after release from snare
150	M-8	90	Suspected death or emigration
44	F-10	6/90	Unknown, in core area
47	F-2	6/90	Natural, poor physical condition, in core area
143	F-8	5/91	Natural, died in avalanche (?), in core area
143c	Ukn-cub	5/91	Natural, died in avalanche (?)
143d	Ukn-cub	5/91	Natural, died in avalanche (?)
5b	Ukn-cub	7/91	Natural, in core area
32	F-2	9/92	Management removal, Bunker Cr., core area
33	M-2	6/92	Management removal, Bunker Cr., core area
UK#42	F-3	5/92	illegal, shot in snare
26	F-4	9/92	Unreported, illegal, Swan Valley

APPENDIX C

Number and current status of all grizzly bears captured within the South Fork Study Area as of December, 1992.

Bear	Sex	Age at Capture	Date First Captured	Current Status
1	F	11.5	09/04/87	Dead bear
3	F	1.5	09/11/87	Drop collar
5	F	7.5	09/16/87	Active
12	F	3.5	05/29/89	Dead bear
13	M	7.5	06/01/89	Dead bear
14	F	11.5	06/01/89	Active
18	F	2.5	06/20/89	Active
22	M	3.5	06/18/89	Active
25	M	4.5	06/09/90	Drop collar
26	F	4.5	06/02/92	Dead bear
32	F	1.5	05/13/91	Dead bear
33	M	1.5	05/21/91	Dead bear
34	F	1.5	05/29/91	Active
35	F	1.5	05/30/91	Active
36	M	4.5	05/30/91	Unknown
42	M	1.5	05/31/90	Unknown
43	M	1.5	06/01/90	Dead bear
44	F	10.5	06/03/90	Dead bear
45	F	19.5	06/05/90	Active
47	F	2.5	06/06/90	Dead bear
48	F	10.5	06/09/90	Active
56	M	12.5	05/17/92	Drop collar
69	F	3.5	07/27/92	Active
71	M	2.5	06/05/90	Active

94	F	8.5	06/06/88	Drop collar
96	F	15.5	08/27/88	Active
97	F	15.5	06/15/88	Dead bear
98	M	1.5	08/27/88	Dead bear
136	M	6.5	06/07/88	Drop collar
137	F	1.5	08/27/88	Dead collar
139	F	4.5	06/03/88	Drop collar
143	F	5.5	05/26/88	Dead bear
144	M	11.5	06/04/88	Dead bear
146	M	5.5	05/27/88	Drop collar
147	F	1.5	09/09/87	Drop collar
148	M	8.5	05/28/88	Dead bear
149	M	8.5	05/30/88	Active
150	M	6.5	06/02/88	Drop collar