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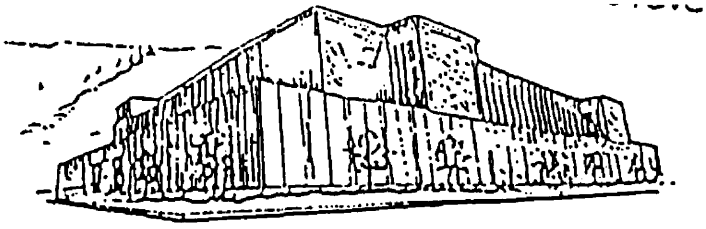

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LINKAGE ZONE IDENTIFICATION AND EVALUATION OF MANAGEMENT OPTIONS FOR GRIZZLY BEARS IN THE EVARO HILL AREA

by

Steven N. Mietz

B.S. Cornell University, 1992

presented in partial fulfillment of the requirements

for the degree of

Master of Science

The University of Montana

1994

Approved by:

Co-chair, Board of Examiners

Co-chair, Board of Examiners

Dean, Graduate School

December 13, 1994

Date

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Mietz, Steven N., M.S., December 1994 Environmental Studies

Linkage Zone Identification and Evaluation of Management Options for Grizzly Bears in the Evaro Hill Area (91 pp.)

Co-Directors: Christopher Servheen and Vicki Watson

The *Grizzly Bear Recovery Plan* (US Fish and Wildlife Service 1993) calls for the study and identification of linkage zones between grizzly bear recovery areas. The Evaro Hill Area, northwest of Missoula, Montana, is the primary linkage zone between two major recovery areas: the Northern Continental Divide Ecosystem and the Bitterroot Ecosystem. The established grizzly population in the Northern Continental Divide Ecosystem and the planned reintroduced population within the Bitterroot Ecosystem could use the Evaro area to maintain genetic interchange between these otherwise separated populations. Rapid development in the Evaro area may permanently block future grizzly movement unless management strategies are developed and implemented now.

To aid in linkage area identification, Servheen and Sandstrom (1993a) of the USFWS Grizzly Bear Recovery Program developed a computer-based Geographic Information System (GIS) model which "scores" a landscape based on its apparent value as grizzly bear habitat and the extent of human development. The model uses four criteria, in the form of GIS layers, to predict grizzly movement patterns: developed human sites, road density, presence or lack of hiding cover, and whether the region is within a riparian area. This model was used, with some alterations, to assess possible linkage zones for grizzly bears in the Evaro area.

The results of running the model indicate that a single linkage zone remains in the Evaro Hill area. This thesis defines several management options to ensure the maintenance of this potential linkage area. The discussion of the management options explains the benefits to bears, identifies the agency or group responsible for implementing the action, and evaluates the economic impact of implementing each management option. An evaluation of the GIS model concludes the discussion section.

This document was designed for use by those interested in grizzly bear conservation efforts to broaden their understanding of the linkage zone selection process and related management efforts in hopes of forging cooperative relationships between affected individuals and groups. Only through coordinated efforts among and within the government, non-profit, and private sectors can the complex social, economic, and biological issues surrounding grizzly bear conservation in the Evaro Hill linkage area be successfully addressed.

ACKNOWLEDGMENTS

The completion of this project was by no means a solo act. There were many people whose interest and encouragement spurred me on to completion of this thesis that I wish to recognize. First, I would like to recognize the help of Per Sandstrom whose technical advice, patience, guidance, and creative imagination was not only a technical necessity for finishing the project, but who acted as a wonderful friend who I look forward to working with for many years. I also wish to express my appreciation to Chris Servheen, not only for his advisory role as Co-chair, but for the wonderful incentive program that he offered me for completing this study - a job, but only when you finish! Chris' overwhelming support for this project was a major factor in my timely completion of this thesis. I am also grateful for the comprehensive and challenging comments that I received from my other committee members, Vicki Watson and Tom Roy. Their advice enabled me to greatly strengthen my thesis.

I would like to recognize the support of this project by the United States Fish and Wildlife Service, Grizzly Bear Recovery Program Coordinator's office. Without this support the project would never have been completed. I wish to thank the entire staff at the Grizzly Bear Recovery Office, but especially Keely Drollinger for putting up with my ramblings and always finding time to help me out. I would also like to thank Roly Redmond and the staff of the Wildlife Spatial Analysis Lab for access to the GIS system. In addition, I would like to thank Dale Becker of the Confederated Salish and Kootenai Tribes and Kevin Shelley of the U.S. Fish and Wildlife Service who provided me with valuable information on the current status of management efforts in the Evaro area. I need to also thank Bob Kiesling for his encouragement to pursue this project and for his help with forming land conservation strategies.

Personally, I owe a debt of gratitude to Melissa Hart and Jim Schumacher for their help with my technical GIS questions and for their smiling faces despite my endless questions. I wish to thank Claudine Tobalske for teaching me everything I know about ARC/INFO and making pretty maps. Finally, I would like to thank all the Bollas who stood by me since those ugly teen years, but especially Tom Walsh and Jorge Gana who constant banter and sincere friendship kept me sane for all these years. Most of all, I would like to thank the two women who have believed in me when I doubted myself and whose encouragement, support, laughter, and love have made life **bear**able, Catherine Mietz and Stephanie Wyse. Thank you all.

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CHAPTER I

Introduction

The grizzly bear (*Ursus arctos horribilis*) was declared threatened in 1975 under the Endangered Species Act (US Fish and Wildlife Service 1993). As part of the mandated recovery efforts, the U.S. Fish and Wildlife Service (USFWS) was required to develop a recovery plan, which they released in 1982. The first major revision of the plan was released in 1993 and included a mandate for the study and identification of linkage zones between grizzly bear recovery areas (US Fish and Wildlife Service 1993). For the purpose of this thesis, linkage zones or areas are regions between recovery areas that contain habitat of sufficient quality and where human influences are low enough to allow grizzly bears to live in and move through the area. The term linkage zone is used instead of wildlife corridor to stress that linkage zones are more than simple travel routes; they can act as places where grizzlies can spend time foraging and traveling with some level of security.

East-west movement opportunities for grizzly bears are extremely limited in Western Montana (Becker et al. 1993). The Evaro Hill Area is the primary linkage zone between two major recovery zones in the lower 48 states: the Northern Continental Divide Ecosystem and the Bitterroot Ecosystem (Figure 1). The established grizzly population in the Northern Continental Divide Ecosystem and the planned reintroduced population within the Bitterroot Ecosystem could use the Evaro area to maintain genetic interchange between these otherwise seperated populations.

Greater Linkage Area

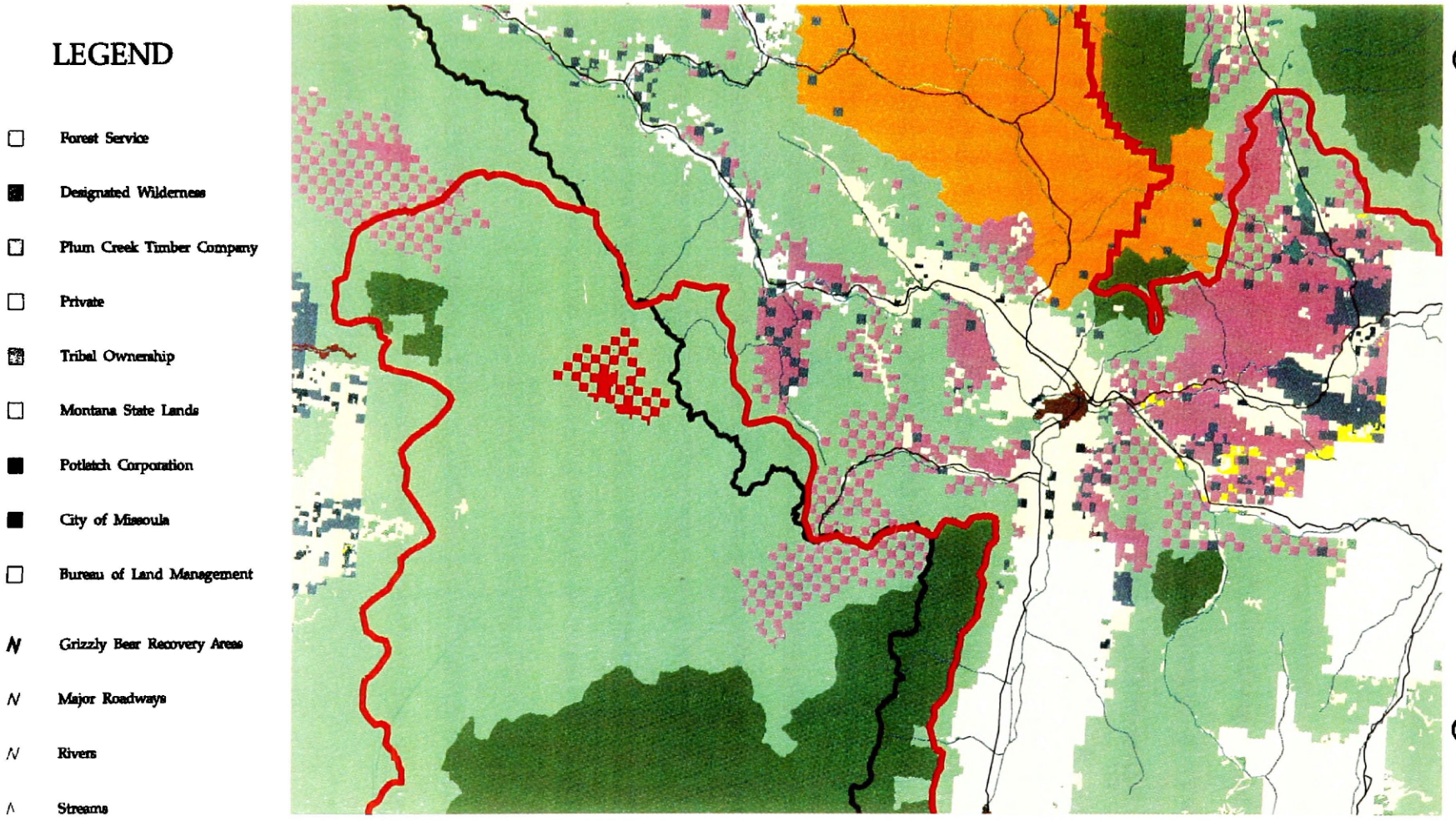


Figure 1

Rapid development in the Evaro area may permanently block future grizzly movement in this critical area unless management strategies are developed and implemented.

To aid in linkage area assessment, Servheen and Sandstrom (1993a) of the Grizzly Bear Recovery Program developed a computer-based Geographic Information System (GIS) model which "scores" a landscape based on its value as grizzly bear habitat and the extent of human development. This model is called the Linkage Zone Prediction (LZP) model. I used this model, with some alterations, to assess possible linkage zones for grizzly bears in the Evaro Hill area. The specific methodologies I used to assess the landscape for linkage zones, including changes from the original LZP model, are described in the methods section of the paper.

The findings from running the model are included in the results section of this thesis. The results indicate that a single linkage zone exists in the Evaro Hill Area. This thesis defines several management options to ensure the maintenance of this movement area. Each management option is described and discussed in detail in the discussion section of this thesis. The discussion of the management options explain the benefits to bears, identify the agency or group responsible for implementing the action, and evaluate the economic impact of different options upon the local human residents of the area. An evaluation of the LZP model concludes the discussion section.

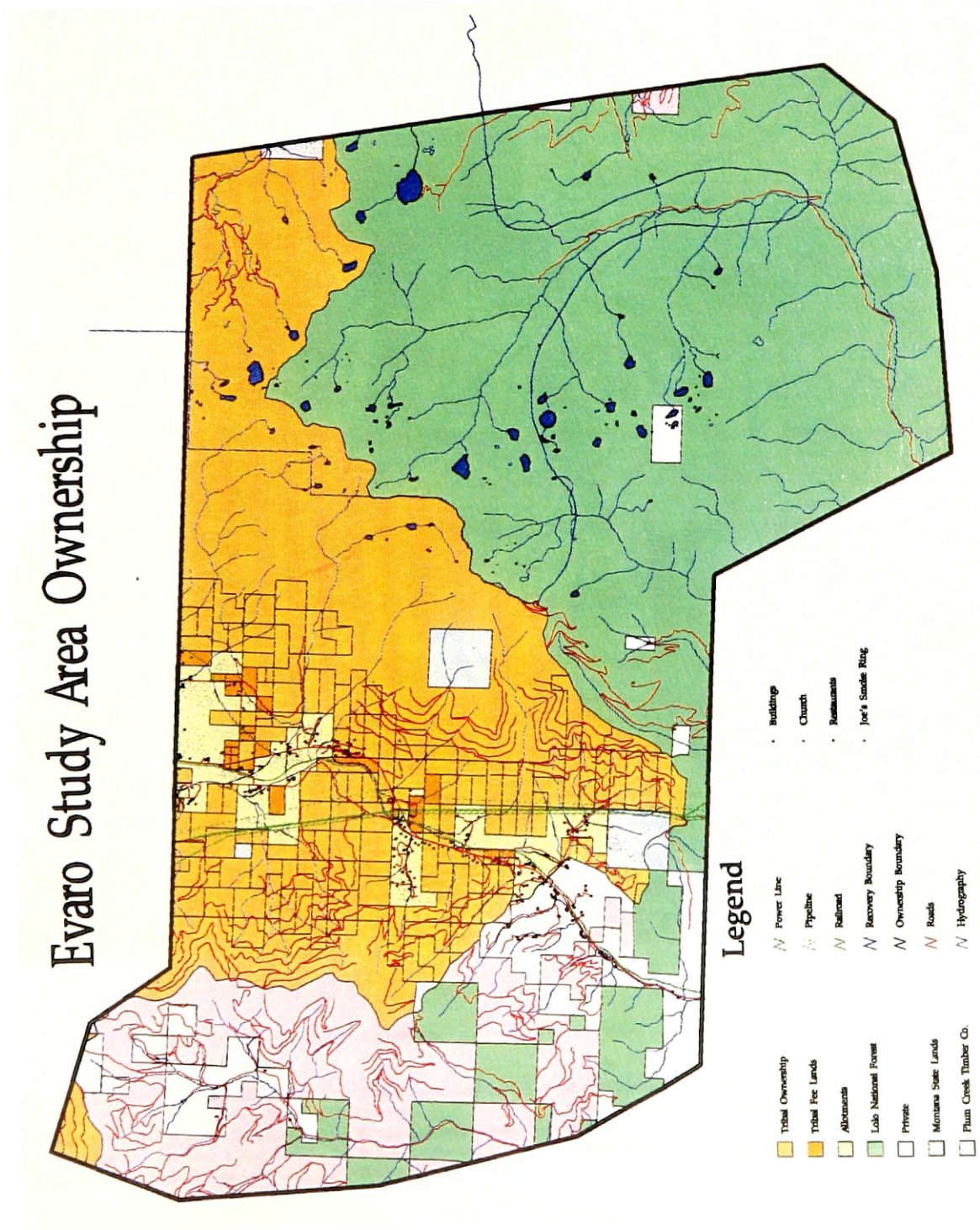
It is my hope that this document will be used by those interested in grizzly bear conservation efforts to broaden their understanding of the linkage zone selection process and related management efforts. This thesis is intended to serve as a framework to establish a working group of individuals dedicated to the preservation of the Evaro Hill linkage area for grizzly bears and other

wildlife. I hope to address the interests and concerns of owners of land in the Evaro area, tribal council members, State and Federal agency officials, and interested citizens who are dedicated to the preservation of the grizzly bear. My greatest wish is to see my findings and recommendations used to implement efforts for the benefit of the grizzly bear and the local community.

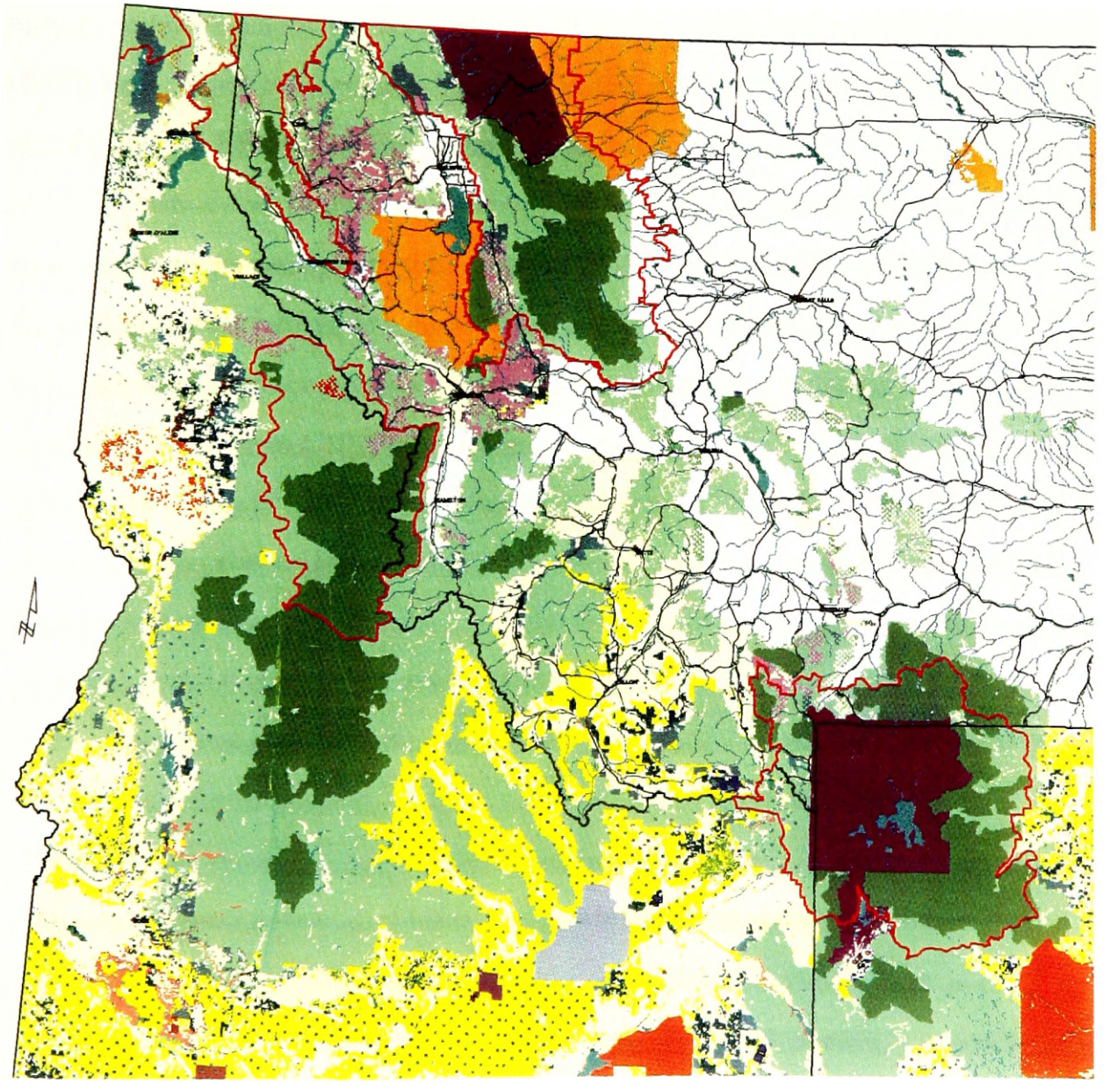
Description of the Study Area

The Evaro study area is located just northwest of Missoula, Montana at latitude 47° 07' 00' and longitude 114° 00' 00' (Figure 2). The study area contains parts of the Rattlesnake Wilderness Area and Jocko Primitive Area to the east and the Ninemile mountain range to the west. Adjacent to the Rattlesnake Wilderness area to the north is the Mission Mountains which contains a small population of grizzly bears, approximately 15 bears (Chris Servheen pers. comm.). East of the Missions, the Bob Marshall Wilderness/Glacier National Park Complex contains a large grizzly bear population. Estimates range from 306 bears (US Fish and Wildlife Service 1993) to 549-813 bears (Dood et al. 1986). To the distant southwest, the Bitterroot Mountains in east-central Idaho have the potential to support another large grizzly population. The Mission Mountains and Bob Marshall Wildernesses and Glacier National Park form the Northern Continental Divide Ecosystem (NCDE) Recovery Area. The Selway-Bitterroot Wilderness is part of the Bitterroot Grizzly Bear Recovery Area. (Figure 3).

Figure 2


Evaro Study Area Ownership
Legend
Tribal Ownership
Tribal Fee Lands
Allotments
Lolo National Forest
Private
Montana State Lands
Plum Creek Timber Co.
Power Line
Pipeline
Railroad
Recovery Boundary
Ownership Boundary
Roads
Hydrography
Building
Church
Restaurants
Joe's Smoke Ring

Grizzly Bear Recovery Areas



LEGEND

- Forest Service
- Designated Wilderness
- National Park Service
- Bureau of Land Management
- Department of Defense
- Fish and Wildlife Service
- Corps of Engineering
- Bureau of Reclamation
- Bureau of Indian Affairs
- Idaho Fish Lands
- Department of Energy
- Private
- Plum Creek Timber Company
- Potlatch Corporation
- Urban Areas
- Tribal Ownership
- ID/MT State Lands
- Water
- Non-described
- Grizzly Bear Recovery Areas
- Major Roadways
- Rivers
- Streams

The Evaro linkage area assessment is part of a larger project to identify and manage for linkage areas between all the recovery areas shown in Figure 3. Linkage zone identification and management efforts must be applied to the east in the Swan-Clearwater Valley and to the south and west in the Upper Clark Fork Valley to ensure the successful movement of grizzly bears between the NCDE and Bitterroot Recovery Areas.

Human development pressures within the larger study area are focused in a small north/south valley called Evaro Hill. Evaro Hill is the most threatened area within the Evaro study area and therefore requires that management options be applied here first to preserve existing movement opportunities. Evaro Hill has one major highway, U.S. Highway 93, that runs north-south along the major drainage in the area, Finley Creek. Most of the development in the valley is immediately adjacent to the highway, including human residences, restaurants, a railroad line, power transmission lines, and a pipeline that all run nearly parallel to the highway.

This linear layout of human development in the valley is typical of many valley bottoms in Montana. A major roadway and adjacent human development create a linear barrier across the valley. In some cases, riparian areas can provide perpendicular linear pathways through this barrier that may allow animals to move safely through developed valley bottoms.

Ownership in the study area is divided between several groups with very different interests (Figure 4). Public lands include the Lolo National Forest and the Montana Department of State Lands, the former controlling the majority of land (48% compared to 1%). Most National Forest land in the study area is within the Rattlesnake Wilderness Area. Private ownership is common in the

lower elevations of the study area. The Confederated Salish and Kootenai Tribes hold much of this land (32%). Corporate timber lands, which cover about 11% of the area, are held by Plum Creek Timber Company. Land within the Flathead Indian Reservation is divided between the tribal ownership (31%), tribal fee lands which are owned and managed by tribe, but not yet trusted into tribal ownership (1%), and tribal allotments which contain mixed ownership including non-tribal members (3%). Tribal lands, Plum Creek lands, and non-wilderness National Forest are managed for multiple-use purposes. Private non-corporate lands make up the remaining five percent of the land.

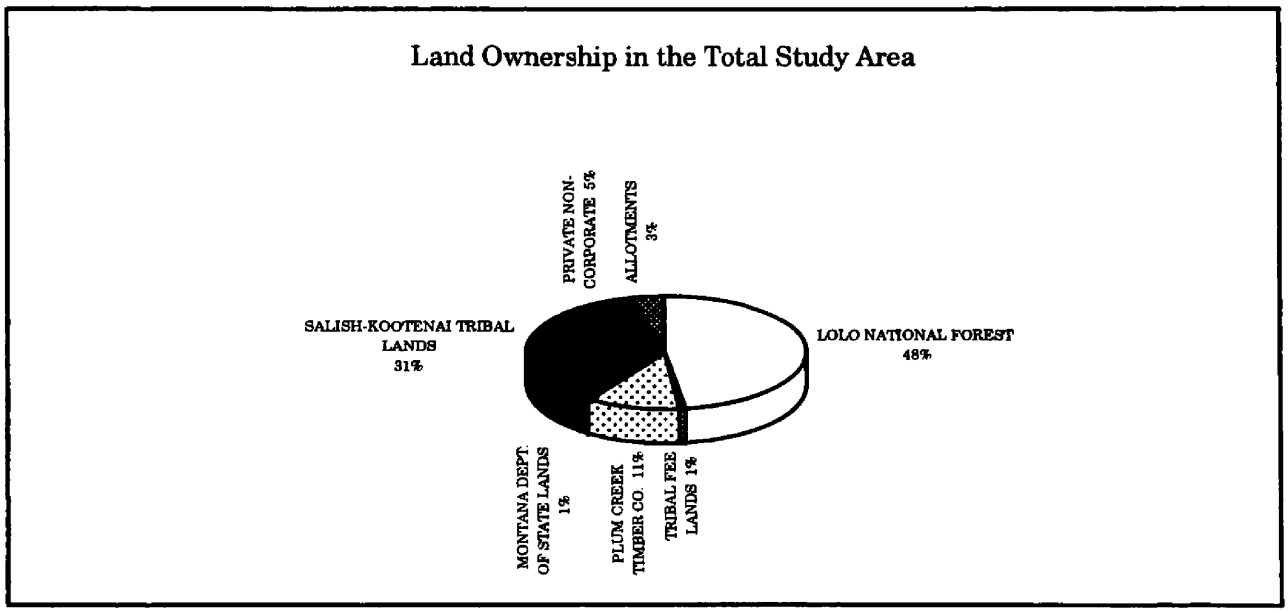


Figure 4. Land Ownership in the Evaro Study Area (184 square miles).

CHAPTER II

Methods

Servheen and Sandstrom's (1993a) Linkage Zone Prediction model was revised by incorporating several components from the Cumulative Effects Model (CEM). The Cumulative Effects Model (Flathead National Forest 1994) was developed by the Interdisciplinary Grizzly Bear Committee to identify grizzly bear linkage areas. These revisions were incorporated to aid in determining possible linkage zones in the Evaro study area. The revisions to the LZP model have increased the accuracy of the prediction and should have the overall effect of making the linkage zones more secure for bears than earlier LZP model linkage zone identifications.

The revised model was run using ARC/INFO and ERDAS software on an UNIX workstation in the Wildlife Spatial Analysis Lab supplied by the Grizzly Bear Recovery Program. Digital data were supplied from several sources including Cartographic Feature Files (CFF) from the Forest Service, Digital Elevation Model (DEM) data from the U.S. Geological Survey, Landsat TM imagery from the U.S. Fish and Wildlife Service, and ownership information from the Salish Kootenai Tribe and the County of Missoula.

Historically, available grizzly bear food types were used in models to predict the presence and movement patterns of bears (Servheen and Sandstrom 1993a). The LZP model differs from this approach in its focus on human activities (Servheen and Sandstrom 1993a). The base assumption of

the LZP model is that human activity in areas of high human development is the primary influence upon grizzly bear distribution, not food availability. Servheen and Sandstrom (1993b) predict that some bears will move parallel to the linear barrier of human development in the valley bottom, periodically testing areas by bobbing into and out of areas of heavy human influence until they reach the relatively undeveloped linkage areas. Other bears may use human-use areas, but the survival of these bears is unlikely due to the high potential for conflict and related bear death or translocation. Therefore, bears that avoid human-use areas are more likely to survive and pass along their genes, perhaps teaching their young this behavior. In effect, a selection process may exist that favors bears that avoid humans and use linkage zones where potential for conflict is least.

The LZP model uses four criteria, in the form of computer-based Geographic Information System (GIS) layers, to predict grizzly movement patterns and habitat use:

- Density and nature of developed human sites
- Road density
- Presence/lack of hiding cover
- Within a riparian area

(Servheen and Sandstrom 1993b).

Data are collected regarding these criteria from digital files, satellite imagery, and field checking. Once collected, these data are converted to 30 x 30 meter squares which are called pixels or cells. Each GIS layer is made up of a grid of these cells or pixels with each 30 x 30 meter pixel or cell assigned a score using the methods described below. The higher the score the greater the danger for grizzly bears.

Human Influence Layer

Danger scores are assigned by different methods for each of the criteria. To determine the danger scores for developed sites, each site is assigned a buffer zone or area of influence around the site. Buffer zones of different sizes are assigned to different kinds of development, based on the subjective level of influence each kind of development would have on a bear.

The LZP and the CEM model differ on the recommended buffer zones sizes for some human sites (Table 1). Generally, the original LZP model buffers were used in the revised Evaro model. However, the buffer size for human residences, schools, manufacturing plants, and churches was increased from 100 meter (LZP model recommendation) to 200 meter (CEM model recommendation). This has the net effect of decreasing the amount of area that is identified as safe habitat for the grizzly, thus increasing the importance of protecting the areas identified as linkage areas by the revised model.

Table 1. Human Developed Sites Buffer Zone Sizes.

Point Feature	LZP Model Buffer	CEM Model Buffer	Evaro Model Buffer
Barn	50	50	50
Residence	100	200	200
School	100	200	200
Manufacturing Plant	100	200	200
Church	100	200	200
Livestock Operation	200	200	200
Restaurant	200	200	200
Community Center	200	200	200
Garbage Dump	200	200	200

Scores were then assigned to each cell or pixel based on the proximity of the area to the "influence zone" or buffer. If the area was within an influence zone it was given a score of 6, within 100m of an influence zone - 5, within 100-200m of an influence zone - 4, and beyond 200m of an influence zone - 2 (Servheen and Sandstrom 1993b).

Road Density Layer

To aid in clarifying differing definitions of different types of roads, the Grizzly Bear Motorized Access Taskforce report has grouped all roads into three categories: open, restricted, and reclaimed/obliterated (Puchlerz and Servheen 1994). Open roads are defined as "a road without restrictions on motorized use." What most people refer to as a closed road, they call a restricted road - "a road on which motorized vehicle use is restricted seasonally or yearlong. The road requires physical obstruction (generally gated) and motorized use is legally restricted." They discourage the use of the term "closed road" because of the disparate definitions that have developed in different groups. The final category is reclaimed or obliterated road. A reclaimed/obliterated road is "a road which has been treated in such a manner so as to no longer function as a road or trail. This can be accomplished through one or a combination of several means including: recontouring to original slope, placement of logging road, or forest debris, planting of shrubs or trees, etc.". The terms open, restricted, and reclaimed/obliterated roads will be referred to throughout the paper and will refer to the above defined categories.

Road density was determined by performing a moving circle analysis on the cartographic feature road files. The moving circle analysis was run using ARC/INFO GIS software. The moving circle analysis was performed in several steps. First, I calculated what size circle would approximate a square mile. At 30 x 30 meter pixel resolution, a 900 meter radius circle very closely approximates a square mile(this creates a circle with 2828 pixels in it). Next, values of 1 were assigned to any pixel with a road in it and 0 if it had no road in it. Then the computer summed the values of each pixel within the circle and gave that value to the center pixel and moved on to the next pixel, hence the term "moving circle". The pixels were then grouped into four road density categories and given a score. A score of 2 was given to pixels with 0 mile per square mile road density, 3 for 0-1 mile/mile^2 , 4 for 1-2 miles/mile^2, and 5 for any density above 2 square miles/mile^2 (Servheen and Sandstrom 1993b).

The road density analysis methods differed in several ways from the original LZP model methodologies. The most important difference is that the road density calculations were computed at 30m x 30m pixel resolution instead of the 50m x 50m pixel resolution used in the original LZP model. This allowed the approximation of a square mile to be more precise (0.98 sq. mile) compared to the original LZP model's approximation of 0.87 sq. mile (Servheen and Sandstrom 1993b).

In the past, only open roads have been used in the moving circle calculation. The CFF files received from the Forest Service contained both open and restricted roads in the Evaro Study Area. Mace and Manley (1993) have studied the influence of roads on grizzly bear habitat selection. They have found that even restricted roads, unless completely obliterated, have a negative impact upon grizzly bears use of the surrounding area. Therefore,

both open and restricted roads were included in the Evaro moving circle analysis. Again, the result should be a more precise evaluation of landscape values and identification of linkage areas.

Earlier moving circle analyses were run using the subroutine SCAN in ERDAS(Servheen and Sandstrom 1993b). The Evaro moving circle analysis was conducted using ARC/INFO's focalsum command. The difference in results would be based upon different algorithms used by the programs to determine the center pixel's value. While the effect upon the results of a moving window analysis is probably negligible, further study could determine which application is more precise in measuring road density.

Cover Layer

Three different vegetation classes are used to score cover characteristics for grizzly bears. These classes are cover, edge, and non-cover. Hiding cover is defined as "vegetation at sufficient density to hide 90% of an adult grizzly bear at 200 feet" (Servheen and Sandstrom 1993b). Edge is the area within 50 meters of hiding cover and non-cover is any area beyond 50 meter of hiding cover.

The hiding cover analysis used Landsat satellite imagery (image taken on July 21, 1991) to get updated data on vegetation. The satellite imagery pixels were separated into cover and non-cover categories based on knowledge of satellite imagery classifications and some limited field checking. Using the cover/non-cover map, a 50 meter buffer was placed around cover to represent edge. With the three vegetation classes described, scores were then assigned

using subjective assumptions about grizzly behavior and related risks associated with non-cover.

Servheen and Sandstrom (1993b) assumed that areas more than 50 meters from cover are not used frequently by bears and pose a greater mortality risk to bears, so non-cover (more than 50 meters from hiding cover) was given a value of 5, while cover was given a value of 2 (Servheen and Sandstrom 1993b). Areas within 50 meters of hiding cover allow some protection to grizzly in the form of a quick escape to hiding cover. Therefore, edge (within 50 meters of cover) is given a value of 3.

Some research has shown that bears use areas within 500 meters of roads less than predicted and no change from predicted use was found in areas beyond 500 meters from a road (Frederick 1991, Aune and Kasworm 1989, Kasworm and Manley 1988, Mattson et al. 1987, Brannon 1984) . In fact, non-cover and edge areas away from roads may contain valuable food sources for the bears and may be used as much as areas with hiding cover. Therefore, non-cover and edge areas more than 500 meters from a road should be treated differently in the model than similiar areas near roads. Taking that into consideration, a revision was made from the original model. A 500 meter buffer was placed on all roads and non-cover values outside this buffer were given a value of 2, i.e. they were assumed to be used as much as areas with hiding cover. Non-cover pixels within the 500 meter buffer still get a score of 5 because of the high danger associated with the lack of cover in roaded areas. Edge outside the 500 meter road buffer was also given a value of 2, while within the road buffer it was given a value of 3.

Riparian Layer

Riparian areas are assumed to have good food sources and provide secure movement and resting areas through human developed areas. Riparian areas are assumed to occupy the first 45 meters on either side of a perennial stream and the first 15 meters on either side of an intermittent stream (Servheen and Sandstrom 1993b). Therefore, perennial streams were given a 90 meter buffer and intermittent streams were given a 30 meter buffer. All areas within those buffers were given a value of 1; outside those areas they received a value of 2.

Combined Danger Score

The sum of all the scores for the four layers provided a single combined danger score. The higher the value, the greater the level of human influence and/or poorer the habitat for the bears. Human influence can be defined as either avoidance of human-use areas by a bear or attraction and increased mortality risk to the bears. Combined scores within the 7-10 range were rated as minimal danger, 11-12 low danger, 13-14 moderate danger, and 15-18 high danger.

Table 2. Summary of Scores.

CATEGORY	SCORE
Developed Human Sites	
Beyond 200 meters of influence zone	2
Within 100-200 meters of influence zone	4
Within 100 meters of influence zone	5
Within influence zone	6
Road Density	
0 mile/mile^2	2
0.01-1 mile/mile^2	3
1.01-2 miles/mile^2	4
Greater than 2 miles/mile^2	5
Hiding Cover	
Cover outside of 500 meter road buffer	2
Edge outside of 500 meter road buffer	2
Non-Cover outside of 500 meter road buffer	2
Cover within the 500 meter road buffer	2
Edge within the 500 meter road buffer	3
Non-Cover within the 500 meter road buffer	5
Riparian/Non-Riparian	
Within riparian buffer	1
Outside riparian buffer	2
Combined Score	
Minimal danger	7-10
Low Danger	11-12
Moderate Danger	13-14
High Danger	15-18

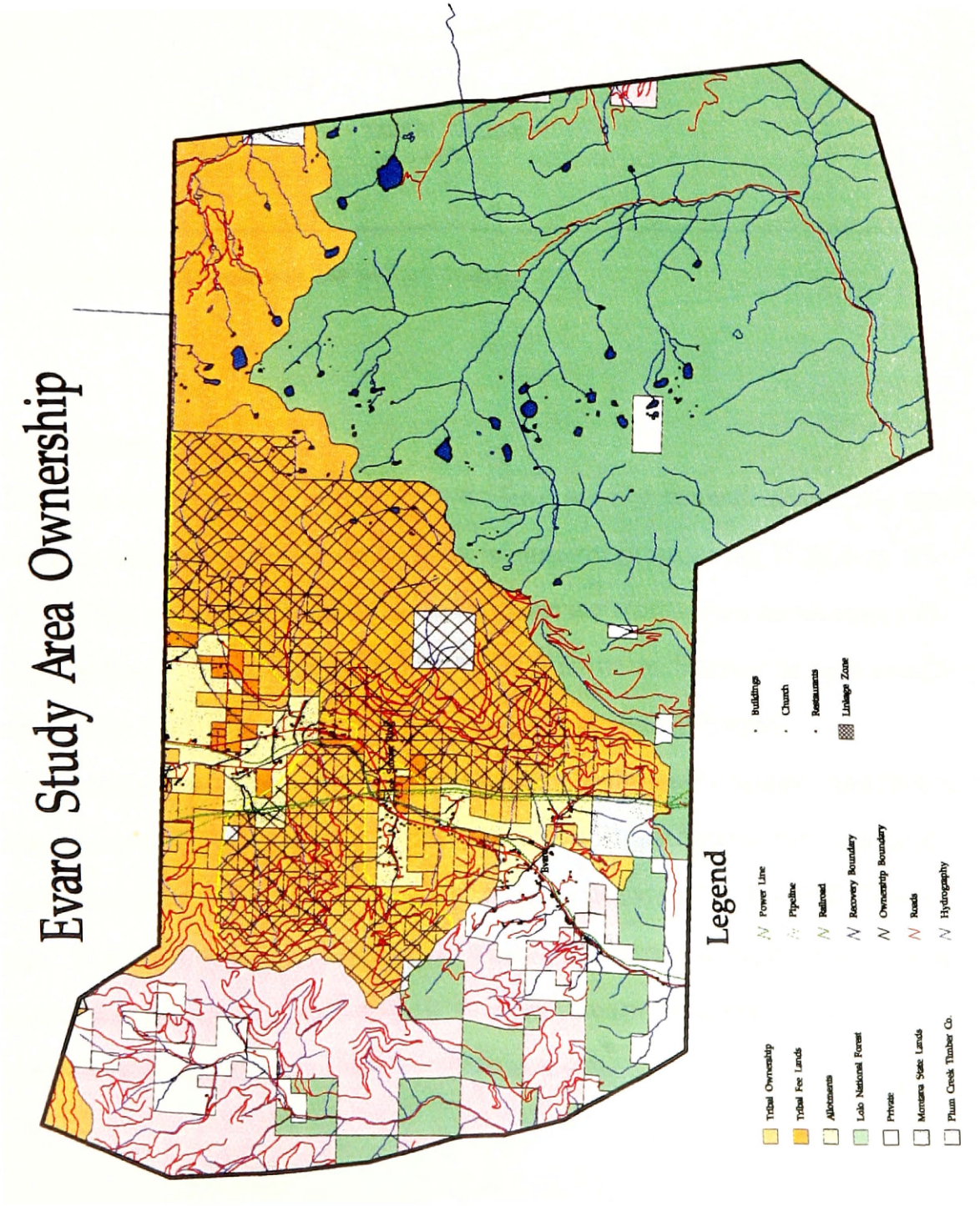
CHAPTER III

Results

Linkage Zone Identification

A linkage area was identified using the combined danger scores to determine those areas with the lowest possible danger from human activities and the greatest possibility that the bears will use the area, i.e. it contains food sources, cover, etc.. The linkage area identification was further refined by limiting the linkage zone to areas that are important for movement opportunities. The final factor that influence linkage zone identification was land ownership. Allotments (private landholdings on the reservation) were excluded whenever possible because of the difficulty of implementing management options on those lands.

The crosshatched area defines the linkage area over an ownership map of the entire study area (Figure 5). The eastern and western boundaries for the linkage area were defined by the ridge lines of the two ranges that enclose the Evaro valley. There are four different owners within the linkage area (Figure 6). The Salish Kootenai Tribe holds the overwhelming majority of the linkage zone ownership (95%). The remaining 5% is divided among allotments, Montana Department of State Lands (DSL), and Tribal Fee Lands.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Roads
Hydrography
Buildings
Church
Restaurants
Linkage Zone

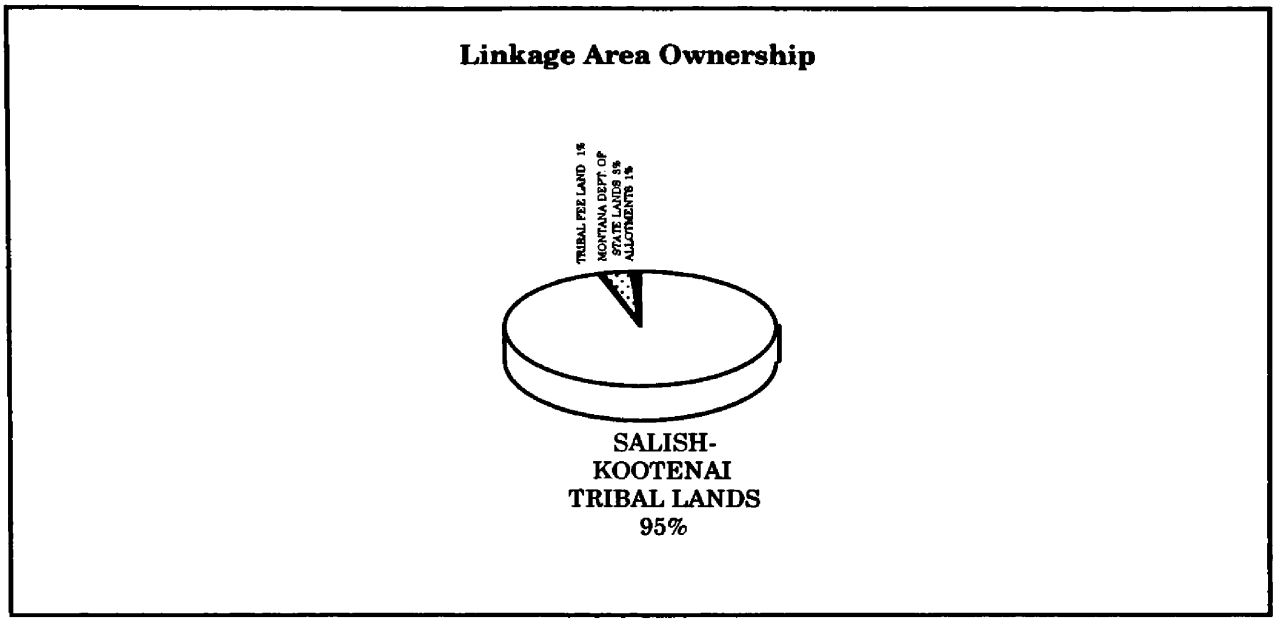


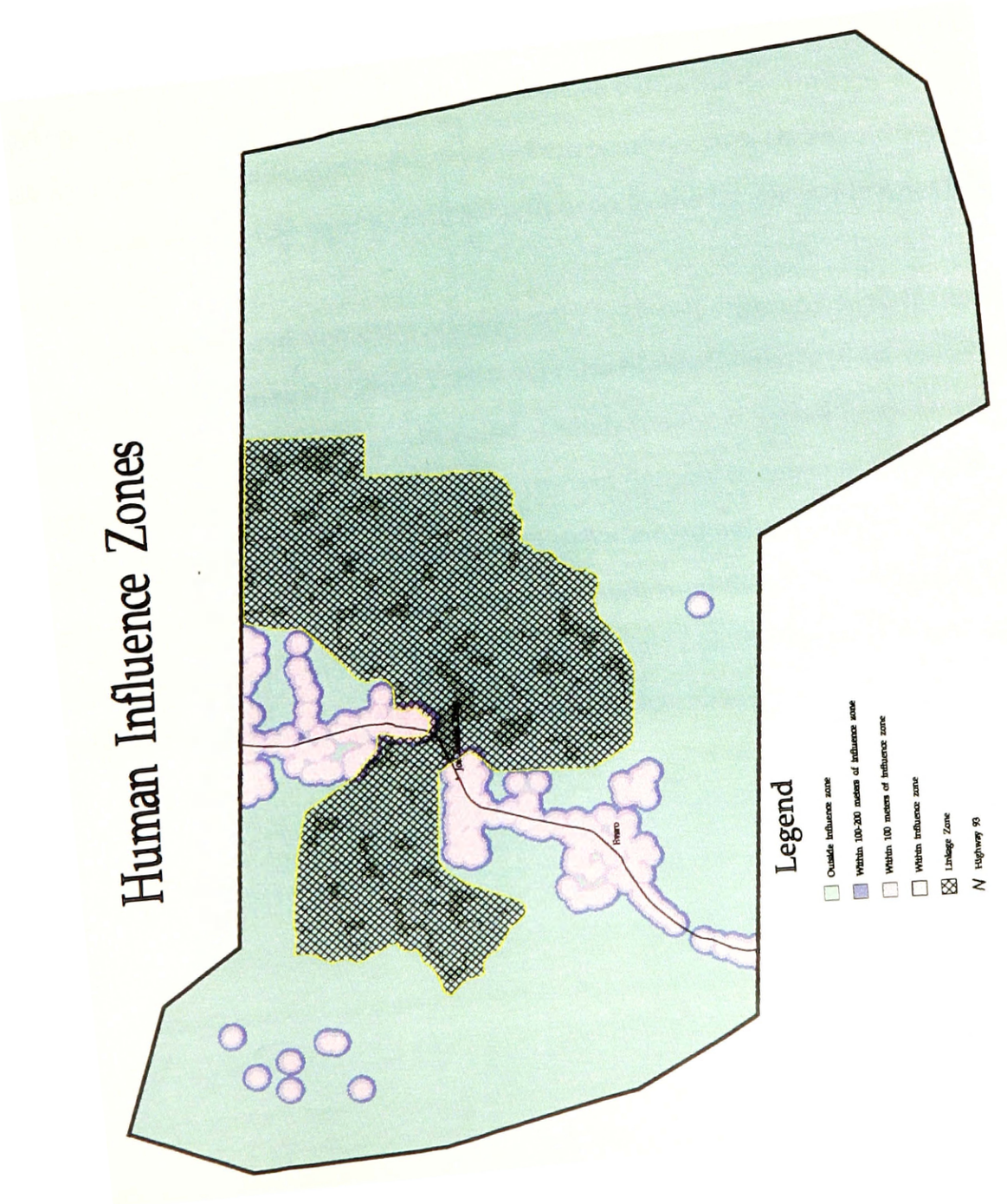
Figure 6. Linkage Zone Ownership (34 square miles).

Human Influence Layer

Human activities and residences are not evenly spaced across the study area. Human influence in the study area is concentrated along Highway 93 (Figure 7). This creates a dangerous linear barrier that bears must cross in the valley bottom. The linkage area through this linear barrier is very small (approximately 1 mile at its narrowest point along the highway).

The human influence map also shows the potential danger that bears will have to navigate once past the highway. Small patches of private land with seven houses currently sit over the ridge to the west in the Mill Creek drainage. Potential currently exists for more development in the area. Long term management options will have to address the problem to wildlife of increased development in the Mill Creek Drainage.

Figure 7


Human Influence Zones
Legend
Outside influence zone
Within 100-200 meters of influence zone
Within 100 meters of influence zone
Within influence zone
Linkage Zone
N Highway 93
Kremmling

Road Density Layer

Average road density for the 184 square mile study area (excluding lakes) is 1.66 miles/mile^2, while within the linkage area it is 2.00 miles/mile^2. The 1.66 miles/mile^2 figure for the study area is reduced by the large expanse of roadless wilderness area in the eastern part of the Evaro study area (Figure 8). The road density map clearly shows how the high road densities are crowded around the developed human sites near Highway 93 and adjacent logging activities. The high average road density value for the linkage area reflects the amount of logging activity that currently occurs there and its relatively small area (34 square miles) compared to the larger study area (184 square miles).

The average road density varies greatly between different owners in the total study area (Figure 9). Plum Creek has the highest density (6.04 miles per square mile) because of logging activities. Salish Kootenai Tribal Lands and Tribal Fee Lands are also above average in road density because of logging activities. Allotments (which is similiar to private ownership on the Flathead Reservation) and private non-corporate have high road densities because of driveways and access roads to houses. In contrast, Lolo National Forest has a low road density because of the Wilderness and Recreation areas.

Figure 8


Road Density
Legend
0 mile per square mile
0.01-1.0 mile per square mile
1.01-2.0 mile per square mile
> 2.01 mile per square mile
Linkage Zone
Highway 93
N

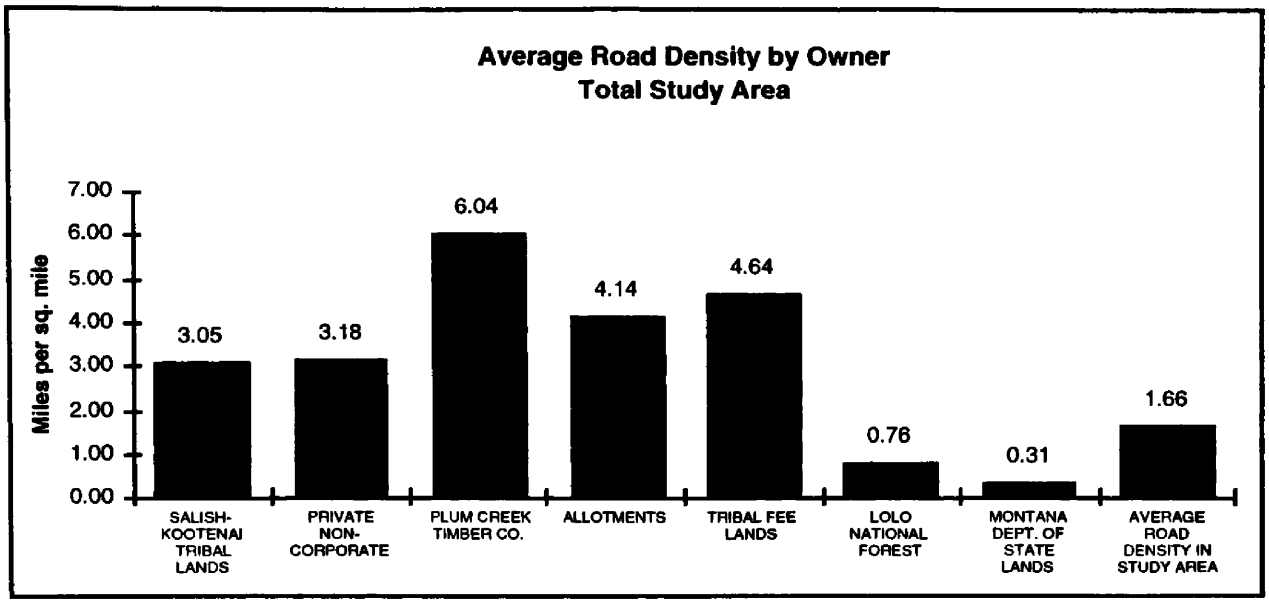


Figure 9. Average Road Density by owner for the total study area (184 sq. mi.).

The average road density also varies greatly between each owner within the linkage zone. Additional road density results are available in Appendix A. These results include the miles of roads per owner for the total study area and linkage area and break down the road density categories by acreage and percentages.

Cover Layer

Recall that the cover layer is divided into six categories that receive three different scores. The majority of the acreage in the study area is cover (score = 2) (Figure 10). Interestingly, the areas within the 500 meter road buffer and outside of the 500m road buffer are nearly identical, with similar acreage in cover, edge, and non-cover categories. The linkage area has similiar percentages in each of the categories.

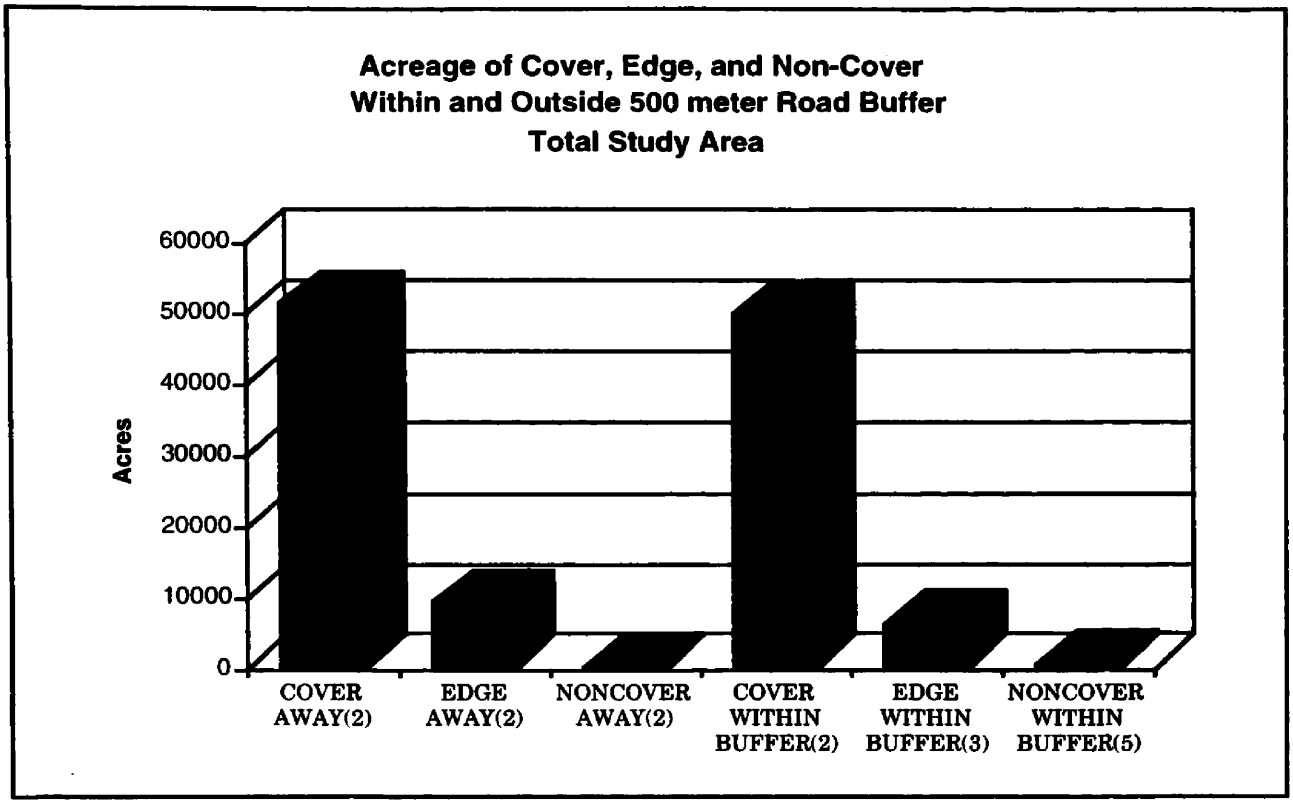
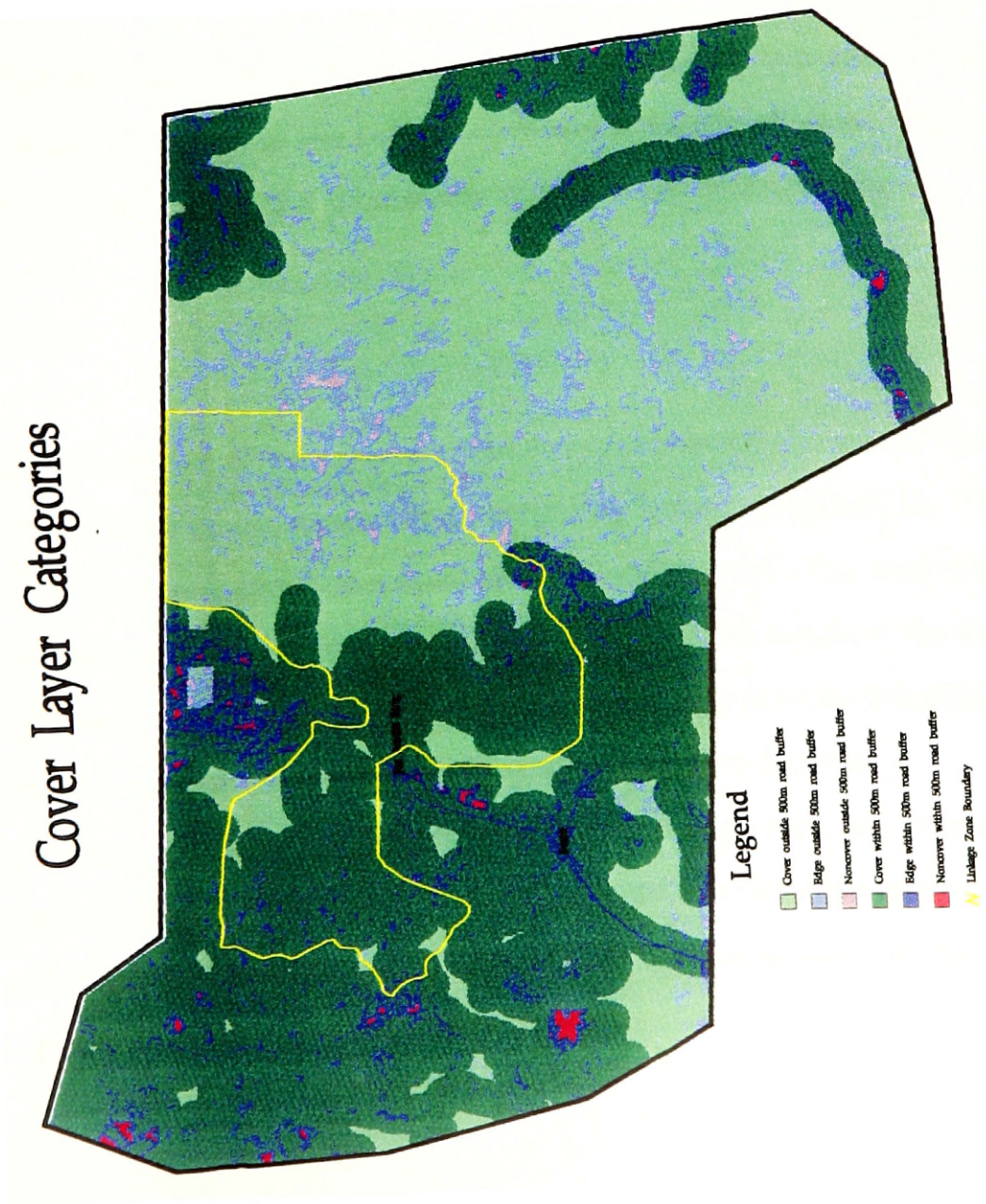


Figure 10. Acreage of Cover, Edge, and Non-Cover within and outside of a 500 meter road buffer for the Total Study Area (184 sq. mi.). Note : Values in parentheses are scores used in LZP model.

Cover, edge, and non-cover within the 500 meter road buffer is concentrated in the western half of the study area near human development (Figure 11). This map also shows the almost identical acreage of each cover type within and outside the road buffer. Areas of light green (cover outside the buffer) are nearly equal in area to areas of dark green (cover within the road buffer). The same is true of edge and non-cover areas.

Similarly within the linkage area, cover, edge, and non-cover categories are even split between those within and outside the road buffer. However, the spatial distribution of the cover categories is the most important factor.

Figure 11


Cover Layer Categories
Legend
Cover outside 500m road buffer
Ridge outside 500m road buffer
Noncover outside 500m road buffer
Cover within 500m road buffer
Ridge within 500m road buffer
Noncover within 500m road buffer
Linkage Zone Boundary

This map shows that areas inside the linkage area in the critical valley bottom bottleneck are mostly within that 500 meter road buffer and that areas outside the road buffer are mostly in the eastern portion of the linkage area at high elevations. However, most of the area around the valley floor bottleneck is either cover or edge. This means that bears should be able to use the abundant cover to hide in or escape to while traveling and foraging in the valley bottom.

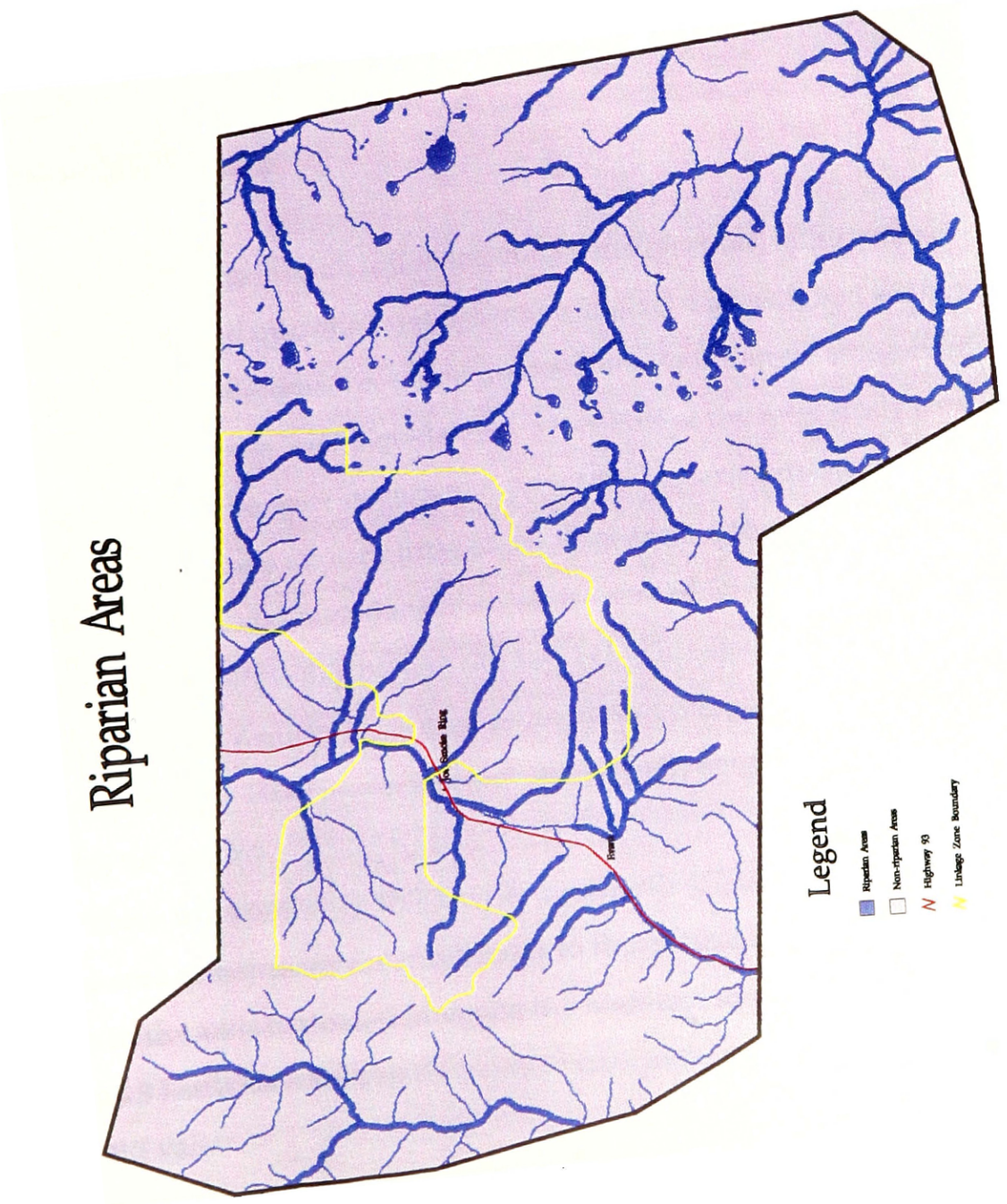
Further analysis of cover layer results is available in Appendix B. These results include an analysis of the percentages and acreages of cover, edge, and non-cover by ownership for the total study area and the linkage zone.

Riparian Layer

A spatial display of the riparian results reveals several areas of riparian habitat in the linkage zone, especially in the valley bottom (Figure 12). The wide riparian areas represent perennial stream buffers, while the narrower areas represent intermittent stream buffers. The riparian areas in the linkage zone usually have cover along the riparian zone that can provide grizzlies some level of visual protection as they move through the valley bottom.

Field checking in the bottleneck area of the linkage zone has revealed that some intermittent streams and wet areas were not included in the cartographic feature files that would normally be used to determine the riparian areas.

Figure 12


Riparian Areas
Legend
Riparian Areas
Non-Riparian Areas
Highway 93
Linkage Zone Boundary

Some alterations were made to the stream files to reflect data gathered in the field especially in the critical valley bottom and east slope of the linkage area. Changes in the riparian files in critical areas show the importance of field checking, especially in critical areas.

Further analysis of the riparian results are available in Appendix C. These results include an examination of the percent riparian of each owner within the total study area and the linkage zone.

Combined Danger Score

Scores from the human influence, road density, cover, and riparian layers were combined into one layer where each pixel was assigned a summary score. The combined scores were then grouped into four danger categories: minimal, low, moderate, and high danger. Over 90% of the total study area is in the minimal or low danger categories (Figure 13). Moderate danger (4%) and high danger (3%) make up very little of the total area in the Evaro study area. However, moderate and high danger areas are spread fairly evenly across the floor of the Evaro Hill valley bottom (Figure 14). This spatial distribution of high and moderate danger areas creates an almost complete linear barrier through the valley. Bear movement across this high danger area has a high potential for conflict.

There is an opening in this barrier just north of Joe's Smoke Ring. The linkage area encompasses areas adjacent to the critical bottleneck of good habitat in the valley bottom. Managing the highland areas on both sides of the Highway 93 bottleneck for grizzly bears is critical for movement across the Evaro Hill valley.

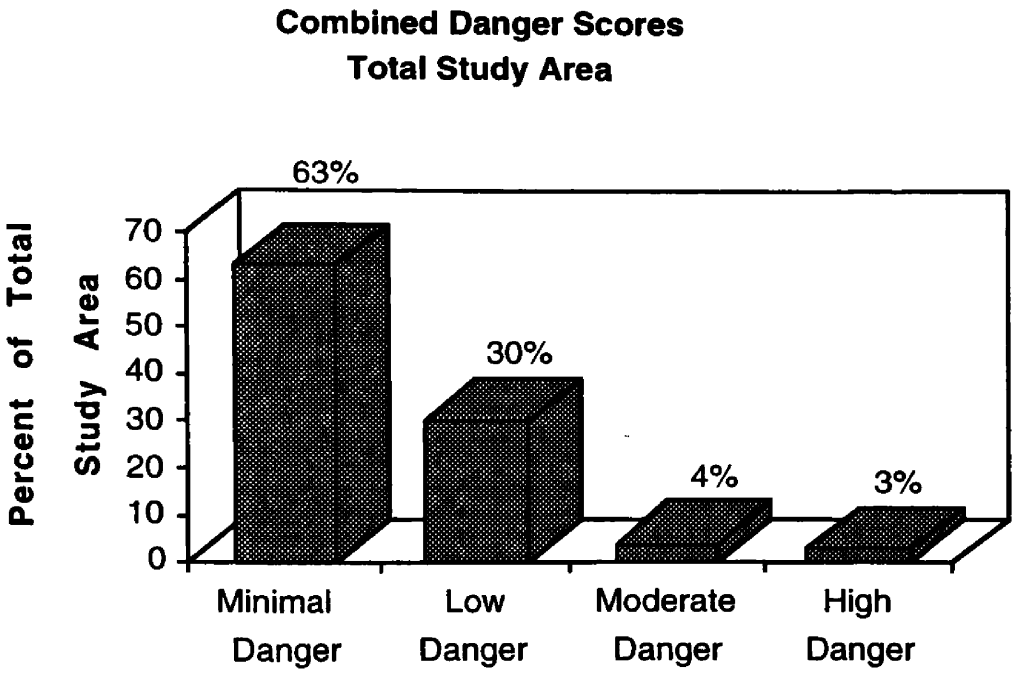
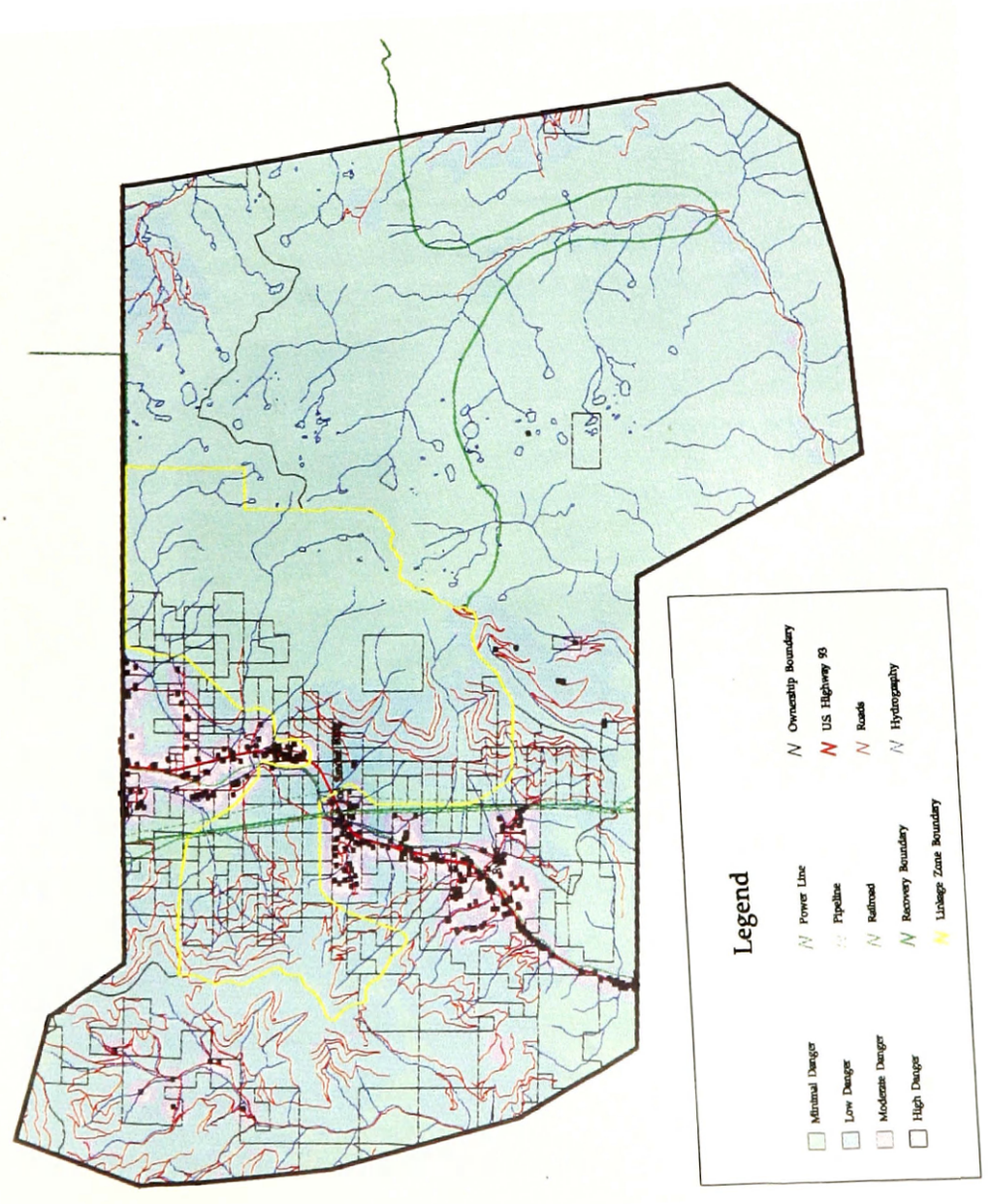


Figure 13. Percentages of areas in combined danger scores categories within the total study area (184 sq. mi.).

Figure 14

Evaro Combined Danger Scored Map



The linkage area was mapped to minimize high danger areas. As a result, over 97% of the area in the linkage zone is in the minimal or low danger category (Figure 15). Proper management within and outside the linkage zone should reduce danger levels for the grizzly.

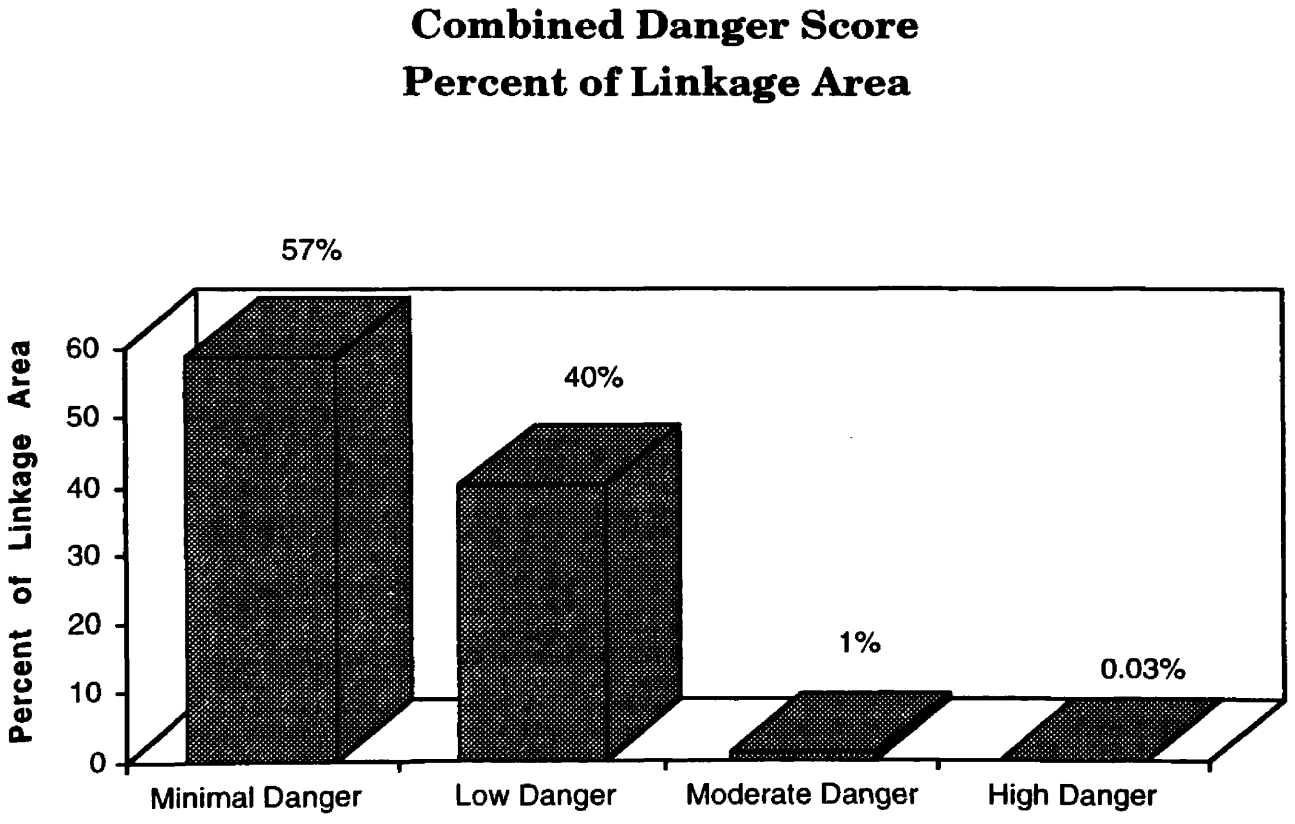


Figure 15. Percentages of areas in combined danger scores categories within the linkage area (34 sq. mi.).

CHAPTER IV

Discussion

Review of Current Situation

Colleen R. Rush writing on the *Non-biological Components of Grizzly Bear Conservation in the Seeley-Swan Valley, Montana: A Problem Analysis* (1994) stated that:

> As human land use practices in grizzly bear habitat change and intensify, and as people move to previously undeveloped areas at an ever-increasing rate, the future of the grizzly bear as a species will be as dependent upon social and political issues as it is on biological data...Wildlife management that fails to incorporate societal values and a broader policy framework will be rendered ineffective by unforeseen obstacles which arise in the social and political arenas.

Following this framework, Rush examined the linkage zone assessment project in the Seeley-Swan Valley and the USFWS's efforts at including the public in management decisions:

> ...the linkage zone process proceeded from a largely technical approach, focusing solely on the needs of the bears and ignoring the needs of the proposed linkage zone residents. The process unraveled because of a failure on the part of the agency to assess the social dimension concurrently with its assessment of the biological dimension.

This assessment of the linkage zone project certainly calls for changes to be made in the linkage zone process. Rush's recommendations called for more training of wildlife professionals in social sciences and for more use of social scientific research methodologies to determine public attitudes so that "socially sensitive, effective conservation and recovery strategies" can be developed. These are laudable goals; however, the lack of specific recommendations regarding their implementation in "real world" situations makes her recommendations somewhat superficial. They fail to address the complex nature of public policy making and how to make anything "socially sensitive" when there are so many different interests with different priorities. In addition, her assessment of the "failure" of the linkage zone process was based on two public meetings, a small sample of a large process. This assessment is circumspect because it looks through a short term window at a process that requires a long term solution. Only assessment over the long term will yield accurate criticisms and recommendations.

However, Rush's claim that the linkage zone assessment is essentially a grizzly bear-centric technical process is correct. Everything I have done so far has focused on a technical assessment of grizzly bear needs. The result has been an identification of a landscape that has habitat attributes that could serve as a linkage zone for grizzly bears. This process has occurred without "assessing the social dimension". I believe that this is the proper and correct first step in developing management policy for grizzly bear linkage zones.

Rush (1994) argues that social dimensions must occur concurrently with biological assessment. That proposed process is problematic. Assuming that linkage zones are necessary for grizzly bear management, identification of linkage areas should be based solely upon biological criteria. An area that is

privately held should not be excluded from a linkage zone simply because the owners of that land might not be grizzly proponents. I would argue that social dimensions of linkage zone management should be considered in the implementation phase after the biological-based assessment and identification of linkage zones is finished. To consider social factors with equal importance to biological factors would corrupt the accuracy of the identification of the linkage zone. Omitting critical habitat from a linkage zone because it is not socially expedient would create an even worse atmosphere of mistrust than Rush described in her paper. Competing players wouldn't know what influence adversaries may have had upon linkage zone boundaries and linkage zones management plans would become disreputable pseudo-scientific documents.

Linkage zones should be clearly presented to the public for what they are - areas that designed for the benefit of the grizzly. From that framework, management plans can be devised with interagency cooperation and public input. The Endangered Species Act gives the USFWS no power to tell people what to do on their private lands. It should be made clear to the public that the intent of linkage zone identification is to act as a guiding document from which policy for public and private lands can be developed.

With that framework in mind, I will detail management options using the linkage zone assessment as my guide. How the linkage zone assessment in the Evaro Hill area is received by various public and private groups and citizens will be based upon its presentation to these groups. If the linkage zone is presented as a guide around which various groups can develop management policy, I believe that it will not be perceived as a threat to their properties or lifestyles by a majority of affected people.

Data supports the notion that citizens and groups in this area will be amenable to grizzly bear management efforts. Jane Frost(1985) conducted a survey to determine the perceptions of Mission Valley residents toward grizzly bears. Frost(1985) found that there was "a strong base of support for the grizzly in the Mission Valley." She found that most people had a favorable attitude toward bears and simply lack specific information about how to live with the grizzly. Dale Becker (pers. comm. 1994), Tribal Wildlife Biologist, stated similiar support exists on the current tribal council both for wildlife issues in general and understanding of grizzly bears needs specifically.

Kellert (1980,1982,1992) has addressed societal values towards wildlife in America. From extensive studies, Kellert(1992) predicts that people whose jobs or property are threatened by grizzlies are probably going to be less supportive of bear management efforts than those whose livelihoods are not based on resource-extraction or land development. Frost (1985) found favorable grizzly bear responses in the Mission Valley came from people who have seen grizzlies and know about their behaviors and needs. Demographically, the strongest grizzly support among Flathead Reservation residents came from younger people and Native Americans (Frost 1985).

Despite disagreement regarding the best way to include people in the decision-making process, all the above authors emphasize the supreme importance of human cooperation for future grizzly bear management success. People are the leading cause of grizzly bear mortality (Grizzly Bear Recovery Plan 1993), but are also their only hope for salvation. Success or failure of recovery efforts in the Evaro Hill area will ultimately rest in humanity's hands.

Recommended Management Options

The Evaro area is currently not being used for grizzly bear movement. Grizzly bear numbers in the lower Mission Mountains and Rattlesnake Mountains are not high enough to push bears to seek new territories. However, this area is of critical importance if there will ever be future movement between the Northern Continental Divide Ecosystem and the Selway/Bitterroot Ecosystem for grizzly bears and other large carnivores. Therefore, it currently might not be necessary to prepare the linkage area for immediate grizzly bear use, but rather the focus should be on maintaining the option for use by grizzly bears in 10 - 20 years. For this reason, possible management options will be divided into two general categories. The first category is immediate management options, whose primary purpose is to prevent any degradation of the linkage area below its current status. Actions in this area are intended both to maintain the current quality of habitat within the linkage zone and to reduce hazards that will take a long time to mitigate or years of education to eliminate. The other category is long term options - those that must be implemented when bear movements are considered more likely. These options are more radical and usually have a larger impact upon the human population.

Short term management options

Table 3 is a matrix that contains the various management options that I recommend and the parties that are responsible for carrying them out and/or have the decision-making power to shape the management policy.

Table 3. Short term management options.

Immediate management actions	Players involved
Establish the Evaro Hill Grizzly Bear Management Committee (EHGBMC)	All affected groups in the area including private individuals, government agencies, and conservation groups.
Review and possible modification of subdivision proposals to minimize or eliminate commercial and residential development within the linkage area (highest priority) and within 2 miles of both sides of the linkage zone	Cooperative efforts between Tribal Council, County of Missoula, USFWS, Montana Fish, Wildlife and Parks (MTFWP) and Montana Department of State Lands (DSL), developers and private landowners.
Mitigation of the effect of Highway 93 expansion	Cooperative efforts of State of Montana Department of Transportation (DOT), Federal DOT, Tribal Council, USFWS, and MTFWP.
Management of attractants	Private residents, USFWS, Tribal Council, County of Missoula, MTFWP
Education of local residents	USFWS, Private Residents, Tribal Council, MTFWP
Establish and implement a long term plan for resource management within linkage area	Tribal Council, USFWS, MTFWP
Seek conservation easements on private holdings within 2 miles of linkage area	Willing private land owners, USFWS, Conservation Groups (land trusts)

Establish Evaro Hill Grizzly Bear Management Committee (EHGBMC)

The critical first step that must be initiated before any management options are proposed and implemented is the establishment of a cooperative relationship between all involved groups. A partial listing of possible involved groups include: area residents, real estate developers, Plum Creek Timber Company, conservation groups, recreation and sporting groups, the Salish Kootenai Tribal Council, the U.S. Fish and Wildlife Service, the County of Missoula, the State of Montana Department of Fish, Wildlife, and Parks (FWP), the State of Montana Department of Transportation (DOT), the State of Montana Department of State Lands (DSL), U.S. Department of Transportation and Lolo National Forest. Various management efforts require different coalitions to be established. However, all management efforts require that local residents and officials interact with federal and state agency officials to determine the best way to implement management actions.

Precedent already exists for cooperative efforts in the grizzly bear conservation arena. The Interagency Grizzly Bear Committee (IGBC) consists of officials from federal and state resource management and wildlife agencies with Canadian and tribal representatives that participate together to establish guidelines for grizzly bear management. This group has made recommendations for grizzly bear management and agreed on definitions of terms. Since the committee is made up of members of affected groups the management recommendations described are reflective of "real world" needs of the bears, agencies, and their constituents. Therefore, the committee's recommendations are more likely to be followed.

I recommend establishing a similiar committee of affected groups in the Evaro Hill Area to address those management efforts that require extensive cooperative activity. The USFWS should be the lead agency that organizes committee. An informational bulletin (see education recommendation) should be sent to all members of the public in the area with the time of a local "town hall" type meeting. Representatives from the above listed groups should be asked to attend a meeting where the purpose of the Evaro Hill Grizzly Bear Management Committee is described by USFWS officials, followed by questions. The meeting should end with encouragement from agency officials for local citizens involvement and the distribution of a form for people to volunteer to sit on the committee. The aim should be to have equal numbers of private citizens as agency officials to dissuade any feelings that the committee favors a certain position.

The purpose of the committee would be twofold. The first purpose would be informational. Members of the committee would be kept up to date on grizzly bear management issues and activities in the area. This should help establish a level of trust between committee members and open up a dialogue on how agency management efforts are being interpreted on the ground by affected citizens. Frost (1985) noted that distrust of government officials stemmed from nuisance bear requests that were not acted upon to the satisfaction of the concerned party. This meeting could get both sides to talk to each other directly about their concerns regarding grizzly bear management. This should improve understanding for both groups and foster the necessary cooperative relationship needed to implement management options effectively.

The second purpose of the committee would be to draw up management strategies for the Evaro Hill area. Different management options such as

obliterating roads or restricting development in the linkage area could be discussed by the committee. After committee input, members could outline strategies that they feel are proper for the area, similiar to the IGBC's management guidelines. These management guidelines could then be presented to the general public in public forums. The public should be more receptive of guidelines established by an interdisciplinary team that includes members from disparate affected groups than anything that is formulated solely by agency biologists.

After establishing general management guidelines, the committee could serve in the role of addressing management problems as they arise. For example, if Walmart wants to open a branch store across from Joe's Smoke Ring, the committee could meet to discuss the biological and social implications of such development and make recommendations to the appropriate decision-making entity. This on-going advisory role should help to place the participating groups and their members into the mainstream of grizzly bear conservation efforts in the Evaro area. People who feel they have effective input will be more willing to make the personal financial sacrifices that will be necessary to maintain the linkage zone in the Evaro Hill area.

Review and possible modification of subdivision proposals to minimize or eliminate commercial and residential development within the linkage area (highest priority) and within two miles of both sides of the linkage zone

The EHGBMC should act as an advisory group to evaluate development proposals within the linkage area carefully. The committee should make recommendations on possible modifications to the original proposal that would

lessen the impact of the development. If the proposed development is too damaging to grizzly bear habitat and cannot be mitigated acceptably, then the committee should advocate rejection of that development. Each proposal should be looked at individually by the multi-group committee and evaluated by its potential to hurt grizzly bear recovery efforts, as well as the social and economic impacts of the development. In the end, the committee can simply make a recommendation to the officials who have the decision making power in the situation. In regards to development within 95% of the linkage zone, the tribal government would have the final decision power. However, the tribe should be amenable to following the committee's recommendations if they are involved in the entire evaluation and recommendation process.

The Evaro Hill Grizzly Bear Management Committee should also act as an advisory group to review any other development proposals within two miles of the linkage zone boundary to determine their impact upon the linkage area. If the impact is considered a threat to grizzly bear movements, proper mitigation efforts should be recommended to reduce the impact of those development activities. The need to discourage development near the linkage area is less than that for developments proposed within the linkage area. However, some areas within 2 miles of the linkage zone could act as good habitat for grizzlies and shouldn't be dismissed simply because they fall outside of the linkage zone boundary. Certain types of developments that could ultimately have effects that extend into the linkage zone should be reviewed.

Just outside the linkage zone, at its narrowest point along Highway 93, is a low income housing development called Schley Homesites. This development sits on tribal land and was set aside by the tribe as a low income housing development years ago. This housing development has been expanding

in recent years and is the perfect example of an area where future development should be carefully reviewed and modified or moved to another site, farther from the critical bottleneck of the linkage area.

Mitigation of the effects of Highway 93 expansion

The State of Montana Department of Transportation (DOT) has proposed an expansion of Highway 93 from two to four lanes in the Evaro area. The DOT has gathered an interdisciplinary team of representatives from affected groups including the USFWS and the Salish Kootenai Tribe. Through efforts of team members to emphasize the importance of the linkage area for wildlife movements, the DOT has released a pre-decision document that outlines mitigation efforts along the part of the highway that passes through the linkage area. Two highway overpasses are planned that will be specifically designed to allow wildlife to go under the highway (Kevin Shelley pers. comm.). The exact details of the design and placement of the overpasses still need to be negotiated.

I applaud the efforts of the entire interdisciplinary team to evaluate, recommend, and implement effective mitigation strategies. This team design is similiar to the proposed EHGBMC which will hopefully be as effective at reaching consensus for grizzly bear management strategies in relation to development proposals. Studies of the effectiveness of these wildlife underpasses for grizzly bear crossing are inconclusive, but promising (Bertch 1991, Foster and Humphrey 1992). While grizzly bear use of underpasses have not been widely documented yet, the attempt at mitigation is recognized and appreciated. Follow through on proper design specifications to maximize

wildlife movements is recommended at this stage. The interdisciplinary team needs to follow the project to completion to make sure that wildlife concerns are not lost later in the design process.

Blocking any highway expansion is another option that should be considered. Currently, the stretch of road within the linkage zone is plagued with a very high number of wildlife mortalities, including approximately 50 deer annually and other species such as black bears and moose kills have been reported (Becker et al. 1993). During observations of traffic patterns during the day and night, I observed almost a continual flow of traffic at all times except for late at night. This traffic could create a barrier to grizzly bear movements across the highway if underpasses are not built. Even if grizzlies find a break in the traffic late at night they run a high risk of being hit by the intermittent traffic that runs on the highway from 2 to 6 am. While the highway expansion will have some negative effects upon potential grizzly bear movements across the highway, the underpass option improves the chances of grizzlies crossing the highway safely.

Management of Attractants

An attractant is improperly stored food or garbage that attracts grizzly into areas where human/bear interaction is high (Grizzly Bear Recovery Plan 1993). Human/bear interactions are dangerous for both people and bears. After spending time near human use areas, bears can lose their fear of humans and become "habituated". These habituated bears are very likely to become conditioned to human food which usually leads to their deaths as they becomes bigger threats to human safety (Grizzly Bear Recovery Plan 1993).

The EHGBMC should identify specific attractants that could lead to increased human/bear interaction and make recommendations on how to mitigate their effects. I have observed several major attractants, some which already create problems with other wildlife, that should be addressed as soon as possible. In a trailer court, just south of where the linkage area crosses the highway, an open garbage truck is regularly visited by black bears. This truck should be replaced with a bear resistant garbage container. Brown Bear Resources has been working with different groups in the Swan/Clearwater valley to help them make their garbage dumpsters "bear resistant" (Brown Bear Resources 1994). These efforts could be duplicated in the Evaro Hill valley.

Two potential big food attractant sites are located near the linkage area - Joe's Smoke Ring and the Sheep Ranch Inn. The managers of these establishments should be approached and the importance of food attraction security should be explained to them. Currently, neither restaurant is sloppy with their food handing practices, but education could help ensure that this positive situation continues.

Local ranchers should be personally notified about potential attractants that they might possess. Unprotected livestock feed is an example of an attractant that could be easily avoided through education about attractants. Similarly, local residents should be educated about possible attractants they might have such as unprotected garbage, gardens, or fruit trees and the potential problems that those attractants might cause.

Education of local residents

Frost(1985) claims that public involvement in grizzly bear management efforts is key to establishing good stewardship practices on private land. She believes that this public involvement should start with education and communication between agency professionals and affected residents. As her survey of Mission Valley residents' attitudes towards grizzlies reveals, those residents who had a higher level of knowledge about the grizzly had the highest level of support for the animal.

Frost (1985) makes several specific recommendations regarding public education. She strongly feels that education efforts must include all information on grizzlies that is available from behavioral information, to habitat needs, to agency efforts at management. Frost (1985) recommends that a mail campaign effort would be an effective method of information dispersal. She suggests that the mail bulletin should contain information described above, in addition to meeting times for the public input workshops. These public meetings, Frost suggests, should take the form of community discussions rather than a lecture format. With the interactive format, she feels the community will feel more involved in the process and gain an understanding of the positions of other residents in the area. Getting residents involved in the process will further their feeling of involvement and hopefully should foster a positive reaction to grizzly bear needs. She states that individual landowners should be approached and specific management strategies developed based on mutual understanding of the owner's and grizzly bear's needs.

This "two-way flow of communication" between agency professionals and local affected residents is crucial for successful implementation of any linkage area management efforts. Frost's recommendation of information bulletin/meeting announcement is one that should be implemented in the Evaro Hill area to inform residents of the linkage area. An education specialist will soon begin working in the Grizzly Bear Recovery Office (pers. cons. Chris Servheen). The purpose of establishing this position is to implement educational efforts for residents who live in areas used by grizzly bears. This educational specialist should coordinate educational efforts including informational bulletins and meetings of the EHGBMC.

Tribal council members and local government officials should be especially encouraged to participate in these informational workshops. The successful implementation of certain management strategies will depend upon the tribal council and local governmental decisions. However, even decisions reached by the tribal council must be accepted by current users of the linkage areas to assure compliance with those decisions. A locked gate can be broken if the user doesn't understand the importance of restricting the use of the area for grizzly bears or doesn't care. Care for the grizzly can hopefully be engendered in public members through education about the grizzly's behavior, habitat needs, and the role that individuals can play in helping the grizzly.

Establish and implement a long term plan for resource management within linkage area

The land within the linkage zone is mostly owned and controlled by the Salish Kootenai Tribes. The tribes currently have conservation land use plans

in place including timber harvest, riparian, grizzly bear, and road management guidelines, that are the a good part of the reason any wildlife corridor still exists in the Evaro area (Becker et al. 1993, CS & KT and BIA 1981). Currently, most of that land is managed for multiple use purposes - logging, grazing, and recreation. A long term resource management plan specifically for lands within the linkage area should be constructed to ensure that the current beneficial habitat values of the linkage area are not significantly degraded in the future.

The EHGBMC should draw up a list of recommendations for the tribal council to consider adopting in regards to management of the lands in the linkage area. The plan should address the desires for future resource extraction and coordinate them with future grizzly bear movement needs. To adequately protect and even enhance the positive habitat values in the linkage zone, the plan needs to address at a minimum logging, road closures, and human development. Other important areas the plan should discuss include recreational uses of the area and vegetation enhancement. The Tribal Wildlife Management Program has called for a similar land-use planning joint effort with the County of Missoula for the Evaro area and should be amenable to cooperative efforts to establish a linkage zone management plan (Becker et al. 1993).

A timeline describing the expected long term logging activities should be designed. Any area that is slated to be logged should be done sooner rather than later to allow cover to regenerate before grizzlies are expected to use the area. The lowland riparian areas close to the critical bottleneck of the linkage area around the highway should have no logging, if possible, to maintain cover and food sources in that dangerous and critical area.

No discussion of logging can occur without a discussion of roads. Road closures after logging will be critical to reduce human/bear interactions and to increase the likelihood of use of the area by grizzlies. Several studies have found that grizzlies are affected by vehicles on open roads and respond by avoiding the area (Frederick 1991). Restricting road access can increase the effective habitat by grizzlies (Mace and Manley 1993). Roads near riparian corridors should be removed permanently by obliteration through revegetation. Since cover and food sources are more likely to be located in riparian areas, reclaiming those roads should reduce the number of human/bear interactions. If an access road is felt to be necessary, then a single, non-riparian road should be chosen from those that already exist and restricted to limited administrative use only (Puchlerz and Servheen 1993) .

Guidelines for future human development and use of the linkage area should be carefully delineated. Future homesites within the linkage area should be prohibited. Currently, one abandoned homesite exists in the linkage area. It should be obliterated before anyone gets an idea to move into it.

Currently, an underground pipeline and several power transmission lines run through the linkage area. All these lines have corridors of straight non-cover and roads associated with them. This creates a dangerous situation in terms of poaching. A potential poacher could sit on a hilltop and see a grizzly crossing the open area under these lines from far away. I recommend limiting access to the roads in these open areas to administrative use only. Over time, this should allow cover to shrink some of these open areas and make it more difficult for potential poachers to get access to these areas.

Recreational use of the linkage area should also be addressed. Grizzlies have been documented to have strong reactions to people on foot. In one

study, 5 of 9 grizzlies retreated over 1 kilometer or out of the drainage after encountering people on foot (McLellan and Shackleton 1989). During times of high grizzly use, the tribe should consider temporarily closing an area for the mutual safety of humans and bears. The decision to limit access to an area temporarily should be made by wildlife officials in the tribal government. I recommend that a description of the conditions when an area should be closed temporarily to recreational use be included in the resource management plan.

Vegetation enhancement should be considered for critical areas that currently have limited cover. Areas near the future highway underpass should have enough hiding cover to make the use of the highway underpass safe for grizzlies.

Seek conservation easements on private holdings within 2 miles of linkage area

Considerable amounts of private holdings exist within two miles of the linkage area that could serve as grizzly bear habitat if properly managed. Conservation easements should be sought from willing local private landowners. Conservation easements are contracts voluntarily entered into by private landholders that define what land use can occur on that parcel of land. Accepting an easement means that you are limiting what can be done on that land. Even if the land is sold, the next owner must normally abide by those restrictions. This usually lowers the property value of the land and subsequently lowers the property tax burden on that land. In addition, the placement of an easement can be considered a donation and be deducted from income taxes over many years. Some private conservation groups even pay landowners who accept an easement on their land. Actions that could be

limited or prohibited by a conservation easement include barring or limiting additional buildings on the land, limiting the amount of logging or road building on the land, or limiting or barring subdivision of the property.

Conservation easement efforts should be concentrated on those allotment lands nearest to the bottleneck area of the linkage zone. While I believe efforts should focus there, that does not preclude trying to get other owners in the surrounding area to enter into an easement agreement. Any land within the study area that could be managed to limit impacts to grizzly bears only enhances the probability that grizzly bears will successfully use the Evaro Hill area as a linkage area.

Long term management options

Long term options should be implemented when grizzlies begin to occupy areas within the study area. If grizzlies do begin to move across the Evaro valley then more intensive efforts at management need to be in place to lower human/bear conflict and lower the overall danger to both grizzlies and human. Since so much becomes variable in the distant future, long term management recommendations are purposely more general and open ended. Table 4 summaries the long term management options and the affected players.

Table 4. Long term management options.

Long term management actions	Players involved
Maintain and intensify short term management efforts	All players mentioned above.
Apply management efforts to Mill Creek Area	USFWS, Private landowners, Lolo National Forest, Plum Creek Timber Company, Tribal Council, MTFWP

Maintain and intensify short term management options

Short term management efforts should be maintained and if possible, intensified in the future if grizzly bears are using the area. Development proposals should be more strictly scrutinized for their potential to cause human/bear interactions. If it is likely that interactions will occur when the development is completed, then the proposed development should be rejected. A more intensive attractant identification and elimination effort should be undertaken when bears are using the area. This includes intensifying public educational efforts about the role they can play in helping or harming the grizzly bear. Every effort should be made to educate every resident around the linkage area about the importance of attractant management and strategies for avoiding human/grizzly interactions. Financial incentives for bear resistant containers may be necessary. Fear about the potential danger to humans and property from grizzly bear presence in the area will probably be high given that

residents currently aren't living with the grizzly. This fear can be reduced through educational efforts that take place now to prepare residents and more intensive efforts when grizzlies are in the area. Logging should be scaled down after grizzly bear occupation and open road density should be reduced through the restriction and obliteration of more roads.

Apply management efforts to Mill Creek area

If bears begin to move across the Evaro valley, they will be faced with some new dangers over the ridgeline to the west in the Mill Creek drainage. Currently, seven houses exist on privately held land and high road densities exist in most areas. A management plan should be designed for this area that minimizes the impacts of these negative items. Educational efforts should be made for the residents in the Mill Creek drainage that increase their knowledge of the grizzly and outline ways to help it and themselves by reducing attractants. Road closures on Plum Creek and Forest Service land could help reduce the number of human/grizzly encounters and open up more habitat for the grizzly to live safely in. Conservation easements on the privately held land should be strongly encouraged.

Economic impact of management options

Economic impact assessment is the cornerstone of many of the decisions our society makes regarding natural resource conservation issues. For better or worse, all management options regarding grizzly bear conservation that are currently being exercised or will be implemented in the

future must address the economic impact of their actions either implicitly or explicitly.

Simberloff and Cox (1987) have raised several questions about the economic cost of wildlife corridors. They note that per unit management costs for linkage areas can be higher than for large refuges and that some management options such as wildlife bridges are expensive. They suggest that it may be cheaper to simply drug the animals and move them around as needed, rather than having them get there themselves (Simberloff and Cox 1987). Indeed this is an option, but it is fraught with difficulties - both biological and economic. Biologically speaking, drugging and moving grizzlies is very disruptive and disorienting to them. Making this intrusive process part of their lifestyle may cause the bears to become habituated to humans. This could lead to more human/bear interactions and eventually higher bear, and possibly human, mortality (Jonkel 1993). In addition, the proposed linkage area will act for the benefit of many different species including (but not limited to): deer, snowshoe hares, coyotes, elk, moose, ruffed grouse, lynx, mountain lions, black bears, and wolves (Becker et al. 1993).

Simberloff and Cox (1987) admit that each particular linkage area should be evaluated on its own biological and economic costs and benefits to determine whether it should be established. I believe the biological benefits of establishing a linkage area in the Evaro area is better than the alternative of human-related movement of bears between large populations. Economically, it is not as clear. There are a large costs that will be incurred in establishing and maintaining the linkage area. The benefits from the linkage area, i.e. grizzly bear preservation, will be shared by everyone who enjoys the fact that grizzlies still exist in Montana, while most of the costs will be concentrated on a

few key players, mainly the Salish Kootenai Tribe and private landholders in areas near the linkage zone. However, one major economic cost, the highway underpass, will be spread out among many people in the form of highway taxes.

Management options that concentrate a financial burden upon an individual or small group should be examined to determine how to universalize the cost burden. For example, federal government purchase of development rights within the linkage area would spread out the cost among more of the people who benefit from the grizzlies existence (U.S. taxpayers), while reimbursing the group (Confederated Salish and Kootenai Tribes) for the loss of economic value of the protected lands.

Clearly, the short-term direct costs of paying for grizzly bear plane rides between the Bob and the Selway-Bitterroot are less than the outlays that will go into the establishment and maintenance of a linkage area in the Evaro Hill area. However, the long term cost of a grizzly bear movement project would probably be astronomical and extremely difficult to predict with any accuracy given the variables of fuels, salaries, and equipment costs. In addition, the program would be subject to budgetary pitfalls on a yearly basis and only be effective for one wildlife species. In contrast, establishing a linkage area provides a stable and more predictable (in terms of economic costs) way to maintain genetic flow between populations for many species. Unfortunately without some reimbursement system, the burden of costs for maintaining the linkage zone falls upon a much smaller group than if bears were moved by planes.

Frost (1985) observes that private residents are required to carry much of the economic burden of grizzly bear conservation in the Mission Valley including property damage and loss of revenue from habitat placed aside for

the specific intent of preservation. While these losses are often not explicitly calculated in economic impact estimates for conservation efforts, these private citizens are implicitly paying some of the costs of grizzly bear protection.

I will examine the economic impacts of each of the management options I described above by evaluating their explicit and implicit costs. Explicit costs are the actual costs to design, discuss, and implement the specific management option. Examples of these costs include salaries of employees who carry out management efforts, administrative costs such as printing costs, and the costs of durable goods such as bear resistant garbage cans. Implicit costs are the hidden costs to the general economy or local residents that are not easily quantifiable. Examples of implicit costs include loss of revenue from not logging or grazing in the linkage area or the loss of tax dollars from residents who would have built houses or businesses in the linkage area.

These costs usually have a negative effect upon local residents, but there are situations where positive economic currents may negate any dampening effect that conservation efforts might have upon the local economy. Increased recreational and tourism use of the area is a large implicate economic benefit that may negate the some, if not all, of the negative economic effects of establishing a linkage zone. As the scenic and recreational value of the area is enhanced through the establishment of protective measures for linkage zone, more income will be generated directly for the tribes through increased use, hunting, and fishing fees and indirectly for the local economy through related increases in the tourism business. The recent move by the Confederated Salish and Kootenai tribes to increase recreational fees (and create new ones such as camping and boating stamps) demonstrates

their understanding of the economic benefits of recreational uses of the land (Missoulian 11/20/94).

Table 5 is a matrix that summarizes the explicit and implicit costs associated with each short term management option. These conclusions are broken down into four general categories: high, medium, low, or no cost. The determination of the costs is based on a review of the related literature, opinions of professionals in this field who are familiar with the area, and my own subjective judgments based upon my understanding of economic and social systems.

Table 5. Explicit and implicit costs of each short term management option.

Management Option	Explicit[1] Cost	Implicit[2] Cost
Establish the Evaro Hill Grizzly Bear Management Committee	low/med	low
Review and possible modification of subdivision proposals to minimize or eliminate commercial and residential development within the linkage area and within 2 miles of both sides of the linkage zone	low to high	low to high
Mitigation of the effect of Highway 93 expansion	high	low
Management of attractants	medium	low
Education of local residents	low	low
Establish and implement a long term plan for resource management within linkage area	med/high	medium
Seek conservation easements on private holdings within 2 miles of linkage area	low/med	low/no cost

1 Explicit costs - Actual costs related to the design and implementation of management options.
2 Implicit costs - Hidden costs to local individuals or any general dampening effect upon the economy caused by implementation of a management option.

Short term management options economic impact

Establishing the Evaro Hill Grizzly Bear Management Committee should have low to medium explicit costs. With only salaries for some government officials to organize and run the meetings and minimal printing costs for informational materials for committee members, I do not foresee large financial outlays will be needed to organize and maintain the EHGBMC. Since many of the members will be volunteer representatives, there is an implicit cost of time spent by these volunteers at the meetings. I feel this cost is low since members of the committee will also receive implicit benefits from being members of the committee such as learning more about the grizzly, making connections with fellow community members, and feeling good about being a member of the decision making team that is helping the bear. Establishing the committee has the potential to yield great results at a relatively low cost. Therefore, I believe this should be among the highest management priorities to be implemented in the Evaro Hill area.

The review and possible modification of development plans inside and outside the linkage zone by the committee should have the same explicit and implicit costs as the ones described above. The greater burden will be felt by the group who has to modify or eliminate their development because of the committee's decision. Their explicit costs could be high if the committee recommends a modification that is costly to implement. Their implicit costs could also be high if the committee blocks their development and they must move to another location delaying the opening of a business or living in a new home. This management option provide extremely important protection from unwise development for the relatively small linkage area and have a low cost to

implement. However, the social costs can vary from an inconvenience to severe hardship to those individuals whose development is reviewed. The effect upon the overall economy is difficult to predict since damping effects upon the local economy from development limitation may be offset by the effect of increased tourism that is dependent upon the maintenance of open areas for its livelihood. Overall, the review and possible modification of development requests must be implemented with local economic, social, and biological effects all given proper consideration.

The mitigation of the effects of the Highway 93 expansion has very high explicit costs that can be measured readily. Once design plans are drawn up for the highway underpasses, cost estimates will be made available that can be used to describe how much more grizzly bear movement is going to cost taxpayers. However, it is critical to note that while the explicit costs for the highway underpass are probably going to be very high, the burden is spread out over millions of taxpayers. Pragmatically speaking, the monies spent for the highway underpass are not being redirected from other conservation efforts, but rather from the building or expanding of other highways. Therefore, if the money is not spent in Evaro it will be spent somewhere else, so it might as well be spent on preserving grizzly bears and giving jobs to local construction workers. The implicit cost of building the underpass are low. Any negative economic impact that building the underpass will cause, i.e. longer delays in the construction of the highway, are fairly negligible. In fact, the economic stimulus caused by the construction efforts will probably have a positive effect on the local economy.

The management or elimination of attractants will probably have moderate explicit effects upon the individuals who will be asked to make the

changes. Government agencies should consider offsetting some of the costs of implementing attractant reduction to encourage residents to reduce human/bear encounters. Every dollar spent in attraction reduction would probably be made back by savings from not having to deal with nuisance bears. The implicit hidden costs are few, mostly in the form of inconveniences, i.e. individuals can't leave garbage unprotected or have an orchard in their backyard. The moderate explicit and low implicit costs make this option easy to implement, relatively cheap, and offers a high yield for relatively small outlays of money or effort.

The education of local residents will have low explicit costs. The only cost will be the employment of the education specialist by the USFWS and the printing and mailing costs of informational bulletins. There is a low implicate cost of time the citizens take to educate themselves. With low explicit costs and implicit costs, education of local residents is an easy, cost-effective, and productive tool for grizzly bear management.

Designing a long term resource management plan for the Evaro Hill linkage area should be relatively inexpensive. The implementation of the management plan should have medium to high explicit costs in the form of lost revenue from logging and grazing activities that may need to be curtailed. This cost will be felt mostly by the Salish Kootenai tribe. The level of the explicit cost to the tribe will be based on the amount of resource extraction that they forgo for the benefit of the grizzly. The implicit costs will be to the forest product companies and ranchers who may lose some areas that they could be log or graze. These hidden costs are probably moderate and will be difficult to tease out from many other influences that act upon the resource extraction

industries. This management option is probably the most costly in terms of the concentration of economic burden relative to the amount of economic cost.

The tribe, in controlling 95% of the linkage area, will be asked to make the largest sacrifices for the grizzly. However, the tribe should receive economic benefit from managing the linkage area for wildlife values. If the tribe develops a plan for resource management in the linkage area that is favorable for the grizzly, the highway department will be more amenable to contributing the large monetary outlays that the highway underpass will require, which will probably provide jobs to many of its members and stimulate economic activities in the area. If the tribe does not commit to managing the linkage area for wildlife values, the highway department may feel it is wasting its money building the underpass and scrap the project. This would mean the tribe would potentially lose a significant amount of revenue that the underpass construction would provide. While this management option does place a large economic burden on the tribe, it also has the possibility to encourage economic growth in that portion of the reservation and provide employment to many of its members. Perhaps the tribe and highway department could negotiate a contract in which the tribe promises certain management activities will take place in the linkage area including road restrictions and reclamation and less logging and the highway department could give preferential treatment for contract work on the highway expansion to companies that employ many tribal members.

Seeking conservation easements on private land has mainly administrative costs associated with the action. Those costs are low to medium depending upon the complexity of the contract drawn up. These administrative costs would probably be carried by conservation land trusts

including Montana Land Reliance, Five Valleys Land Trust, or the Montana Nature Conservancy. Of course, if these groups engage in buying development rights from landowners then the explicit costs would rise substantially. Any implicit costs would be related to the restriction of certain economic activities on the land. Since the easements would be entered into voluntarily and usually have the impact of lowering the property tax burden upon the landholder, I believe the implicit costs of conservation easements would be negligible.

Long term management options economic impacts

Table 6 summarizes the costs related to designing and implementing long term management options. Long term economic impacts are difficult to predict given the amount of conditions that become variable in the long term, including interest rates, real estate costs, taxation, and commodity prices. Fluctuations in any of these variables can cause significant economic impacts upon the implementation of management options.

Table 6. Explicit and implicit costs of long term management options.

Management Option	**Explicit Cost**	**Implicit Cost**
Maintain and intensify short term management efforts	med/high	med/high
Apply management efforts to Mill Creek Area	med/high	low/med

Maintaining and intensifying the short term management efforts in the future will probably be both explicitly and implicitly more costly than earlier efforts. As education efforts and attraction mitigation are stepped up when bears are using the linkage area, the cost of intensifying even those low cost efforts will rise. The review and modification of development proposals will certainly be more expensive as the criteria to evaluate the proposals become more strict and more modifications are recommended.

Applying management efforts to the Mill Creek area will have moderate to high explicit costs. Attraction management, education, and development modifications should be no more costly in the Mill Creek area than in the Evaro valley bottom. Restricting or obliterating roads on Forest Service and Plum Creek land will have moderate to high costs depending upon the extent of reclamation conducted. Reducing timber harvests on forested lands will have high implicit and explicit costs. If timber harvests are reduced, Plum Creek and the Forest Service will experience losses of revenue from the timber sales. There will also be associated hidden costs related to the economic depressing effects of not harvesting that timber. These costs are difficult to describe, but should be fairly low, given the small amount of land in the Mill Creek area that would be effected.

Economic impacts are difficult to predict in the complex socioeconomic climate of the Evaro Hill area. Many factors contribute to a healthy economy in the area, including wildlife and recreation, and those economic factors should not be overlooked when examining the economics of a management option. As in many areas in Montana, economic questions about the use of resources in the future are divided between short term, tangible economic gain from resource extraction and human development of natural areas versus the long

term, somewhat nebulous economic strength gained from conservation and preservation of natural areas. Evaro Hill and much of Montana is at a cross road where it must decide what it will base its economic future upon. Shall it continue the boom/bust economy of resource extraction or shift to a more stable, conservation oriented, tourism and value added economy like many other Rocky Mountain States have done. For the grizzly bear, there is only one choice.

Conclusions

The value of linkage zones to grizzly bear conservation is now becoming increasingly evident. Efforts to link large protected populations of grizzlies by linkage zones will require coordination of government agencies, local governing bodies, and private citizens. The linkage zone in the Evaro Hill area provides a special management challenge since it lies almost exclusively on private land. The success of all of the management efforts will ultimately rest in the sincere efforts of agency officials to communicate grizzly bear information, research, and needs to the affected public. With the funding of an education specialist by the Grizzly Bear Recovery Program, the USFWS has taken the first step toward addressing this need for communication.

Maintaining linkage zones will involve sacrifices, both societal and individual. Open democratic process has the best hope of allowing society to protect biodiversity while minimizing unequally distributed sacrifices among individuals. Only through cooperative efforts among and within the government, non-profit, and private sector can the complex social, economic,

and biological issues surrounding grizzly bear conservation be successfully addressed.

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APPENDICES

Appendix A - Road density results

Salish Kootenai Tribal Lands have the highest road density related to their multiple use management of their lands in the linkage area (Figure 16). Allotments and tribal fee lands have lower densities in the linkage area. These areas are used primarily for grazing and therefore don't have the high road density associated with logging activities on tribal lands.

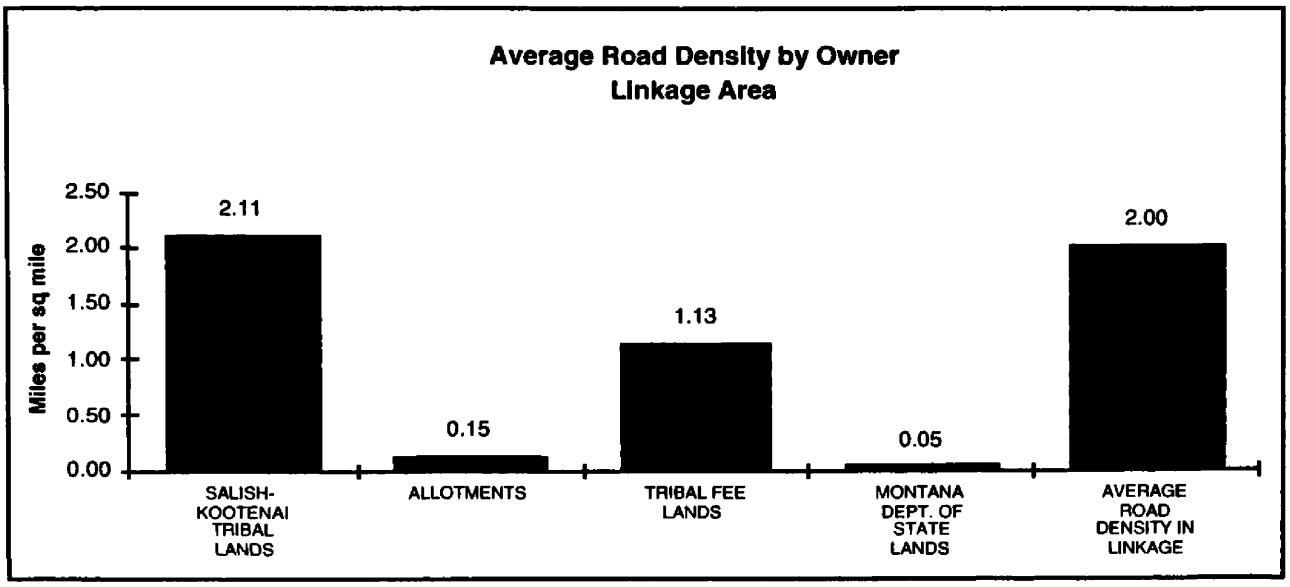

Figure 16. Average Road Density by owner within the linkage area (34 sq. mi.).

Salish Kootenai Tribal lands and Plum Creek Timber Company lands have the most total road miles with 171.37 and 118.92 respectively (Figure 17). Logging is the reason for the majority of these roads. Tribal lands contain almost all of road mileage within the linkage area with 69.14 miles of roads out of a total of 69.44 miles.

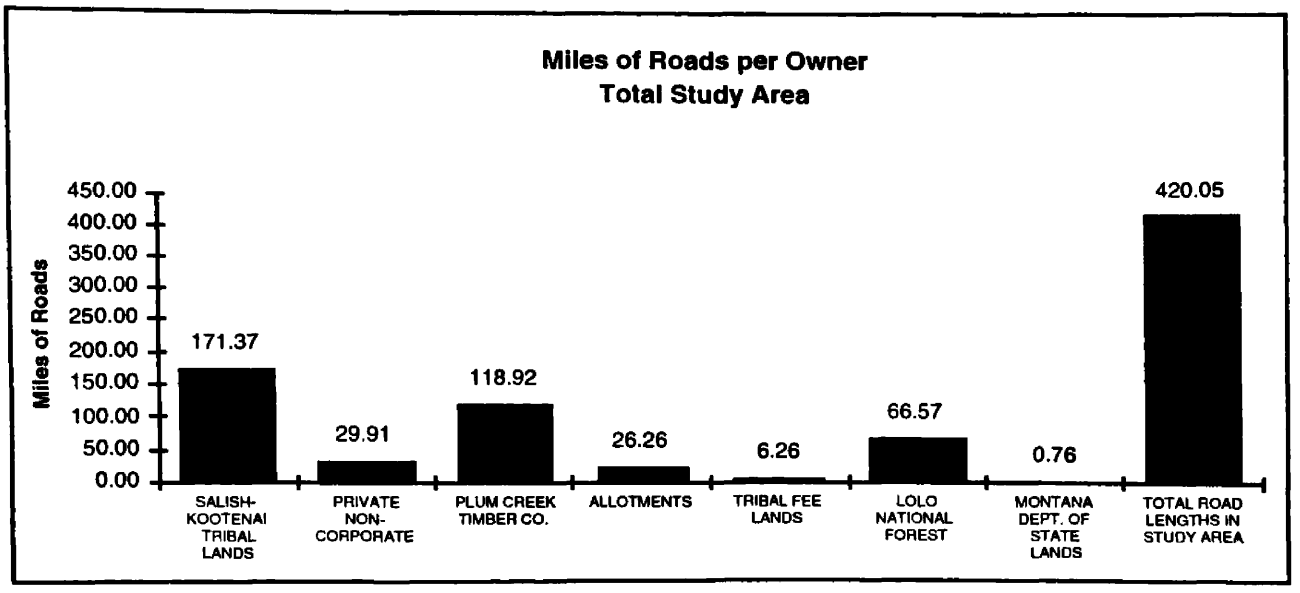

Figure 17. Miles of Roads per owner in the total study area (184 sq. mi.).

The high zero mile/mile^2 acreage value (40%) is due to the large amount of roadless wilderness area to the east of Evaro Hill (Figure 18). Almost as high as the roadless areas are the high road density areas (greater then 2 miles/mile^2) which take up about 38% of the total study area. This high percentage demonstrates the large amount of roaded development that has already taken place in the western part of the study area.

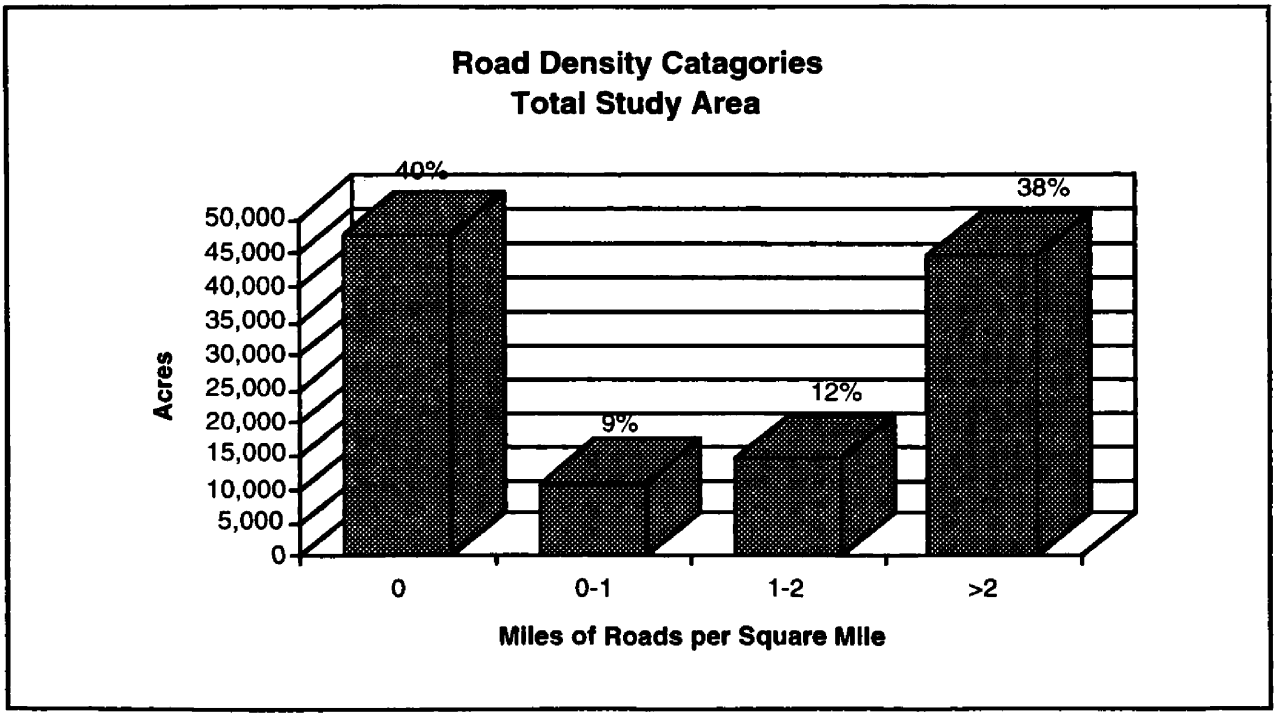

Figure 18. Road Density Categories for the Total Study Area (184 sq. mi.).

The linkage area contains a similiar distribution of road densities (Figure 19). The largest road category within the linkage area (which is located in the developed western part of the study area) is the greater than 2 miles per square mile category at 46%. However, roadless areas on the eastern end of the linkage zone form a sizable portion of the linkage area with 37% of the area. While road densities above 2 miles per square mile are usually considered

unacceptable for grizzly bears, good riparian habitat and hiding cover, and the lack of human influence sites in most of the linkage zone make it less dangerous for the bears than other high road density areas in the study area. Certainly, road density reduction should be a primary goal of future management efforts.

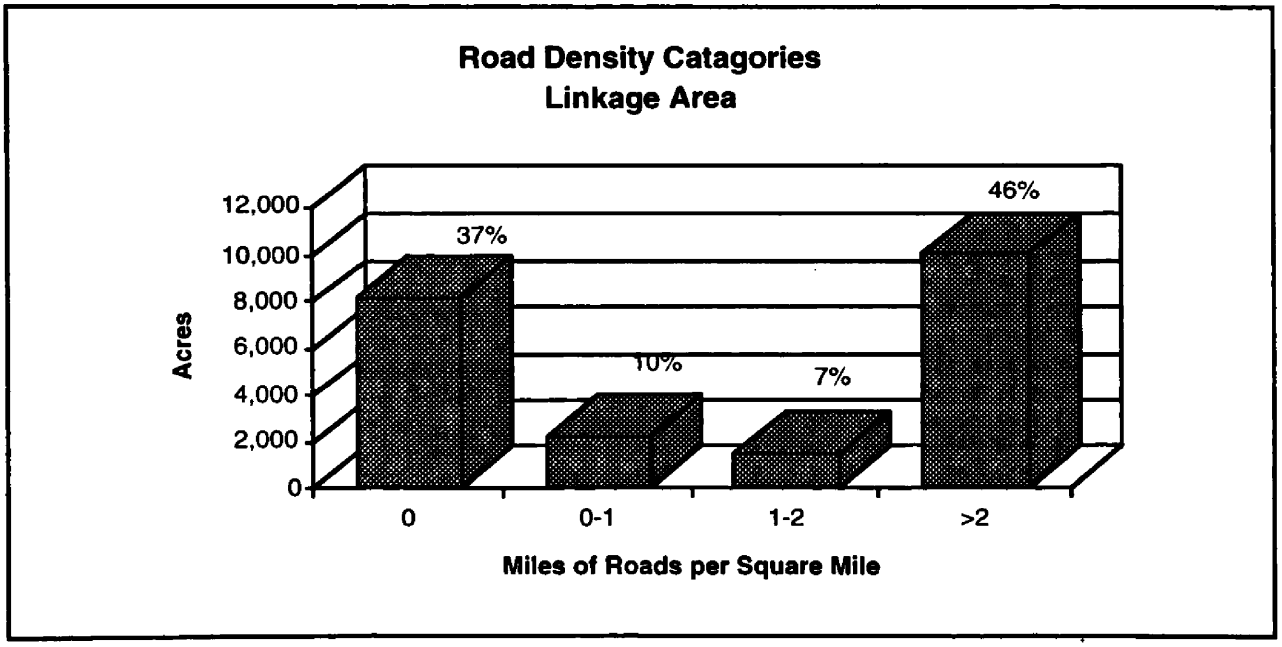

Figure 19. Road Density Categories within the Linkage Area (34 sq. mi.).

Appendix B - Cover Layer Results

In the next four charts, cover represents all categories that get a score of 2 in the LZP model, i.e. cover outside buffer, edge outside buffer, non-cover outside buffer, and cover inside buffer. Edge represents edge within the 500 meter road buffer (score = 3) and non-cover equals non-cover within the buffer (score = 5). Categories with values equal to 2 dominate the total study area including about 90% of the area (Figure 20). Of the owners, only allotments and tribal fee lands have significant percentages of their land as edge and non-cover within the 500 meter road buffer.

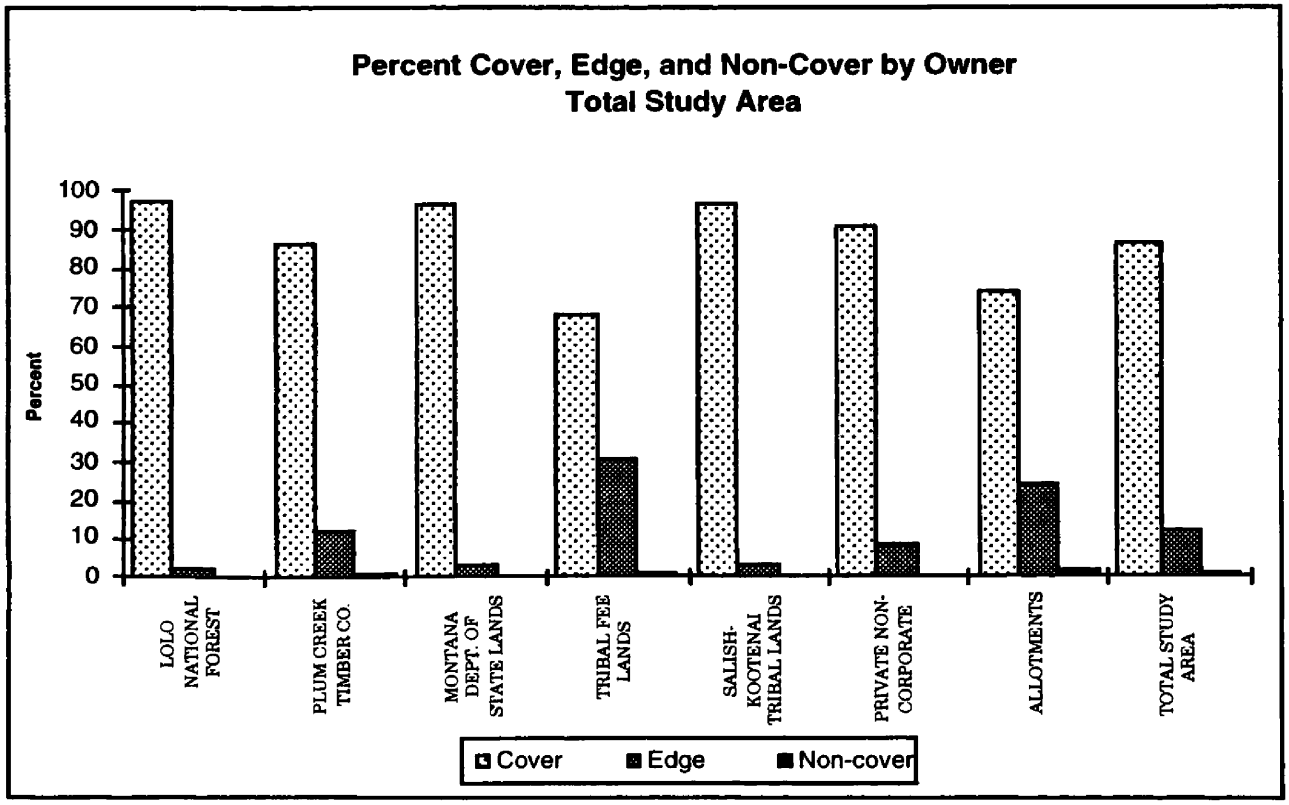

Figure 20. Percent of Cover, Edge, and Non-Cover by Owner for the Total Study Area (184 sq. mi.) Note: cover represents all categories that get a score of 2 in the LZP model, i.e. cover outside buffer, edge outside buffer, non-cover outside buffer, and cover inside buffer. Edge represents edge within the 500 meter road buffer (score = 3) and non-cover equals non-cover within the buffer (score = 5).

Within the linkage area good hiding cover values dominate (over 97%) and none of the owners within the linkage area deviate far from this standard (Figure 21).

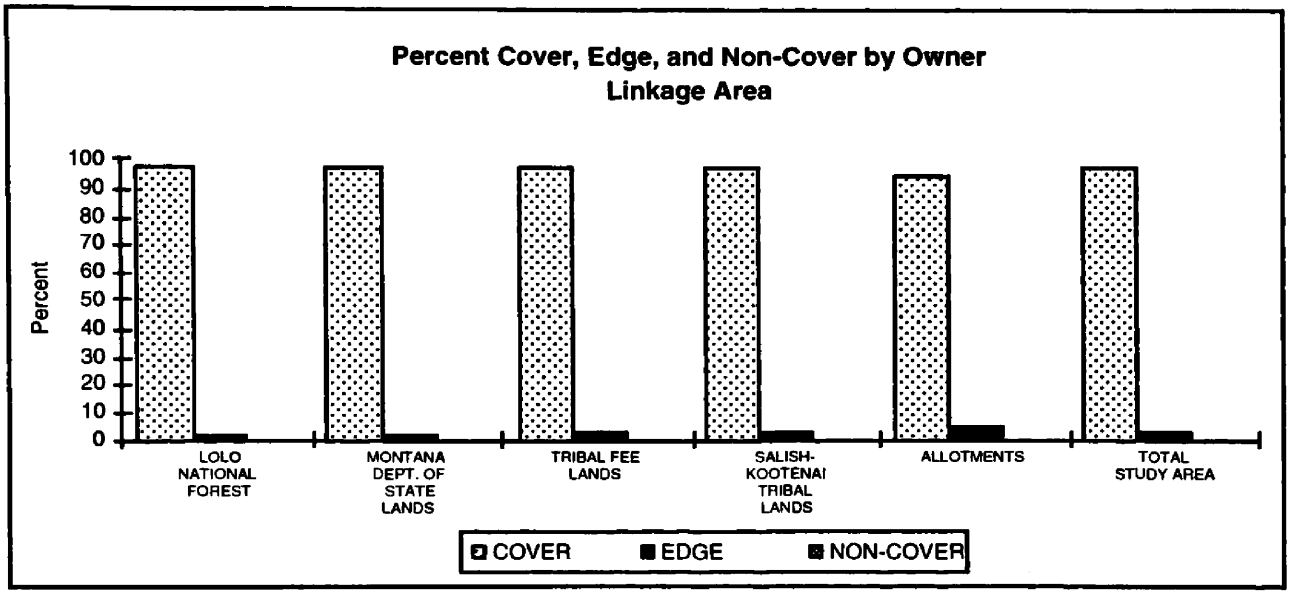

Figure 21. Percent of Cover, Edge, and Non-Cover by Owner within the Linkage Area (34 sq. mi.).

Total acreage contained in the three score categories shows similar dominance of cover features (Figure 22). The high cover values in the Lolo National Forest and the Salish Kootenai Tribe are related to the large amount of forested land that they own in the total study area.

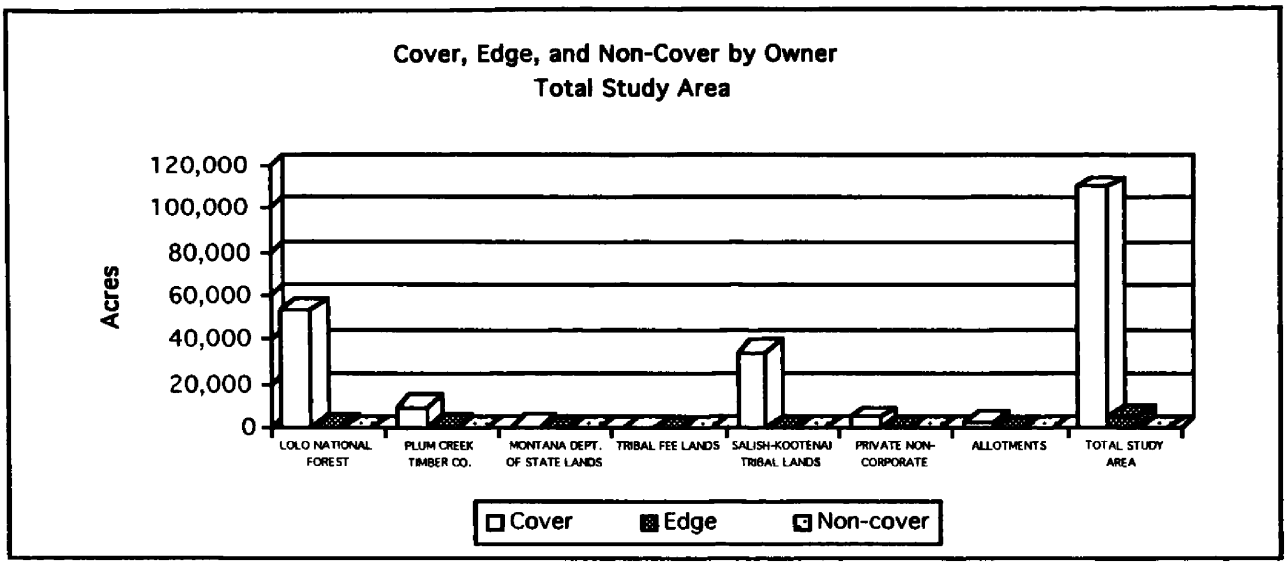

Figure 22. Acreage of Cover, Edge, and Non-Cover by owner in the total study area (184 sq. mi.).

The Salish Kootenai Tribal lands have the largest amount of good hiding cover values because of the large amount of land they own in the linkage area (Figure 23).

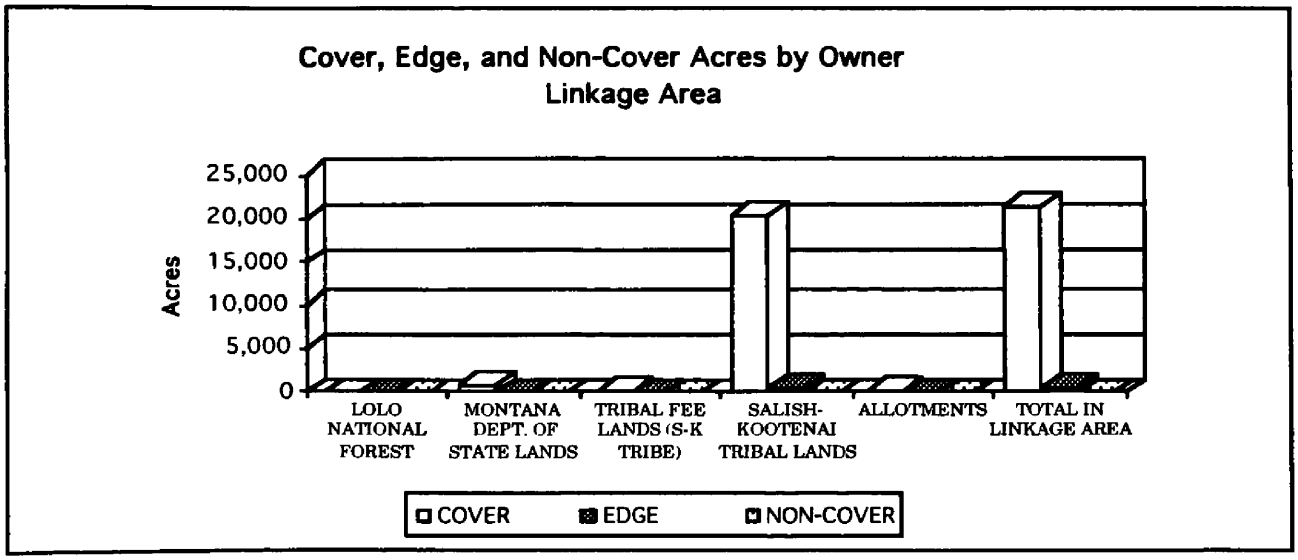

Figure 23. Acreage of cover, edge, and non-cover by owner within the linkage area (34 sq. mi.).

Appendix C - Riparian Layer Results

Allotments and private non-corporate owners have the greatest amount of riparian area as a percentage of their total holdings (Figure 24). These owners have the highest percentage of riparian because they are located in the valley bottom where many streams intersect and join Finley Creek. This is problematic because of the importance of riparian areas for providing hiding cover and feeding habitat for grizzlies and the limited management options that can be exercised on private non-corporate holdings.

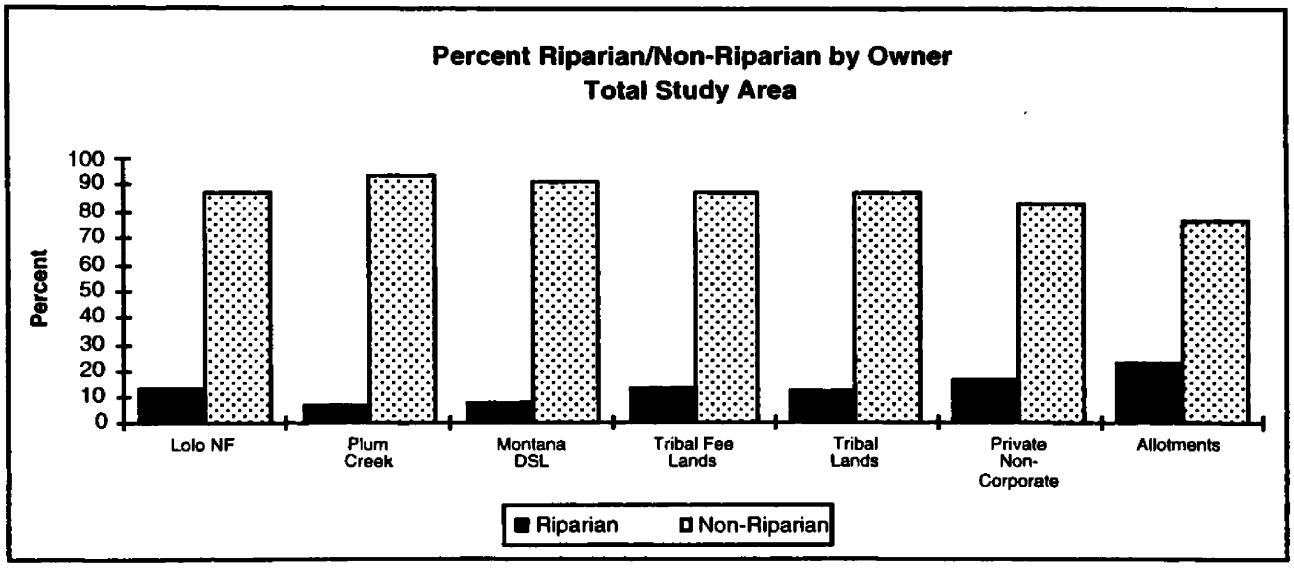

Figure 24. Percent of riparian and non riparian areas by ownership in the total study area (184 sq. mi.).

The percentage of riparian areas for allotments is somewhat lower within the linkage area as compared to the entire study area (Figure 25). Tribal ownership controls most of the riparian areas within the linkage area.

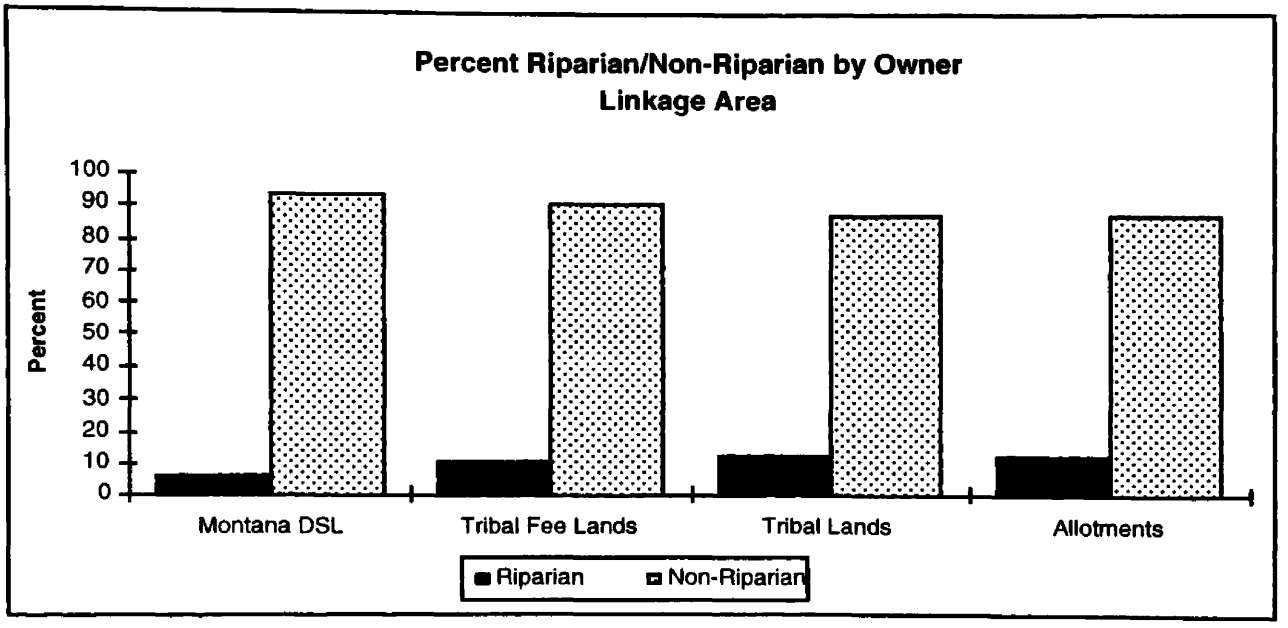

Figure 25. Percent of riparian and non riparian areas by ownership within the linkage area (34 sq. mi.).

Appendix D - Evaluation of LZP Model

The Linkage Zone Prediction Model is an excellent tool for evaluating landscapes for linkage zone value on the landscape level. The quality of the model's predictions are, of course, based on the quality and availability of the data that is run through the model. With that in mind, I have several recommendations for improvement of the LZP model, beyond the changes already outlined in this paper, that should increase the accuracy of linkage zone identification using currently available, reliable data. As new, high quality data becomes available and basic research increases our understanding of grizzly bear needs, the model should be reevaluated to see it is addressing the new information.

Riparian Layer

This layer of the four criteria used in the LZP model is the one that is in the most need of improvement. Currently, buffers of varying sizes around water features are used to determine the "riparian area". While this method is efficient, it is hardly an accurate representation of a riparian area. To better represent a riparian area, several factors should be considered including vegetation, slope of terrain, and soil types. Per Sandstrom (pers. comm.) has promoted using some of these factors in determining the riparian layer for future models.

Some data exists to determine vegetation and the slope of the terrain. Riparian vegetation is detectable from aerial photographs and could be used as a criteria in determining the size and shape of the riparian area. Recent aerial photographs were not available in the Evaro area, so this method was not

used. If photographs become available, I recommend riparian vegetation delineation be performed.

Once riparian vegetation has been identified, Digital Elevation Models (DEM's) exist at 30m x 30m pixel resolution that could determine the slope of the terrain. Slope could be used to determine stream bottoms, flood plains, and alluvial fans. Vegetation and slope could be used together with field checking (ground truthing) to make a much more accurate representation of the true riparian area for analysis purposes. When data is available, soil types could also be overlaid to better hone the assessment.

More extensive riparian descriptions, including field checking, can become a cumbersome process. Possible mitigation of that problem would be to focus on critical areas. In the Evaro Hill linkage zone, a detailed riparian layer should be made for the one mile stretch of the linkage zone that crosses Highway 93. This would help highway officials determine the best areas for highway underpasses.

Cover Layer

Determining cover/non-cover pixel values can be improved through more extensive field surveys. Field surveys should include sending individuals into the field to check pixel classifications made in the lab against what exists in the real world. For example, if there is an area on the cover/non-cover map that is identified as cover, but upon survey in the field is really non-cover, that information should be recorded and changes made to the cover/non-cover map in the lab. Again, there are limits to the amount of field checking that can be

done on the landscape level, therefore the focus of field efforts should be in critically important areas.

Grizzly Bears have been observed using areas within 500 meters of a road significantly less than expected (Aune and Kasworm 1989;Kasworm and Manley 1988). For this reason, I recommend keeping the 500m buffer overlay on the cover/non-cover/edge layer to determine scores.

Human Influence Layer

There are weaknesses in the scoring system of the human influence layer. The presence of major attractants like the garbage truck and restaurants near the linkage area is not given enough weight in the current scoring system of the LZP model. With only a 200 meter buffer, the garbage truck is given the same danger weight as human residences. I believe that the possible attraction of garbage dumps and restaurants is greater than human residences and therefore pose a larger threat to the bears. This greater threat should be represented in the human influence layer by a higher human influence danger buffer, perhaps 300 meters. I recommend that further discussion and research regarding the relative danger of human point sites needs to be initiated to ensure that proper danger buffers are used in the LZP model. The increase in certain danger scores will help the model more precisely indicate safe passages for grizzly bears.

The CEM model has outlined influence zones for many human influences for which no point data currently exists. If these data become available, I believe they should be added to the LZP model. However, for the Evaro Study

Area predictions, the LZP model included all major human point influences that exist in this area.

Road Density Layer

Kasworm and Manley (1990) have calculated that mean distances to roads for radio collared grizzly bears in the Cabinet/Yaak area increased from 655m to 1,122m when a seasonally restricted road was opened. Mace and Manley (1993) found while the grizzlies were effected by both open and restricted roads, grizzly bears avoidance of areas near open roads was greater than near restricted roads. Currently, the LZP model does not address the differing avoidance behaviors of grizzlies between open and restricted roads. I think that this difference in avoidance could be addressed by adding another calculation to the road density scoring methodology.

I recommend that the current moving circle analysis for road density be run as described in this paper. Once the road density is determined, a 500 meter buffer should be made around all roads in the original road file. Within the 500 meter open road buffer, pixels should be given a value of 2 while restricted road buffer should be given a value of 1 (2:1 ratio attempts to roughly mimic the 655m:1,122m difference). These buffered values should then be added to the scored values previously determined in the moving circle analysis to get a new road influence score. Table 7 demonstrates possible outcomes from adding the open/restricted score to previous road density scoring:

Table 7. Possible total road influence scores.

Road Density Influence	Score	Open Road	Total Road
0 mile/mile2	2	2	4
0.01-1 mile/mile2	3	2	5
1.01-2 miles/mile2	4	2	6
Greater than 2 miles/mile2	5	2	7

Road Density Influence	Score	Restricted Road	Total Road
0 mile/mile2	2	1	3
0.01-1 mile/mile2	3	1	4
1.01-2 miles/mile2	4	1	5
Greater than 2 miles/mile2	5	1	6

Increasing the weight of open roads compared to restricted roads should improve the model's prediction of grizzly sensitivity to and the mortality risk associated with roads. Combined scoring categories should be adjusted to reflect the increased values of the road density layer.

Combined Scored Layer

If these recommendations are used, comparisons should be made between scored map results from the old model's methodology compared to the new results. Since many of these suggestions require more time and effort, especially field checking, comparisons should identify which changes made significant improvements in the model's accuracy. If no noticeable difference in model results is found in a certain layer, then the more extensive work could possibly be avoided. In the case of the Evaro Hill analysis, I believe the

implementation of these suggestions will only serve to emphasize further the previous findings and recommendations.

Appendix E - Topographical Relief Map of Evaro Study Area

Figure 26

Topographical Map of Evaro Study Area