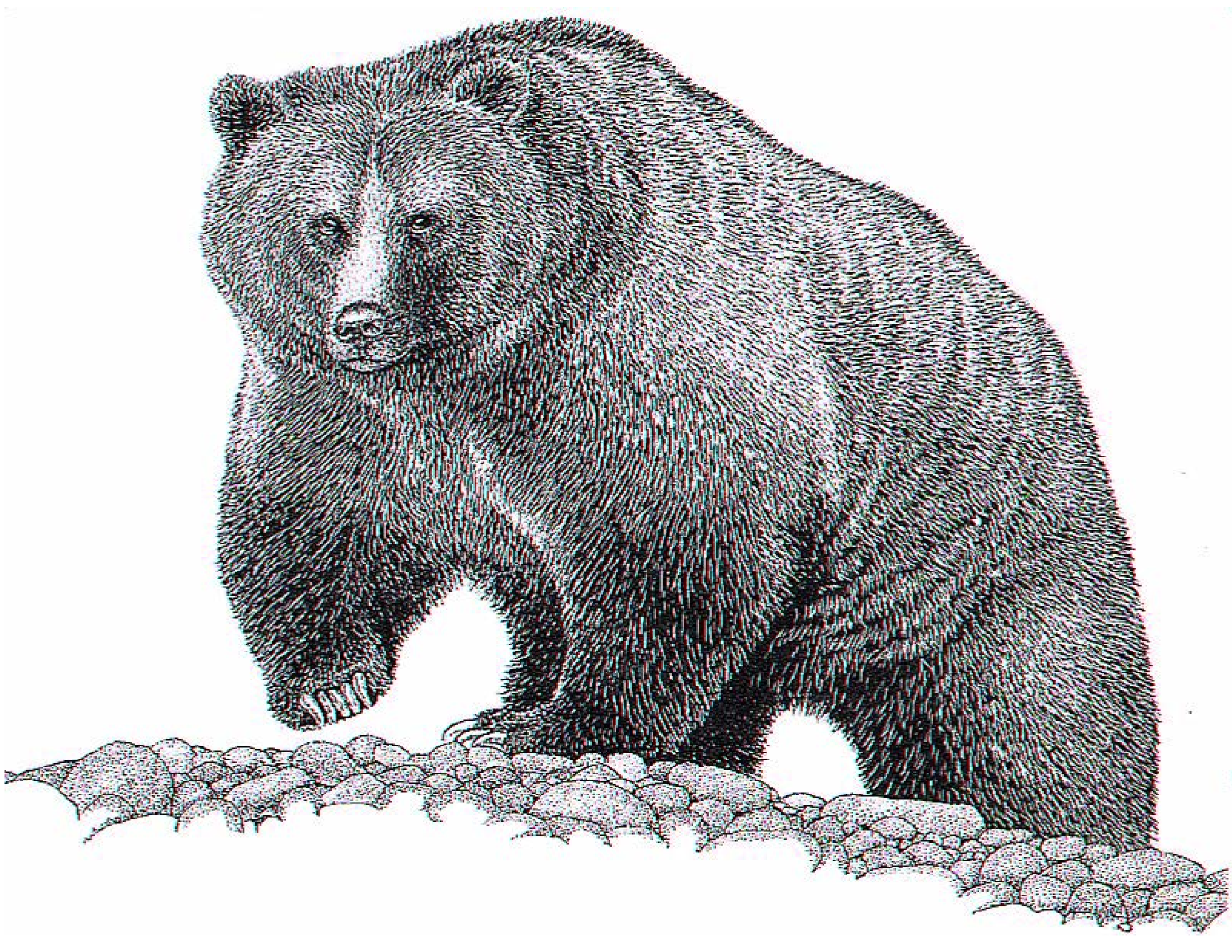
GRIZZLY BEAR AND ROAD DENSITY RELATIONSHIPS IN THE SELKIRK AND CABINET - YAAK RECOVERY ZONES



Prepared by:

Wayne L. Wakkinen, Idaho Department of Fish and Game, HCR 85, Box 323J, Bonners Ferry, ID 83805

Wayne F. Kasworm, U.S. Fish and Wildlife Service, 475 Fish Hatchery Road, Libby, MT 59923

April 1997

EXECUTIVE SUMMARY

This report examines the relationship between grizzly bear distribution and motorized access routes (roads and motorized trails) in the Selkirk and Cabinet/Yaak ecosystems. It uses standardized techniques to provide information that may be used to develop access management standards for the two ecosystems.

Road density maps were developed for both ecosystems. Roads were classified as open, gated, barriered, or vegetated. We calculated total road density, open road density, and core area (area outside of the zone of influence of any open or gated road).

Preference or avoidance for road density classes were examined. Available habitat was determined by generating home ranges of six female grizzly bears from radiotelemetry information. Use was defined by the specific telemetry locations of the radiomarked bears.

Total road density >2 mi/mi^2 and open road density >1 mi/mi^2 were used less than expected (avoided) and unroaded areas in both categories were used more than expected (preferred). Core areas were used greater than expected (preferred). We therefore suggest that the proportion of the home ranges with >2 mi/mi^2 total road density, >1 mi/mi^2 open road density, and the amount of core area are appropriate access management standard categories.

We examined the relative influence of each road type on bear distribution. Open roads influenced bear distribution the most. Bear response to vegetated and barriered roads appeared more similar to unroaded habitat than bear response to gated roads. Total road densities in other areas have included barriered roads. We suggest that if barriers on roads are effective, these roads may be removed from the total road density calculations. The following values for total road density include only open and gated roads.

The amount of area within six female grizzly bears' home ranges with a total road density >2 mi/mi^2 averaged 26%. Home ranges averaged 33% open road density >1 mi/mi^2, and 55% of the home ranges were comprised of core area.

We suggest that common access standards be developed for both the Selkirk and Cabinet/Yaak ecosystems. Similar patterns of bear use were observed in both areas. While no minimum core area size was determined, we suggest that if a minimum size occurs it is likely between 2 mi^2 and 8 mi^2. Narrow strips of core habitat may fit some minimum size criterion but would likely not provide effective core habitat for bears. Consideration should be given to habitat quality in the proximity of road closures. Certain types of habitat may not be sufficiently represented in all Bear Management Units and require additional protection (e.g., spring range or high quality foraging sites).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Roads and other motorized access routes can negatively impact many large mammals, including grizzly bears (see Frederick 1991 for a partial review). Increased access can increase mortality, displace animals from high quality habitat, and increase habituation to humans. Human-caused mortality has been identified as the most important factor currently influencing grizzly bear populations (Peek et el. 1987, Servheen et al. 1994). Large populations of grizzly bears have persisted where frequency of contact with humans was low (Storer and Tevis 1955, Brown 1985, Servheen 1989). Areas that offer significant amounts of secure habitat with low motorized access have typically retained healthy bear populations.

Management of roads within grizzly bear habitat is a widely used practice and a means to provide needed security to retain a grizzly bear population. Reduced motorized access can lower mortality rates, minimize displacement from important habitat, and minimize habituation to humans.

Recognizing current and potential impacts of roads, the Interagency Grizzly Bear Committee (IGBC) requested that road density standards be developed for all grizzly bear recovery zones using a standardized method. Geographical Information Systems (GIS) coupled with recovery zone-specific data available from radiomarked grizzly bears allows for a means to develop area-specific road standards. Mace and Manley (1993) used a “moving window” road density analysis, coupled with grizzly bear home range information, to determine levels of road density within female grizzly bear home ranges and tested whether these levels were used more or less than expected. An access management task force was later convened and developed a report suggesting an approach using the moving window analysis to develop access management guidelines (IGBC 1994). This report is based on those suggestions.

Numerous individuals contributed to the completion of this analysis. We extend special thanks to Gary Neier, Jack Zearfoss, and Dale Hawley of the Kootenai National Forest, Chris Jacobson of the Panhandle National Forest, Bruce McKenzie of the B.C. Ministry of Environment, and Dave Gruenhagen of the Idaho State Department of Lands for data acquisition and analysis. We thank Suzanne Audet, Michele Eames, Mike Fairchild, Rich Harris, Jim Hayden, Tim Layser, Bob Summerfield, Rob Wielgus, and Pete Zager for critical reviews of the report.

GOALS AND OBJECTIVES

The goal of this report is to analyze and present information on grizzly bear relationships to human access routes in the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones. Specific objectives were to:

1. Develop a complete digitized access (road) layer for the Canadian and U.S. portions of the Selkirk and Cabinet-Yaak recovery zones.

2. Calculate home ranges within recovery zones using data from radiomarked grizzly bears.

3. Determine levels of road densities (open and total roads) and core area (no open or gated roads) within grizzly bear home ranges by superimposing the home ranges over the digitized road layer. This will be accomplished in a GIS format using a “moving window” analysis.

4. Determine preference/avoidance of different road densities using the home range information and the digitized road layer.

The results in this report will be used to assist development of access management alternatives for public review and implementation by the appropriate agencies.

STUDY AREA

Selkirk Mountains Grizzly Bear Recovery Zone (SMGBE)

The SMGBE encompasses approximately 2,200 mi^2 of the Selkirk Mountains of northeastern Washington, northern Idaho and southern British Columbia (Fig. 1). Approximately 1,150 mi^2 (53%) lie in the U.S., with the remainder in B.C. Most of the land in the U.S. portion is under jurisdiction of the U.S. Forest Service (USFS), with lesser land holdings by the Idaho Department of Lands (IDL) and private parties. Lands in the B.C. portion of the study area are either publicly owned or privately owned by timber companies.

Grizzly bear research began in the SMGBE in 1983. Since that time, 38 different grizzly bears have been captured in Idaho, Washington, and British Columbia. Thirteen adult female grizzly bears have been monitored during that time period.

For the purpose of this analysis the SMGBE was further broken into two smaller study areas. The northern study area is entirely in British Columbia north of Provincial Highway 3. This area contains large tracts of private timber land. Land ownership, access management and human activity levels in this area are considerably different from other portions of the Selkirks.

The southern study area contains the U.S. portion of the SMGBE and that portion of the SMGBE within B.C. south of Highway 3. Grizzly bears use this area as one contiguous piece of habitat and access management and human use levels in this area are relatively uniform throughout.

Cabinet-Yaak Grizzly Bear Recovery Zone (CYEGB)

The CYGBE includes approximately 2,600 mi^2 in northwest Montana and northern Idaho (Fig. 2). It is contiguous with grizzly bear habitat in the Yahk, Moyie, and Kootenay Rivers of southeast British Columbia. Approximately 90% of the recovery zone in the U.S. is administered by the Kootenai, Idaho Panhandle, and Lolo National Forests.

Grizzly bear research utilizing radiocollared individuals has been ongoing in the CYGBE since 1983. These efforts have resulted in the capture of 18 grizzly bears, but only 3 adult females. Of the 18 bears, 3 were captured in the Cabinet Mountains and only one was an adult female. One of the first bears captured in the Yaak area in 1986 was an adult female. This female and her daughter were used in this analysis.

Radiolocation data is available from the Cabinet Mountains as a result of the monitoring of bears transplanted from B.C. However, this analysis focused on grizzly bears in the Yaak area because more data were available on native bears in that portion of the recovery zone and complete road databases were not available for the Cabinet Mountains. All grizzly bears were trapped within the U.S., but several collared bears utilized home ranges that overlapped the international boundary with some male home ranges extending almost 20 mi into B.C. Population estimates for the Cabinet Mountains were 15 or fewer bears and the Yaak portion of the recovery zone may hold 20-25 bears.

Portions of these recovery zones included in the road analysis were determined by overlaying the home ranges of adult female grizzly bears. The area encompassed within the home ranges then became the road analysis area.

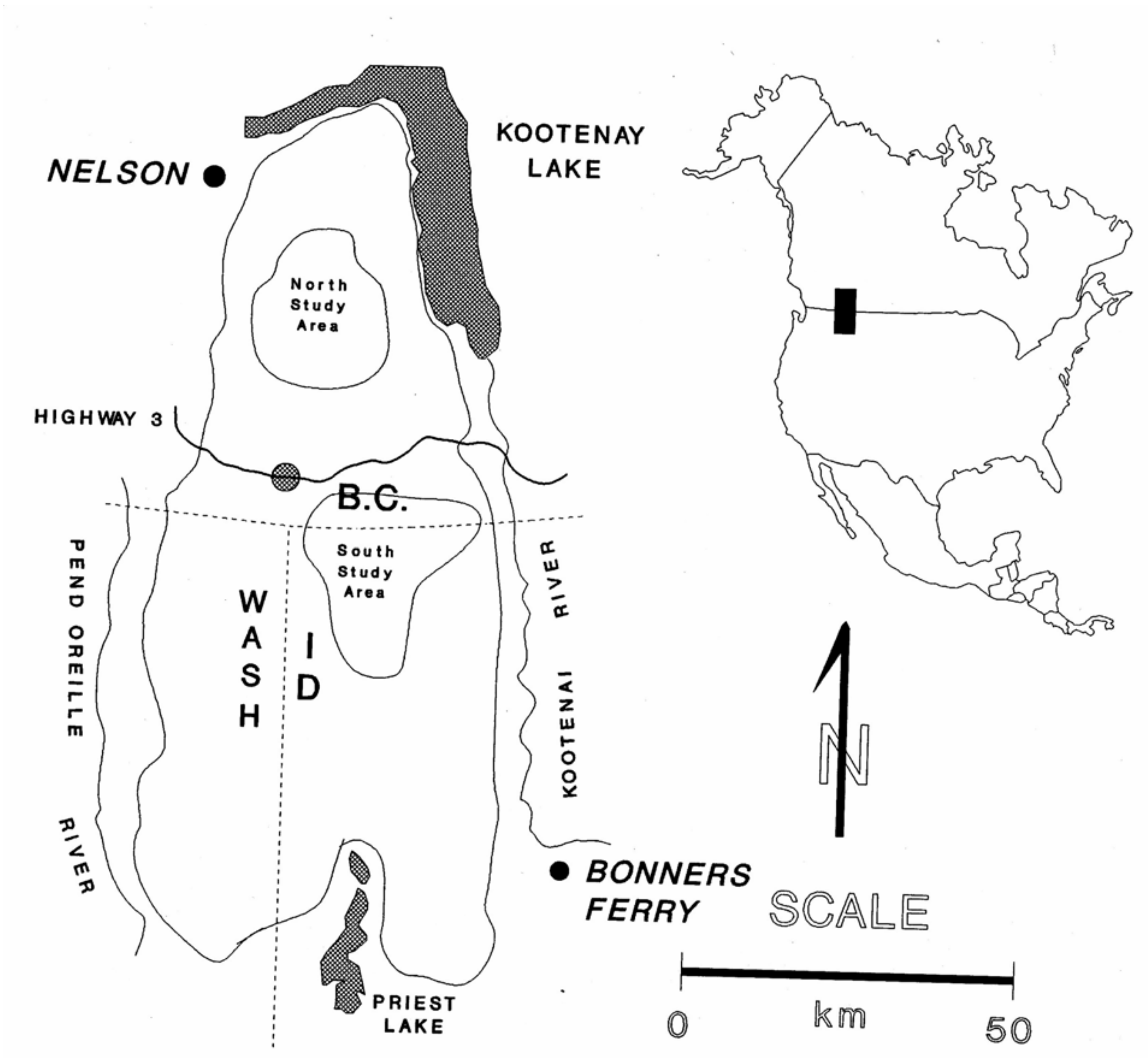


Figure 1. The Selkirk Mountain grizzly bear recovery zone and road analysis study area.

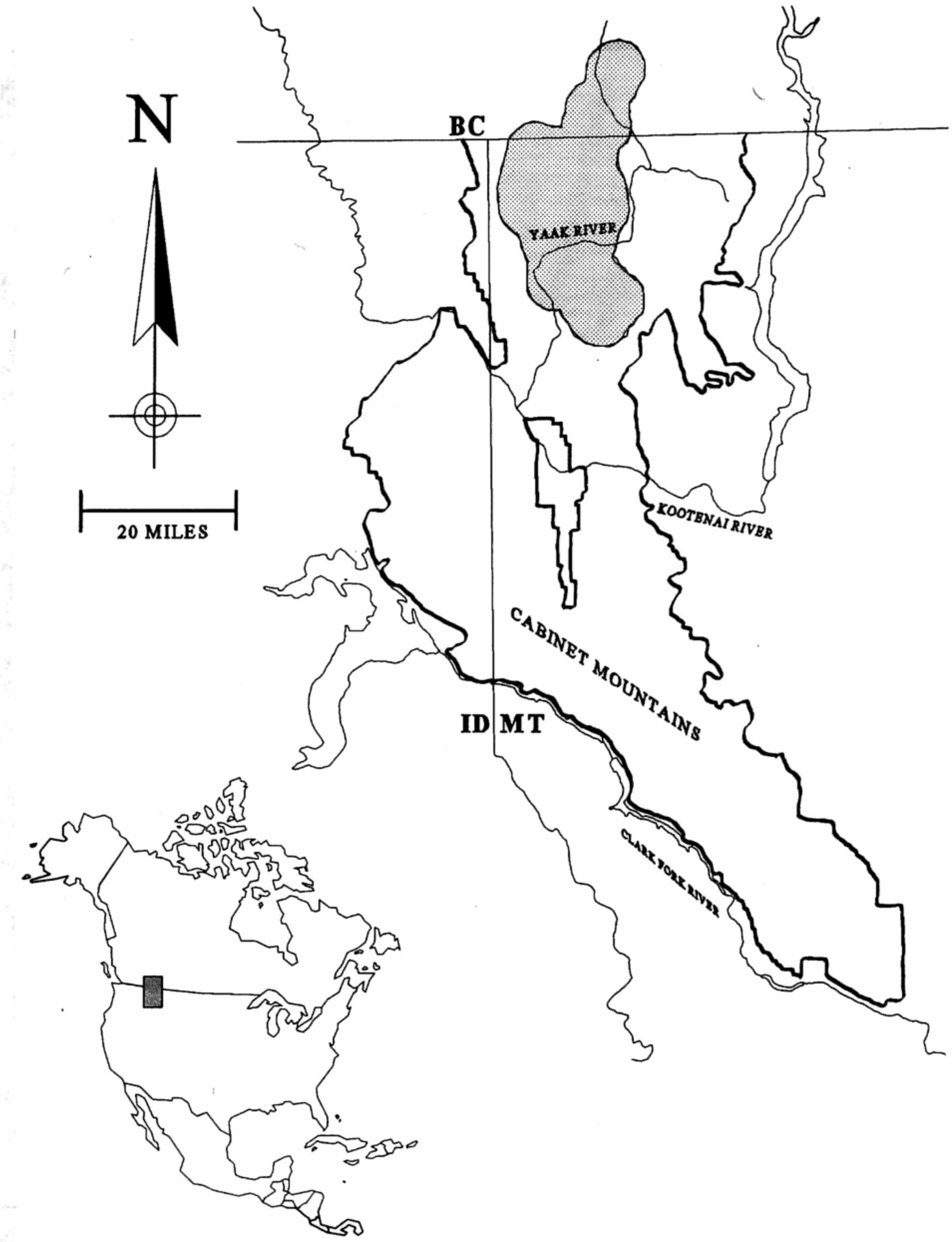


Figure 2. The Cabinet-Yaak grizzly bear recovery zone and road analysis study area.

METHODS

Transportation Mapping

A digitized road layer was acquired for the study areas. Specific data for road status during this period were compiled with help of the USFS, IDL, and B.C. Ministry of Environment. In the U.S. portion of the Selkirk Recovery Zone, road base maps were developed using road status for 1990 and was compared to bear locations collected from 1989 to 1991. The Cabinet-Yaak road database was for 1991 and compared to bear locations from 1991 to 1994. These maps were generated because of stability of the road system during these time periods and the availability of radiotelemetry data. Databases were checked against road closure maps and aerial photography from the sample period. Digital road information for the B.C. portion of each recovery zone was obtained from the B.C. Ministry of Environment. No information on road status (closures or navigability) was available and all roads were treated as open with no restriction on use. Therefore, analysis for the North Selkirk study area was limited to total roads only. Development of annual or seasonal road databases for the years sampled would have reduced location sample sizes to a level inadequate for analysis.

Definitions of travel routes follow the IGBC Task Force Report on Access Management (IGBC 1994). Roads were defined as; "all created or evolved routes that are greater than 500 feet long and are reasonably and prudently driveable with a conventional passenger car or pickup." Trails were defined as; "all created or evolved access routes that do not qualify as a road. Trails are not reasonably and prudently driveable with a conventional passenger car or pickup." All travel routes were mapped and classified into one of the following categories (Table 1):

1. <u>Impassable roads</u> - Roads that are not reasonably or prudently passable by conventional 4 wheeled passenger vehicles, motorcycles, or all-terrain vehicles;
2. <u>Restricted roads</u> - Roads that are legally restricted, typically with gates. Administrative use may occur;
3. <u>Barriered roads</u> - Roads legally restricted with permanent barriers, typically in the form of berms or rocks. No administrative use is permitted;
4. <u>Open roads</u> - Roads open to motorized use during any portion of the active bear season;
5. <u>Open motorized trails</u> - Trails that are passable by motorcycles or all-terrain vehicles and are not legally restricted;
6. <u>Open nonmotorized trails</u> - Trails that are not reasonably or prudently passable by motorcycles or all-terrain vehicles, but are not legally restricted;
7. <u>Low use nonmotorized trails</u> - Trails that are legally restricted to all motorized vehicles and receive 20 or fewer parties per week of use;
8. <u>High use nonmotorized trails</u> - Trails that are legally restricted to all motorized vehicles and receive greater than 20 parties per week of use.

For purposes of analysis, 3 categories of access were of interest. Specifically, these were the amount of open roads or trails that provided motorized access with no restrictions, the amount of total roads that had some level of access unimpeded by vegetation, and the amount of area within the home range but outside the zone of influence of any road with motorized access. Therefore, the following definitions were used initially in this report: Open roads = 4 and 5; Total roads = 2, 3, 4, and 5; and Core = area > 0.31 mi from 2, 4, 5, and 8. Core was defined as area outside the zone of influence (0.31 mile) of any open road, gated road, motorized trail, or high use nonmotorized trail (IGBC 1994).

The effectiveness of road closures such as gates has been questioned (Platt 1992). This issue was not addressed in this analysis because there was no accurate database available for our study areas that corresponded with the time of sampling and this issue was not part of our objectives.

Road Density Calculations

All roads were digitized in a vector format. It was necessary to convert these to a raster format to conduct the moving window analysis. In this ARCINFO conversion, a 30 x 30 m grid was superimposed on the vector map. Any cell that contained a line segment was considered a road cell and any empty cell was considered roadless. There is an "expansion" of road length calculations during this conversion process. Therefore, we calculated a "correction factor" based on the length of roads in the vector format (considered to reflect the true length of roads) divided by the length of roads in the raster format. For example, if 100 mi of road existed in vector format and 120 mi in raster format, the correction factor would be 100/120 or 0.83. On these study areas the correction factor was 0.805.

We used a "moving window" GIS modeling routine in ARCINFO to convert the linear road maps into a map of road densities based on a 30 x 30 m pixel (cell) size. Effective road density around each pixel was determined by calculating the amount of road within 1 mi^2 around each pixel. A circular "window" 1 mi^2 in size (900 meter radius) was centered on each pixel and the amount of road within this area was computed. This window size was selected for two reasons: 1) Ease of interpretation. The USFS has used road densities expressed in mi/mi^2 in calculating current grizzly bear access standards and the public has a "feel" for road densities expressed in mi/mi^2. Therefore, there is currently a reference point with which agencies and the public can use to measure results of this analysis. 2) Comparability. Moving window results have previously been reported in mi/mi^2 and other units of measure (i.e., km/km^2) would not allow comparisons.

Table 1. Lengths of access routes within road analysis study areas.

	Miles of access routes within a study area		
Access type	North Selkirks	South Selkirks	Yaak
Open roads	480.7	296.6	296.6
Restricted roads	n/a	115.4	136.0
Restricted barriered roads	n/a	68.4	124.9
Impassable roads	n/a	124.2	8.2
Motorized trails	n/a	0	30.7
Restricted motorized trails	n/a	0	102.8
High use nonmotorized trails	n/a	0	0
Low use nonmotorized trails	n/a	n/a	n/a

Home Range

We used CALHOME computer software to calculate 95% utilization isopleth home ranges for individual female bears using the adaptive kernel estimator as described by Worton (1987). Radiolocations averaged 8.3 $\pm$ 5.1 days apart ($\pm$ C.I.) in the SMGBE. Radiolocations averaged 4.7 $\pm$ 0.29 days apart for females and 5.1 $\pm$ 0.43 days apart for males in the CYGBE. Given the movement potential of grizzly bears, this time span between locations was deemed to be statistically independent as suggested by White and Garrott (1990). All locations were obtained from aircraft during daylight hours, primarily in the morning. The time span over which home ranges were calculated varied, depending on the duration of monitoring for each bear. Only independent animals were included in home range analysis; young bears still dependent on their mother were eliminated from analysis.

Use/Availability Analysis

"Available" habitat for this analysis was determined by generating home ranges for female grizzly bears that were included in the analysis. Individual home ranges were then layered on top of one another. The resulting cumulative area was considered to be available to Selkirk and Cabinet-Yaak grizzly bears (i.e., because at least one female grizzly bear occurred, it was assumed that the area contained suitable habitat and that all bears had the option of also occupying that location).

"Use" was defined by the specific telemetry locations of radiomarked grizzly bears. All grizzly bear locations within the "available" area were superimposed on the map and assigned to a road density class corresponding to the cell under the location.

Use and availability analysis was used to examine the relative effect of each road type on grizzly bear habitat use patterns. Open roads, gated roads, barriered roads, and vegetated roads were the subject of analysis. Each road type was buffered by 500 meters and proportions of radiolocations occurring within these zones were compared to the percentage of area occurring within each buffer zone as well as unroaded areas. Buffer zones were established in order based upon an ascending level of human use: (1) vegetated roads, (2) barriered roads, (3) gated roads, (4) open roads. Therefore the buffer zone from open roads superceded all other road types where they adjoined. This analysis was conducted on the composite female home range and individual female home ranges.

Preference or avoidance for or against road density classes or core habitat was calculated using a Chi-square (X^2) test and Bonferroni confidence intervals as described by Neu et al. (1974). This compares the goodness of fit of used versus available road density categories or core habitat. The test was first conducted to see if there was a difference between use and availability ($p \leq 0.10$). If a difference was detected, we then used 90% Bonferroni confidence intervals to determine which of the categories were used more than expected and which were used less than expected. This analysis was conducted on total road density, open road density, and core habitat.

For both total and open road density calculations the following categories were used: 0, >0.0-1.0, >1.0-2.0, >2.0 mi/mi^2. We also conducted total road density analysis with barriered roads removed from the data base to investigate the influence of barriered roads on preference/avoidance.

Core was defined as area outside the zone of influence (0.31 mi) of any open road, gated road, motorized trail, or high use nonmotorized trails (IGBC 1994). Roads can exist inside core area, but require closure devices that are permanent such as earth berms, large boulders, or dense vegetation.

For the SMGBE only adult females were included in the analysis. In the CYGBE we had telemetry information on only 2 female grizzly bears. One bear was a subadult for most of the monitoring period. We included data from 2 male grizzly bears in the CYGBE in an effort to aid interpretation of road use data. All comparisons were considered significantly different at $P \leq 0.10$.

Assumptions and Data Limitations

Numerous assumptions and data limitations are inherent in this analysis and must be considered in its interpretation. These include: (1) Grizzly bears used in this analysis were assumed representative of the population. (2) Radiolocations were assumed representative of grizzly bear habitat use patterns. (3) Information on habitat features such as topography, vegetation, or food availability was not available for all portions of the study areas. (4) Information on road closure effectiveness was not available and we assumed all closures to be effective. (5) Seasonality of access route closures was not considered because of small sample sizes. (6) Information on levels of human use of access routes was not available. (7) The base year for study area road maps was assumed representative for all years of radiolocations analyzed.

RESULTS

Distribution of Radiolocations

Radiolocations from each recovery zone were summarized by month to examine seasonal distribution of the sample (Table 2). Variable dates of den entry and exit produced some variation at the extremes of the sample period. The months of May through October produced fairly balanced samples for most study areas with the exception of females in the North Selkirk study area. Average days between radiolocations on the Selkirk study areas was 8.3 $\pm$ 5.1. Average days between radiolocations on the Yaak study area was 4.7 $\pm$ 0.29 for females and 5.1 $\pm$ 0.43 for males.

Table 2. Monthly distribution of radiolocations from Selkirk and Yaak study areas, 1989-1994.

			Percentage of radiolocations									
Study Area	Sex	*n*[a]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Selkirk	Female	360	0.0	9.5	10.3	18.2	18.4	15.3	14.1	9.8	4.3	0.0
South Selkirk	Female	117	0.0	10.9	6.9	12.0	12.0	16.0	19.4	15.4	6.9	0.6
Yaak	Female	312	0.3	5.1	14.7	14.7	15.7	15.1	17.6	11.9	4.2	0.6
	Male	182	0.0	8.8	13.7	14.3	15.9	15.4	16.5	11.0	4.9	1.6

[a]Sample size may vary in later calculations because of adaptive kernel home range estimation and study area boundaries.

Home Range

Complete home range information is provided in Appendix B. Percent of the cumulative home range and the individual home ranges in various ownerships is presented in Table 3.

Table 3. Ownership for grizzly bear home ranges from Selkirk and Yaak study areas, 1989-1994.

		Percent Ownership			
Area	Bear	Federal	State	Private[a]	Canadian
South Selkirk	Cumulative	55.2	21.7	3.3	19.8
	867	60.6	30.2	2.7	6.4
	1015	42.8	4.5	1.3	51.4
	1084	51.6	44.4	4.0	0.0
	1087	76.5	15.2	5.6	2.7
Yaak	Cumulative	73.9	0	1.2	24.9
	106	98.3	0	1.7	0
	206	69.3	0	1.5	29.2

Use/Availability Analysis of Road Type

The relative effect of road type on grizzly bear habitat use patterns was analyzed with use and availability statistics. Each road type was buffered by 500 meters and the area of each zone was compared to the proportion of radiolocations occurring in that zone.

Selkirk and Yaak study areas provided similar results with unroaded areas used greater than expected and zones around open roads used less than expected (Table 4). Vegetated, barriered, and gated road zones were not significantly different from availability. However use of vegetated and barriered roads was 51-106% greater than availability for both study areas, while use of gated roads was 10% less to 32% greater than availability. This would indicate that most influences of roads on bears are from open roads. Although sample sizes are small, bear response to vegetated and barriered roads appears more similar to unroaded habitat than bear response to gated roads.

Of 6 individual female bears used in this analysis, 3 used area around open roads less than expected and 1 used unroaded area more than expected (Table 5). One female used area around a vegetated road less expected. All other categories received use that was not significantly different from expected.

Table 4. Percentages of use and availability of road types buffered by 500 meters for grizzly bears in the South Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

		Road category buffered by 500 meters (percent)				
Area	Category	Unroaded	Vegetated	Barriered	Gated	Open
South Selkirk	Availability	47.0	4.8	3.7	9.9	34.6
4 bears, n=111 locations	Female use	60.4 (+)	9.9	7.2	9.0	13.5 (-)
	90% CI	49.6-71.2	3.3-16.5	1.5-12.9	2.7-15.3	6.0-21.1
Yaak	Availability	32.2	6.2	5.5	9.0	47.1
2 bears, n=302 locations	Female use	37.1	9.6	8.3	11.9	33.1 (-)
	90% CI	30.6-43.6	5.7-13.5	4.6-12.0	7.6-16.3	26.8-39.4
2 bears, n=87 locations	Male use	52.9 (+)	9.2	3.4	4.6	29.9 (-)
	90% CI	40.4-65.3	2.0-16.4	0.0-8.0	0.0-9.8	18.5-41.3

Table 5. Percentages of road types buffered by 500 meters available (A) within individual home ranges of female radiomarked grizzly bears, Selkirk and Yaak study areas, 1989-1994. A (+) following the use category indicates use (U) significantly greater than available and a (-) indicates use significantly less than available.

		Road category buffered by 500 meters (percent)				
Area	Bear	Unroaded	Vegetated	Barriered	Gated	Open
South Selkirk	867 A	43.5	7.1	6.5	14.7	28.2
	867 U	55.9	20.6	8.8	11.8	2.9 (-)
	90% CI	36.1-75.7	4.5-36.7	0.0-20.1	0.0-24.6	0.0-9.7
	1015 A	43.3	6.7	4.6	9.3	36.1
	1015 U	69.8 (+)	2.3	7.0	4.7	16.3 (-)
	90% CI	53.5-86.1	0.0-7.70	0.0-16.0	0.0-12.1	3.2-29.4
	1084 A	62.5	6.9	3.0	9.4	18.3
	1084 U	73.7	0.0 (-)	5.3	10.5	10.5
	90% CI	50.2-97.2	0.0-0.5	0.0-17.2	0.0-26.9	0.0-26.9
	1087 A	36.1	12.2	5.4	11.2	35.1
	1087 U	26.7	20.0	6.7	13.3	33.3
	90% CI	0.1-53.2	0.0-44.0	0.0-21.6	0.0-33.8	5.0-61.6
Yaak	106 A	38.8	7.7	6.6	13.1	33.9
	106 U	45.1	11.1	11.8	13.1	19.0 (-)
	90% CI	35.7-54.5	5.2-17.0	5.7-17.8	6.7-19.4	11.6-26.3
	206 A	29.0	5.7	5.1	8.9	51.3
	206 U	28.7	8.4	4.9	10.5	47.6
	90% CI	19.9-37.5	3.0-13.8	0.7-9.1	4.5-16.5	37.8-57.3

Total Road Use/Availability Analysis

Comparisons of grizzly bear use of total road density categories to availability produced similar results in all study areas (Table 6). Bears exhibited greater than expected use of the roadless category and less than expected use of total road densities greater than 2 mi/mi^2. All other categories received use that was not significantly different from expected.

Of 13 female bears examined for total road density use, roadless habitat was used greater than expected by 4 bears (Table 7). Five bears used the >2 mi/mi^2 class less than expected. No animals used total road densities <1 mi/mi^2 less than expected or used total road densities >1 mi/mi^2 greater than expected.

Table 6. Percentages of use and availability of total road density categories for grizzly bears in Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

		Total road density classes (percent)			
Area	Category	0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
North Selkirk	Availability	32.5	21.2	21.3	24.9
7 bears, n=335 locations	Female use	45.1 (+)	23.6	19.1	12.2 (-)
	90% CI	39.0-51.2	18.4-28.8	14.3-23.9	8.2-16.3
South Selkirk	Availability	33.9	15.7	17.8	32.5
4 bears, n=111 locations	Female use	52.3 (+)	16.2	14.4	17.1 (-)
	90% CI	41.6-62.9	8.4-24.1	6.9-21.9	9.1-25.1
Yaak	Availability	23.0	14.5	19.2	43.3
2 bears, n=302 locations	Female use	29.5 (+)	14.2	19.9	36.4 (-)
	90% CI	23.6-35.4	9.7-18.7	14.7-25.0	30.2-42.6
2 bears, n=87 locations	Male use	36.8 (+)	21.8	23.0	18.4 (-)
	90% CI	25.2-48.4	11.9-31.8	12.9-33.1	9.1-27.7

Table 7. Percentages of total road density classes available (A) within individual home ranges of female radiomarked grizzly bears, Selkirk and Yaak study areas, 1989-1994. A (+) following the use category indicates use (U) significantly greater than available and a (-) indicates use significantly less than available.

Area	Bear	0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
North Selkirk	1044 A	50.3	21.1	18.4	10.3
	1044 U	58.8	17.6	23.5	0 (-)
	90% CI	32.1-85.6	0.0-38.4	0.1-46.6	0.0-0.1
	1045 A	39.0	19.9	19.7	21.4
	1045 U	46.5	18.6	18.6	16.3
	90% CI	29.5-63.6	5.3-31.9	5.3-31.9	3.7-28.9
	1047 A	27.9	19.8	21.2	31.2
	1047 U	63.0 (+)	22.2	7.4 (-)	7.4 (-)
	90% CI	42.1-83.8	4.3-40.2	0.0-18.7	0.0-18.7
	1048 A	26.7	27.9	20.7	24.7
	1048 U	26.3	39.5	18.4	15.8
	90% CI	15.0-37.6	26.9-52.0	8.5-28.4	6.4-25.2
	1056 A	40.3	20.5	22.7	16.4
	1056 U	69.5 (+)	11.9	13.6	5.1 (-)
	90% CI	56.1-82.9	2.4-21.3	3.6-23.5	0.0-11.5
	1075 A	32.7	22.9	20.2	24.2
	1075 U	44.6	25.0	16.1	14.3
	90% CI	29.8-59.5	12.0-38.0	5.1-27.1	3.8-24.8
	1076 A	32.3	20.9	20.2	26.6
	1076 U	31.6	19.3	33.3	15.8
	90% CI	17.8-45.4	7.6-31.0	19.3-47.3	5.0-26.6
South Selkirk	867 A	30.0	16.3	16.7	36.9
	867 U	55.9 (+)	14.7	11.8	17.6 (-)
	90% CI	36.8-75.0	1.1-28.3	0.0-24.1	3.0-32.3
	1015 A	31.5	17.0	18.6	32.9
	1015 U	48.8 (+)	20.9	11.6	18.6 (-)
	90% CI	31.8-65.9	7.0-34.8	1.0-22.6	5.3-31.9
	1084 A	55.4	14.3	10.9	19.3
	1084 U	68.4	15.8	5.3	10.5
	90% CI	44.5-92.3	0.0-34.5	0.0-16.7	0.0-26.3
	1087 A	31.0	16.4	21.1	31.4
	1087 U	33.3	6.7	40.0	21.1
	90% CI	6.1-60.6	0.0-21.1	11.6-68.4	0.0-43.1
Yaak	106 A	32.3	13.5	17.1	37.1
	106 U	38.6	15.7	16.3	29.4
	90% CI	29.7-47.4	9.1-22.3	9.6-23.0	21.2-37.7
	206 A	18.9	14.8	20.0	46.4
	206 U	19.3	13.1	24.1	43.4
	90% CI	12.0-26.7	6.8-19.4	16.2-32.1	34.2-52.7

Total Road Use/Availability with Barriered Roads Removed

Comparisons of grizzly bear use of total road density categories to availability when barriered roads were removed from the data base produced similar results in the south Selkirks and Yaak (Table 8). The northern Selkirks were not included in this analysis because of the lack of a detailed roads data base.

Bears used the 0 mi/mi^2 road category more than expected. Females in the south Selkirks and males in the Yaak used road densities of >2 mi/mi^2 less than expected. All other categories received use that was not significantly different from expected.

Of 6 individual female bears used in this analysis, 3 used total road densities >2 mi/mi^2 less than expected (Table 9). Three females used the roadless category more than expected. One female used the 1-2 mi/mi^2 less than expected. All other categories received use that was not significantly different from expected.

Table 8. Percentages of use and availability of total road density categories (without barriered roads) for grizzly bears in Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

		Total road density (without barriers) classes (percent)			
Area	Category	0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
South Selkirk	Availability	37.0	17.2	19.4	26.4
4 bears, n=111 locations	Female use	55.5 (+)	20.9	16.4	7.3 (-)
	90% CI	44.8-66.1	12.2-29.6	8.5-24.3	1.7-12.8
Yaak	Availability	26.8	16.4	21.7	35.1
2 bears, n=302 locations	Female use	36.4 (+)	16.6	16.9	30.1
	90% CI	30.2-42.6	11.8-21.4	11.8-21.7	24.2-36.1
2 bears, n=87 locations	Male use	44.8 (+)	18.4	20.7	16.1 (-)
	90% CI	32.9-56.8	9.1-27.7	11.0-30.4	7.3-24.9

Table 9. Percentages of total road density classes (without barriered roads) available (A) within individual home ranges of female radiomarked grizzly bears, Selkirk and Yaak study areas, 1989-1994. A (+) following the use category indicates use (U) significantly greater than available and a (-) indicates use significantly less than available.

		Total road density (without barriers) classes (percent)			
Area	Bear	0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
South Selkirk	867 A	35.6	18.9	19.4	25.1
	867 U	55.9(+)	26.5	14.7	2.9(-)
	90% CI	36.8-75.0	9.5-43.4	1.1-28.3	0.0-9.4
	1015 A	34.9	18.3	19.5	27.3
	1015 U	55.8(+)	20.9	11.6	11.6(-)
	90% CI	38.8-72.8	7.0-34.8	0.7-22.6	0.7-22.6
	1084 A	56.8	15.5	13.5	14.3
	1084 U	68.4	15.8	5.3	10.5
	90% CI	44.5-92.3	0.0-34.5	0.0-16.7	0.0-26.3
	1087 A	34.9	18.7	22.6	23.8
	1087 U	33.3	13.3	46.7	6.7(-)
	90% CI	6.1-60.6	0.0-33.0	17.8-75.5	0.0-21.1
Yaak	106 A	38.4	13.7	20.2	27.7
	106 U	51.6 (+)	16.3	10.5 (-)	21.6
	90% CI	42.6-60.7	9.6-23.0	4.9-16.0	14.1-29.0
	206 A	21.7	17.3	22.8	38.2
	206 U	20.0	17.2	24.1	38.6
	90% CI	12.6-27.4	10.2-24.3	16.2-32.1	29.6-47.7

Open Road Use/Availability Analysis

Open road density was not calculated for the northern Selkirk study area because attributing of the road database was incomplete. Therefore we could not determine which roads might be restricted and whether a restriction included a gate or a permanent barrier.

Comparisons of grizzly bear use of open road density categories to availability produced greater than expected use of the 0 mi/mi^2 by bears in both the South Selkirk and Yaak study areas (Table 10). Selkirk bears exhibited less than expected use of open road densities in excess of 1 mi/mi^2. Female and male grizzly bears in the Yaak area used areas with open road densities greater than 2 mi/mi^2 less than expected. All other categories received use that was not significantly different from expected.

Of the 6 female bears examined for open road density use, the 0 mi/mi^2 open road class was used greater than expected by 2 individuals (Table 11). Two bears exhibited less than expected use of the 1-2 mi/mi^2 class and 4 bears used the > 2 mi/mi^2 class less than expected. No animals used open road densities of 0 mi/mi^2 less than expected or used open road densities >1 mi/mi^2 greater than expected.

Table 10. Percentages of use and availability of open road density categories for grizzly bears in Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

Area	Category	Open road density classes (percent)			
		0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
South Selkirk	Availability	49.4	16.0	17.6	16.9
4 bears, n=111 locations	Female use	73.6 (+)	10.9	10.0 (-)	5.5 (-)
	90% CI	64.2-83.1	4.2-17.6	3.6-16.4	0.6-10.3
Yaak	Availability	34.9	17.8	21.4	25.9
2 bears, n=302 locations	Female use	48.0 (+)	17.5	20.2	14.2(-)
	90% CI	41.6-54.5	12.6-22.5	15.0-25.4	9.7-18.7
2 bears, n=87 locations	Male use	52.9 (+)	19.5	16.1	11.5 (-)
	90% CI	40.9-64.9	10.0-29.1	7.3-24.9	3.8-19.2

Table 11. Percentages of open road density classes available (A) within home ranges of radiomarked grizzly bears, Selkirk and Yaak study areas, 1989-1994. A (+) following the use category indicates use (U) significantly greater than available and a (-) indicates use significantly less than available.

Area	Bear	Open road density classes (percent)			
		0 mi/mi^2	0-1 mi/mi^2	1-2 mi/mi^2	> 2 mi/mi^2
South Selkirk	867 A	55.3	16.6	15.5	12.6
	867 U	88.2 (+)	8.8	2.9 (-)	0 (-)
	90% CI	75.4-100	2.5-20.1	0.0-9.7	0-0
	1015 A	50.3	14.1	14.8	20.1
	1015 U	65.1	16.3	7.0	11.6
	90% CI	48.2-82.0	3.2-29.4	0.0-16.0	0.3-23.0
	1084 A	70.4	13.0	10.0	6.7
	1084 U	78.9	5.3	10.5	5.3
	90% CI	57.2-100	0.0-17.2	0.0-26.9	0.0-17.2
	1087 A	50.0	14.5	19.5	15.9
	1087 U	57.1	7.1	35.7	0 (-)
	90% CI	26.4-87.9	0.0-23.2	5.9-65.5	0-0
Yaak	106 A	50.6	14.9	18.5	16.0
	106 U	67.3 (+)	14.4	10.5 (-)	7.8 (-)
	90% CI	58.8-75.8	8.0-20.7	4.9-16.0	3.0-12.7
	206 A	29.6	18.9	22.5	29.0
	206 U	27.6	20.7	30.3	22.5(-)
	90% CI	19.3-35.9	13.1-28.2	21.8-38.9	13.7-29.0

Core Habitat Use/Availability Analysis

Core habitat calculations were made on the south Selkirk and Yaak study areas only. Core habitat was defined as areas greater than 0.31 mi from open roads or roads that do not have permanent closures (IGBC 1994).

Comparisons of grizzly bear use of core habitat produced identical relationships in both study areas (Table 12). Bears used core habitat greater than expected and used non-core habitat less than expected.

Six female grizzly bear home ranges were analyzed for core habitat use patterns (Table 13). Three of these females used core habitat greater than expected and non-core habitat less than expected. No individuals used core habitat less than expected or non-core more than expected.

Table 12. Percentages of use and availability of core habitat for grizzly bears in Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

Area	Category	Core	Non-core
South Selkirk	Availability	54.6	45.4
4 bears, n=111 locations	Female use	77.5 (+)	22.5 (-)
	90% CI	69.7-85.2	14.8-30.3
Yaak	Availability	44.1	55.9
2 bears, n=302 locations	Female use	55.0 (+)	45.0 (-)
	90% CI	49.4-60.6	39.4-50.6
2 bears, n=87 locations	Male use	66.7 (+)	33.3 (-)
	90% CI	56.8-76.6	23.4-43.2

Table 13. Percentages of core habitat available (A) within home ranges of radiomarked grizzly bears,

Selkirk and Yaak study areas, 1989-1994. A (+) following the use category indicates use (U) significantly greater than available and a (-) indicates use significantly less than available.

Area	Bear	Core	Non-core
South Selkirk	867 A	55.3	44.7
	867 U	85.2 (+)	14.3 (-)
	90% CI	73.4-97.2	2.8-26.6
	1015 A	53.4	46.6
	1015 U	79.1 (+)	20.9 (-)
	90% CI	66.9-91.2	8.8-33.1
	1084 A	71.5	28.5
	1084 U	78.9	21.1
	90% CI	60.6-97.3	2.7-39.4
	1087 A	53.7	46.3
	1087 U	53.3	46.7
	90% CI	28.1-78.6	21.4-71.9
Yaak	106 A	53.3	46.7
	106 U	68.0 (+)	32.0 (-)
	90% CI	60.6-75.4	24.6-39.4
	206 A	40.0	60.0
	206 U	42.0	58.0
	90% CI	33.9-50.0	50.0-66.1

The South Selkirk study area was divided among 52 polygons of which 42 were classified as core and 10 were non-core habitat (Table 14). Of 10 polygons that had at least one radiolocation, 6 were in core habitat. Core habitat polygons used by female bears ranged from 0.22-124.3 mi^2 , but 94% of female radiolocations occurring in core habitat were in polygons greater than 4.0 mi^2 and 88% of locations occurred in polygons greater than 10.0 mi^2 . Core polygons without radiolocations ranged in size from 0.00005-4.06 mi^2 .

The Yaak study area was divided among 81 polygons of which 73 were classified as core and 8 were non-core habitat (Table 14). Radiolocations from female bears occurred in 18 core polygons that were 0.14-43.03 mi^2 . Ninety-four percent of locations from female bears were in core polygons greater than 3.0 mi^2 and 89% of locations occurred in polygons greater than 4.0 mi^2 . Male radiolocations occurred in 9 core habitat polygons that ranged in size from 3.1-43.03 mi^2 . No locations occurred in core polygons less than 3.0 mi^2 and 90% of locations occurred in polygons greater than 4.0 mi^2 . Core polygons without radiolocations ranged in size from 0.0003-2.61 mi^2 .

Analysis of use and availability was conducted on 6 categories of polygon size to determine if there was a minimum size polygon that grizzly bears would utilize or could be detected (Table 15). Though few statistical differences occurred in the samples, both study areas produced similar trends. Female use percentages from the Selkirks and the Yaak were less than 50% of expected values for the 0-2 mi^2 category. The difference between use and availability was less at 2-4 mi^2, and increased again at 4-6 mi^2 and at 6-8 mi^2 before use percentages exceeded availability in the 8-10 mi^2 and >10 mi^2 categories. The only statistically significant difference for females occurred in the Yaak study area where use was greater than availability for core polygons of 8-10 mi^2.

Table 14. Number and size of core and non-core polygons within the South Selkirk and Yaak study areas.

	South Selkirks		Yaak	
	Number	Size (mi^2)	Number	Size (mi^2)
Total polygons	52	0.00005-124.3	81	0.003-215.49
Core polygons	42	0.00005-124.3	73	0.003-43.03
Non-core polygons	10	0.009-83.5	8	0.003-215.49
Core polygons with radiolocations	6	0.22-124.3	18	0.14-43.03
Core polygons with female radiolocations	6	0.22-124.3	18	0.14-43.03
Core polygons with male radiolocations			9	3.1-43.03

Table 15. Percentages of use and availability of core polygon categories for grizzly bears in Selkirk and Yaak study areas. A (+) following the use category indicates use significantly greater than available and a (-) indicates use significantly less than available.

		Core polygon size classes					
Area	Category	0-2 mi^2	2-4 mi^2	4-6 mi^2	6-8 mi^2	8-10 mi^2	> 10 mi^2
South Selkirk	Availability	4.7	4.7	4.5	0	5.2	80.9
n=86	Female use	1.2	4.7	0	0	5.8	88.4
Yaak	Availability	5.9	10.2	2.3	4.2	4.9	72.4
n=164	Female use	3.0	7.9	1.2	0.6	12.8 (+)	74.4
n=87	Male use	0 (-)	10.3	0 (-)	0 (-)	8.6	81.0

DISCUSSION

Human use of roads has negatively impacted and continues to impact large carnivore and ungulate populations. Roads can affect populations in at least 2 ways; by displacing animals from otherwise suitable habitat because of high levels of disturbance and by increased human access resulting in higher mortality from hunting, illegal killing, and removal due to habituation.

Human use of roads appears to influence bear distribution in our study areas. In this study, bears used areas of high road density less than expected. In all areas, total road density >2 mi/mi^2 was used less than expected. In the south Selkirks, females used open road densities >1 mi/mi^2 less than expected while females and males in the Yaak ecosystem used areas of >2 mi/mi^2 of open road density less than expected. Use of core areas parallel that of total and open road use. Bear use consistently occurred in core area while avoiding non-core habitat.

Our results indicate that open roads have the greatest influence on grizzly bear distribution and therefore must be considered in any access management decision. Core area (areas with no open or gated roads) were also strongly preferred by bears and should also be included in any access management decisions. Use/availability results regarding vegetated, barriered, and gated roads were not statistically significant, but appeared to indicate greater use of vegetated and barriered roads which lacked any motorized use. Use of vegetated and barriered roads was 51-106% greater than availability for both study areas, while gated roads received 10-32% less use than expected. Vegetated roads are currently not included in total road calculations. Given these results, it may be appropriate to remove barriered roads from total road calculations as well. Inclusion of barriered roads may mask or dilute the true influence of open and gated roads in a use/availability analysis. We have presented total road calculations with and without barriered roads for comparative purposes.

Our attempt at identifying a useful minimum core polygon size was hampered by small sample sizes. We suggest that if a minimum size occurs, it is likely between 2 mi^2 and 8 mi^2. Furthermore we believe that narrow strips of core habitat that may fit some minimum size criteria likely will not provide effective core habitat for bears.

While small sample sizes likely affected our ability to detect some differences that may have been present, it is important to note that use patterns were consistent throughout the study. In no cases, either in pooled data or when investigating individual home range use, did results indicate a higher than expected use of highly roaded areas (>2 mi/mi^2) or a lower than expected use of low road densities (<1 mi/mi^2). Furthermore, comparison of the results for adult female 106 in the Yaak study area to the Selkirks indicated identical use patterns for open road classes and core habitat.

Interpretation of our results must consider the design of our use/availability analysis. Selection of an area of use by grizzly bears in relation to human access has several hierarchical levels (Mace et al, in press). We did not examine grizzly bear use patterns of roaded environments across the entire ecosystem to determine if bears selected home ranges in less roaded areas (first order selection). Rather, we identified patterns of greater or lesser than expected use within existing home ranges of bears relative to access route density (second order selection). The test of first order selection would have required a complete access route map for these ecosystems during the monitoring period. Accurate mapping on this scale was not within logistic constraints of this study.

Interpretation of information presented in this report must also consider the small sample sizes involved. These concerns relate not only to number of locations for each bear monitored, but also total number of bears monitored. Results for open road and core area analysis are based on 6 female grizzly bears. Two of those bears were killed by humans after the period they were monitored for this report (867 and 1015). The female bears from the Yaak area have a mother-daughter relationship. The daughter was only 6 years-old in 1994 when she produced her first litter of cubs and much of the location data was from a time when she was establishing a home range as a 3-5 year-old. Subadult female home ranges are known to decline in size as they approach reproductive age (Knight et al. 1984). Use of specific areas within the home range are likely to change as a product of learning. The mother in this association has produced 5 litters totaling 11 cubs during 1986-96. At least 9 of 18 bears captured in this ecosystem are related to this individual.

Several factors that may affect grizzly bear use of roaded habitats were not evaluated in this analysis. Vegetation and associated foods can affect distribution of bears and might therefore affect patterns of use. Habitat and food distribution maps were not complete for both ecosystems. A vegetation map exists for the U.S. portion of the CYGBE and will be analyzed at a later date (Tanimoto 1996). Efforts are under way in the SMGBE to investigate use patterns in relation to habitats as well. Levels of human use on roads could influence grizzly bear use of these areas, but this information was not available for analysis.

Daily use patterns of bears could affect results from this analysis. All radiolocations were obtained during daylight hours and were primarily made during the morning hours because of air conditions and flight safety. If bears made use of roaded areas during the hours of darkness, our samples could be biased. Twenty-four hour activity monitoring of bears has been conducted in both study areas. In the Selkirk Mountains there appeared to be 2 major peaks in activity, occurring from 0600 till 1000 hours and from 1700 till 2100 hours. The least active period lasted from 0100 to 0400 hours (Latour and Van Miltenburg 1988). Similar activity patterns were recorded in the Cabinet Mountains (Kasworm and

Manley 1990). Eight of 14 24-hour monitoring sessions were characterized as diurnal, 3 were crepuscular, and 3 were nocturnal. Two of the nocturnal sessions occurred among male bears during late October following the start of hunting season.

Studies from other areas have produced similar results. In the North Fork of the Flathead River of south east British Columbia 24-hour monitoring indicated that bears were active mostly in the daylight hours with peaks in the morning and evening (McCann 1991). Bears appeared to make greater use of the hours of darkness during fall. In the South Fork of the Flathead River bears were strongly diurnal during all seasons with very little activity during the night (E.A. Wenum Pers. Comm.). Bears along the East Front of north-central Montana had variable activity peaks depending upon their home ranges (Aune and Kasworm 1989). Backcountry bears were more likely to be active during the daylight hours and lowland bears were more likely to be active during the hours of darkness.

These studies would indicate that bears were much less likely to be active during the hours of darkness and daytime radiolocations would likely sample times when bears were foraging. We therefore believe that a lack of monitoring during the hours of darkness did not bias the results of our analysis.

Road influences on grizzly bears in the Cabinet Mountains have been previously investigated (Kasworm and Manley 1990). That report focused on use/availability analysis of influence zones around roads and found that bears used habitat within 0.57 mi of open roads less than expected. These results are consistent with our findings.

A similar moving window, univariate analysis of road density and grizzly bear use patterns was conducted in the South Fork of the Flathead River (Mace and Manley 1993). Their analysis resulted in similar patterns of grizzly bear distribution in relation to road densities. As in this study, they found less than expected use of total road densities in excess of 2 mi/mi^2 of total roads and less than expected use of open road densities in excess of 1 mi/mi^2 of open roads by adult female grizzly bears.

Even though bears appeared to respond to similar road densities, the percentage of the home range of different road categories varied (Table 16). South Fork bears had a larger percentage of their home range comprised of areas with no motorized access (core) and a smaller percentage of their home range was made up of the higher road densities.

Table 16. A comparison of the composition of female cumulative home ranges in relation to total and open road densities and core area; South Fork of the Flathead, Selkirk, and Yaak study areas.

		Percent of female cumulative home ranges		
Category	Standard	South Fork[a]	Selkirk	Yaak
Total Roads	>2.0 mi/mi^2	19	32.5	43.3
Open Roads	>1.0 mi/mi^2	19	34.5	47.3
Core	% home range	68	54.6	44.1

[a] taken from Flathead National Forest Plan Amendment #19 (USFS 1995).

There are many possible explanations for the observed differences. Perhaps bears in the Selkirk and Yaak study areas had no areas available to them which would allow for larger core areas or significant areas with lower road densities. Without a comparison of a large area (first order selection) we will not be able to answer that question.

Another explanation may have to do with the computer packages used to conduct the analyses. Our study used ARCINFO, where the South Fork study used EPPL7 software. Different programs result in slightly different values, especially in the vector-to-raster conversion.

Levels of human use on the roads may also affect bear distribution. If there were consistently higher human use levels in the South Fork study area, bears may more strongly avoid roads. Habitat differences and juxtaposition of roads to quality habitat may further affect bear distribution. A multivariate analysis of the same data indicated that habitat quality and levels of human use on roads can also affect bear distribution (Mace et al. In press.). Greater bear density within the South Fork study area may also influence bear behavior in relation to roads.

We will likely not know all reasons for the differences in results among these study areas. However, we feel the results presented here best describe grizzly bear distribution in relation to roads for the Selkirk and Yaak study areas.

RECOMMENDATIONS

1. Common access standards should be adopted between the Cabinet-Yaak and Selkirk ecosystems. Given the similar patterns of grizzly bear use in relation to human access and the small sample sizes involved, we foresee no reason to develop separate access management standards for the Selkirk and Cabinet-Yaak ecosystems. Development of a single set of access standards would provide administrative simplicity, and be biologically sound for these ecosystems which are less than 15 mi apart at their closest point and possess similar habitat.

2. Access standards should be conservative and promote recovery of the small populations of grizzly bears inhabiting these ecosystems. Both of these grizzly bear ecosystems are currently listed as threatened populations. Grizzly bear population estimates are 45-55 for the Selkirks and 30-40 for the Cabinet-Yaak. Both populations were petitioned for uplisting to endangered status. The U.S. Fish and Wildlife Service responded with findings of not warranted in the Selkirks and warranted but precluded because of other listing actions in the Cabinet-Yaak. These factors emphasize the need for conservative management designed to provide habitat for a recovered population of grizzly bears.

3. Use and availability statistics in this report should be used to assist development of access standards. Statistics regarding use and availability can provide a basis for development of standards, but survival and reproductive success must be considered when selecting animals or results which may be the basis for standards.

4. Techniques involving methodology and computer software must be standardized. Techniques of analysis for this report were similar to those employed in the South Fork of the Flathead River, but there were differences in computer software used (Mace and Manley 1993, USFWS 1993). Standardization of techniques across all ecosystems is necessary for purposes of biological comparisons, ease of application by the agencies involved, and improved understanding by the public.

5. Road information from all portions of the ecosystems, including adjacent areas in Canada, needs to be completed and resulting databases should be standardized. All portions of the ecosystems need completed road databases. This would allow further analysis using home range information from the Cabinet Mountains and facilitate impact evaluation during development of access standards. These databases should include Canadian portions of the Selkirks and the area directly north of the Cabinet-Yaak. All databases must be created in a standardized manner with consistent attributing of features necessary for analysis.

6. Minimum size or configuration of core habitat could not be established with this data set, but larger blocks of core are likely beneficial to bears. All habitat greater than 0.31 mi from an open or gated road was considered core habitat in this analysis. Our attempt at identifying a useful minimum core polygon size was hampered by small sample sizes. We suggest that if a minimum size occurs, it is likely between 2 mi^2 and 8 mi^2. Furthermore we believe that narrow strips of core habitat that may fit some minimum size criteria likely will not provide effective core habitat for bears.

7. Road closures should consider adjacent habitat and prioritize high quality areas. Consideration should be given to habitat quality in proximity to road closures. Certain types of habitat may not be sufficiently represented in all Bear Management Units and require additional protection (e.g., spring range or high quality foraging sites). Additional habitat analysis utilizing the radiolocation database could guide this process.
8. Resolve the issue of barriered roads in density calculations. Examination of influences of road type on bears did not produce a statistically significant result, but appeared to indicate that barriered roads have less influence on bear distribution than gated roads. Results comparing total road calculations with and without barriered roads showed no statistical relationship. We suggest that if barriers on roads are effective, these roads may be removed from total road density calculations.

LITERATURE CITED

Aune , K. And W. Kasworm. 1989. East Front grizzly bear study; final report. Mont. Dep. Fish, Wildl. And Parks, Helena. 332pp.

Brown, D.E. 1985. The grizzly bear in the Southwest. Univ. Okla. Press, Norman. 274pp.

Frederick, G.P. 1991. Effects of forest roads on grizzly bears, elk, and gray wolves: a literature review. USDA, Kootenai Nat. For. Pub. No. R1-91-73. Libby, MT. 53pp.

Interagency Grizzly Bear Committee Taskforce Report. 1994. Grizzly bear/motorized access management. 8pp.

Kasworm, W.F. and T.L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. Int. Conf. Bear Res. and Manage. 8:79-84.

Knight, R.R., D.J. Mattson, and B.M. Blanchard. 1984. Movements and habitat use of the Yellowstone grizzly bear. Interagency Grizzly Bear Study Team, U.S. Dep. Int., Natl. Park Serv. Unpubl. Rep. 177pp.

Latour, J.B. and L. Van Miltenburg. 1988. Activity patterns, daily movement, and home ranges of grizzly bears (*Ursus arctos horribilis*) in the Selkirk Mountains Ecosystem. M.S. Thesis. Agric. Univ. Of Wageningen, the Netherlands. 32pp.

Mace, R.D. and T.M. Manley. 1993. South Fork grizzly bear study: progress report. Montana Dept. Fish, Wildl, and Parks. 38pp.

Mace, R.D., J.S. Waller, T.L. Manley, L.J. Lyon, and H. Zuring. In press. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. J. Appl. Ecol.

McCann, R.K. 1991. Activity measures of free-ranging grizzly bears (*Ursus arctos*) in the Flathead drainage. M.S. Thesis. Univ. Of Brit. Col. Vancouver, B.C. 116pp.

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

Platt, T.M. 1992. Cabinet-Yaak grizzly bear ecosystem 1992 Forest Service road closure program compliance inventory. Dep. Environ. Studies, Univ. Of Mont. Missoula. 39pp.

Peek, J.M., M.R. Pelton, H.D. Picton, J.W. Schoen, and P. Zager. 1987. Grizzly bear conservation and management: a review. Wild. Soc. Bull. 15:160-169.

Servheen, C. 1989. The status and conservation of the bears of the world. Int. Conf. Bear Res. and Manage. Monogr. Series 2:1-32.

Servheen, C., F. Hovey, B. McLellan, R. Mace, W. Wakkinen, W. Kasworm, D. Carney, T. Manley, K. Kendall, and R. Wielgus. 1994. Report of the northern ecosystem researchers on grizzly bear population trends in the North and South Forks of the Flathead, and the Blackfeet Indian Reservation of the NCDE; the Cabinet-Yaak ecosystem; and the Selkirk ecosystem; and future data needs to improve trend estimates. Report to the Interagency Grizzly Bear Committee, Missoula, MT. 14pp.

Storer, T.I. and L.P. Tevis, Jr. 1955. California grizzly. Univ. Calif. Press, Berkeley. 335pp.

Tanimoto, P. 1996. A satellite image-based vegetation classification of the Kootenai National Forest and sensitive species habitat modeling. U.S. Dep. Agric. Kootenai Nat. For. Libby, Mont. 39pp.

U.S. Fish and Wildlife Service. 1993. Final biological opinion on the Lost Silver timber sale on Hungry Horse District, Flathead National Forest. USFWS, Helena, Mont. 31pp.

U.S. Forest Service. 1995. Amendment 19 to the Flathead National Forest Plan. U.S. Dep. Agric. Flathead Nat. For. Kalispell, Mont. 139pp.

White, G.C. and R.A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, Inc., San Diego, Calif. 383pp.

Worton, B.J. 1987. A review of models of home range for animal movement. Ecol. Model. 38:277-298.

APPENDIX A. TECHNICAL DATA

This appendix is intended to describe the technical atmosphere under which this analysis was conducted. It will provide guidance to replicate the analysis if so desired.

GIS software, including version: The moving window analysis was conducted with ARCINFO GIS software, Ver. 7.03.

Pixel size: Pixel size for the analysis was 30m x 30m.

Road density calculations: A moving circular window 1 mi^2 in size was used. The radius of the window was fixed at 0.56 mi (30 pixels).

Core area analysis: All open and gated roads were buffered by 0.31 mi. Permanently barricaded roads were allowed in core. No minimum size of a polygon was required for inclusion in core.

Home Range Calculations: Program CALHOME was used to calculate 95% utilization isopleths using the Adaptive Kernel estimator as described by Worton (1987). The automatic grid cell size calculation option was used.

Statistical Significance: Comparisons were considered significant at the $p < 0.10$. Bonferroni confidence intervals at the 0.10 level were used to identify significant differences between categories following a significant Chi-Square analysis.

APPENDIX B. INDIVIDUAL GRIZZLY BEAR INFORMATION

Appendix B Table. Home range sizes, fates, and reproductive history of radiocollared grizzly bears that were included in the road density analysis for the Selkirk and Cabinet-Yaak Recovery Zones.

Bear	Sex	Age (1991)	Years monitored for road analysis	Radio locations	Composite 95% kernel home range (mi^2)	Fate / cause of mortality	Years monitored for reproduction	Cubs produced
867	F	13	1989-91	38	282	Dead / Human	9	7
1015	F	11	1989-91	44	116	Dead / Human	5	4
1044	F	20+	1989	25	18	Dead / Natural	1	0
1045	F	11	1989-90	50	155	Collar failure	2	2
1047	F	13	1989	27	58	Collar loss	1	2
1048	F	20+	1989-91	76	68	Collar failure	3	0
1056	F	11	1989-90	67	72	Collar failure	4	3
1075	F	13	1989-91	58	173	Collar loss	3	0
1076	F	20+	1989-91	57	103	Dead / Natural	3	2
1084	F	20+	1989-90	20	131	Collar failure	5	2
1087	F	12	1989	15	83	Collar loss	1	3
106	F	13	1991-94	162	115	Collar loss	11	11
128	M	8	1991-92	88	1,016	Collar failure	N/A	N/A
206	F	3	1991-94	150	335	Collar loss	3	2
244	M	5	1992-94	95	249	Collar loss	N/A	N/A