

**HABITATS, TRAILS, AND CAMPGROUND SITUATIONS
ASSOCIATED WITH GRIZZLY-HUMAN CONFRONTATIONS
IN GLACIER NATIONAL PARK, MONTANA**



Master of Science Thesis
UNIVERSITY OF MONTANA

M. STEVEN NADEAU
1987

Chris,
Thanks for all your help
and friendship through
this. May we continue to
work together to help
the great-bear.

Steve

HABITATS, TRAILS, AND CAMPGROUND SITUATIONS ASSOCIATED WITH
GRIZZLY-HUMAN CONFRONTATIONS IN GLACIER NATIONAL PARK, MONTANA

By

M. Steven Nadeau

B.S., University of Maine at Orono, 1980

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

University of Montana

1987

Approved by



Chairman, Board of Examiners

Dean, Graduate School

17 March 1987
Date

ABSTRACT

Nadeau, M. Steven, M.S. Winter, 1987. Wildlife Biology

Title: Habitats, Trail and Campground Situations Associated with
Human-Grizzly Confrontations in Glacier National Park, Montana. (91 pp.)

Directors: Dr. Bart O'Gara, Dr. Chris Servheen

Beards CW

Habitats, trails, human and grizzly bear *Ursus arctos* behavior were analyzed in 3 phases to identify problem situations in Glacier Park. Phase 1 involved reviewing Park bear observation records from 1980 through 1984 and identifying and mapping grizzly-human confrontation sites. Analyses of plot data collected at confrontation sites revealed distinct seasonal shifts in habitat use that were correlated with bear feeding habits. Discriminant function analyses separated confrontation sites from control sites with an overall accuracy of 64%, which then increased to 86% when sites were grouped seasonally and compared to control sites. Sight distance and distance to water at confrontation sites were significantly less ($P < 0.001$) than distances measured for the random sample.

Phase 2 involved analyses of trends in observations, confrontations, and bear-caused human injuries from 1980 through 1984. Observation records reflected a pulse in female productivity correlated to good huckleberry *Vaccinium* spp. productivity, and was followed by an increase in subadult sightings 2 years later. Females with young were most frequently observed off-trail and were found in decreasing numbers where visitor use increased. Observations of subadults proportionally increased in areas with greater visitor use. Hikers confronting bears off trail were more likely to be injured than hikers on low and especially high use trails, suggesting increased hiker safety near habituated and less dominant bears.

Phase 3 involved nocturnal movements of grizzlies in a campground situation. Grizzlies used the trails and investigated areas near the campground more frequently at night than during the day. Bears consistently avoided the campground when people were camped there but frequently traveled through the campground when campers were absent. Females with young avoided the area during the day, but investigated the area at night in proportion to their presence in the population, suggesting temporal resource partitioning in response to predictable visitor use.

Table of Contents

Abstract	ii
Table of Contents	iii
List of Tables	v
List of Figures	vi
Acknowledgements	vii
1. INTRODUCTION	1
2. HABITATS AND TRAIL SITUATIONS ASSOCIATED WITH GRIZZLY-HUMAN CONFRONTATIONS	5
2.1. Introduction	5
2.2. Study Area and Methods	7
2.2.1. Observation and Confrontation Records	7
2.2.2. Habitat Analyses	8
2.2.3. Trail Analyses	9
2.2.4. Visitor Use	9
2.2.5. Seasonal Breakdown and Statistical Analyses	10
2.3. Results and Discussion	10
2.3.1. Visitor Use, Grizzly Activity, and Confrontations	10
2.3.2. Habitat Component Selection and Key Vegetation	13
2.3.3. Confrontation and Control Site Separations	14
2.3.4. Seasons vs. Control	17
2.3.5. Confrontations vs. Controls	18
2.3.6. Trail Situations	19
2.3.7. Habituation	20
2.4. Summary and Conclusion	25
3. TRENDS IN OBSERVATIONS OF GRIZZLY BEARS AND GRIZZLY-HUMAN CONFRONTATIONS AND INJURIES IN GLACIER PARK	26
3.1. Introduction	26
3.2. Study Area and Methods	27
3.3. Results	30
3.3.1. Reliability of Observation Data	30
3.3.2. Age/Sex Ratios	31
3.3.3. Activity Patterns	34
3.4. Discussion	43
3.4.1. Age/Sex	43
3.4.2. Habituation	46
3.5. Summary	47

4. MOVEMENTS OF GRIZZLY BEARS NEAR A CAMPGROUND IN GLACIER PARK	49
4.1. Introduction	49
4.2. Study Area and Methods	50
4.2.1. Nocturnal methods	51
4.2.2. Diurnal methods	52
4.2.3. Habitat	52
4.3. Results and Discussion	53
4.3.1. Habitat Use in Bear Valley	53
4.3.2. Visitor Use	55
4.3.3. Diurnal and Crepuscular Bear Activity	56
4.3.4. Nocturnal Bear Activity	57
4.3.5. Bear Management at the Chalet	64
4.4. Summary and Conclusions	65
5. CONCLUSIONS	67
6. REFERENCES CITED	71
Appendix A. Drainages and Trails Studied	77
Appendix B. Map of Study Area	78
Appendix C. Species List	79
Appendix D. Species List	80
Appendix E. Species List	81
Appendix F. Special Features	82
Appendix G. Habitat Types	83
Appendix H. Habitat Types	84
Appendix I. Discriminant Function	85
Appendix J. Discriminant Function	86
Appendix K. Discriminant Function	87
Appendix L. Discriminant Function	88
Appendix M. Discriminant Function	89
Appendix N. Bear Valley	90
Appendix O. Bear Valley	91

LIST OF FIGURES

CHAPTER II

	PAGE
1. Sight distance along trails at confrontation and control sites. All categories are significantly different.	21
2. Distance categories to surface water at confrontation and control sites. Both categories are significantly different.	23

CHAPTER III

1. Chances of being injured during a confrontation in areas of different levels of visitor use. Low-visitor use areas are off-trail, moderate use areas are low to moderate use backcountry trails, and high-use areas are high visitor use trails.	39
2. Relationships between visitor use as indicated by backcountry permits issued (permits), confrontations, and injuries by grizzly bears in Glacier National Park, from 1980 through 1984.	41

CHAPTER IV

1. Diurnal and crepuscular grizzly bear movements and relative abundance of grizzlies using travel routes around Granite Park, 1982 through 1984.	60
2. Nocturnal grizzly bear movements and relative abundance of grizzlies using travel routes around Granite Park, 1982 and 1983.	62

LIST OF TABLES

CHAPTER II

	PAGE
1. Annual averages of backcountry permits issued, confrontations, and human injury by month.	12
2. Percent occurrence of grizzly bear habitat components occurring at confrontation sites by season, with comparative control sites.	15
3. Discriminant function results of all tests run using stepwise selection and 1 function with 95 confrontations, and 124 controls.	16

CHAPTER III

1. Age/sex composition of grizzly bears reported in Glacier National Park for 3 separate studies in the population.	32
2. Yearly composition of age/sex classes observed or involved in confrontations from 1980 through 1984 in Glacier National Park.	36
3. Percent occurrence of observations, confrontations, and human injuries between age/sex classes off trail and on low and high visitor use trails.	37
4. Percent occurrence of observations, confrontations, and visitor activity occurring in different time periods of the day.	38

Acknowledgements

Without the help and cooperation of many people, agencies, and grant foundations this study could never have been completed. I owe my gratitude to many friends who make the wildlife profession enjoyable, despite the demands. I would like to thank Chris Servheen for input and extended discussions, countless reviews of proposals, and for having faith. Thanks to Bart O'Gara for insight, and leadership, and allowing me to grab-the-bull-by-the-horns. Dan Pletscher's scrutiny with humor is very appreciated. I also thank Kerry Foresman for review of the manuscripts, and Cliff Martinka for repeated review of countless proposals, and obtaining permission for me to conduct this project in the Park. Many discussions with Chuck Jonkel were enlightening and helped keep me on track.

Statistical help was received from Dave Patterson and Dick Lane. Mark Haroldson spent many hours helping me on the computer, and adding insightful discussions on grizzly bears. I thank Wendal Hann and Rose Leach from the USFS for information and guidance with the habitat sampling methodology I used. Clerical assistance, the most tedious part of any study, was received from Marty Smith, Scott Snelson, Carla Dove, Brian Sommers, Mike Hurley, and Darcy Hover; I thank them. A special thanks to my field assistant, Rick Armstrong, whose virtually uncompensated time, friendship, and knowledge of plants was invaluable. Thanks to Steve Frye, whose friendship and guidance helped in many ways. Kim Wilson, Ken Pitt, Bob Litchfield, and Jere Johnson, all bear rangers with love for the bear,

helped in obtaining grizzly movement data. Many other rangers, too numerous to name, have helped in many ways over the years. The Granite Park Chalet women were more than gracious; a special thanks to Kathy Larson and Arlene Mulvaney.

Cooperation of the Glacier Park Administration, the USFS, in particular the Hungry Horse Ranger District, and the Granite Park Concessionair, Lanny Luding, was greatly appreciated. The Montana Cooperative Wildlife Research Unit added countless benefits of association, and from the Grizzly Recovery Coordinator's Office, Janie Spencer helped enormously.

A special thanks to my parents and family who put up with a vagabond, a dreamer, a student, a grizzly wrestler, and a few of my bad characteristics as well.

Funding for this study was received from the National Wildlife Federation, National Rifle Association, National Parks and Conservation Association, and the Max McGraw Wildlife Foundation. The nocturnal study was funded by the National Park Service while I was an employee of theirs.

Chapter 1

INTRODUCTION

Understanding the behavior and ecology of grizzly bears *Ursus arctos* is critical to the management of areas where grizzly bears and humans come into contact. In the contiguous United States, the grizzly bear is listed as "threatened" under the Endangered Species Act, therefore management agencies are legally bound to maintain viable grizzly bear populations in the areas where they now exist. In addition, millions of dollars have been spent studying grizzly bear ecology and ecological responses to human activities. Despite these efforts and the grizzly bears' scarcity throughout most of its range in the contiguous United States, grizzly-human conflicts continue to occur. Improving grizzly bear management by reducing grizzly-human conflicts and consequential injuries and death to both species is therefore essential. This study represents a step toward that goal.

Although grizzly bears commonly use forested areas, research identifies the importance of open areas as sources of food. Most grizzly bear habitat studies indicate the importance of vegetative diversity for grizzly bear survival. Mealy et al. (1977) rated avalanche chutes, stream bottoms, wet meadows, and burns as the types of vegetation communities highest in food producing value. Radio telemetry research has identified seasonal habitats most frequently used by grizzly bears to be those habitats highest in quality foods (Hamer 1983, Aune and Stivers 1983, McLellan in prep.).

In most areas, a grizzly bear's activity patterns are determined by seasonal food availability. Many bears travel great distances to forage on seasonally available and concentrated food sources (Craighead and Craighead 1972, Mundy and Flook 1973, Herrero 1978, Russel et al. 1978). While traveling to and from these seasonal food sources, as well as while feeding at these sites, grizzly bears frequently encounter humans.

Instead of a geographic territory, a grizzly maintains, through mutual intolerance of certain other bears as well as aggressive defense, an individual space that centers on the bear as it moves through its home range. The extent of the individual distance and the bear's response to its violation vary with the individual, the situation, and the season (McArthur 1982).

Although grizzly bear populations in the contiguous United States have generally diminished or stabilized, the grizzly population in Glacier National Park, Montana seems to be increasing (Keating 1986). Grizzly bears range through most of the Park in search of food and in response to behavioral pressures, consequently increasing the potential for interactions between the 2 species.

Grizzly bear - human conflicts in Glacier Park increased linearly until 1980, in relation to the increase in Park visitation (Martinka 1982). However, visitor use activities have drastically changed from the 1970's to 1984. Although the number of visitors entering the Park since 1977 increased steadily until 1984, people camping in the backcountry have decreased since 1977 (Glacier National Park, unpubl. data). In 1977, backcountry visitor nights peaked at 30,448 and declined to 15,032 in 1984, a 51% decrease. No accurate data are available on day use within

the Park. Although many observers feel that there may be an increase in short-distance day hikers, others believe that both day and overnight use have declined. Despite this decrease in overnight backcountry visitor use, and unknown trends in day use, grizzly-inflicted injuries and death to humans have increased (Glacier National Park, unpubl. data). This increasing rate of human injury by grizzly bears, and an apparent reduction in grizzly bears' wariness of people (McArthur 1980), were generally accepted as a cause-and-effect relationship; the increased number of hiker injuries was a direct result of bears' loss of fear of people (Schneider 1980, Kittredge 1982, McCullough 1982). Stuart (1978) predicted that as visitor use increased, a corresponding increase in grizzly-inflicted injuries could be expected. Stuart's management models were based on backcountry campground use, contact indices (not rates), and trail data. At the time of his study, campground use was increasing. From 1977 through 1984, campground use decreased, however grizzly - human contact rates and injuries increased. Therefore, evidence suggests that other factors have come into play and seem to conflict with Stuart's models.

In 1982, McArthur completed a study in Glacier National Park that supported the contention that bears frequenting areas of high visitor use respond to human encounters in a "neutral" or non-aggressive fashion. In addition, McArthur (1982) postulated that bears in areas of low visitor use more frequently responded to visitor encounters with fear-induced aggression. These behavioral traits were attributed to habituation, defined as "the waning of a response as a result of repeated stimulation" (Petrinovich 1973).

Canadian researchers have proposed park management under the contention

that grizzly-human confrontations are dependent upon site factors. Certain characteristics of trails, such as whether they pass through grizzly bear habitat, the time of year when trails are used, the extent of visibility along a trail, and the relationship of a trail to noisy streams or dense cover, all influence the chances of a sudden encounter with a grizzly bear (Herrero et al. 1983). Although these theories were intuitively sound, they had never been scientifically tested and were thus considered speculation.

This study was conducted to examine in detail reasons for grizzly bear-human confrontations in Glacier National Park. The specific objectives were to: 1) identify trails, campgrounds, and other backcountry areas of Glacier National Park that have consistently been sites of grizzly bear concentrations, or bear-human conflicts from 1980 through 1984, and 2) identify and analyze a range of habitat variables, and trail and campground situations that are associated with grizzly-human confrontations.

This thesis is a combination of 3 manuscripts, all of which are being submitted for publication. Chapters II and III, Habitats and Trail Situations Associated with Grizzly-Human Confrontations, and Trends in Observations of Grizzly Bears and Grizzly/Human Confrontations and Injuries in Glacier Park, are being submitted to the Wildlife Society Bulletin. Chapter IV, Movements of Grizzly Bears Near a Campground in Glacier National Park, has been accepted for presentation at the Bear-Human Conflict Symposium in Yellowknife, NWT, Canada (April, 1987).

Chapter 2

HABITATS AND TRAIL SITUATIONS ASSOCIATED WITH GRIZZLY-HUMAN CONFRONTATIONS

2.1. Introduction

Grizzly bears *Ursus arctos* have killed 3 backcountry campers and injured an additional 10 hikers on or near trails in Glacier National Park from 1980 through 1984. Hikers suddenly confronting a grizzly are the most frequent victims of grizzly bear attacks on people (Herrero 1970, 1976, 1985; Martinka 1971). Of the nearly 2000 backcountry grizzly observations reported in Glacier Park from 1980 through 1984, 205 (10%) involved sudden encounters, and about 5% (N=10) of these encounters resulted in human injury (Nadeau, 1987b). Decreasing the chances of sudden encounters is therefore an important management concern.

Most managers have felt it impossible to predict potential confrontation sites due to the seemingly random location of confrontations in the backcountry. Most human injuries have been related to grizzly bears conditioned to human food, bears becoming habituated to humans, or females protecting young (Mundy and Flook 1973, Herrero 1976). Only recently has research been conducted on other potential problem situations (Stuart 1978, McArthur 1982, Herrero et al. 1983, McCrory et al. 1985)

Habitat use and food preference studies of grizzly bears were conducted in

Glacier National Park from 1967 through 1971 (Martinka 1972), and again in 1979, 1984, and 1985 (Riggs and Armour 1980, Kendall 1984, Baldwin et al. 1985). Observations and scat analyses have identified seasonal habitat and food selection by bears in Glacier National Park (Kendall 1986). Intensive studies near the Park indicated similar selection (Jonkel 1977, Aune and Stivers 1983, McLellan 1983). These data suggest that generalized grizzly bear locations can be predicted, given bear foraging behavior, time of year, and preferred food locations. Canadian researchers have recommended increasing sight distance and rerouting trails around foraging areas to reduce sudden encounters (Herrero et al. 1983, McCrory et al. 1985). The success of this approach is dependent upon meeting two major assumptions: 1) grizzly bears exhibit preferences for certain components in a habitat mosaic under given conditions, and 2) these preferences are significant enough that a quantifiable decrease in human-grizzly contact rates can be achieved by funneling visitors into habitats not preferred by bears (Riggs and Armour 1980).

The null hypothesis tested in this study was that confrontations occurred at random and were independent of habitat variables. To test this, habitat variables were measured at confrontation and control sites, and discriminant function analysis was used to characterize the habitat factors valuable in predicting confrontation sites. In addition, this paper identifies trail situations, physical features, and other parameters that are associated with human/grizzly confrontations in Glacier Park.

2.2. Study Area and Methods

Glacier National Park is located in Northwestern Montana. Intensive climatic, vegetative, and topographic descriptions of the Park are found in Dightman (1967), Habeck (1970), and Martinka (1974). Research was conducted in 5 major drainages (subdistricts) on the east side of the Park known as Goathaunt, Belly River, Many Glacier, Cut Bank, and Two Medicine, and along 2 trails on the west side known as the Highline and Avalanche Lake trails. Six of these 7 drainages were considered high visitor-use areas.

2.2.1. Observation and Confrontation Records

Computer printouts of bear observations in Glacier Park were obtained from the archives of the National Park Service in Washington D.C., where they were stored in several formats. Computerized observation data from 1980 through 1984 were verified by comparisons with original field forms, then coded, reduced, and sorted to create a consistent data base. Only observations of grizzly bears in the backcountry with accurate locations were used. Data transcribed for each record included: date, time, drainage, location (using Universal Transverse Mercators - UTM's), observer type (visitor, employee, etc.), group size, distance from bear, bear cohort (lone adult, productive female, subadult), and comments. Any of several factors defined a confrontation: 1) human injury occurred; 2) human-bear distance was ≤ 30 m, (but could have been as great as 150 m dependent upon other criteria); 3) observer commented that the bear was surprised and fled or charged; 4) the bear investigated or approached a human or human belongings; or 5) the

observer climbed a tree, played dead, or performed other evasive maneuvers. Because bear and human behavior are so variable, any of the above criteria could have originated from the same set of circumstances. Therefore, the emphasis of the field work was to determine elements of the site that may have allowed the confrontation to occur.

The results were based on 95 of the 205 backcountry confrontations occurring from 1980 through 1984. Only 95 confrontations were believed to be accurately located and were within the drainages studied. Where confrontations occurred, UTM's were transcribed by hand on 7.5 minute USGS topographical maps. Subsequent field investigations of many confrontation sites included a final check on the location with Park rangers or others most familiar with that particular confrontation.

2.2.2. Habitat Analyses

Field research was conducted from 25 June to 16 September 1985. Ninety-five confrontation sites were described using the USFS "Quick Plot" methodology for mapping grizzly habitat (Hann 1985). Fifty-two habitat and physical feature parameters were documented on each 404 m² (0.1 acre) plot. Habitat components along trails were transcribed on topographical maps from 1968 black and white aerial photographs, then confirmed in the field. In addition to plots at confrontation sites, similar data were gathered at 124 control plots in components representative of those occurring along trails throughout the study area (Hann 1985). An attempt was made to map all major changes in habitat type and component occurring along the trails investigated.

2.2.3. Trail Analyses

At each confrontation site sampled, trails were described by estimating: 1) sight distance (m) along the trail in both directions, but not necessarily perpendicular to the trail (ocular estimate of distance at which 90% of the bear would be concealed), 2) distance to water, and type of water (lake, creek, etc.), and 3) comments. Systematic sampling was used to obtain control data for trails. After all habitat and trail data were obtained at confrontation sites, trails previously investigated were again visited. Control data on sight distance and distance to water were documented after precisely 10, 15, or 20 minute hiking periods. Hiking periods were determined prior to entering the field, and were chosen to divide the trail section into approximately equal numbers of control and confrontation plots.

2.2.4. Visitor Use

Backcountry visitor use between months were compared using backcountry camping permits issued during that month. Although camping was an unknown fraction of the total visitor use in the backcountry, it was assumed to closely reflect trends in monthly use of the backcountry. This assumes that a monthly or annual fluctuation in camper use for any reason (i.e. weather) would result in a similar fluctuation in day use. This assumption is based on research conducted by McArthur (1982:34). Backcountry permits were used by Stuart (1978) in his management models for human use of grizzly bear habitat, and limitations of these data were discussed.

2.2.5. Seasonal Breakdown and Statistical Analyses

All data were grouped and analyzed by month and foraging periods. Foraging periods included the spring period (1 May - 14 July), transition (15 July - 14 August), and fall period (15 August - 30 October). The transition period was further categorized into low transition (<1700 m), and high transition (>1700 m) periods. These periods were determined by plant phenology and bear feeding habits as described in most of the current literature, and dates of bear-human confrontations (Glacier National Park, unpubl. data).

Discriminant function analyses defined the linear combination of habitat and physical feature variables that best described confrontation sites by season (Nie et al. 1980). Variable means were compared using standard t tests. Distributions were compared using G-tests (Sokal and Rohlf 1980). Simultaneous confidence intervals were compared using the Bonferonni Z tests (Marcum and Loftsgaarden 1980). Tests were considered significant at $P \leq 0.05$.

2.3. Results and Discussion

2.3.1. Visitor Use, Grizzly Activity, and Confrontations

Overnight use of backcountry campgrounds in Glacier National Park has declined since 1977, when it peaked at 30,448 visitor nights. In 1980, 22,079 visitor nights were logged from May through October, and that declined to 14,755 visitor nights in 1984 (unpubl. Park data).

Although differences occurred between years, proportions of visitor use between months remained relatively stable. Ninety-nine percent of the

backcountry confrontations on record occurred from 1 May through 30 October. Ninety-seven percent of the backcountry visitor use and most grizzly activity also occurred during these months. Visitor use increased until August when it peaked, and then declined through the remainder of the months. Confrontations and human injury, however, peaked in July (Table 1). Confrontations per visitor were proportionally highest in May and declined linearly until October ($r^2=0.874$ $P<0.001$).

Although visitor use was lowest in May, confrontation rates were highest. During May and June, bears remained at low elevations feeding on spring greenup, and visitors were restricted to low elevation trails due to snow pack. Telemetry data in other areas show high levels of diurnal grizzly activity and low elevation foraging habits at this time (Aune and Stivers 1983, Hamer and Herrero 1983, McLellan 1983, Schleyer 1983).

Visitor use continued to increase into July as numbers of confrontations and human injuries peaked. Visitor use was highest during August, but confrontations decreased and human injury did not occur. Research in areas outside the Park indicated an increase in home range size for females (Hamer and Herrero 1983), seasonal dispersal to summer range (Craighead 1976:104, Russel et al. 1979:56), and an increase in diurnal activity (Schleyer 1983:51) during the transition period. Telemetry data near and in Glacier Park indicated that grizzly bears conducted exploratory excursions as berries started to ripen and spring foods dried out (McLellan pers. commun.). In addition, hikers were using most areas of the Park trail systems by mid-July. All these factors combined to create an increased

likelihood of confrontations and injuries at this critical time. Park data dating from 1956 through 1985, indicated a peak in grizzly-human problems during the transition period.

If a hiker suddenly confronted a grizzly in September, the probability of being injured was higher than at any other period. Visitor use during the fall period decreased in early September (after Labor Day). The fall foraging period in Glacier Park was characterized by migrations of bears to concentrations of berries (Schaffer 1971, Martinka 1974, McLellan 1983, Kendall 1985). Observations and confrontations occurred during all hours of the day (Nadeau 1987b), suggesting much diurnal and crepuscular activity by grizzly bears.

Table 1. Annual averages (1980-1984) of backcountry permits issued, confrontations with all backcountry users, and human injury by month.

	May	June	July	Aug.	Sept.	Oct.	Sum
Permits	174	1622	5626	7418	1860	216	16916
Confrontations	2.2	8.4	13.6	13.2	2.8	0.4	40.6
Human Injury	0.0	0.4	1.0	0.0	0.6	0.0	2.0

2.3.2. Habitat Component Selection and Key Vegetation

Research in areas near and in the Park indicated the importance of key species in the diets of grizzlies (Mace and Jonkel 1986, Martinka and Kendall 1985). Spring scat analyses of black *Ursus americanus* and grizzly bears within the Park indicated that most of the bears' diets during the spring and early summer consisted of cow parsnip (16%) *Heracleum lanatum*, grasses and sedges (40%), and other herbaceous material (17%) (Martinka and Kendall 1985). During the spring period, 50% (N=32) of the confrontations occurred in avalanche slopes, riparian zones, alder *Alnus* spp. thickets, and shrub-forb associations near water. Twenty-two percent of the spring confrontations occurred in timbered shrubfields. These component types were the most important during spring (Table 2).

The transition period was characterized by a shift in habitat selection by bears and a consequential shift in confrontation locations. Confrontation sites were distributed among a variety of habitat components and elevations representing the variation in bear food availability. In general, cow parsnip growth peaked at lower elevations in mid-July. During this time, younger and more palatable vegetative parts were available at higher elevations, and the corms of glacier lilies *Erythronium grandiflorum* and bulbs of spring beauty *Claytonia lanceolata* became available at higher elevations. At the same time, huckleberries *Vaccinium* spp. and chokecherries *Prunus* spp. became locally abundant at lower and mid-elevations (Kendall 1986). Habitat components containing these species comprised the majority of the transition period confrontations (Table 2).

During the fall berry foraging period starting in mid to late August,

huckleberries were ripe and available throughout the Park (Kendall 1986). I have observed 13 grizzly bears in the study area during September in a 1.5 km² area feeding on huckleberries. Large concentrations of grizzlies feeding on huckleberries on the Apgar Mountain Range have been documented (Schaffer 1971, Kendall 1986). About half of the confrontations (52%) occurred in components characterized by a minimum of 25% canopy cover of a single berry species, especially huckleberry, chokecherry, serviceberry *Amelanchier alnifolia* or mountain ash *Sorbus* spp. (Table 2). During the study period, relative huckleberry productivity was good for 3 years and poor for 2 years (Kendall 1986). Other berry producing shrubs occurred frequently (95 times in 62 plots with 9% mean canopy cover) at the transition and fall period confrontation sites and may have comprised a substantial alternate food supply. Bears moved to lower elevations by late September and some confrontations again occurred in hardwood riparian and timbered forbfield areas (15%).

2.3.3. Confrontation and Control Site Separations

Discriminant function analysis showed that habitat variables separated sites of confrontation from controls with an overall accuracy of 64% using 1 function. Confrontation sites were categorized by foraging period, and each period was tested against the control sites with an overall separation accuracy from 73 to 83%. Separation of individual periods from the total sample produced 74 to 86% correct classifications. Even when all 4 periods were separated simultaneously, the function achieved correct classification for more than 62% of the cases. No more than 6 variables were needed to correctly classify the periods (Table 3).

Table 2.-Percent occurrence of Grizzly Bear Habitat Components occurring at confrontation sites by season, with comparative control sites.

GB Component	Spring ¹ (N=32)	Lo Trans ² (N=26)	Hi Trans ³ (N=15)	Fall ⁴ (N=22)	Mean (n=95)	Control ⁵ (124)
Alder shrub/snowchute	9	12	13		8	3
Alder shrub/forbfield	3		7		2	2
Shrubfield snowchute	3				1	3
Chokecherry shrubfield	6	23		5	9	0
Forbfield	3			5	2	5
Natural grassland/dry					0	8
Huckleberry shrubfield		8	20	14	8	7
Shrubfield		4		9	3	1
Shrubfield/forbfield	9		13	5	6	8
Mtn. Ash Shrubfield *	16	4			6	2
Open snowchute					0	3
Aspen					0	3
Cottonwood	6			9	4	2
Partl timber/riparian	3				1	2
Riparian aspen		8			2	0
Riparian streambottom					0	1
Rock					0	1
Serviceberry shrubfield	3				0	2
Timbered shrubfield	22	19	20	9	18	29
Timbered forbfield		4	13	14	6	3
Timbered huckleberry	16	19	13	23	18	14
Timbered mtn. ash				5	1	7
Timbered serviceberry				5	1	2

1\Spring season is 1 May through 14 July.

2\Lo trans season is 15 July - 14 August with elevations <1700 m.

3\Hi trans season is 15 July - 14 August with elevations >1700 m.

4\Fall is 15 August - 30 October.

5\Control--plots indicative of available habitat where no confrontations occurred during the study period.

*most occurred in snowchutes with spring bear foods available.

Table 3. Discriminant function results of all tests run using stepwise selection and 1 function with 95 confrontations, and 124 controls.

Groups Classified	Number of Independent Variables	Percent of Cases Correctly Classified
All Periods:Control	5	64.4
Spring ¹ :Control	6	73.7
Lo Trans ² :Control	6	74.0
Hi Trans ³ :Control	4	82.4
Fall ⁴ :Control	4	72.6
Periods Simultaneously	5	62.1
Spring:Other Periods ⁵	4	73.7
Lo Trans:Other Periods	4	75.8
Hi Trans:Other Periods	3	86.3
Fall:Other Periods	3	73.7

1-Spring period (1 May - 14 July) (N=32)

2-Low Transition Period (15 July - 14 August, elevation <1700 m) (N=26)

3-High Transition Period (15 July - 14 August, elevation >1700 m) (N=15)

4-Fall Period (15 August - 30 October) (N=22)

5-Other Periods= combination of the 3 remaining periods

2.3.4. Seasons vs. Control

Confrontations during the spring period were discriminated by less dominant tree canopy cover and herb cover, and greater shrub cover and grass/sedge cover than the controls. Seventy percent of the confrontation sites had canopy cover with even overstory. These discriminant variables were characteristic of the thick shrub *Alnus* spp. associations along riparian zones and avalanche chutes where most confrontations occurred in spring.

Confrontation sites at low elevations during the transition period were discriminated by greater second dominant tree canopy cover, shrub cover, and grass/sedge cover than the control. More than 70% of the sites were again characterized by even overstory canopy height with the structural stage most frequently being shrubs. These variables were characteristic of avalanche slopes, willow flats *Salix* spp., and open berry shrub fields. Also, timbered shrub fields with huckleberry and fools huckleberry *Menziesia ferrugina* were common confrontation sites at this time. Bears were still frequenting moist forb areas, but had shifted foraging activity to low-elevation berry shrubs.

High-elevation confrontations during the transition period were discriminated by less herb cover, more bear food cover, and steeper slopes than controls. These variables were descriptive of high-elevation glacier lily forbfields, avalanche slopes, and berry shrubfields where bear foods were generally high quality and concentrated.

Confrontations during the fall foraging period were discriminated by less second dominant shrub cover, greater bear food and grass cover than controls,

and coniferous forest life form with sapling size or larger trees. These variables characterized high and mid-slope timbered huckleberry shrubfields under a mixed height canopy of subalpine fir *Abies lasiocarpa* and Englemann spruce *Picea engelmannia*. When all periods were separated simultaneously, many cases in the fall were grouped with other periods. This may have reflected the variation in fall food availability during the 5 years of the study; the bears returned to areas indicative of other foraging periods.

2.3.5. Confrontations vs. Controls

When all confrontation sites were combined into 1 group, and compared to controls, 5 variables separated the groups. Grass and shrub cover was greater, and herb cover less than the control, and elevation was generally higher than the control sites. About 46% of the confrontations sites, and about 80% of the control sites, had overstories of varying heights. These variables described sites with good quantities of grasses (mean=33% cover) among thick (mean=53% canopy) shrub cover. Most frequently, confrontations occurred in avalanche chutes, or berry shrubfields where canopy covers of the lifeform (shrub or tree) were not of varying heights.

2.3.6. Trail Situations

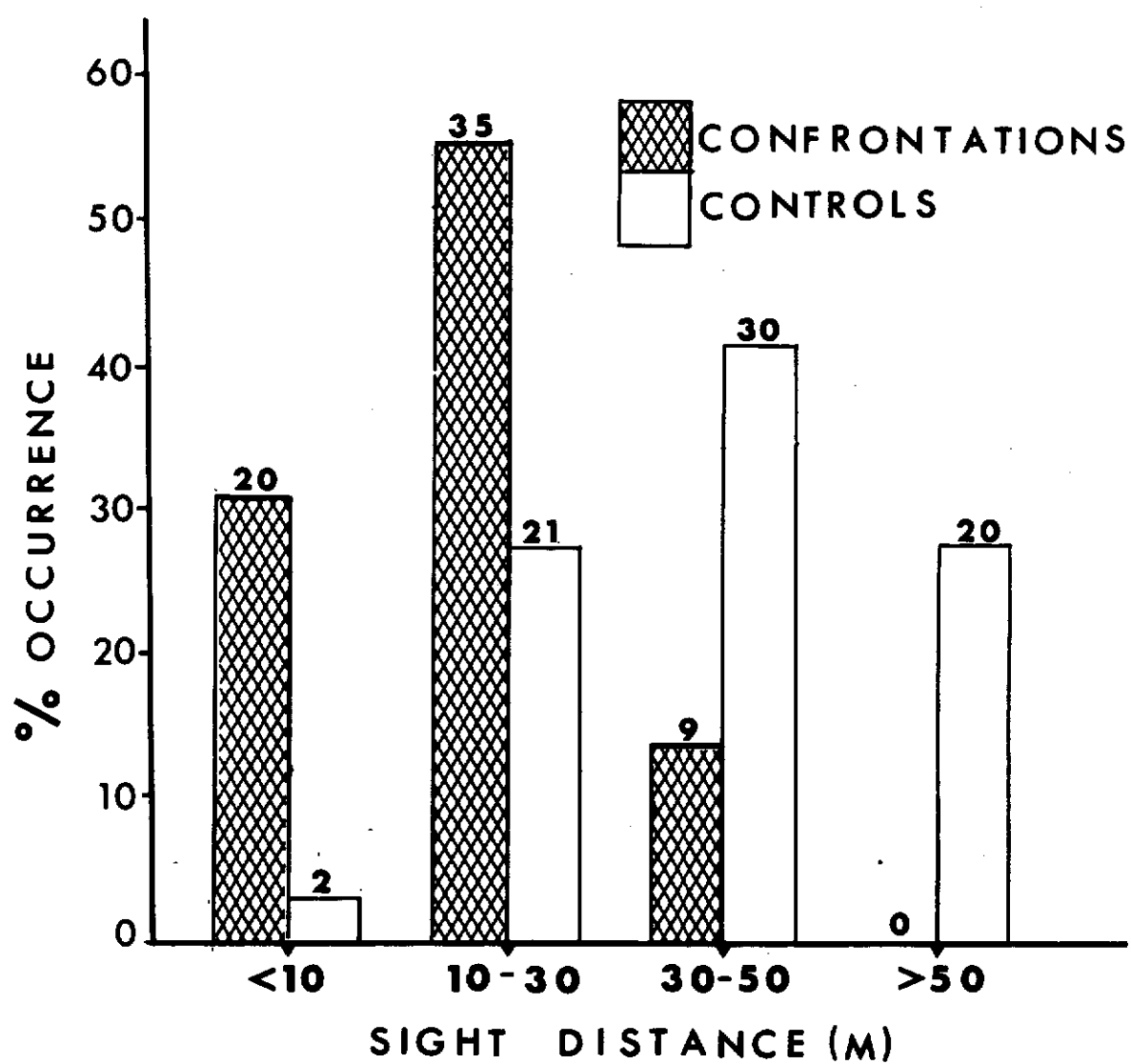
Sight distance at confrontation sites was shown to be significantly different than control sites ($P < 0.001$ d.f.=3 $G=55.82$). Sight distances of less than 30m were present in 86% (N=64) of the confrontation sites but only 32% (N=73) of the control sites ($P < 0.001$ d.f.=1 $G=64.07$). No confrontations occurred where sight distance was > 50 m, however, 27% of the control plots had sight distance > 50 m (Fig. 1).

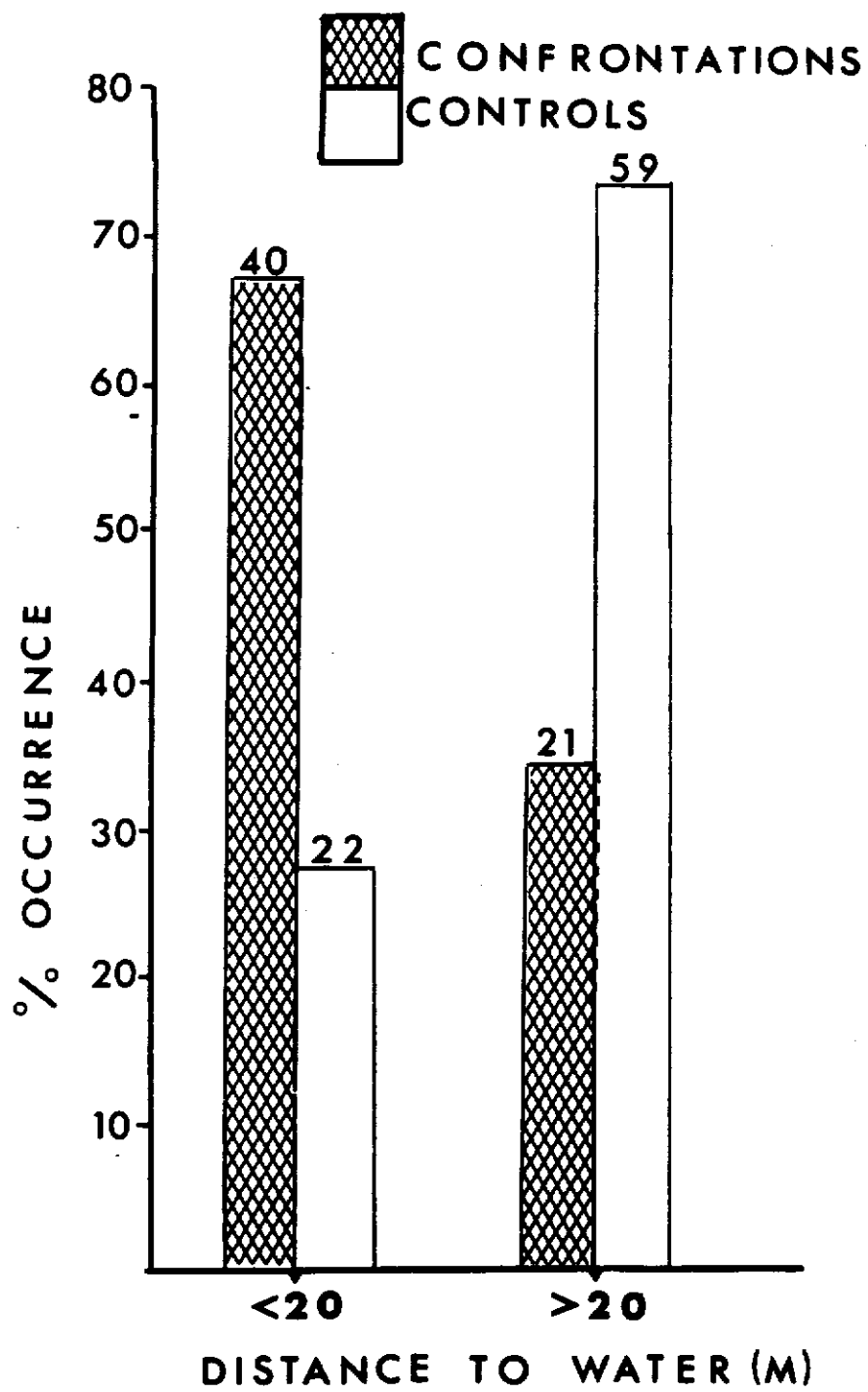
Distance to water at confrontation sites was significantly less than found at control sites ($P < 0.001$ d.f.=1 $G=19.83$) (Fig. 2). This was especially evident during the spring foraging period when 87% of the confrontations occurred at < 20 m to water, compared to 27% (N=81) of the control sites ($P < 0.001$ d.f.=1 $G=8.7$). Running water was frequently present on spring foraging sites, then gradually dried up in many areas as the season progressed.

Bears travel along and feed near creeks and river bottoms throughout their active seasons. The lush forb and thick shrub associations found near water combine to create food and cover for bears. In addition to short sight distances due to thick shrubs, noise is frequently associated with running water, which effectively conceals warning sounds by hikers. Trails in Glacier Park cross hundreds of creeks and often follow the contour into the creek bed creating a blind turn in thick brush, often near noisy running water. My data show these situations were important factors leading toward grizzly bear-human confrontations. Trail visibility was found to be restricted to 61 m or less, in 90% of the random sites visited in Glacier Park by Stuart (1977), and was believed to be responsible for many of the grizzly - human contacts.

2.3.7. Habituation

Bear behavior undoubtedly has major implications toward likelihood of confrontations. Habituation is defined as the waning of a response when a reward or punishment is discontinued (McCullough 1982:28). In a park situation, habituation may result in an increased occurrence of confrontations due to the increased likelihood of bears remaining in close proximity to trails (McCullough 1982). My research however, supports McArthur's (1982) findings indicating that bears habituated to humans may be startled less and therefore involved in fewer full charges resulting in human injury. My study was conducted in areas that seasonally receive intensive visitor use (Glacier National Park, Unpubl. data, McArthur 1982, Baldwin et al. 1985). Confrontations per visitor decreased linearly as the summer progressed, and bear-caused human injury was non existent in August when visitation was highest. The waning of the fear response is frequently reported in behavior research (Peeke and Peeke 1973, Petrinovich 1973). My data from Glacier National Park suggest that as seasons progress, grizzly bears may have reduced perceptions of humans as a threat, and may not respond to confrontations with fear-induced aggression.





2.4. Summary and Conclusion

Analyses of confrontation sites in addition to recent research on bear feeding habits strongly support the theory that habitat selection processes do exist for grizzly bears as a response to changing food availability, and that site selections are predictable between seasons. Variables measured at confrontation sites correctly classified and separated them from the control sites. Therefore, significant differences suggest the rejection of the null hypothesis, and we can conclude that confrontations do not occur at random and are dependent upon habitat and site specific variables.

Phenology and location of preferred foods, such as cow parsnip, glacier lily, and globe huckleberry are important indicators for predicting time and location of bear feeding areas in Glacier National Park.

Several other factors, in addition to feeding sites or key habitat components near trails, combine to create hazardous areas. Sight distance of ≤ 30 m, and distance to water of ≤ 20 m along trails are very important factors leading to confrontations.

These results suggest that bear management can be enhanced through identification of seasonally important grizzly feeding areas and travel routes, then rerouting visitor use or redesigning trails in dangerous areas. These management actions would thereby reduce sites of grizzly bear-human confrontations in the future.

Chapter 3

TRENDS IN OBSERVATIONS OF GRIZZLY BEARS AND GRIZZLY-HUMAN CONFRONTATIONS AND INJURIES IN GLACIER PARK

3.1. Introduction

Injuries inflicted by grizzly bears *Ursus arctos* on recreationists in U.S. and Canadian parks prior to 1970 predominantly involved campers and bears conditioned to human foods (Herrero 1970, 1985). From 1970 through 1979, most injuries occurred when hikers suddenly confronted a female with cubs (Mundey and Flook 1973, Herrero 1976, McArthur 1982). From 1980 through 1984, lone adults and subadult bears inflicted the majority of injuries in Glacier National Park (Glacier National Park, unpubl. data). From 1980 through 1984, grizzlies in Glacier have killed 3 backcountry campers and injured an additional 10 hikers on or near trails. Several authors have suggested that the increased number of injuries to humans may be a direct result of increased human visitation, and the resultant lack of fear of humans by bears (Schneider 1980, Martinka 1982, McCullough 1982). McArthur (1982), however, suggested that habituation of grizzly bears to hikers reduced the rate of fear-induced charges and consequent injuries.

This study further explores habituation in terms of hiker safety, reviews fluctuating cohort representation in the grizzly bear population of Glacier National Park, and details recent trends in visitor use and grizzly-human confrontations.

3.2. Study Area and Methods

Glacier National Park is located in northwestern Montana. Long, steep-walled valleys and precipitous mountains extend along the Continental Divide which bisects the Park east from west. Park climate is classified as continental with maritime modifications (Dightman 1967). More detailed descriptions of Park topography, geology, and vegetative communities are discussed in Martinka (1974), Ross (1959), and Habeck (1970), respectively.

Observation records of bears in Glacier Park from 1980 through 1984 were obtained from the archives of the National Park Service in Washington, D.C.. In addition, more recent data were obtained from Park files. To assure accuracy, computer records were hand-verified from original field observation forms. Observation records were coded, reduced, and sorted to create a consistent data base. Only backcountry grizzly bear observations were used in order to reduce biases associated with differently habituated roadside bears, and deal only with people in the backcountry who may confront grizzlies. Data transcribed for each record included date, time, drainage, management area (trail type, or off-trail), Universal Transverse Mercator (UTM) location, observer type (visitor, NPS employee, etc.), group size, distance from bear, bear cohort (lone adult, maternal female, subadult), and comments. Cases were further sorted into confrontations from these records. Any of several factors defined a confrontation: 1) human-bear distance was ≤ 30 m (but could have been as great as 150 m depending on other criteria); 2) observer commented that the bear was surprised and fled or charged; 3) the bear investigated or approached a human or human belongings; or

4) the observer climbed a tree or played dead and the bear investigated. Any of the above situations could have originated from the same set of circumstances because of the variability in bear and human behavior. Therefore, these criteria were designed to identify problem situations and not necessarily problem bears. Records of human injury were reviewed (Glacier National Park, Unpubl. data) and only injuries incurred from direct and sudden confrontations were used in analyses. Due to the differences between campground and trail problems, and nocturnal associations with campground problems, campground incidents were not considered in these analyses, but are discussed in chapter IV of this thesis.

The results were based on 1776 backcountry grizzly observations and 185 backcountry confrontations occurring from 1980 through 1984. Observation accuracy was checked by comparing first-hand visitor reports with trained observer (Park Ranger) reports. In this manner, cohort identification and integrity of observations were tested prior to analyses. The sex and/or age classes in observations of individual bears were used to compute population composition. Adults (lone females, males), productive females, and subadults (smaller with lanky appearance) were categorized. No attempt was made to identify individual bears due to an individual's varied coloration and appearance as the summer progressed. Age/sex ratios of bears sighted were compared between low-use trails, high-use trails, off-trail reports, and between low- and high-visitor use drainages.

Visitor use levels along trails were grouped using trail classifications as found on Glacier Park's Bear Observation Form as follows: A. high-use trail, B. backcountry trail, and C. off-trail. High-use trails were classified as high visitor

use, backcountry trails as low/moderate visitor use, and off-trail as low visitor use. Further help in categorizing trails was obtained by using trail maintenance classes as follows: A. high-use = intensive maintenance, B. moderate-use = moderate maintenance, and C. low-use = low maintenance (wilderness management). In addition, personal knowledge gained through 4 years in the Park, as well as estimations from backcountry rangers who were most familiar with the area were used in categorizing trails. Because of the marked difference between levels of visitor use on trail types, integrity of the groups was assured. Nonetheless, without data on actual visitor use numbers on these trails, biases may be present, and certain analyses could not be completed.

Backcountry visitor use between months were compared using backcountry camping permits issued during that month. Although camping was an unknown fraction of the total visitor use in the backcountry, it was assumed to closely reflect trends in monthly use of the backcountry. McArthur (1982:34) analyzed the seasonal distribution of hikers in the Many Glacier Area of the Park. McArthur's monthly distributions of hikers were similar to those found by analyzing the backcountry permits issued on a Parkwide scale. This assumes that a monthly fluctuation in camper use for any reason (i.e. weather) would result in a similar fluctuation in day use. Backcountry permits were used by Stuart (1978) in his management models for human use of grizzly bear habitat, and limitations of his data were also discussed.

Estimates of densities for grizzly bear populations were beyond the scope of this paper. Distributions were compared using the G-test (Sokal and Rohlf, 1981)

as programmed by Haden (1984). Simultaneous confidence intervals within categories of variables were compared using Bonforonni Z tests as programmed by Matchett (1984). Tests were considered significant at $P \leq 0.05$.

3.3. Results

3.3.1. Reliability of Observation Data

A potential bias associated with misclassification of adult and subadult grizzlies was reduced by comparing Park employee (trained observers) observations with those of verified visitors (untrained observers). These comparisons indicated that lone adult and subadult bears comprised similar proportions of observations by each observer type ($P > 0.25$ d.f.=2 $G=0.124$). Productive females however, comprised a significantly larger proportion of the bears observed by Park employees ($P < 0.001$ $k=3$ $Z=4.38$). Females with young were usually easily identified, therefore biases involved with misidentification in this cohort were assumed minimal. Consequently, factors other than the reliability of the observer were assumed to be responsible for the difference in numbers of family groups reported between observer types. To reduce the biases associated with these differences, observations from both observer types were combined for the following analyses.

3.3.2. Age/Sex Ratios

Age/sex ratios (1980 through 1984) were not significantly different than those found in Glacier Park by Martinka (1974) and McArthur (1982) ($P > 0.1$ d.f.=2 $G=3.57$) (Table 1). However, significant differences occurred in proportions of sex/age groups sighted each year. Of particular interest was the 74% increase in observations from 1982 through 1983. Along with the overall increase in sightings, the number of subadults reported in 1983 ($N=137$) was 585% higher than in 1982 ($N=20$). This pulse in subadult sightings followed a 2 year lag behind a 97% increase in productive female sightings from 1980 through 1981. The 2-year lag coincided with the period that most cubs remained with their mothers. Presumably in 1983, many subadults dispersed from family groups, hence the pulse in subadult sightings. Many of these bears were no longer distinguishable as subadults in 1984, and some may have died during the winter and early spring. Consequently, an increase in adult and a decrease in subadult sightings occurred in 1984 (Table 2).

Table 1. Age/sex composition of grizzly bears reported in Glacier National Park for 3 separate studies in the population.

Area	N	Lone Adults	Subadults	Family Groups
Glacier Park ^a (1980-1984)	1627	0.469	0.243	0.288
Many Glacier ^b and Granite Park (1980-1981)	211	0.559	0.213	0.227
Glacier Park ^c (1967-1971)	350	-----0.723-----		0.277

a This study

b McArthur (1982:35)

c Martinka (1974:24)

Significant differences occurred in age/sex classes between off-trail sightings and low/moderate-use trails ($P < 0.001$ d.f.=2 $G=30.35$), and between off-trail sightings and high-use trails ($p < 0.001$ d.f.=2 $G=31.90$). In both cases, proportionally more females with young were reported in the off-trail situations than on the low/moderate-use ($P < 0.001$ $k=3$ $Z=5.73$) and high-use trails ($P < 0.001$ $k=3$ $Z=5.43$). Proportionally fewer subadults were also reported off-trail than on low/moderate-use ($P < 0.01$ $k=3$ $Z=3.01$) and high-use trails ($P < 0.001$ $k=3$ $Z=3.95$). No significant differences occurred in age/sex classes between low/moderate-use and high-use trails ($P > 0.25$ d.f.=2 $G=1.64$) (Table 3). Fifteen drainages receiving low visitor use were compared to 14 drainages receiving high visitor use, and age/sex classes were not significantly different ($P > 0.25$ d.f.=2 $G=0.784$).

Although no significant differences occurred between proportions of age/sex classes in low- and high-visitor use drainages, many more bears were reported on the low/moderate-use trails ($N=276$) than on high-use trails ($N=190$), and more in high-use drainages ($N=1602$) than in low-use drainages ($N=117$). In general, high-use drainages had high quality bear foods (Nadeau 1987a) and better visibility than the low-use drainages.

No significant differences in age/sex ratios occurred between observations, confrontations, and human injury ($P > 0.25$ d.f.=4 $G=5.23$). These data suggest that no single age/sex class comprised a larger proportion of confrontations or injuries than would be expected by ratios observed in the population.

Proportions of observations in areas off-trail, or on low/moderate-use, or high-use trails were significantly different than confrontations in the same

categories ($P < 0.001$ d.f.=2 $G=174.48$). Proportion of injuries to confrontations was highest off-trail, and decreased significantly as visitor use increased along trails ($P < 0.05$ d.f.=2 $G=6.486$) (Fig. 1). These data suggest higher potential for injury if a bear is confronted off trail with decreasing danger on low- and high-use trails.

3.3.3. Activity Patterns

Visitor activity periods in the backcountry were monitored and analyzed for the Two Medicine Subdistrict in 1984 (Baldwin et al. 1985). Because human activity is habitual (i.e. stopping for lunch at noon, etc.), visitor activity periods were assumed to be similar in other areas of the Park throughout the study period. Significant differences occurred between proportions of visitor use per time period and proportions of bear observations per time period ($P < 0.05$ d.f.=3 $G=7.82$). Evenings received 17% of the visitor use but comprised the time period when 25% of the bears were observed. Mornings comprised 30% of the human use and only 25% of reported observations. This suggests more bear activity in the evenings when fewer people saw more bears than any other period of the day. No significant differences ($P > 0.25$) were noted in the time of day individual age/sex groups were seen, suggesting temporally similar patterns of activity between groups. No significant difference occurred between visitor activity periods and time of confrontations ($P > 0.25$ d.f.=3 $G=0.869$), which suggested no particular time of day when the probability of confrontations was greater (Table 4).

During 1980, 22,079 visitor nights were logged from May through October in Glacier National Park, they declined 33% to 14,755 visitor nights by 1984 (unpubl. Park data). Proportions of visitor use between months, though unequal, remained

relatively stable from year to year. Visitor use peaked in August but numbers of confrontations and human injuries peaked in July. The proportion of confrontations per backcountry permit was highest in May and decreased linearly until October ($r^2=0.874$ $P<0.001$), suggesting a decreased likelihood of a confrontation later in the summer. However, the likelihood of getting injured during a confrontation was greatest in September and least likely in August (Fig. 2).

Table 2. Yearly composition of age/sex classes observed in the population or involved in confrontations from 1980 through 1984 in Glacier National Park.

	Subadults	Adults	Families
1980			
Observations(%)	53(24)	130(58)	41(18)
Confrontations(%)	6(21)	18(62)	5(17)

1981			
Observations(%)	22(10)	123(55)	79(35)
Confrontations(%)	8(35)	9(39)	6(26)

1982			
Observations(%)	20(8)	137(57)	85(35)
Confrontations(%)	6(22)	15(56)	6(22)

1983			
Observations(%)	137(28)	184(38)	161(33)
Confrontations(%)	14(26)	23(43)	16(30)

1984			
Observations(%)	71(20)	189(52)	103(28)
Confrontations(%)	13(30)	20(45)	11(25)

Table 3.- Percent occurrence of observations, confrontations, and human injuries between age/sex classes off-trail, and on low- and high-use trails. Unidentified age/sex classes were not included in the table but were used in other analyses.

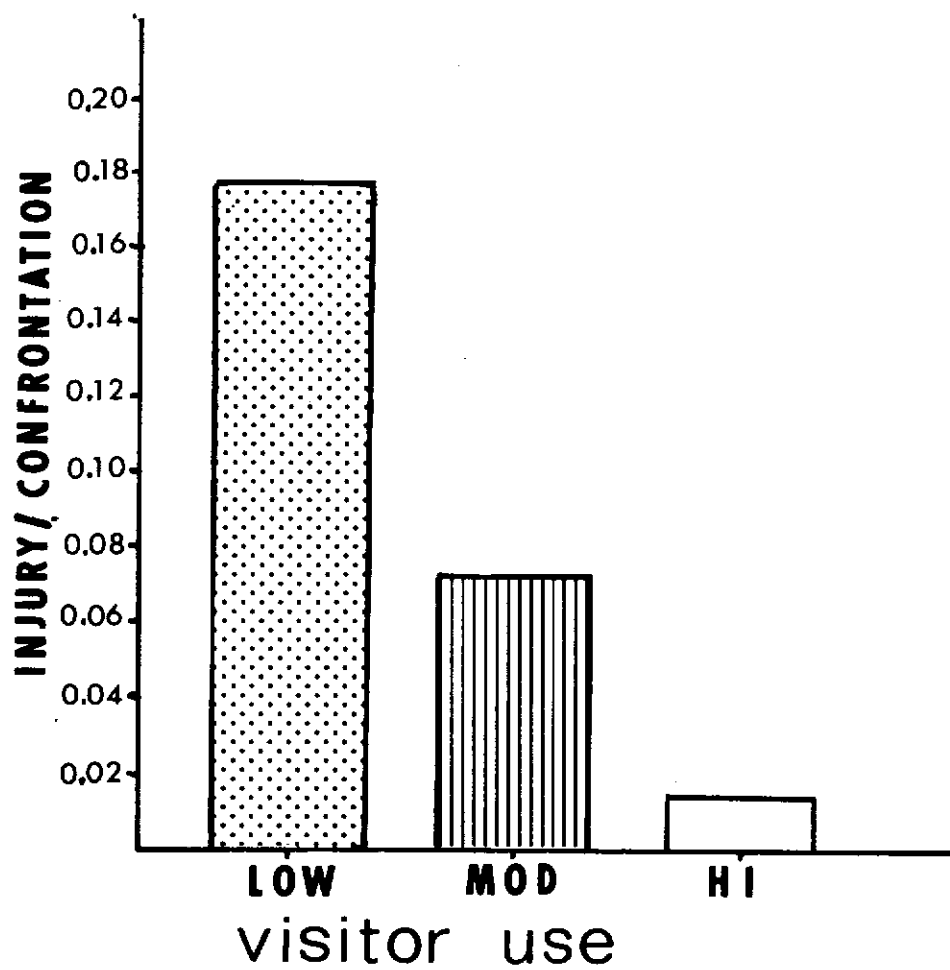
	OFF-TRAIL			!	LOW-USE TRAIL			!	HIGH-USE TRAIL		
	obs.	confr.	injury	!	obs.	confr.	injury	!	obs.	confr.	injury
	(N=1019)	(N=24)	(N=4)	!	(N=276)	(N=71)	(N=5)	!	(N=187)	(N=57)	(N=1)
Subadults	16	25	0	!	25	23	20	!	30	28	100
Adults	48	38	75	!	56	62	40	!	52	44	0
Families	36	38	25	!	20	15	40	!	18	28	0

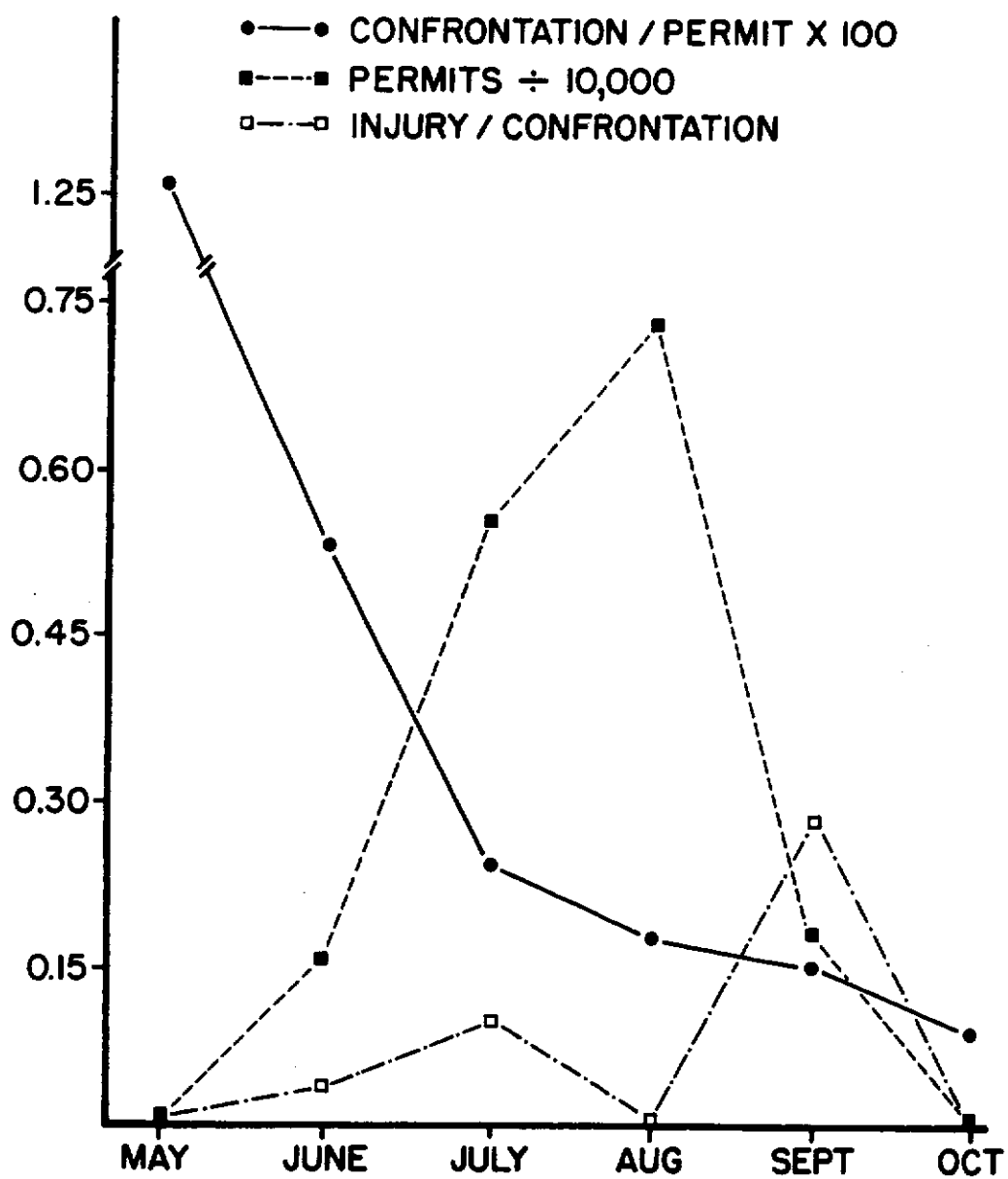
Table 4. Percent occurrence of observations, confrontations, and visitor activity occurring in different time periods of the day.

	SUNRISE ! (600-900)!	MORNING ! (900-1200)!	AFTERNOON ! (1200-1700)!	EVENING (1700-2200)
Observations (N=1676)	10	25	39	25

Confrontations (N=185)	12	32	39	16

Visitor Activity (N=195)	10	30	43	17





3.4. Discussion

The bias associated with observer reliability was found to be much less than expected after comparing age/sex frequencies of observations between observer types. Reasons for the higher frequency of productive females in the observation records of Park employees could have been due to: 1) productive females generally have smaller home ranges than do any other cohort (Hamer et al. 1978:6), therefore the locations of females may have been repeatedly predicted and observed by employees, whereas visitors would be less likely to randomly observe females with such frequency; and 2) productive females in some areas tend to prefer upper slopes and side basins that generally have good visibility (Russell et al. 1979:62). These data suggest that productive females prefer off trail areas, and subjective observations tend to show that rangers are more likely to hike with heads up and frequently know which habitats attract bears. Because of these factors, visitor reports may be a more random representation of cohort proportions in a population. However, due to avoidance of trails by productive females, the most accurate estimation may be the average of employee and visitor reports combined.

3.4.1. Age/Sex

Martinka (1974) attempted to identify individual bears from observation records. My analyses showed cohort proportions similar to Martinka's without the separation of individual bears. Using this method, similar results were obtained, and ease of analyses was greatly enhanced. Two different studies in Glacier Park

with similar results (Martinka 1974, McArthur 1982) may further substantiate the value of observation reports for cohort classification, or reflect similar biases inherent in observations.

Pulses in subadult sightings followed the increase in female productivity by 2 years. The increase in fecundity may have been caused by very good huckleberry productivity in 1980 and 1981 and a consequential increase in female productivity as discussed by Wimsutt (1963). This has been shown to happen for black bears *Ursus americanus* (Rogers 1976, Beecham 1980), and grizzlies (Knight pers. commun) following good years of good mast and berry production. Shifts in population or cohort size may be detectable with review of observation data. An increase in subadult numbers may mean an increase in subadult bear-human problems. It would follow that predicting years of increased problems may be possible by recognizing years of high female productivity. Years of increased problems become especially evident when bears are faced with a widespread mast crop failure (Schorgeer 1946, Hatler 1967). Confrontations with subadults doubled in Glacier from 1982 (N=26) to 1983 (N=53), which correlated with the increase in subadults sightings, as well as an overall poor huckleberry crop in 1983 (Kendall 1983). Following an excellent year for huckleberry production in 1982 (Kendall 1983), family group sightings increased in 1983, but declined in 1984 following the poor huckleberry crop of 1983.

Productive females were most frequently seen in areas with fewest people. Trails with even the least amount of human travel seemed to be enough disturbance to prevent females with young from using them as much as areas with

no disturbance during daylight hours. Although trails were not randomly placed, they did traverse the majority of bear habitat found in Glacier Park. Habitat analyses (Nadeau 1987a) indicated very high quality bear habitat along trails, consequently, the quality of habitat may not have constituted the reason for avoidance. In addition, Nadeau (1987c) found that females with young in a study area in Glacier Park will use trail areas at night in numbers proportional to their occurrence in the population. This temporal partitioning of resource use also occurred when visitor use declined for the season; bears used the trails more frequently during the day in September than they did during July and August (Nadeau 1987c).

Subadults, the most subordinate age class, were observed in greater proportions on the high-use trails than in other management areas (off-trail or low/moderate-use trails). In a population that has presumably reached carrying capacity (Martinka 1974), and may still be increasing (Keating 1986), subadults may avoid higher ranking bears and occur in greater numbers in areas that may be considered suboptimal due to their proximity to human disturbances, an apparently acceptable tradeoff. These data support previous theories (McArthur 1982, Nadeau 1983) on reasons for increased bear sightings in general, and subadult sightings in particular in Glacier Park.

3.4.2. Habituation

Bear habituation to humans has been cited as a possible explanation for increased confrontation rates and injuries in a park situation (McCullough 1982). Conversely, my results support McArthur's (1982) findings which indicate that bears which habituate to humans may in fact be involved in fewer full charges resulting in human injury. Habituation is defined as the waning of a response when a reward or punishment is discontinued (Petronovich 1973).

Bears are significantly more likely to injure a hiker when confronted off-trail, with decreasing likelihood on low- or high-use trails. These data suggest that bears that are habituated to humans may be less likely to injure a human when confronted. Females with young are generally considered least likely to habituate to humans (Hornocker 1962, Herrero 1976). The trend in injuries since 1970 shows changes in the age/sex class of involved bears. The recent (1980 through 1984) shift away from injuries by females with young may be due to these bears learning to avoid trail areas during high-visitor use periods.

Habituation is not to be confused with conditioning which is more frequently associated with food rewards. Conditioning is learning by receiving a reward or punishment for a given response (behavioral act) to a given stimulus (McCullough 1982:28). The 3 deaths that occurred in 1980 were believed to involve food and human conditioned bears (Glacier National Park, unpubl. data). Strong evidence supports the theory that food conditioned bears are much more dangerous than their unconditioned counterparts (Herrero 1985:130). The waning of the fear response is the most frequently reported form of habituation in behavioral

research (Peeke and Peeke 1973, Petronovich 1973). This phenomenon is recognizable at the McNeil River bear concentrations (Egbert 1978). Grizzlies may be modifying their fear response when confronting hikers in Glacier and consequently not responding with fear-induced aggression. The linear reduction of confrontations from May to October, and the absence of injuries in August (which is the month that receives most visitor use) may also reflect the benefits of the habituation process.

The fluctuation in injury/confrontation rates between months may also reflect food stress periods for the grizzly. Injuries in Glacier National Park from the late 1950's through 1984, peaked during late July and mid-September (Glacier National Park, unpubl. data). These periods also correlate with increased bear movements, and changing availability and types of foods. Berry development peaks during August through mid-September at varying elevations (Kendall 1985). As food becomes more abundant during the summer, grizzlies' aggressiveness toward each other may diminish (Egbert 1978), and their aggressiveness toward people may also diminish (McArthur 1980).

3.5. Summary

Observational biases in bear reporting may not be as great as previously believed. Trained observers and visitors reported proportionally equivalent numbers of subadult and lone adult bears. Observation reports seem to represent trends in the proportion of cohorts in the population. Huckleberry productivity was shown to correlate with bear productivity and fluctuations in grizzly bear-human

confrontations. Consequently, the frequency of bear observations in addition to data on berry productivity and availability may be used to predict years of increased problems.

My studies further confirm that habituation may be a factor in the reduction of grizzly-human confrontations on high use trails. A grizzly female with young is less likely to habituate to humans (Herrero 1985), and therefore is more likely to avoid trails with even the least amount of human use. In contrast, subadults are more likely to be present in proportionally larger numbers along high use trails than any other management area. Grizzly bear-human confrontations occur with equal probability at any hour of the day. Confrontations and injuries peak during the latter part of July, but the injury rate per confrontation is highest in September. This would indicate that 1) on high use trails, frequent observations may not necessarily indicate danger, 2) off-trail encounters with grizzlies could be more dangerous, 3) although bears are usually less active during mid-day, confrontations may occur as frequently as at other times, 4) most bear people conflicts occur in late July, but 5) you are most likely to be hurt during a grizzly confrontation during September.

Chapter 4

MOVEMENTS OF GRIZZLY BEARS NEAR A CAMPGROUND IN GLACIER PARK

4.1. Introduction

Six human deaths were inflicted by grizzly bears in Glacier National Park from 1967 through 1985. These deaths all occurred in situations where hikers were camped. One occurred at Granite Park Campground in 1967. Bears using the Granite Park area consistently were fed garbage, and a female conditioned to garbage was blamed for the camper's death and was destroyed. Immediately following the incident, the garbage was removed, the campground was relocated, and ranger visits to the campsite were increased. At another campground in 1976, less than 12 km from Granite Park, a camper was killed by a grizzly. This prompted another review of bear management policies in Glacier. In 1977, intensive bear and people management were initiated at Granite Park to reduce the possibility of unfavorable human/bear encounters. A Bear Management Ranger was stationed at Granite every night from 4 July through Labor Day, and since 1982, through the end of September. The Ranger's major duties were to assure clean camping techniques by people staying at the campground and to monitor bear movements in the area. From 1977 through 1985, no human/bear conflicts at Granite Park resulted in human injury. However, 2 hikers were injured by a grizzly bear < 1 km from the campground in September 1986.

A proposal was considered in 1981 to build a "bear proof" shelter for hikers at Granite Park. Due to the lack of scientific evidence indicating grizzly bear use of the Granite Park area at night, a research project was initiated in 1982. Research was designed to gather information relating to nocturnal use patterns of grizzly bears.

This paper reviews the movements of grizzly bears in the Granite Park Area in relation to a campground and backcountry chalet during the period from 1982 through 1984. Temporal and spatial distributions of grizzly bears and seasonal differences in relation to natural food availability and human use are discussed.

4.2. Study Area and Methods

Glacier National Park is located in northwestern Montana and is characterized by rugged mountains and a continental climate. Freezing temperatures and snow can occur during any month. A more detailed description of Glacier Park can be found in Martinka (1974), and McArthur (1982). Research was conducted in the central portion of the Park in a 6.5 km² area of Granite Park and an area unofficially called Bear Valley (Fig. 1). Common habitat types (Pfister et al. 1977) include subalpine fir *Abies lasiocarpa*/beargrass *Xerophlum tenax*-globe huckleberry *Vaccinium globulare* (Abla/xete-vagl), and subalpine fir/woodrush *Luzula hitchcockii* (Abla/luhi). Early-successional stages are common due to wildfires in the area during 1936 and 1967 and annual spring snowslides (McArthur 1982). Elevations in the study area range from 1700 m to 2500 m.

A network of trails used intensively by day hikers, 1 campground, a trail

cabin, and a backcountry chalet are located in the study area. The campground has a nightly limit of 4 parties, the chalet houses 48 guests and 9 employees, and the trail cabin houses the Ranger and trail crew. The chalet overlooks a bench area of prime grizzly habitat called Bear Valley that annually generates more grizzly bear sightings than any other area of similar size in Glacier Park (Glacier Park, unpubl. data).

4.2.1. Nocturnal methods

Nocturnal research was conducted for 47 nights during September 1982 and 1983, and for 15 nights from 4 July through 31 August 1983. Bear movements through the campground area were analyzed using an intensive grid census technique. This required placing grids on hiking trails and game trails in areas of expected bear use, and randomly distributing grids along trails within 1 km of the campground as well as in the campground. The grids were raked at sunset and checked for tracks shortly after sunrise. Tracks were measured to determine relative age/sex class (adult and subadult combined, and female with young). A starlight scope was used on clear nights during September 1982. Observations of the campground and chalet area were conducted for 15 minutes hourly from dark until about 0100 hours, then every 2 hours until dawn. The starlight scope was not used in 1983 or 1984. In addition to the above methods, a daily survey was conducted in search of scats, tracks, diggings, or other bear sign.

4.2.2. Diurnal methods

Intensive data on diurnal observations were recorded for 27 days during September 1982, and from 4 July through 26 September 1983. These data included date, time, weather (temperature, relative humidity, cloud cover, wind speed and direction, precipitation), bear description, location (plotted on a 15 minute topographical map), bear's distance to chalet, trail, and campground, and number of people present in the campground. In addition, a narrative was recorded on bear behavior and interactions with conspecifics, humans, and other animals. Data on bears near the chalet, collected by the Bear Management Rangers stationed at the chalet in 1984, were also used. Reports for 125 bear groups were used in these analyses.

4.2.3. Habitat

In 1982, huckleberry availability was mapped by hiking through the study area once a week and investigating different aspects, elevations, and slopes in a 0.5 km perimeter around the campground. A 0.5 km transect with 10 marked huckleberry bushes was positioned directly downslope of the campground to determine huckleberry productivity and development. When 70-90% of the berries on the marked bushes were purple, they were considered ripe. The same transect was used in 1983 to compare development and productivity between years. In addition, data were used from a berry productivity study that was conducted Parkwide by the Park research staff (Kendall 1986).

Vegetation in the Granite Park Area including Bear Valley was mapped in

1985 using recent Forest Service methodology (Hann 1985). Fifty-two habitat and physical feature variables were documented at 30 separate 404 m² (0.1 acre) plots. Each plot was characteristic of a specific habitat component chosen with the use of aerial photos and ground surveys. Habitat maps were overlaid with locations of grizzly observations to determine observed use of habitat in the study area.

Data were entered into the University of Montana DEC20 computer system and analyzed using 1022 data base management (Jackson 1982). Differences in habitat use between years, and other distributions were compared using the G-test (Sokal and Rolf 1982).

4.3. Results and Discussion

4.3.1. Habitat Use in Bear Valley

Analyses of grizzly bear observations in Bear Valley identified significant shifts in use of habitat components between months ($P < 0.001$ d.f.=6 $G=98.95$) Three major foraging strategies were recognized: 1) July--digging for bulbs and corms, 2) August--foraging on forbs, digging for bulbs, and corms, and 3) late August- late September--foraging on berries, digging for bulbs, and corms. Once snow had receded enough to expose glacier lily *Erythronium grandiflorum*/spring beauty *Claytonia lanceolata* fields, bears arrived in the area and began digging corms and bulbs. Glacier lilies were abundant (10-50% cover) in all habitat components in Bear Valley and extensive digs were noted throughout the area for lilies and spring beauties. Although spring beauties were not as abundant as glacier lilies, they were available in most components and in some areas

comprised 50% cover. Although components used in July differed between years, they were not significantly different ($P > 0.05$ d.f.=6 $G=12.47$).

Bear Valley has poor drainage with a slow winding stream and 2 ponds. This hydric influence creates an area of dense willow *Salix* spp. (80% canopy), lush dense grass (70% cover) interspersed with dense horsetail *Equisetum arvense* (70%cover), glacier lily (10%cover), and wild onion *Allium* spp. (5% cover). Thirty percent of the observations of bears feeding in Bear Valley during August occurred in these hydric sites, and the rest were in glacier lily and huckleberry dominated areas. Of the bears observed feeding in these hydric sites, most (97%) occurred during August and September. Significant differences were noted between years in the types of habitats used by bears during August ($P < 0.025$ d.f.=6 $G=14.63$).

Huckleberry productivity and development varied greatly between years, consequently, very significant differences occurred in use of habitat by bears between years ($P < 0.001$ d.f.=6 $G=24.54$). Huckleberries were most abundant but ripened latest in 1982. Huckleberry productivity decreased in 1983, and the berries ripened about 1 week earlier than in 1982. Productivity was lowest in 1984, and berries ripened almost 3 weeks earlier than in 1982. These trends were consistent Parkwide, productivity decreased 61% from 1982 to 1983 and another 60% from 1983 to 1984 (Kendall 1985). Because of the abundance of berries in 1982, 84% ($N=30$) of the bear observations in Bear Valley during September occurred in huckleberry shrubfields. During 1983, huckleberries were patchy in distribution, therefore bears were observed concentrated in a smaller area of Bear Valley where berries were most abundant. Bears were also frequently observed digging glacier

lilies and spring beauties. The extremely poor huckleberry year in 1984 caused bears to use other foods. Five of the 12 sightings during September 1984, occurred in the hydric area, and bears were frequently seen digging glacier lily corms. Because of the lack of berries in the area during 1984, the usual congregation of bears feeding on huckleberries was never observed.

4.3.2. Visitor Use

Three major trails received intensive visitor use in the Granite Park Area: the Highline, Loop, and Swiftcurrent Pass trails. Day use in the area was documented during 1980 and 1981, and reportedly peaked during late July and early August (McArthur 1982). More than 200 hikers were counted during a 3 hour period along a 12 km section of the Highline Trail in early August. Most hikers never walk as far as the chalet. Those that do, however, generally hike to the chalet and back in 1 day using several different trails. Overnight use at the Granite Park Campground was highest during August, but use varied between years. No more than 4 parties of 4 people each were allowed at the campground in 1 night. Annual overnight use from 1982 through 1984 was 663, 515, and 445 visitor-use nights respectively, an overall reduction of 33% in 3 years. Use of Granite Park Chalet remained relatively constant between years throughout the peak season with a nightly average of about 30 guests and 9 employees (Belton Chalets, pers. commun.). Visitor use was restricted mostly to trails, and Bear Valley received virtually no visitor use throughout the summer.

4.3.3. Diurnal and Crepuscular Bear Activity

The sex/age composition of grizzly bears observed at Granite Park was significantly different than observed in the Park population ($P < 0.05$ d.f.=2 $G=6.25$) (Martinka 1974, McArthur 1982, Nadeau 1987b). Females with young comprised a larger proportion of bears observed in Bear Valley (40%) than in the Parkwide population (29%) (McArthur 1982, Nadeau 1987b). Most observations during the day occurred in Bear Valley. Bear movements within 0.5 km of the chalet were 81% crepuscular ($N=31$), occurring either before 1000 hours or after 1800 hours. Only 6 (19%) bears were observed traveling through the area between 1100 and 1700 hours. Of the bears observed traveling within 0.5 km of the chalet during daylight, 39% were subadults, 42% lone adults, and 13% females with young.

Nine of the 12 grizzly bears observed within 0.25 km of the campground during daylight were seen before 1000 hours or after 1800 hours. Of these, 5 (42%) were lone adults, 6 (50%) subadults, and 1 (8%) was a female with young. Likewise, 77% of the bears that came within 0.5 km of the campground during daylight did so before 1000 hours and after 1800 hours ($N=26$). Of these, 23% were lone adults, 42% subadults, and 31% females with young. Although the differences in age/sex proportions were not significant between distances ($P=0.22$), there was a trend toward more females being observed further away from the campground.

Bears traveling near the chalet/campground area in daylight typically used 3 travel routes (Fig. 1). These routes were characterized by gently sloping timbered draws connecting Swiftcurrent Pass and Bear Valley, as well as movements between Bear Valley and the bench area to the west and north of the campground.

The weather was sunny 47% of the time and was either cloudy or precipitation was falling the remaining 53% of the time (N=15) that bears were within 0.25 km of the chalet. However, no significant difference in weather was noted between the days grizzly bears were near the chalet and the general weather present throughout the summer.

4.3.4. Nocturnal Bear Activity

Bears that traveled within a 0.5 km radius of the campground/chalet area came closer to the campground at night than during the day. Bears were documented traveling through and investigating the campground at night 5 times from 1982 through 1983 when campers were not present. Only once from 1977 through 1985 was a grizzly documented investigating the campground when people were present. This was a subadult that had been frequently seen in the area, and on this occasion it walked through the campground just prior to dark. Bear activity within a 0.5 km radius of the chalet/campground area at night increased during September but not significantly ($P=0.16$). Detectable bear activity only occurred 20% of the nights sampled (N=15) during July and August. However, bear activity was documented on 40% of the nights sampled during September (N=47). Increased nocturnal bear activity near the campground during September may be a response to the decrease in visitor use of the area and ripening huckleberries.

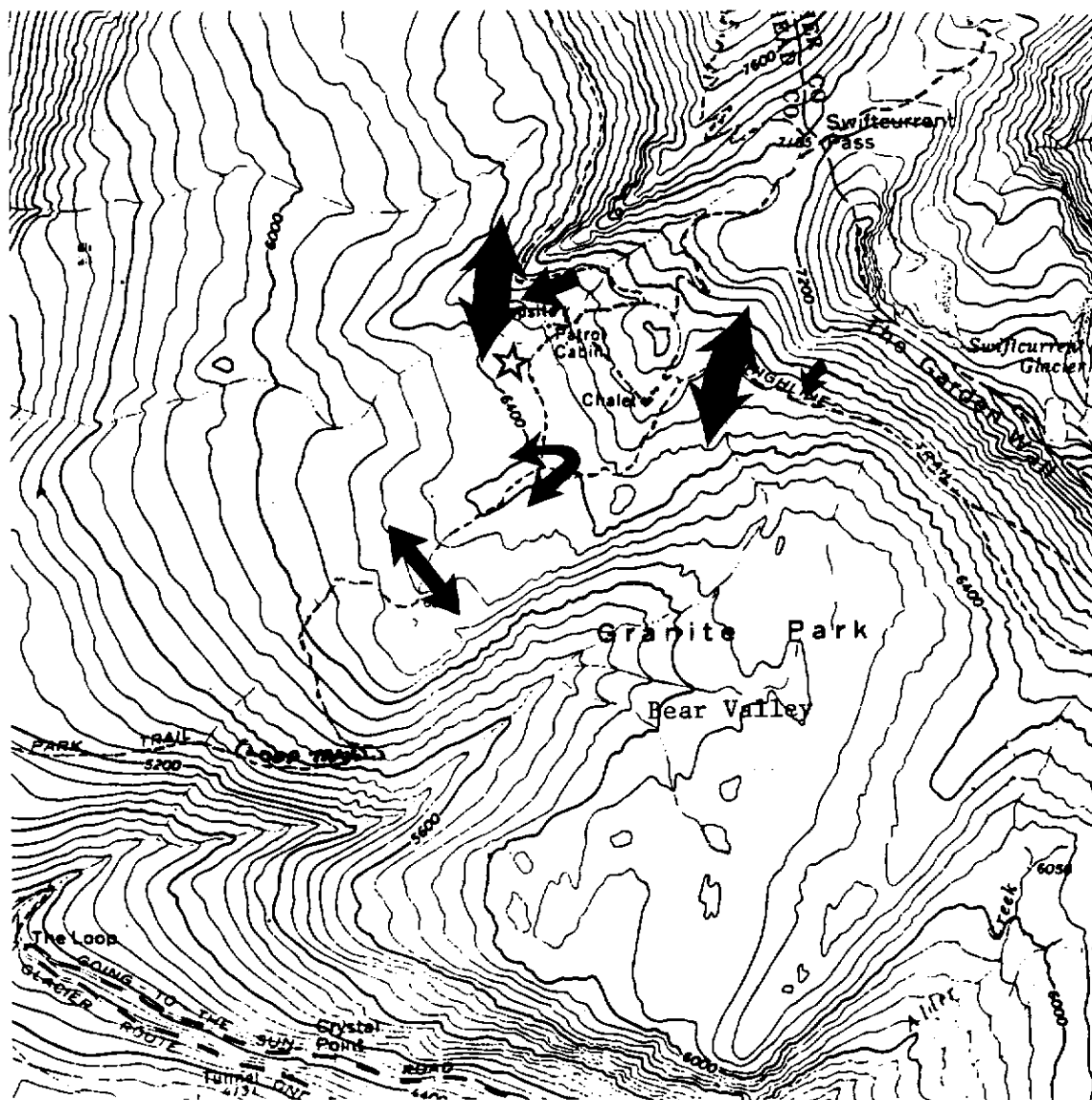
Thirty percent of the bears traveling through the area (<1 km from chalet) at night (N=30) were females with young, and 70% were either subadults or adults. These ratios were not significantly different than diurnal observations that occurred either Parkwide or at Granite Park.

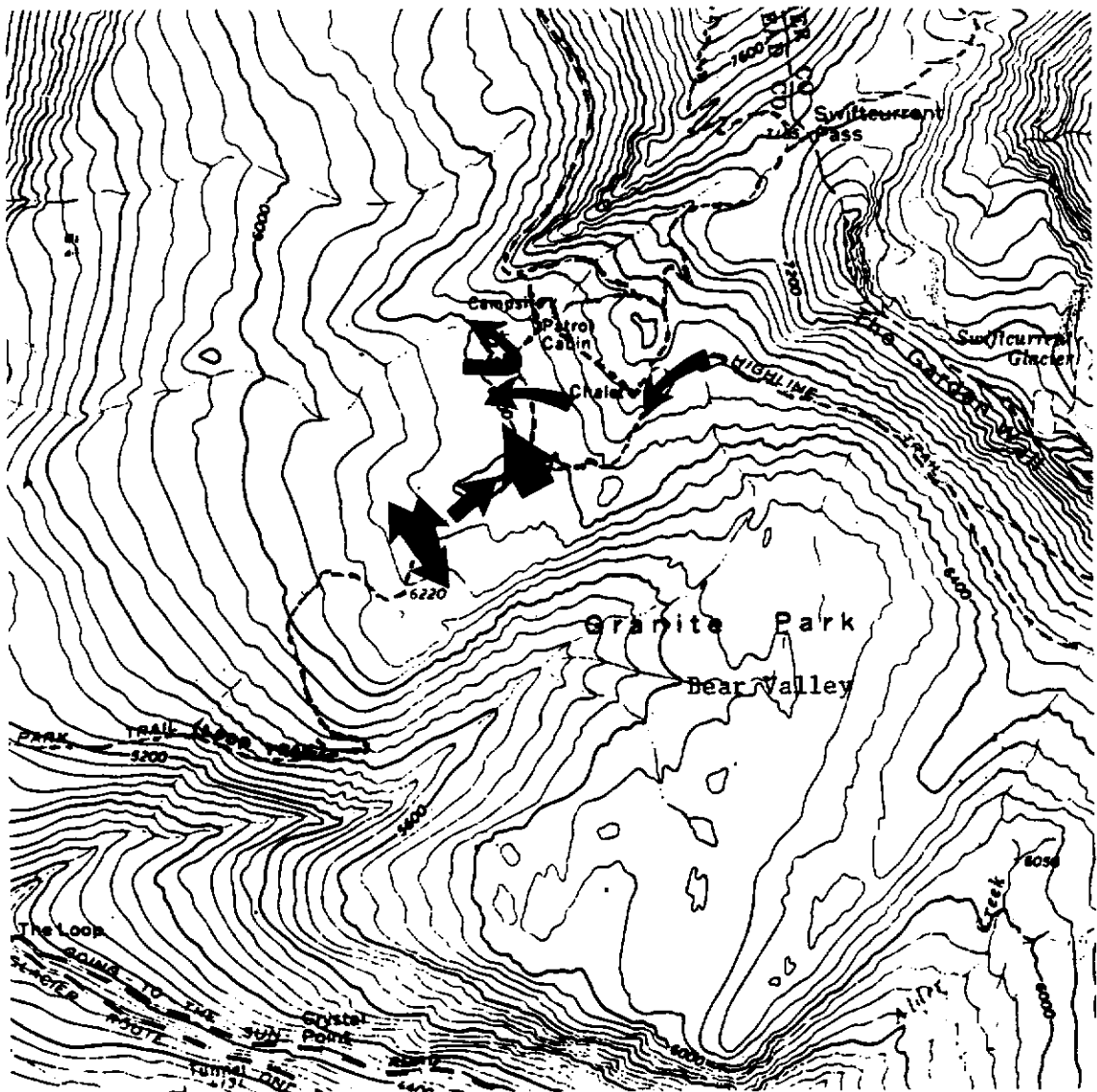
Bears traveling through the area at night frequently traveled along trails (Fig. 2). The campground trail passes within 4 m of one tent site, and on at least 2 occasions, a grizzly walked down the trail past a tent, outside of the designated campground, without stopping to investigate. Bears walked up the loop trail (N=6), and tracks were found going every direction across the loop trail, especially at a preferred nocturnal crossing route near the campground trail junction. In general, bears tended to come from the Bear Valley area and move in a northwesterly direction past the campground. On nights when bears investigated the campground (N=5), they usually approached from the southeast (Bear Valley side) and moved through in a northwesterly direction, then headed down slope below the campground (Fig. 2).

Although bear activity increased in the campground area at night, it was not clear whether they did so because of the cover available from darkness (Servheen 1981), or whether they responded to the reduced levels of human activity. Increased nocturnal activity along roads near the Flathead River were noted when diurnal vehicular activity was intensive (McLellan 1986).

Prior to 1984, the campground regulations sign was constructed of wood. Bears entering the campground invariably knocked the sign down and bit or clawed it. This marking behavior was a frequent occurrence on wooden signs throughout the Park. At 1 nocturnal crossing area, subalpine fir trees had been bitten and broken off at varying heights. This appeared to have occurred over a number of years, and may have been similar to the more common "marking trees" found at lower elevations.

During 1982 and 1983, 41% (N=22) of the bears traveling through the chalet/campground area (<0.5 km from chalet or campground) did so on partly cloudy nights or nights clearing after a storm. Thirty-six percent traveled through on nights when the weather was dominated by snow or rain, and only 23% traveled through on clear nights. During September 1982, 92% (N=13) of the bears traveled through the area on nights that were at least partly cloudy. Because general nocturnal weather data were not available, no comparisons to weather during movements was possible. The starlight scope does not function properly on cloudy nights, therefore, it was not very useful and bears were not observed. However, trends in the track grid data suggested that bears more frequently moved immediately following a change in weather, especially a clearing after a storm, than at other times.





4.3.5. Bear Management at the Chalet

A Ranger trained in bear and people management was stationed at Granite Park every night the chalet was open, and throughout most of September after the chalet closed for the season. The Ranger's major duties were to patrol the campground area at least twice daily to assure that campers had properly prepared and stored their food. The Ranger also educated the campers and chalet guests on proper camping techniques in grizzly country, and spoke on bear ecology often while watching bears in Bear Valley. When bears were seen in the chalet/campground area, the Ranger assured that people kept their distance. A constant monitoring of the bears in the area was an attempt at keeping bear - human conflicts to a minimum.

Due to the intensive grizzly bear and human activities at Granite Park, the bears have achieved a high degree of habituation. However, because bears have not been allowed to obtain human food since the late 1960's, they have not learned to associate humans with the food reward, and a subsequent peaceful coexistence seems to have resulted. The seemingly dangerous situation with bears traveling through the area at all hours may not be as dangerous as it first appears, as long as continued vigilant monitoring efforts and predictable human use patterns are maintained. Similar grizzly/human conditions occur at Katmai National Park, Alaska, near the grizzly congregations along McNeil River.

In contrast, campgrounds that do not receive intensive monitoring efforts may be more dangerous despite lower levels of grizzly bear activity in the area. On frequent occasions, Rangers patrolling backcountry campgrounds find improper

food storage and sloppy camping techniques. Once a bear obtains a food reward, the conditioning process occurs and bears may then become more dangerous (Herrero 1985). Since 1967, 4 of the 6 human deaths in Glacier National Park were inflicted by bears that were known to have obtained garbage, and the other 2 incidents were believed to have involved food conditioned bears as well (Glacier Park, unpubl. data).

4.4. Summary and Conclusions

Habitat use by grizzly bears in Bear Valley varies between months and years. Variations are most closely associated with the fluctuations in huckleberry productivity and phenology. Bears tend to use the trails more frequently and venture closer to the Campground and Chalet area at night and during September than at other times. Females with young used the trails and ventured closer to the chalet and campground area more frequently at night and during crepuscular periods than during the day, suggesting temporal resource partitioning. Bears (with the exception of 1 subadult) avoided entering the campground when people were present but frequently traveled through when people were absent. Vigilant bear monitoring and intensive people education and management seems to be an effective, temporary solution to preventing many problems from developing in a potentially volatile situation between grizzly bears and humans.

Despite efforts by the Park, grizzly bears are still able to obtain human foods not only from the occasional camper, but also from dumps and improperly stored garbage in areas bordering the Park. This fact, coupled with knowledge that grizzly

bears range great distances throughout their active seasons, elucidates potential conflicts involving food-conditioned bears. Because relatively little is known of grizzly bear movements in Glacier National Park, management is based on problems as they arise. To attain a higher level of knowledge concerning habituated bears and their subsequent behavior relative to humans, a radio telemetry study should be designed to monitor bear and human activity near core areas of visitor use.

Chapter 5

CONCLUSIONS

Grizzly bears and humans cohabitate most of what remains of grizzly bear habitat. Isolated patches of dense grizzly bear populations and intensive human use provide a testing ground for the adaptiveness and behavioral flexibility of the grizzly bear. That grizzly bears throughout their range occasionally injure a human is not surprising, but that it does not occur more frequently is amazing, until one recognizes the ability of the bears to adapt to people.

Grizzly bears are often described as unpredictable. This is true to the extent that all bears have different "personalities", and exhibit different traits due to different learning experiences. However, underlying similarities between ecosystems and behavioral traits have been elucidated through intensive research conducted during the last 30 years. This research has provided managers with guidelines whereby varied management philosophies can be incorporated with mandates for the preservation of grizzly bears.

This study was conducted to identify problem situations in grizzly bear management, then create a predictive model for use in the reduction of grizzly bear - human conflicts. Varied data collected by myself, managers, and other researchers were assimilated and analyzed to identify problem situations. The data presented in the preceding chapters displays grizzly bear feeding habits, specific trail and campground situations, human activity, bear behavior in relation to humans, and other factors that combine to create grizzly bear-human conflicts.

My study shows that predicting certain types of grizzly bear behavior is possible and that 3 major factors influence the probability of confrontations. Trails with short sight distance that are close to water, and that pass through seasonally important feeding areas are most likely to be areas of grizzly-human confrontations. Even if the above 3 factors were remedied however, some confrontations would probably still occur.

Habitat use by grizzly bears involves optimum foraging strategies within the confines of sociobehavioral limits. The majority of grizzly bears will forage on seasonally important foods with the least amount of energy expended in defense of that food, themselves, or their offspring. Depending on the area the bear uses as a homerange, it may have to contend with frequent interruptions by humans as well as other bears. Encounters with humans in a park situation frequently cause the bear to habituate to predictable human use patterns and sensory cues, thereby reducing the need for aggressive defense of individual space. A bear on a trail or near a campground is more likely to avoid humans if it has not been conditioned by a food reward. Bears that have become habituated to humans most frequently avoid humans, but may also respond neutrally or aggressively.

Habituated bears on trails are frequently considered less dangerous than those in a campground situation (Herrero, 1985). Movements of grizzlies near Granite Park Campground during this study increased nocturnally. However, grizzlies avoided entering the campground when people were present, but did enter when people were absent. This natural avoidance of people was enhanced when human foods were not available to the bears. Therefore, proper

management of campsites is imperative to reduction of nocturnal grizzly-human conflicts.

My study displays the importance of observation records as a management aide for defining trends in grizzly populations, confrontations and behavior. Peaks in observations of family groups and subsequent peaks in subadult sightings suggested synchronous breeding possibly related to huckleberry productivity.

Confrontations were also highest during the years of increased sightings. Records indicated that females with young were most frequently seen off-trail and that even the least amount of visitor use reduced the diurnal use of trails by productive females. Alternately, subadults preferred areas of high visitor use. The distribution of bears in relation to visitors suggests a heirarchal arrangement with the more dominant bears and productive females selecting areas away from human disturbances. Injuries inflicted by bears were least likely to occur on trails that received high visitor use, and most likely to occur off-trail where visitor use is unpredictable. This suggests increased hiker safety near habituated and less dominant bears.

This study provides information and defines guidelines whereby managers can effectively reduce confrontations between humans and grizzly bears. Notwithstanding the effectiveness of observation records for obtaining needed information, much improved data could be gathered using radio-telemetry, thus reducing many of the biases associated with observations. A telemetry study could accurately locate feeding, travel, and bedding areas close to human activity; define the effects of human activity and potential habituation on bear ecology;

elucidate movements of specific age/sex cohorts Parkwide; and improve management potential. Continued research on grizzly-human interactions is necessary to stay abreast of the behavioral and habitat use dynamics involving grizzly bears and humans in Glacier National Park.

Chapter 6

REFERENCES CITED

- Aune, K., and T. Stivers. 1983. Rocky mountain front grizzly bear monitoring and investigation. Ann. Rep. to Mt Dep. Fish Wildl. Parks, Helena, Mt. 180pp.
- Baldwin, S. B., B. R. Butterfield, R. G. Wright, and G. E. Machlis. 1985. Habitat and visitor mapping in the Two-Medicine area of Glacier National Park: Combining information-gathering techniques. Contr. Rep. to Natl. Park Serv., Univ. Idaho, Moscow. 95pp.
- Beecham, J. 1980. Some population characteristics of two black bear populations in Idaho. Pp. 201-204 in C. J. Martinka and K. L. McArthur, eds., Bears--their biology and management. 4.
- Craighead, F. C., Jr., and J. J. Craighead. 1972. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildl. Monog. 32:1-35.
- _____. 1976. Grizzly bear ranges and movements as determined by radiotracking. Pp. 97-109 in Pelton, M. R., J. W. Lentfer, and G. E. Folk. eds. Bears--their biology and managment. IUCN Publ. New Ser. no. 40.
- Dightman, R. A. 1967. Climate of Glacier National Park, Montana. Bull. Glacier Natural Hist. Ass., 7:1-9.
- Egbert, A. L. 1978. The social behavior of brown bears at McNeil River, Alaska. Ph.D. Thesis. Utah State Univ., Logan. 117pp.
- Habeck, J. R. 1970. The vegetation of Glacier National Park, Montana. Spec. Rep., 132pp.
- Haden, J. 1984. Fortran Program-The G-Test. Forestry/Wildlife computer Library, Univ. Montana, Missoula.
- Hamer, D., S. Herrero, R. T. Ogilvie, and T. Toth. 1978. Ecological studies of the Banff National Park grizzly bear, Cascade/Panther region 1978 (year 3). Parks Canada, Western Region, Calgary, Alberta. Unpubl. 86pp.
- _____, and S. Herrero. 1983. Ecological studies of the grizzly bear in Banff Natl.

- Park. Final Rep. Parks Canada, Western Region, Calgary, Alberta. Unpubl. 106pp.
- Hann, W. 1985. An integrated system for the grizzly bear component mapping and description process, "The Quick Plot". US Dep. Agric., USFS Techn. Manual, Missoula, Montana. 22pp.
- Hatler, D. F. 1967. Some aspects in the ecology of the black bear *Ursus americanus* in interior Alaska. Unpubl. M.S. Thesis, Univ. of Alaska, College. 111pp.
- Herrero, S. 1970. Human injury inflicted by grizzly bears. *Science* 170:593-598.
- _____. 1976. Conflicts between man and grizzly bears in the national parks of North America. Pp. 121-145 in Pelton, M.P., J.W. Lentfer, and G.E. Folk, eds. *Bears-their biology and management*. IUCN Publ. New Ser. 40.
- _____. 1978. A comparison of some features of the evolution, ecology, and behavior of black and grizzly/brown bears. *Carnivore* 1:7-17.
- _____, W. McCrory, and B. Pelchat. 1983. The application of grizzly bear habitat evaluation to trail and campsite locations in Kananaskis Provincial Park, Alberta. Paper to 6th Intern. Conf. on Bear Res. and Manage., Grand Canyon, Arizona. 30pp.
- _____. 1985. *Bear Attacks, their causes and avoidance*. Winchester Press, Piscataway, N.J. 287pp.
- Hornocker, M. G. 1962. Population characteristics and social and reproductive behavior of the grizzly bear in Yellowstone National Park. M.S. Thesis, Univ. Mont., Missoula, MT. 94pp.
- Jackson, K. 1982. Primer, system 1022, data base management system. Software House, Cambridge, Mass. 141pp.
- Jonkel, C. 1977. The border grizzly project. Ann. Rept. 2, Univ. Montana, Missoula. 134pp.
- Keating, K. A. 1986. Historical grizzly bear trends in Glacier National Park, Montana. *Wildl. Soc. Bull.* 14:83-87.
- Kendall, K. C. 1983. Grizzly bear population trend studies in Apgar Mountains, Glacier National Park. Nat. Park Serv. Prog. Rep., Glacier National Park, Montana. 37pp.

- McArthur, K. L. 1980. Habituation of grizzly bears to people: a hypothesis. *Int. Conf. Bear Res. and Manage.* 5:322-327.
- _____. 1982. Interactions between grizzly bears and hikers in Glacier National Park, Montana. M.S. Thesis, Oregon State Univ., Corvallis. 100pp.
- McCrary, W., S. Herrero and P. Whitfield. 1985. Using grizzly bear habitat information to reduce human-grizzly bear conflicts in Kokanee, Glacier and Valhalla Provincial Parks, BC. pp. 24-30 in Contreras G.P. and K.E. Evans, eds. *Proceedings-Grizzly Bear Habitat Symposium*, Missoula, Mt. USFS General Tech. Rep. INT-207.
- McCullough, D.R. 1982. Behavior, bears, and humans. *Wildl. Soc. Bull.* 10:27-33.
- McLellan, B. N. 1983. Aspects of behavior of grizzly bears in response to hydrocarbon exploration and the presence of humans. unpubl. rep., Dept. of Animal Science, Univ. B.C., Vancouver. 50pp.
- _____. 1986. The effects of roads and motorized vehicles on grizzly bears in the North Fork of the Flathead River, B.C.. unpubl. rep. Dept. of Animal Science, Univ. B.C., Vancouver. 51pp.
- _____. in prep. Habitat use by grizzly bears in the North Fork of the Flathead River. Chap. in Ph.D. Thesis, Dept. of Animal Science, Univ. B.C., Vancouver.
- Mealey, S. P., C. J. Jonkel, and R. Demarchi. 1977. Habitat criteria for grizzly bear management. *Int. Congr. Game Biol.* 13:276-289.
- Mundy, K., and D. R. Flook. 1973. Background for managing grizzly bears in the national parks of Canada. *Can. Wildl. Serv. Rep. no. 22.* 35pp.
- Nadeau, M. S. 1983. Hypothesis explaining increase in bear reports. Memo: Glacier National Park, Montana. 4pp.
- _____. 1987a. Chapter II in *Habitat, trail, and campground situations associated with grizzly bear-human confrontations in Glacier National Park, Montana.* M.S. Thesis. Univ. Montana, Missoula. 100pp.
- _____. 1987b. Chapter III in *Habitat, trail, and campground situations associated with grizzly bear-human confrontations in Glacier National Park, Montana.* M.S. Thesis. Univ. Montana, Missoula. 100pp.
- _____. 1987c. Chapter IV in *Habitat, trail, and campground situations associated with grizzly bear-human confrontations in Glacier National Park, Montana.* M.S. Thesis. Univ. Montana, Missoula. 100pp.

- Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1980. SPSSX, Users Guide. McGraw-Hill Book Co. New York. 806pp.
- Peeke, H. V. S. and S. C. Peeke. 1973. Habituation in fish with special reference to intraspecific aggressive behavior. Pages 59-83 in H. V. S. Peeke and M. J. Herz, eds. Habituation. Academic Press, New York.
- Petrinovich, L. 1973. A species-meaningful analysis of habituation. Pp. 141-162 in H. V. S. Peeke and M. J. Herz, eds. Habituation. Academic Press, New York.
- Pfister, R., B. Kovalchik, S. Arno, and R. Presby. 1977. Forest habitat types of Montana. USDA For. Serv. Gen. Tech. Rept. INT-34. 174pp.
- Riggs, R. A. and C. Armour. 1980. A hypothesis for predicting grizzly bear habitat use in spring floodplain habitat mosaic with special reference to reducing human-bear contact rates. Unpubl. Rep. Natl. Park Serv., Glacier National Park, Montana 28pp.
- Rogers, L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. N. Amer. Wildl. Nat. Res. Conf. 41:431-438.
- Ross, C. P. 1959. Geology of Glacier National Park and the Flathead Region Northwestern Montana, USDI Geologic Survey Professional Paper 296. 125pp.
- Russell, R. H., J. W. Nolan, N. G. Woody, and G. H. Anderson, and A. M. Pearson. 1978. A study of the grizzly bear *Ursus arctos* in Jasper National Park. A Progress Report 1976 and 1977. Can. Wildl. Serv. Rep. for Parks Canada. Edmonton, Alberta. Unpubl. 95pp.
- _____, J. W. Nolan, N. G. Woody, and G. H. Anderson. 1979. A study of the grizzly bear *Ursus arctos* in Jasper National Park. Can. Wildl. Serv. Rep. for Parks Canada. Edmonton, Alberta. Unpubl. 136pp.
- Schaffer, S. C. 1971. Some ecological relationships of grizzly bears and black bears in the Apgar Mountains in Glacier National Park, Montana. M.S. Thesis, Univ. Mont., Missoula. 134pp.
- Schleyer, B. O. 1983. Activity patterns of grizzly bears in the Yellowstone Ecosystem and their reproductive behavior, predation, and the use of carrion. M.S. Thesis, Montana State Univ., Bozeman. 130pp.
- Schorger, A. W. 1946. Influx of bears into St. Louis County, Minnesota. J. Mammal. 27:177.

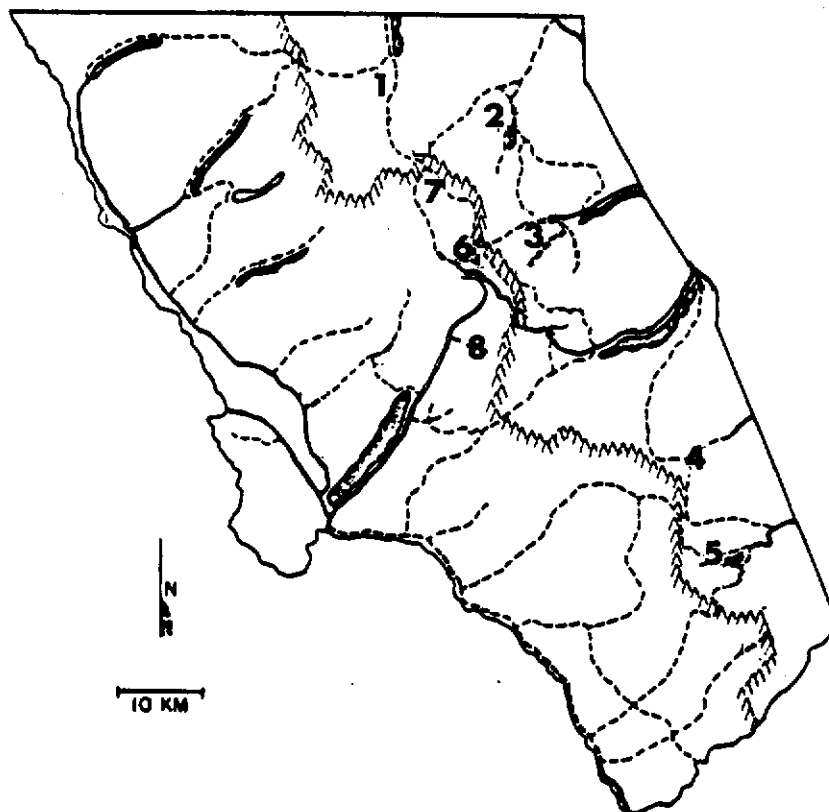
- Schneider, W. 1980. Bears or hikers. Backpacker 8(5):36-42.
- Servheen, C. 1981. Grizzly bear ecology and management in the Mission Mountains, Montana. Ph.D. thesis, Univ. Montana, Missoula, MT. 138pp.
- Stuart, T. W. 1977. Exploration of optimal backcountry travel patterns in grizzly bear habitat. Inter. Conf. Bear Res. and Manage., Kalispell, Montana. 4:25-32.
- , 1978. Management models for human use of grizzly bear habitat. Trans. N. Amer. Wildl. Nat. Res. Conf. 43:434-441.
- Sokal R. R. and F. J. Rolf. 1981. Biometry. W. H. Freeman and Company, New York. 859pp.
- Wimsatt, W. A. 1963. Delayed implantation in the Ursidae with particular reference to the black bear *Ursus americanus*. A. G. Enders, ed. Delayed implantation. Univ. Chicago Press.

Appendix A
Drainages and Trails Studied

Table A1.--Major drainages and trails investigated during the study.
Locations of drainages are numbered and mapped on the following page.

1. Waterton/Goathaunt--Boulder Pass, Waterton River, and Stoney Indian Pass trails.
2. Belly River--Belly River, Stoney Indian Pass, Elizabeth and Helen Lake Trails.
3. Many Glacier--Swiftcurrent Pass, Ptarmigan, Iceberg Lake, Grinnel Glacier, Cataract Creek, and Cracker Lake Trails.
4. Cut Bank--Cut Bank Pass and Medicine Grizzly Trails.
5. Two Medicine--Dawson Pass, Upper Two Medicine, South Shore, and Old Man Lake Trails.
6. Upper McDonald--Granite Park and Bear Valley Area, and the Loop Trail.
7. Mineral Creek--Highline from Granite to 50 Mountain.

Appendix B
Map of Study Area



Appendix C

Species List

Table B1.-Species, % occurrence and % canopy cover of dominant plants found in confrontation sites by season, and those found in control sites. Species preceded by * are bear foods. Spring (May 1 - July 14), Low Trans (July 15-Aug. 14, <1700 m), Hi Trans (July 15-Aug 14 >1700 m), Fall (Aug. 15 to Oct. 30).

Species Name	Spring %Occ. %CC (N=32)		Low Trans %Occ. %CC (N=25)		Hi Trans %Occ. %CC (N=15)		Fall %Occ. %CC (N=22)		Control %Occ. %CC (N=116)	
TREES										
Abies lasiocarpa	87	15	72	25	100	30	82	26	100	21
Picea engelmannii	44	17	64	14	33	36	54	22	63	20
*Pinus albicaulis					7	10	14	1	9	10
Pinus contorta	19	30	40	16					17	28
Pinus monticola									9	30
Populus tremuloides	28	29	44	25			14	28	9	30
Populus trichocarpa	6	30							3	25
Pseudotsuga menziesii	3	30					9	35	9	14
SHRUBS										
Acer glabrum	9	20	4	30	7	60	5	20	11	29
Actea rubra	13	4	4	3	20	8			9	3
Alnus incana	3	40	4	40						
Alnus sinuata	31	42	24	40	13	65	5	20	22	28
*Amelancia alnefolia	38	11	48	13	7	10	36	17	34	9
*Arctostaphylos uva-ursi	6	30	4	20			9	25	1	3
*Berberis repens	6	15	8	12			18	6	10	5
Ceanothus velutinus			4	10						
Cornus stolonifera									1	20
*Crataegus douglasii	3	30							3	16
Holodiscus discolor									2	1
Juniperus communis	8	16	4	1					2	2
Ledum glandulosum							5	1		
*Lonicera involucrata			8	30	13	10			3	25
Menziesia ferruginea	22	26	28	27	7	20	14	31	27	32
Oplopanix horridum									1	20
Pachistima myrsinites	3	10					5	30	3	23
*Prunus emarginata			4	30					1	30
*Prunus virginiana	6	20	20	36			5	50	1	20
*Rhamnus alnifolia	6	17	8	60					1	60
*Ribes lacustre									3	21
*Ribes montigenum			4	1	7	20				
*Ribes spp.	16	24			13	8	9	15	3	12

Appendix D

Species List

Table B1.--continued

SHRUBS									
*Rosa woodsii							5	3	1 10
*Rubus parviflora	25	34	20	32	13	20			33 31
*Rubus idaeus					7	3			3 21
Salix spp.	16	21	20	20	7	50	23	26	8 31
*Sambucus racemosa	13	10	4	10	13	6			6 9
*Sorbus scopulina	47	18	48	9	40	9	23	8	42 11
*Sorbus sitchensis			4	10			18	10	2 25
*Shepherdia canadensis	3	10	4	3					8 12
Spirea betulifolia	28	13	52	10	13	10	14	13	22 11
Spirea densiflora									
Symphoricarpos albus	19	25	4	20			14	17	19 11
Taxus brevifolia	3	10							
*Vaccinium caespitosum			8	50					3 5
*Vaccinium globulare	53	17	68	16	67	22	55	29	56 19
*Vaccinium membranaceum					20	3	9	7	2 11
*Vaccinium myrtilloides									9 14
*Vaccinium scoparium			8	6			5	1	14 20
FORBS									
Achillea millefolium	3	20							2 30
*Allium schoenoprasum					7	3	14	17	3 4
*Angelica arguta	13	6					18	11	24 11
*Angelica dawsonii	31	9	16	6	13	1	9	6	2 1
*Angelica spp.	3	20					5	10	3 17
Antennaria spp.			4	20					2 1
Arnica cordifolia	28	17	20	3			18	38	25 25
Arnica latifolia	6	40	12	15			27	16	18 21
*Aster spp.			12	20			5	10	7 19
*Astragalus spp.					7	20			
Athrium filix-femina			4	30					10 29
*Calamagrostis canadensis	25	17	40	28	20	20	45	24	24 19
*Calamagrostis rubescens	3	1					14	63	5 27
*Carex geyeri	44	29	40	36	40	15	23	22	14 15
*Carex spp.	3	50	8	60	20	18			12 21
*Castilleja spp.					13	12			4 5
Chimaphila umbellata			4	10					6 27
*Cirsium spp.							5	1	3 4
*Claytonia lanceolata					7	10	9	7	
Clintonia uniflora	28	16	48	18			9	15	37 21
Cornus canadensis									2 1
Disporum hookerli			4	30	7	50			1 40

Appendix E

Species List

Table 81.--continued

<i>Epilobium angustifolium</i>	34	20	16	28	20	11	18	25	18	26
* <i>Erythronium grandiflorum</i>	19	22	4	1	80	26	41	36	22	25
* <i>Equisetum arvense</i>	3	3	4	1						
* <i>Festuca idahoensis</i>	9	4	4	10	7	1				
* <i>Festuca scabrella</i>	3	20	4	30						
* <i>Fragaria</i> spp.	19	16	28	20	40	3	23	19	19	14
<i>Galium triflorum</i>	22	6	12	11	7	3			20	9
* <i>Graminoide</i> spp.	22	24	16	30	40	19	27	22	37	33
<i>Gymnocarpium dryopteris</i>	3	40	8	45						
* <i>Hedysarum sulpherenscens</i>							5	3	3	14
* <i>Heracleum lanatum</i>	56	9	32	8	13	15	14	13	34	15
<i>Heracium</i> spp.									1	1
<i>Listera cordata</i>			4	30						
* <i>Lomatium dissectum</i>			12	1			5	1		
* <i>Lomatium</i> spp.	6	1	4	30					1	1
<i>Luzula hitchcockii</i>	6	15	4	1	40	28	32	27	16	28
<i>Mitella breweri</i>	3	20							2	25
* <i>Osmorhiza</i> spp.	9	4	12	4			9	1	16	3
<i>Penstemon</i> spp.	6	10			40	12			3	35
<i>Potentilla</i> spp.							5	30	1	10
<i>Pyrola seclunda</i>					4	3				
<i>Pyrola</i> spp.			4	3					3	35
* <i>Senecio triangularis</i>	9	11	16	6	40	6	36	4	23	12
<i>Smilacina racemosa</i>	3	1							4	4
<i>Smilacina stellata</i>	9	10	4	10			9	11	11	6
<i>Solidago</i> spp.			8	30			5	40		
<i>Streptopus amplexifolius</i>	3	3	4	1			14	4	11	10
* <i>Taraxacum</i> spp.	3	1					5	3	1	1
* <i>Thalictrum occidentale</i>	50	14	68	8	33	8	50	17	43	18
<i>Tiarella trifoliata</i>	3	20	8	16					9	19
* <i>Valeriana sitchensis</i>	16	8			53	5	27	8	8	8
* <i>Veratrum viride</i>	3	20	4	20	7	40				
<i>Viola canadensis</i>	3	30	4	30	7	30			3	14
<i>Viola orbiculata</i>	19	4	12	20	13	6	9	1	18	10
<i>Xerophyllum tenax</i>	53	18	68	27	73	30	59	29	43	33

Appendix F

Special Features

Table C1.--Percent occurrence of special features at confrontation and control sites by season.

Special Feature	Spring (N=32)	Lo Trans (N=25)	Hi Trans (N=15)	Fall (N=22)	Control (N=116)
None	13	15	20	36	33
Aval. Chute, non scoured	19	12	20	9	10
Aval. Chute, scoured	3	0	0	5	3
Scree	0	0	0	5	1
Floodplain	6	0	0	9	2
Swale	9	4	13	5	15
Seep	3				2
Upland Forest, near water	28	19	13	9	18
Valley Bottom, near water	3	0	0	5	4
Other	16	50	33	18	12

Spring: May 1 - July 14.

Lo Trans:Low Transition=July 15 - Aug. 14 (elev. < 1700m).

Hi Trans:High Transition=July 15 - Aug. 14 (elev. > 1700m).

Fall: Aug. 15 - Oct. 30.

Appendix G

Habitat Types

Table D1.--Percent occurrence of habitat types by season, all seasons combined, and control.

Habitat type	1 Spring (N=32)	2 Lo Trans (N=26)	3 Hi Trans (N=15)	4 Fall (N=22)	Mean (N=95)	Control (N=124)
Scree						2
Scrubland						1
Hardwoods	9	4		5	6	4
Grass type	3				1	1
Alnus Series	6		7		3	
Salix series					0	2
Forb meadow					0	1
Shrub type	9	4			4	7
Abla/Clun	3				1	
Abla/Clun/Clun	13	4		5	6	15
Abla/Clun/Arnu					0	4
Abla/Clun/Xete	3	23		5	8	6
Abla/Clun/Mefe	13	15	7		9	12
Abla/Gatr					0	1
Abla/Caca					0	1
Abla/Caca/Caca		4	13	9	5	2
Abla/Caca/Gatr				5	1	2
Abla/Mefe	3	12			4	2
Abla/Mefe/Xete				5	1	3
Abla/Xete		4			1	1
Abla/Xete/Vagl	13	15	40	27	21	11
Abla/Xete/Vasc					0	1
Abla/Vasc/Vasc					0	1
Abla/Alsl				5	1	1
Abla/Luhl/Vasc					0	3
Abla/Luhl/Mefe				5	1	
Pial/Abla			7	5	2	1
Undetermined *	22	15	27	23	21	19

* Could not be keyed due to ecotonal situation.

1/Spring period was 1 May to 14 July.

2/Lo Trans period was 15 July to 14 August, elevations < 1700 m.

3/Hi Trans period was 15 July to 14 August, elevations > 1700 m.

4/Fall period was from 15 August to 30 October.

Appendix H

Habitat Types

Table D2.--Key to abbreviations of names of habitat types (Pfister et al. 1977) found along trails at confrontation and control sites.

Abbreviation	Scientific Name	Common Name
Abia/Aist	<u>Abies lasiocarpa/Alnus sinuata</u> h.t.	Subalpine fir/sitka alder h.t.
Abia/Caca -Caca	<u>Abies lasiocarpa/Calamagrostis canadensis</u> h.t. <u>-Calamagrostis canadensis</u> phase	Subalpine fir/reedgrass h.t. -reedgrass phase
Abia/Clun -Clun -Gatr -Mefe -Vaca -Xete	<u>Abies lasiocarpa/Clintonia uniflora</u> h.t. <u>-Clintonia uniflora</u> phase <u>-Galium triflorum</u> phase <u>-Menziesia ferruginea</u> phase <u>-Vaccinium caespitosum</u> phase <u>-Xerophyllum tenax</u> phase	Subalpine fir/beadlily h.t. -beadlily phase -bedstraw phase -fool's huckleberry phase -dwarf huckleberry phase -beargrass phase
Abia/Gatr	<u>Abies lasiocarpa/Galium triflorum</u> h.t.	Subalpine fir/beadstraw h.t.
Abia/Luhl -Vasc -Mefe	<u>Abies lasiocarpa/Luzula hitchcockii</u> h.t. <u>-Vaccinium scoparium</u> phase <u>-Menziesia ferruginea</u> phase	Subalpine fir/woodrush h.t. -whortleberry phase -fool's huckleberry phase
Abia/Mefe -Xete	<u>Abies lasiocarpa/Menziesia ferruginea</u> h.t. <u>-Xerophyllum tenax</u> phase	Subalpine fir/fool's huckleberry h.t. -beargrass phase
Abia/Vasc -Vasc	<u>Abies lasiocarpa/Vaccinium caespitosum</u> h.t. <u>-Vaccinium caespitosum</u> phase	Subalpine fir/dwarf huckleberry h.t. -dwarf huckleberry phase
Abia/Xete -Vagl -Vasc	<u>Abies lasiocarpa/Xerophyllum tenax</u> h.t. <u>-Vaccinium globulare</u> phase <u>-Vaccinium caespitosum</u> phase	Subalpine fir/beargrass h.t. -globe huckleberry phase -dwarf huckleberry phase
Pia1/Abia	<u>Pinus albicaulis/Abies lasiocarpa</u> h.t.	Whitebark Pine/Subalpine fir h.t.

Appendix I

Discriminant Function

Table E1.--Categories and explanations of abbreviations
for variables used in the discriminant function analyses.

*Dominant tree canopy cover (DTCC)	1/Slope (SLOPE)
Second dominant tree canopy cover (SDTC)	2/Elevation (ELEV)
Second dominant shrub canopy cover (SDSC)	3/Life form (LF)
Dominant herb canopy cover (DHCC)	4/Structure (ST)
Second dominant herb canopy cover (SDHC)	5/Mixed canopy (MC)
First bear food canopy cover (BFCC)	
Grass/sedge canopy cover (GC)	

*All canopy covers estimated to closest of following groups:
 1%, 1-5%, 5-15%, 15-25%, 25-35%, 35-45%, 45-55%, 55-65%, 65-75%,
 75-85%, 85-95%, 95-100%;
 1,2/Slope and elevation measured continuously and not grouped.
 3/Life form grouped into: 1)conifer 2)shrub 3)grassland;
 4/Structure grouped into: 1)seedling 2)sapling 3)pole 4)mature
 5)old growth;
 5/Mixed canopy: 1)yes 0)no

Appendix J

Discriminant Function

Table E2.-Mean and significance of discriminant variables used for separations of confrontations by season from control sites, using stepwise discriminant function.

Variable	Control Mean	U-Statistic Significance	Confrontation			
			Season(*)	Other seasons		
May 1 to July 14			(*)			
SDSCC	15.9	0.0024	22.5	20.4	10.7	11.0
DTCC	32.7	0.0002	22.5	28.4	30.1	35.0
DHCC	42.3	0.0001	33.4	40.8	38.7	47.7
GC	24.5	0.0000	33.3	36.2	23.9	36.4
SDHCC	24.2	0.0000	19.4	26.2	22.9	28.2
MC	.800	0.0000	.312	.269	.800	.682
July 15 to Aug. 14 (LO)			(*)			
ST	3.3	0.0133	2.9	2.6	3.0	3.2
SDTCC	9.0	0.0017	10.6	11.4	1.2	8.3
SDSCC	16.0	0.0017	22.5	20.4	10.7	11.0
MC	.800	0.0007	.312	.270	.800	.682
GC	24.5	0.0001	33.3	36.2	23.9	36.4
BFCC	11.0	0.0001		10.0		
July 15 to Aug. 14 (HI)			(*)			
ELEV	5278	0.0000	5079	5116	6317	5616
SLOPE	23.8	0.0000	27.8	21.7	39.3	19.7
SDHCC	24.5	0.0000	19.4	26.2	22.9	28.2
BFCC	11.0	0.0000	13.4	10.0	17.5	18.0
Aug. 15 to Den entrance			(*)			
BFCC	11.0	0.0043	13.4	10.0	17.5	18.0
SDSCC	16.0	0.0022	22.5	20.4	10.7	11.0
LF	1.4	0.0014	1.6	1.5	1.3	1.2
GC	24.5	0.0011	33.3	36.2	23.9	36.4

Appendix K

Discriminant Function

Table E3.-Discriminant function values for tests run on confrontations: for all seasons combined and the controls, individual seasons and controls, and individual seasons and the other seasons combined.

# of Functions	Eigen Value	Canonical Correlation	Wilks Lambda	Chi Square	D.F	Significance
All Seasons:Control						
1	0.128	0.3364	0.887	25.408	5	0.0001

Spring ¹ :Control						
1	0.274	0.4637	0.785	35.835	6	0.0000

Lo Trans ² :Control						
1	0.209	0.4159	0.827	26.975	6	0.0001

Hi Trans ³ :Control						
1	0.300	0.4803	0.769	34.616	4	0.0000

Fall ⁴ :Control ⁵						
1	0.140	0.3506	0.877	18.228	4	0.0011

Spring:Other Seasons						
1	0.371	0.5204	0.729	28.785	4	0.0000

Lo Trans:Other Seasons						
1	0.274	0.4642	0.784	22.081	4	0.0002

Hi Trans:Other Seasons						
1	0.777	0.6613	0.562	52.611	3	0.0000

Fall:Other Seasons						
1	0.206	0.4136	0.829	17.166	3	0.0007

1-Spring: 1 May - 14 July.

2-Lo Trans: 15 July - 14 Aug., elevations < 1700 m.

3-Hi Trans: 15 July - 14 Aug., elevations > 1700 m.

4-Fall: 15 August - 30 October.

5-Control: representative habitat found along trails

Appendix L

Discriminant Function

Table E4.-Mean and standard error of discriminant variables used for separation of each season from the remaining seasons combined, using stepwise selection and one function.

Variable	Other Seasons Mean	Strd. error	Season(*)	All Seasons Other Seasons				Mean
May 1 July 14			(*)					
Elev	5576	88.7	5079	5116	6317	5616	5409	
SDHCC	26.1	1.3	19.4	26.3	22.9	28.2	23.9	
SDSCC	14.8	1.2	22.5	20.4	10.7	11.0	17.4	
BFCC	14.6	1.5	13.4	10.0	17.5	18.0	14.2	

July 15 to Aug 14 (elev. <1700m)			(*)					
ELEV	5519	86.0	5079	5116	6317	5616	5409	
MC	.536	0.06	0.31	0.26	0.80	0.68	0.46	
SDHCC	23.0	1.3	19.4	26.3	22.9	28.2	23.9	
BFCC	15.7	1.4	13.4	10.0	17.5	18.0	14.2	

July 15 to Aug 14 (elev. >1700m)			(*)					
Elev	5239	64.0	5079	5116	6317	5616	5409	
MC	.400	0.06	0.31	0.26	0.80	0.68	0.46	
Slope	23.6	2.4	27.8	21.7	39.3	19.7	26.1	

Aug 15 to Oct. 30			(*)					
SDSCC	19.5	1.2	22.5	20.4	10.7	11.0	17.4	
DHCC	39.7	1.7	33.4	40.8	38.7	47.7	39.6	
LF	1.4	0.06	1.5	1.5	1.3	1.2	1.4	

Elev: Elevation SDHCC: Second Dominant Herb Canopy Cover

SDSCC: Second Dominant Shrub Canopy Cover

MC: Mixed Canopy (yes=1,no=0) BFCC: Bear Food Canopy Cover

Slope: Percent Slope SDSCC: Second Dominant Shrub Canopy Cover

DHCC: Dominant Herb Canopy Cover

LF: Life Form 1=Tree 2=Shrub 3=Grass/Forb

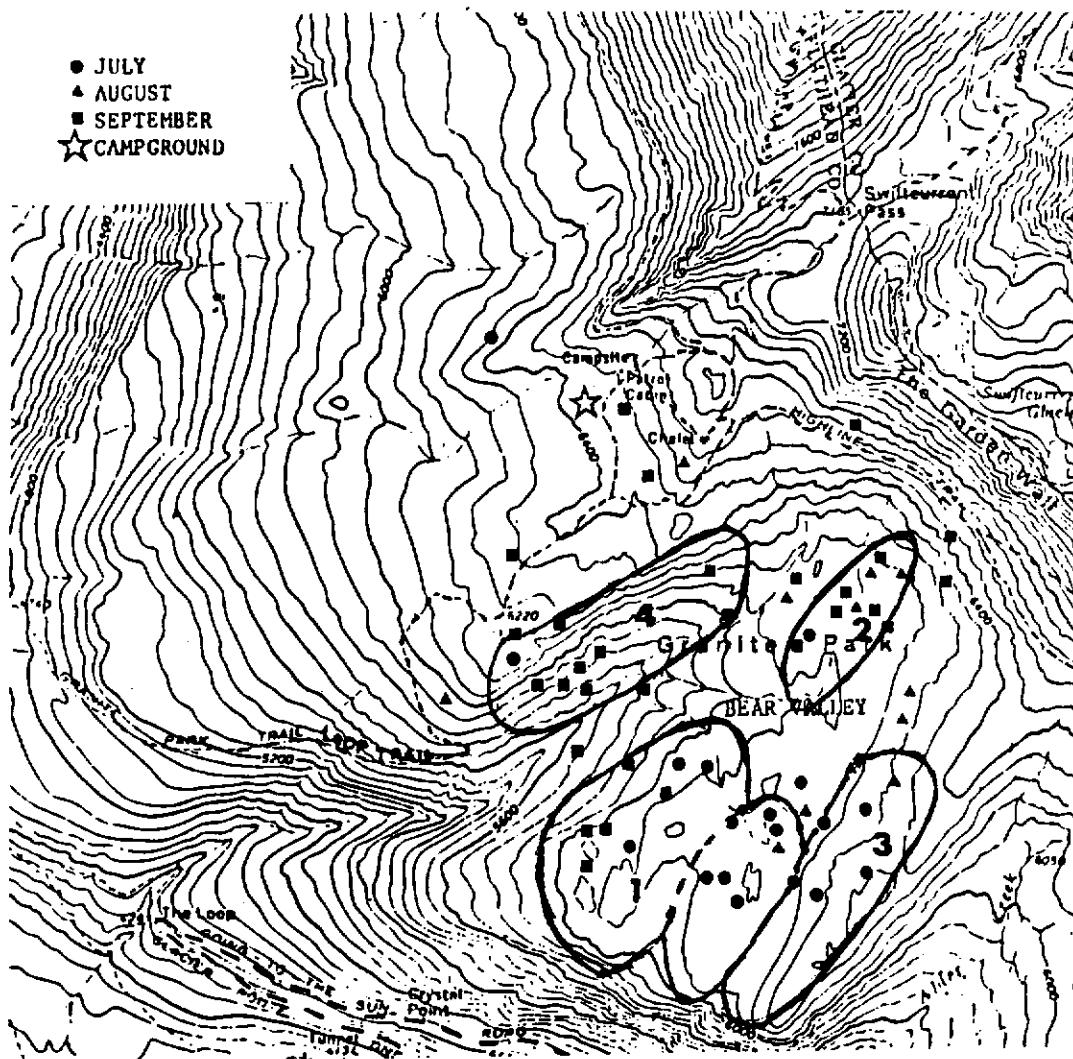
Appendix M
Discriminant Function

Table E5.-Mean and significance of selection variables used in stepwise discriminant function separations of combined confrontation sites from control sites.

Variable	Control Means	Confrontation Site Means	U-Statistic Significance	Standard Error
GRASS COVER	24.5	33.3	0.0045	2.25
MIXED CANOPY (1=yes,0=no)	0.80	0.46	0.0017	0.05
SEC. DOM. HERB COVER	24.5	23.9	0.0010	1.08
ELEVATION	5278	5409	0.0003	67.5
SEC. DOM SHRUB COVER	16.0	17.4	0.0001	1.06

Appendix N

Bear Valley



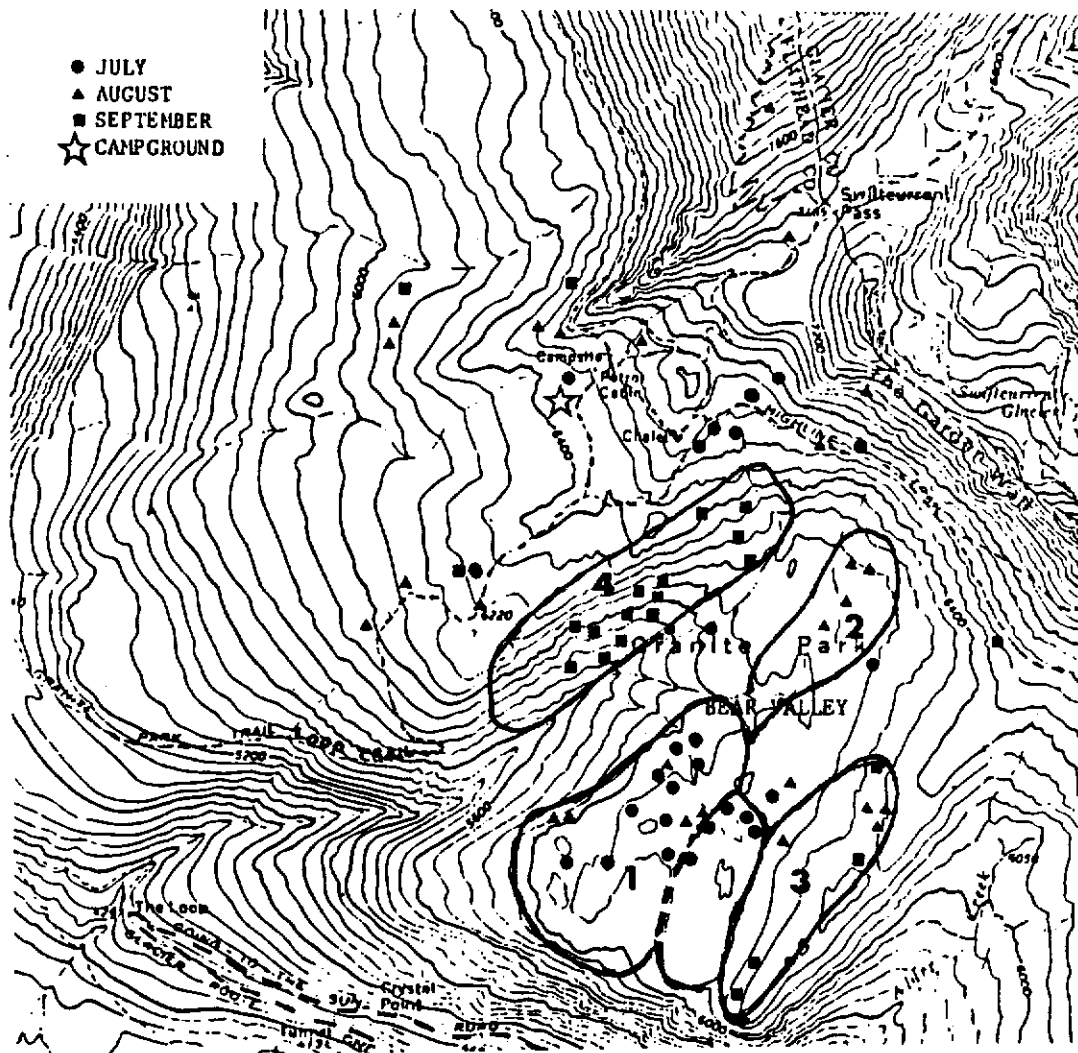
Observations of grizzly bears at Granite Park during 1982, and major habitat components in which they were observed.

1. Bear foods were predominantly glacier lily, spring beauty, and grass.
2. Bear foods were predominantly horsetail, grass, and wild onion.
3. Bear foods were predominantly glacier lily, spring beauty, and huckleberries.
4. Bear foods were predominantly huckleberries.

Areas in which no bears were observed were predominantly forested, but nonetheless had excellent bear foods available.

Appendix O

Bear Valley



Observations of grizzly bears at Granite Park during 1983.

and major habitat components in which they were observed.

1. Bear foods were predominantly glacier lily, spring beauty, and grass.
2. Bear foods were predominantly horsetail, grass, and wild onion.
3. Bear foods were predominantly glacier lily, spring beauty, and huckleberries.
4. Bear foods were predominantly huckleberries.

Areas in which no bears were observed were predominantly forested, but nonetheless had excellent bear foods available.

