



Activity patterns of grizzly bears in the Yellowstone ecosystem and their reproductive behavior, predation and the use of carrion
by Bart Otis Schleyer

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in
Fish and Wildlife Management
Montana State University
© Copyright by Bart Otis Schleyer (1983)

Abstract:

In 1979 and 1980 I conducted a study on the activity patterns of free-ranging grizzly bears (*Ursus arctos horribilis*) equipped with motion sensitive radio-transmitters in the Yellowstone ecosystem.

Data included general observations on behavior, reproductive behavior, predation and the use of carrion. A least squares analysis of variance procedure was used to study the relative importance between activity and time of day, time of year, individuality among bears, lunar phase, reproductive state, and four weather related factors. These explained a significant portion of the variation in activity. The level and probability of activity indicated that bears were least active shortly before denning or after emergence and were most active during the breeding season months. During the spring grizzlies were crepuscular and more diurnal than during the summer. In the summer they were nocturnal with crepuscular activity peaks while fall activity was mainly, during the crepuscular period at sunset with some nocturnal activity. Grizzly-human encounters could possibly be lowered if hikers avoided dense timber and restricted summer travel to the hours between 1030 and 1800. One grizzly had reversed or diurnal activity patterns. Published black bear studies indicate that their activity patterns are the reverse of grizzlies. This reversal affords a possible species niche separation by time territory. The major factors believed to affect activity patterns were intraspecific and interspecific social dominance, temperature regulation, seclusion from human disturbance, food habits and availability. It appears that predation by grizzlies on large ungulates in the Yellowstone ecosystem has been underrated and that a real behavioral difference between this and populations in other study areas may exist. All of the study bears used carrion and three preyed on elk. Grizzlies typically dragged carcasses to sites within the timber, covered them with soil, and bedded within 50 meters. The ability to travel over snowpack was estimated to be five times greater for grizzlies than for large ungulates. Breeding activity was observed once and one pairbond between "mates" lasted two months. Four instances of tree climbing were noted.

ACTIVITY PATTERNS OF GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM
AND THEIR REPRODUCTIVE BEHAVIOR, PREDATION AND THE USE OF CARRION

by

Bart Otis Schleyer

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Masters of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

May 1983

8649 57

APPROVAL

of a thesis submitted by

Bart O. Schleyer

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Date

May 18, 1983

Sheldon H. H. H.
Chairperson, Graduate Committee

Approved for the Major Department

Date

5/18/83

J. M. L. L.
Head, Major Department

Approved for the College of Graduate Studies

Date

5-18-83

Michael Malone
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements of a master's degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his/her absence, by the Director of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Bart Otto Schlager

Date May 15, 1983

ACKNOWLEDGEMENT

The dedication, extreme efforts and sacrifices of many people other than myself made this study possible. I express sincere appreciation to the following: Dr. R.R. Knight, NPS, for the research opportunity, helpful advice, aid in preparation of, and reviewing the manuscript; Dr. H.D. Picton, MSU, Chairman of my committee, who provided helpful advice and greatly aided in the preparation of the manuscript; the Interagency Grizzly Bear Study Team (IGBS) for financial assistance, equipment and aerial radio-tracking data; Sandy Lambers, Carrie Hunt, Bert Harting, Jim Slowikowski, Sue Alt, Katherine Kendall, and Wendy Greenburg (IGBS) who dedicated many long sleepless nights monitoring activity; the many personnel from Yellowstone National Park and Hebgen Lake Ranger District, U.S. Forest Service for their cooperation, assistance and patience; Georgia Ziemba, MSU for excellent service in the statistical analysis and preparation of figures; Dr. R.L. Eng for reviewing the manuscript; Sue Crowfoot (IGBS), Louise Greene and MSU Word Processing Center for the typing; Gallatin Flying Service for aerial tracking; and to my parents, Dr. and Mrs. Otis Schleyer and grandparents for their much appreciated encouragement, support, and patience.

This study was conducted in conjunction with the IGBS. Funding was provided by the National Park Service, the U.S. Fish and Wildlife Service, and the Montana Agricultural Experiment Station.

TABLE OF CONTENTS

	Page
APPROVAL PAGE.	ii
STATEMENT OF PERMISSION TO USE	iii
VITA	iv
ACKNOWLEDGEMENT.	v
TABLE OF CONTENTS.	vi
LIST OF TABLES	ix
LIST OF FIGURES.	xi
ABSTRACT	xvi
INTRODUCTION	1
THE STUDY AREA	3
General	3
Flora	3
Climate	6
Fauna	7
METHODS.	9
RESULTS.	17
Movements	17
Home Range Overlap vs. Territoriality.	17
Factors Affecting Activity.	21
Temperature.	27
Relative Humidity.	31
Types of Precipitation or Lack of It	31
Amount of Precipitation.	33
Wind	34
Lunar Phase.	35
Reproductive State	36
Activity Patterns	37
Seasonal Effects on Activity	37

TABLE OF CONTENTS--Continued

	Page
Spring	39
Summer	41
Fall	42
Yearly Average	42
Individual Bear Activity Patterns (Daily Routines) . . .	46
Yearly Average (Spring-Fall) Activity Patterns of "Nocturnal Bears"	46
Activity Patterns of "Diurnal Bears"	54
Human-Related Disturbance	55
Predation and the Use of Carrion	57
Behavior of Grizzlies Using Carcasses as a Food Source	58
DISCUSSION	63
LITERATURE CITED	74
APPENDICES	79
Appendix A - Data Concerning Predation and the Use of Carrion, Tree Climbing, and Reproductive Behavior.	80
Predation and the Use of Carrion	81
A Morphological Characteristic of Grizzlies That is Advantageous for Snow Travel	81
Predation	85
Behavior of Grizzlies Using Carcasses as a Food Source	86
The Caching of Carcasses	87
Tree Climbing	88
Reproductive Behavior.	88
Pair Bonding	88
Reproductive Biology	92
Fighting	94
The Family Unit.	96
Appendix B - Aerial Monitoring History Figure and Carcass Use Tables.	99
Appendix C - Case Histories	105
Activity Patterns.	106
Walking Lethargy.	106
Human-Related Disturbances	107
Reproductive Behavior.	115
Copulatory Behavior	115
Fighting and Agression.	118

TABLE OF CONTENTS--Continued

	Page
Predation, Caching and Related Behavior . . .	120
Carcass Caching	124
Tree Climbing	126
The Trailing of a Family Group by a Male	
Grizzly	128
Reaction to Weather Conditions.	129

LIST OF TABLES

	Page
Table 1. Capture history on the five study bears and three offspring of Bear 38 which were instrumented during 1978, 1979, and 1980	10
Table 2. Monitoring periods for the study bears during 1979 and 1980	18
Table 3. The distribution of Bear Activity Records (BAR) broken down by bear, month and year. . . .	22
Table 4. Minimum home ranges for the five study bears during 1979 and 1980	23
Table 5. Analysis of variation in the activity level of grizzly bears in the Yellowstone ecosystem with respect to time of year, time of day, differences among bears, reproductive state, lunar phase, and weather related factors, 1979-1980	25
Table 6. Analysis of variation in the probability of activity of grizzly bears in the Yellowstone ecosystem with respect to time of year, time of day, differences among bears, reproductive state, lunar phase, and weather related factors, 1979-1980	26
Table 7. The distribution of Bear Activity Records (BAR) broken down by bear, season, and nocturnal, diurnal and crepuscular periods	53
Table 8. Estimates of track area ₂ , standing weight-load-on-track (in gm/cm ²), and traveling weight-load-on-track (for careful travel; one foot off the ground) for 6 grizzlies, a human (with and without snowshoes and/or 34 Kg backpack), and 4 species of ungulates (4½ years old and over) from Kelsall's (1969, 1971) works	83

LIST OF TABLES--Continued

	Page
Table 9. IGBS aerial flight data on possible breeding pairs of grizzlies sighted or located (radio) together during 1979	90
Table 10. IGBS aerial flight data on possible breeding pairs of grizzlies sighted or located (radio) together during 1980	91
Table 11. Summary for carcasses inspected and known to be fed upon by grizzlies during 1979 and 1980	101
Table 12. Summary of IGBS aerial observations of grizzlies feeding on carcasses during 1979	103
Table 13. Summary of IGBS aerial observations of grizzlies feeding on carcasses during 1980	104

LIST OF FIGURES

	Page
Figure 1. Map of the study area	4
Figure 2. Minimum home ranges for the three male study bears, 1979-1980 (and including 1978 for Bear 35)	19
Figure 3. Minimum home ranges for the two female bears and two of Bear 38's yearlings, 1980 (and including 1979 for Bear 38).	20
Figure 4. Comparison of the yearly average (spring-fall) activity levels for five individual grizzlies and both sexes, 1979-1980. Activity is converted from code to the average hourly activity per day.	24
Figure 5. Relationship between temperature (in C) and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during 1979 and 1980 are included	29
Figure 6. Relationship between temperature (in C) in the spring and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during the spring of 1979 and 1980 are included.	29
Figure 7. Relationship between temperature (in C) in the summer and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during the summer of 1979 and 1980 are included.	30

LIST OF FIGURES--Continued

	Page
Figure 8. Relationship between temperature (in C) in the fall and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All activity records (BAR) within each temperature range during the fall of 1979 and 1980 are included	30
Figure 9. Relationship between percent relative humidity and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each relative humidity range during 1979 and 1980 are included	32
Figure 10. Relationship between type of precipitation and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) obtained within each precipitation type during 1979 and 1980 are included	32
Figure 11. Relationship between amount of precipitation (in cm) and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) obtained within each precipitation range during 1979 and 1980 are included	34
Figure 12. Relationship between lunar phase and the average activity level (converted from code to the average number of minutes active per half hour time block) of grizzly bears. All bear activity records (BAR) obtained within each lunar phase during 1979 and 1980 are included	35
Figure 13. Relationship between reproductive state and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained for bears within each reproductive state during 1979 and 1980 are included.	38

LIST OF FIGURES--Continued

	Page
Figure 14. Relationship between time of year (month) and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained within each month during 1979 and 1980 are included	38
Figure 15. Relationship between time of year (season) and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained within each season during 1979 and 1980 are included	39
Figure 16. Seasonal comparison (summer vs. spring) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block. All bears combined	40
Figure 17. Relationship between the average activity level (in minutes active per half hour time block) of grizzly bears and nocturnal, diurnal and crepuscular periods, 1979-1980. All bears combined	41
Figure 18. Seasonal comparison (summer vs. fall) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined	43
Figure 19. Seasonal comparison (fall vs. spring) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined	44
Figure 20. Yearly average (spring-fall) activity pattern of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined.	45

LIST OF FIGURES--Continued

	Page
Figure 21. Relationship between the average activity level of the four "nocturnal bears" combined and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.	47
Figure 22. Relationship between the average activity level of Bear 40 (the "diurnal study bear") and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.	47
Figure 23. Comparison of the yearly average (spring-fall) activity patterns of Bear 15 and Bear 35, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted.	49
Figure 24. Comparison of the yearly average (spring-fall) activity patterns of Bear 38 and Bear 50, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted.	50
Figure 25. Relationship between the average activity level of Bear 38 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block. Note that the zero bear activity records obtained for sunrise during fall (see Table 7) is labeled as zero activity.	51
Figure 26. Relationship between the average activity level of Bear 50 and nocturnal, diurnal and crepuscular periods, 1980. The activity level is shown in minutes active per half hour time block.	51

LIST OF FIGURES--Continued

	Page
Figure 27. Relationship between the average activity level of Bear 15 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block	52
Figure 28. Relationship between the average activity level of Bear 35 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block. Note that the zero bear activity records obtained for sunrise and sunset during spring (see Table 7) are labeled as zero activity	52
Figure 29. Comparison of the yearly average (spring-fall) activity patterns of Bear 40 and the other four study bears combined, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted . . .	56
Figure 30. Relationship between the average activity level of grizzlies using a carcass as a food source and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.	59
Figure 31. Relationship between the average activity level of grizzlies using food sources other than a carcass and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block	59
Figure 32. Comparison of the average activity patterns of grizzlies using a carcass as a food source and those using other food sources (not feeding), 1979-1980. Points indicate the average number of minutes active per half hour time block	60
Figure 33. Aerial monitoring histories of the five study bears during 1979 and 1980	100

ABSTRACT

In 1979 and 1980 I conducted a study on the activity patterns of free-ranging grizzly bears (Ursus arctos horribilis) equipped with motion sensitive radio-transmitters in the Yellowstone ecosystem. Data included general observations on behavior, reproductive behavior, predation and the use of carrion. A least squares analysis of variance procedure was used to study the relative importance between activity and time of day, time of year, individuality among bears, lunar phase, reproductive state, and four weather related factors. These explained a significant portion of the variation in activity. The level and probability of activity indicated that bears were least active shortly before denning or after emergence and were most active during the breeding season months. During the spring grizzlies were crepuscular and more diurnal than during the summer. In the summer they were nocturnal with crepuscular activity peaks while fall activity was mainly during the crepuscular period at sunset with some nocturnal activity. Grizzly-human encounters could possibly be lowered if hikers avoided dense timber and restricted summer travel to the hours between 1030 and 1800. One grizzly had reversed or diurnal activity patterns. Published black bear studies indicate that their activity patterns are the reverse of grizzlies. This reversal affords a possible species niche separation by time territory. The major factors believed to affect activity patterns were intraspecific and interspecific social dominance, temperature regulation, seclusion from human disturbance, food habits and availability. It appears that predation by grizzlies on large ungulates in the Yellowstone ecosystem has been underrated and that a real behavioral difference between this and populations in other study areas may exist. All of the study bears used carrion and three preyed on elk. Grizzlies typically dragged carcasses to sites within the timber, covered them with soil, and bedded within 50 meters. The ability to travel over snowpack was estimated to be five times greater for grizzlies than for large ungulates. Breeding activity was observed once and one pairbond between "mates" lasted two months. Four instances of tree climbing were noted.

INTRODUCTION

A study of the "daily routine" (activity patterns) of free-ranging grizzly bears (Ursus arctos horribilis) in the Yellowstone ecosystem was conducted in 1979 and 1980 as part of the research effort of the Interagency Grizzly Bear Study Team.

The Craigheads (1974) conducted detailed research on grizzlies within the Yellowstone ecosystem during the 1960's, but the closing of the open pit dumps in Yellowstone National Park brought about a change in the overall ecology of this bear population. Shortly thereafter, the Interagency Grizzly Bear Study (IGBS) was created and has conducted a broad research program including studies of the seasonal and annual movements, the seasonal food habits and habitat use of the free-ranging grizzly in the Yellowstone ecosystem (Mealey 1975, Blanchard 1978, Graham 1978, Kendall 1981). These investigations have noted a utilization of different habitat types and a shift in food habits through the changing seasons and, in addition, important forage items have been determined. Sizemore (1980) reported upon the daily movements of four grizzlies in West Central Montana. Amstrup and Beecham (1976) and Garshelis and Pelton (1980) have published studies of black bear activity patterns. The main objective of my research was to determine the time, duration and nature of activities of free-ranging grizzly bears on a 24-hour basis. Other objectives

were to report general observations on behavior, reproductive behavior, predation and the use of carrion.

This study included two field seasons. The 1979 field season lasted from 11 June to 13 September while the 1980 season extended from 19 March to 2 September, then from 7 October through 25 October.

STUDY AREA

General

This research was concentrated in an approximate 4200 km² (1622 mi²) area (Figure 1) located in the western half of Yellowstone National Park and contained within the 20,000 km² (7,722 mi²) study area established by the Interagency Grizzly Bear Study Team (IGBS) (Knight et al. 1975). Included in this section is the Sage Peak and Hebgen Lake area of the Gallatin National Forest, Montana, west of the park. The study area includes the Gallatin Mountain Range on the northwestern border with a crest elevation of 2876 m (9435 ft). Electric Peak, situated in the northeastern border, is the highest peak, on the study area reaching 3382 m (10,992 ft). The Norris, Gibbon, Lower, Midway and Upper Geyser Basins all fall within its boundaries. The Hebgen Lake basin, with elevations of about 1981 m (6500 ft) includes areas with the lowest elevation. In the geologic past many of the physiographic features were shaped by extensive volcanism and glaciation. The peculiar geology of the park has been described by Chittenden (1949), Fischer (1960), and Keefer (1976).

Flora

The vegetation of the study area can be divided into two major zones and two smaller zones (Despain, 1973). A lodgepole pine (Pinus contorta) zone covers the largest area, followed by a spruce-fur zone

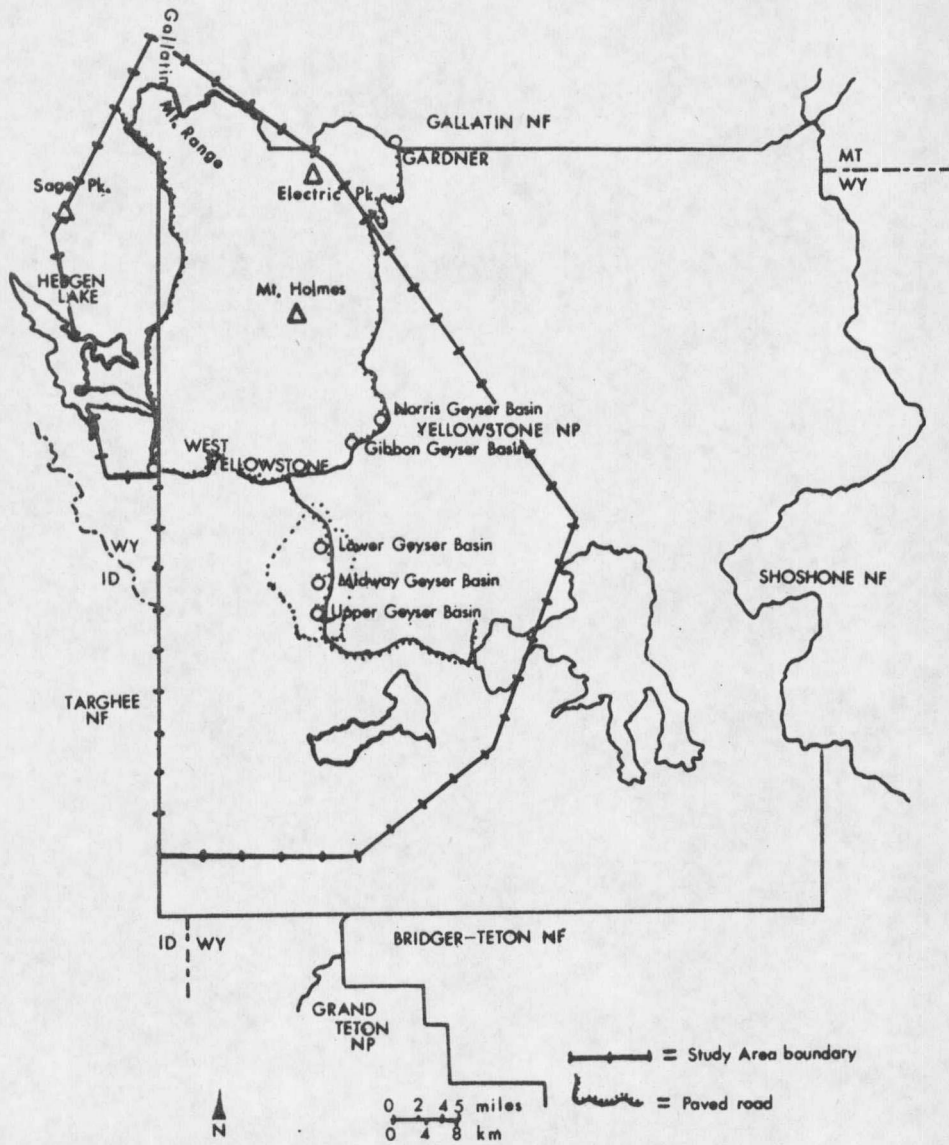


Figure 1. Map of the study area.

which also covers a fairly large area. A small area near Electric Peak is covered by a Douglas-fir (Pseudotsuga menziesii) zone and alpine tundra exists above about 3048 m (10,000 ft).

Climax lodgepole pine dominates the lodgepole pine zone with very little or none of the understory consisting of spruce or fir. This zone, which occurs at elevations between 2316-2560 m (7600-8400 ft), is underlain mainly by quarternary rhyolite flows and receives 51-102 cm (20-40 in) precipitation per year. In this zone lodgepole pine is slow growing and trees with diameter at breast height (dbh) of 30-51 cm (12-20 in) may be in excess of 300 years of age. Good spruce-fir stands may develop on sites with a more favorable moisture regime such as on north-facing slopes, pond margins or drainage ways. In the understory as well as the overstory, whitebark pine may also be present. Soils derived from rhyolite are nutritionally poor and the lodgepole dominated climax is probably determined by this fact in combination with the relatively low precipitation of the area.

Spruce-fir forests in successional young to mature states dominate the spruce-fir zone. The young stands are characterized with a good representation of both spruce and fir, especially in the understory, and the lodgepole pine included in these stands is relatively fast growing. Spruce or fir may be fairly evenly mixed in the overstory of the mature stands or either may dominate. Whitebark pine may be a major component in this zone and in certain areas, especially near timberline, it may be the dominant species the cones of which at times become an important food source for grizzly bears (Kendall 1981). The spruce-fir zone either has an annual precipitation greater

than 102 cm (40 in) or is underlain by tertiary andesitic bedrock, or both, and lies about 2560 m (8400 ft).

In the Douglas-fir zone the dominant forest type is Douglas-fir, but meadows with various grasses and big sagebrush (Artemisia tridentata) cover more area within the zone. Very large, well scattered, fire-scarred trees with an understory of smaller Douglas-fir characterize the forest in this zone. Aspen (Populus tremuloides) stands are common while stands of lodgepole pine can occasionally be found, and individuals of both spruce and fir can be found along streams. This zone lies between about 1829-2316 m (6000-7000 ft). The area is underlain by glacial till of various thickness derived from Absaroka volcanics and granites upstream. The annual precipitation of this area is less than 51 cm (20 in).

Alpine tundra exists on areas above about 3048 m (10,000 ft). These areas are small and island-like, and common plants include alpine plants such as moss campion (Silene acaulis), native dandelions (Taraxacum sp.) and mountain avens (Dryas sp.).

Meadows and parks as well as geothermal areas also occur on the study area. Grasses, sedges (Carex spp.), willows (Salix spp.), and marsh reedgrass (Calamagrostis spp.) characterize the vegetation of the meadows. On the drier sites, bluegrass (Poa spp.) and Idaho fescue (Festuca idahoensis) are the dominant grasses.

Climate

Long, cold winters and short, cool summers are characteristic of the area. Records for West Yellowstone, Montana (NOAA, 1940-1969),

show the mean annual temperature for 1940-1969 was 1.7 C (35 F). January was the coldest month with a mean temperature of -10.6 C (12.9 F), while July was the warmest with a mean of 15.3 C (59.5 F). Temperature extremes as low as -40 C (-40 F) and temperatures well below -17.8 C (0 F) are not uncommon. The average annual precipitation for the 1940-1969 period was 58.3 cm (23 in), with the greatest generally occurring during the month of June. In the mountainous regions above 2134 m (7000 ft), most precipitation occurs in the form of snow, with snow depths for some local areas often reaching 1016 cm (400 in). Due to missing data in NOAA records, there were no average annual temperatures recorded for 1979 or 1980. Monthly records, however, show that during 1979, the June through September field season was characterized with average temperatures about 1 C (1.7 F) above the norm. Temperatures for the 1980 field season averaged about 2.7 C (4.8 F) below the norm. During 1979 records show that West Yellowstone received about 21 cm (8.35 in) below normal amount of precipitation. During 1980 the amount of precipitation was about .94 cm (.37 in) below the norm (U.S. Department of Commerce, 1979-1980).

Fauna

Animal life is abundant in the study area. Large herbivores are very common and at times become a food source for bears, especially during the spring months as carrion. Elk (Cervus elaphus nelsoni) are the most abundant and widely distributed of the large ungulates. Large herbivores found in lesser numbers include bison (Bison bison), moose (Alces alces shirasi), mule deer (Odocoileus hemionus), bighorn

sheep (Ovis canadensis canadensis), and though very limited in distribution and numbers, the pronghorn antelope (Antilocapra americana).

Secondary consumers common to the area include grizzly bears (Ursus arctos horribilis), black bear (Ursus americanus), coyotes (Canis latrans), and many avian predators and scavengers.

In many meadow areas pocket gophers (Thomomys talpoides) and voles (Microtus sp.) are numerous and are sought out by grizzly bears for food at times. Many other species of small mammals are found within the study area.

METHODS

Bears were captured (Table 1) by IGBS trapping crews in culvert traps as well as in Aldrich, spring-activated, foot snares. The IGBS determined the home ranges for these bears using the minimum area method (Stickel 1954). Sernylan (phencyclidine hydrochloride) or M-99 (Etorphine) were injected intramuscularly to immobilize the bears. Motion sensitive radio-transmitters (Telonics, Inc.) were fitted on selected grizzly bears. These transmitters operated in fast and slow pulsing modes, as activated by a mercury switch depending on the spatial position of the collar. A steady pulsing signal in one of the two modes indicated inactivity while a signal changing from one pulse mode to another indicated the position of the collar was being altered, thus activity of the bear. Changes in head position of a resting bear also produced a somewhat erratic mode, but based on observations and the transmitted signal of radio-collared bears recovering from drug immobilization, criteria were found to separate this situation from other forms of activity. The erratic mode due to slight head movements of a resting bear generally lasted from a brief period up to two or three minutes and was typified by few (one-three) changes in the pulse mode per minute. This activity was typically followed by long periods of steady mode (i.e. total inactivity), as also noted by Garshelis and Pelton (1980). Movement was verified by a change in the position of the bear from the observer relative to

Table 1. Capture History on the five study bears and three offspring of Bear 38 which were instrumented during 1978, 1979, and 1980.

Bear No.	Sex	Age ¹	Date	Location	Wt ³	
					Lbs	Kg
15	M	7	08-10-78(RI) ²	Fir Ridge, Mt	475	216
15	M	7	08-16-78(RT)	Fir Ridge, Mt	475	216
15	M	7	08-18-78(RT)	Fir Ridge, Mt	475	216
15	M	7	08-28-78(RT)	Fir Ridge, Mt	475	216
15	M	8	07-27-79(RI)	Fir Ridge, Mt	350*	158
15	M	9	06-18-80(RT)	Fir Ridge, Mt	350	158
35	M	3	07-18-78(I)	Togwatee Lodge, Wyo.	225	102
35	M	4	08-11-79(RI)	Fir Ridge, Mt	300	136
35	M	5	06-19-80(RI)	Fir Ridge, Mt	325	147
38	F	7	08-12-78(I)	Fir Ridge, Mt	300	136
38	F	8	10-04-79(RI)	Fir Ridge, Mt	400	181
38	F	9	06-12-80(RI)	Fir Ridge, Mt	400	181
45 ⁴	M	Cub	10-04-79(I)	Fir Ridge, Mt	110*	50
G-8 ⁴	M	Cub	10-04-79(NI)	Fir Ridge, Mt	75	34
G-9 ⁵	M	Cub	10-04-79(NI)	Fir Ridge, Mt	115*	52
54	M	1	06-10-80(I)	Fir Ridge, Mt	120	55
55	M	1	06-11-80(I)	Fir Ridge, Mt	170*	77
40	M	4	04-18-79(I)	Nez Perce Cr, YNP	275	124
40	M	5	05-15-80(RT)	Rabbit Cr, YNP	400	181
50	F	Ad	05-15-80(I)	Nez Perce Cr, YNP	275	124

¹ Ad = adult, males over 4 years old and females over 5 years old.

² I = Bear instrumented with radio.

NI = Bear not instrumented.

RI = Bear reinstrumented.

RT = Bear retrapped, but not reinstrumented.

³ Weight; *indicates scale weight.

⁴ Cub G-8, later thought to become bear 54.

⁵ Cub G-9, later thought to become the solitary yearling.

magnetic north as well as changes in signal strength. A bear feeding in a localized area would not change positions to any great degree. Activity in this case was determined by the number of pulse mode changes per minute (>3 per minute for a duration of at least three minutes indicated activity) and the duration of the erratic mode.

Instrumented bears were tracked on the ground using a Telonics or AVM receiver and a hand-held two element Yagi antenna. Three permanent directional monitoring antennas were erected to provide longer range reception. Monitored bears were located by approaching the animal using the portable antenna or by triangulation using either type of antenna.

Bears were monitored from positions as near to the bear as possible without disturbing the animal and which produced the best radio reception. This position was influenced to a great degree by topography and vegetation. Once located, a bear was monitored either continuously or at regular one-quarter to one-half hour intervals until the radio signal was lost.

Monitored bears were routinely located during IGBS aerial tracking flights. "Lost" bears were thus shortly relocated, reducing the time spent in ground searching and making the study feasible since grizzlies range over such a vast amount of area.

Different bears were monitored depending on their locations, the amount of data already obtained on a particular bear, and, the periods when the various bears were equipped with working collars.

Standard data recorded included date, bear identification number, observers, receiver type, observation time, location of observer, magnetic direction of bear from observer, signal strength, and transmitter mode. Lunar phase, temperature, precipitation, winds, relative humidity, and reproductive status were recorded for each bear day (BD). Relative humidity was determined hourly with a sling psychrometer when possible during portions of each field season. Instrument problems limited the extent and number of readings taken. Bear feeding sites, day beds, and scats were also recorded.

It was desired to test the effects of various factors on activity versus non-activity as well as their effects on the amount or level of activity. Therefore two activity measures were considered in the analysis. One measure is referred to as the level of activity (coded) and the other is referenced as probability of activity.

Thirty minute time blocks, referred to as bear activity records (BAR) were used in determining activity periods and the level of activity. The activity level of bears was coded with the following scale:

<u>Minutes Active</u>	<u>Coded Activity</u>
0 - 1	1
1 - 3	2
3 - 6	3
6 - 10	4
10 - 15	5
15 - 21	6
21 - 25	7

<u>Minutes Active</u>	<u>Coded Activity</u>
25 - 29	8
29 - 30	9

One minute intervals were used at the upper and lower limits of the coding scale in order to distinguish animals which were totally active or inactive during time blocks involved.

Average hourly activity per day was computed by multiplying the daily average activity levels per half hour time block (BAR) by 48. This may result in some bias if there wasn't a random scatter of BAR for the time period (i.e., month, season, etc.), in question.

Prior to any analysis it was decided that bears coded with a 1, 2, or 3, which represents anywhere from 0 to 6 minutes of activity in a 30 minute time block, were essentially inactive. Bears coded with a 4 through 9 were considered as being active within that period.

Nocturnal, diurnal, and crepuscular periods were also used to better visually portray activity by portion of a day. Crepuscular periods were considered to include the 30 minute time blocks in which sunrise and sunset occurred as well as the 30 minute time blocks following sunrise and preceding sunset.

Two procedures are used in analyzing and presenting the data. A least squares analysis of variance procedure was used to study the relative importance between activity and the other factors recorded. This analysis allows relationship between activity and each factor, such as time of day, to be computed and free from other compounding effects such as season and bear effects.

The second procedure consists of computing the percentage of observations where activity was recorded. When an indicator variable is used as the dependent variable (1 = activity, 0 = no activity) in an unweighted least squares analyses and a categorized or discrete variable as its independent variable, then the probability of activity estimate is identical to the percentage of observations where activity occurred. This procedure is therefore consistent with the least squares analysis. It serves as a measure of the uniformity of activity through various time periods.

Seasonal divisions were made based on factors thought to affect activity, such as the assumed peak breeding season (June 1 - July 30) and the timing of shifts in food habits found by the IGBS. From the time the bears emerged from their dens until the end of May was designated as spring, while summer was considered to last from June through August, and fall included September, October and November, though no observations were made in November. This appears to be a good breakdown since season explained a significant portion of the variance in activity of grizzlies. Throughout the paper, yearly average activity measures refer to the period from den emergence to den entrance. Due to the scatter and incompleteness in the BAR obtained for individual bears on a half hour basis, the yearly average (spring-fall) activity levels computed for any comparisons involving individual bear activity patterns is a seasonally non-weighted average of all BAR. For any other comparisons, the mean activity measures for each season (spring-fall) and the time period of concern within each season, were computed and given equal weight when computing the yearly average activity

measures. Therefore, the summer season which contained the vast majority of the BAR did not distort the yearly average activity measures or patterns. However, some bias may have resulted from the few and scattered BAR obtained for both fall and spring.

Weight loads in gm/cm^2 were calculated for the five study bears to estimate the ability of grizzly bears to travel through snow. First, estimates for the size of each bear's four feet were drawn onto centimeter graph paper using measurements from IGBS trapping forms. The area in cm^2 was visually estimated for both the front and hind feet. This included the area of the claws as well as the area on the front foot from the anterior-most point of the toe pads back to the palmar (posterior pad). Observations of deeply sunken tracks in the snow revealed that weight is also supported by this portion of the forefeet. Weight-load-on-track estimates were then derived by dividing the estimated spring live weight (in grams) of a bear by the total area of its four feet (in cm^2 for the standing weight-load estimate).

To determine what I refer to as traveling weight-load-on-track measurements (for careful travel only one foot off the ground at any time), 75% of the total track area was used in the equation.

The same method was used to estimate the comparable measurements for an 86-kg person wearing size 10½ hiking boots or modified bear paw style snowshoes with and without a 34-kg backpack. For the traveling weight-load estimates (one foot off the ground) for a human, however, only half the total track area entered into the equation. For comparison, weight-load on track estimates for four species of ungulates were obtained from Kelsall's works (1969, 1971).

Carcasses which were known to have been fed upon by a bear were examined for evidence of predation by the bear. This included examining the spinal column for breaks, especially in the cervical region, checking for hemorrhages beneath the skin (Murie 1948), and searching the immediate area for signs of a struggle. A femur and the lower mandible were collected from the carcass for later determination of age and condition of the animal at time of death. Age determination was made by examining mandibular tooth replacement and wear.

RESULTS

Movements

Home ranges for the five study bears are summarized in Table 2 and Figures 2 and 3. All three males had larger ranges than the females. This follows the pattern set by the averages of all bears monitored by the IGBS. Within a grizzly's home range there appears to be several to many small ranges where movement is concentrated which are referred to by the IGBS as biological centers of activity.

My observations indicate that some bears may have biological centers in which they move from one to another in some sort of circuit. The study bears often remained for a few days to a week in an area with a radius of about 1.6 km^2 (1 mi^2). They would then leave these sites and travel to another area, often many kilometers away. This process would often be repeated with the bear returning to a bio-center occupied previously. These shifting bio-centers were often located in the same habitat types with the same apparent distribution, quantity, and types of bears' foods present, and at nearly the same elevation and aspect, and thus at the same phenological stage of vegetative growth.

Home Range Overlap vs. Territoriality

Intraspecific tolerance was indicated by extensive overlap in the home ranges of grizzlies of the opposite sex as well as for grizzlies

Table 2. Minimum home range for the five study bears during 1979 and 1979.

Bear No.	Sex	Age ¹		Range ² (mi ²)		Range ² (km ²)		No. of Locations		Interval (days)	
		1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
15	M	8	9	148	--	238	--	42	13	365	170
35	M	4	5	67	93	108	150	24	26	317	254
38	F	8	9	44	44	71	71	33	42	365	366
40	M	4	5	285	71	459	114	48	17	256	193
50	F	--*	Ad	--	59	--	95	--	26	--	231
45 ³	M	cub	1	44	--	71	--	10	--	53	--
G-8 ⁴	M	cub	1	44	8	71	13	--	14	--	120
G-9 ⁵	M	cub	1	44	8	71	13	--	14	--	115

¹Ad = Adult; males over 4 years old, females over 5 years old.

²Ranges sizes calculated only with minimum of 14 locations.

* -- = Data not obtained.

³Bear 45 lost his collar and ear tags while still a cub. Two of these siblings were recaptured when yearlings and it is thought that the bear newly labeled as bear 55, was originally labeled as bear 45. *Killed in 1985*

⁴Cub G-8, later thought to become bear 54. *5/24/85 by Mgt.*

⁵Cub G-9, later thought to become the solitary yearling.

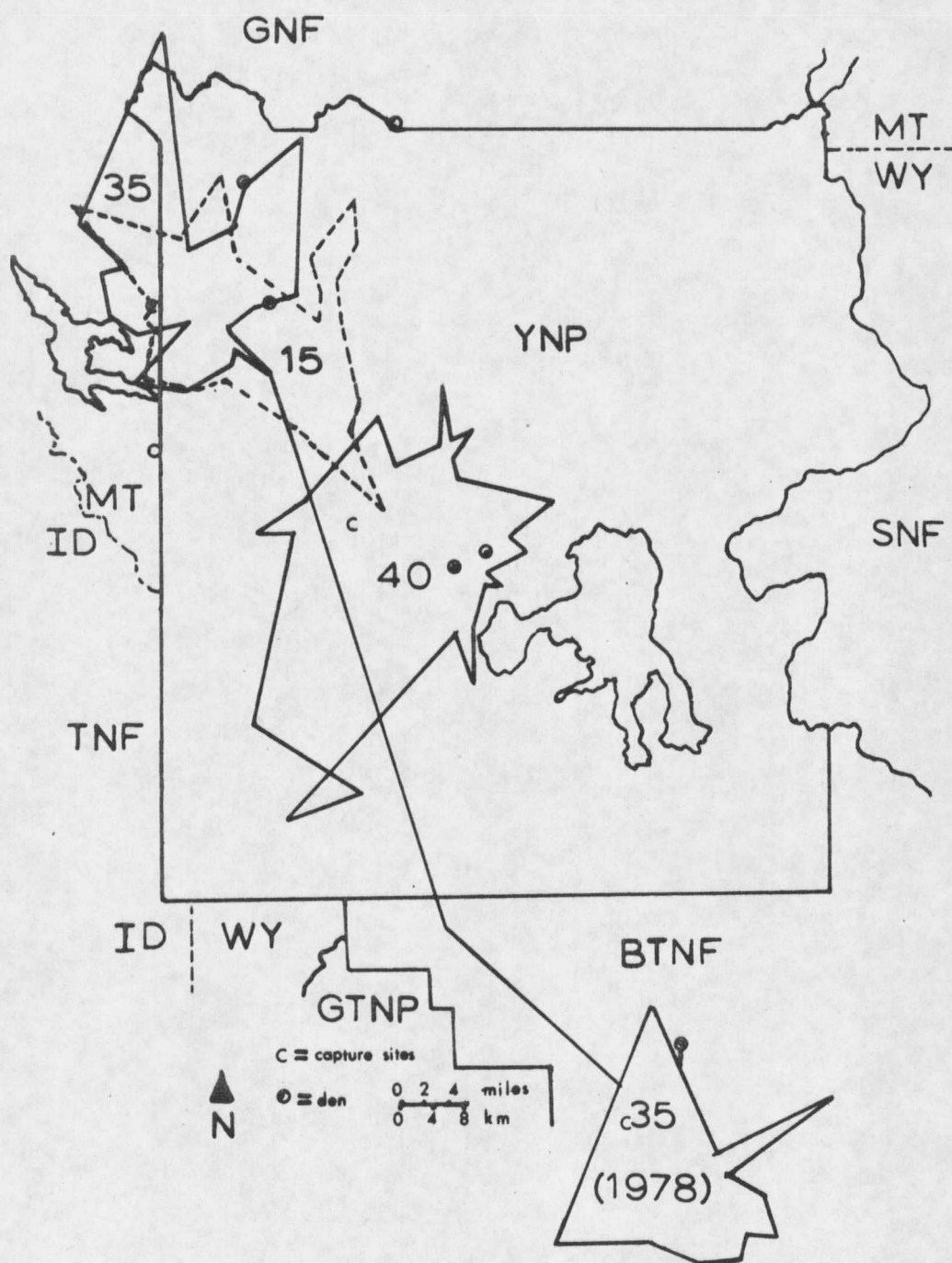


Figure 2. Minimum home ranges for the three male study bears, 1979-1980 (and including 1978 for Bear 35).

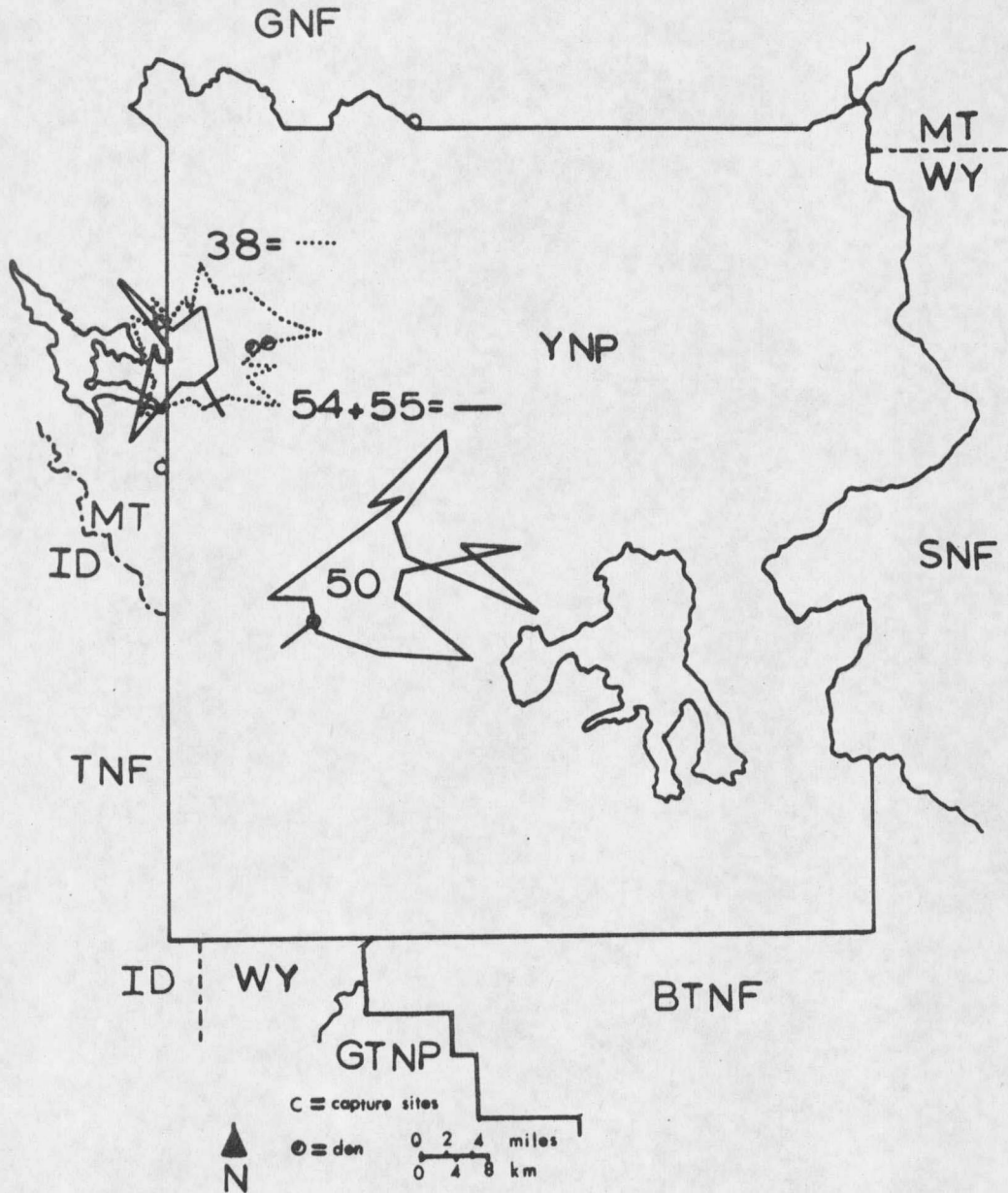


Figure 3. Minimum home ranges for the two female study bears and two of Bear 38's yearlings, 1980 (and including 1979 for Bear 38).

of the same sex. Numerous grizzlies, both collared and unmarked, were known to conduct daily routines and seasonal activities within the same general space and time without apparent defense or conflict, disregarding the behavior of males while defending or attempting to acquire a mate. Defense of feeding areas such as a carcass sometimes occurred; however, no territorial defense of home ranges or bio-centers was observed or thought to occur. This indicated that an avoidance reaction as described by Pearson (1975) now operates among the grizzly population since the closure of the dumps. A dominance hierarchy as reported for this population by Hornocker (1962) requires frequent contact between bears as was present when the dumps were open.

Factors Affecting Activity

The two field seasons resulted in 2518 bear activity records (BAR) for the five study bears (Tables 2 and 3). Monitoring periods are summarized in Table 3 and 4.

Activity levels of grizzlies in the Yellowstone ecosystem greatly varied with the time of year (month and season), time of day (half hour), and the food source (Tables 5 and 6). Some bears were found to be more active than others ($p < .001$; see Figure 4). For example, males were found to be more active than females ($p < .001$; see Figure 4). Other peculiarities involving bears such as individual responses to time of year and time of day also contributed to the overall variation in the level of activity.

Table 3. Monitoring periods for the study bears during 1979 and 1980.

Bear No.	BH ¹			BAR ²			BD ³			BAD ⁴		
	1979	1980	Total	1979	1980	Total	1979	1980	Total	1979	1980	Total
15	228	120	348	377	192	569	18	18	28	7.9	4	11.9
35	106	307	413	147	523	670	11	29	40	3	10.9	13.9
38	65	192	257	96	313	409	12	22	34	2	6.5	8.5
40	39	148	187	66	252	318	5	12	17	1.4	5.3	6.7
50	--	307	307	--	552	552	--	22	22	---	11.5	11.5
Total	438	1074	1512	686	1832	2518	46	95	141	14.3	38.2	52.5

¹Bear Hours (BH) = The number of one-hour time blocks during which a bear was monitored.

²Bear Activity Records (BAR) = The number of half-hour time blocks (cases) during which a bear was monitored.

³Bear Day (BD) = A day during which a bear was monitored for any period (includes days dropped from analyses).

⁴Bear Activity Days (BAD) = The number of bear activity records (BAR) divided by the 48 half hour time blocks needed to make a 24 hour period, which results in the actual number of days a bear was monitored.

Table 4. The distribution of Bear Activity Records (BAR) by bear, month and year.

Bear Number	March		April		May		June		July		August		September		October		BAR Total by Bear
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	
15	0	112	0	61	0	19	0	0	38	0	339	0	0	0	0	0	569
35	0	0	0	0	0	17	0	73	0	237	147	161	0	35	0	0	670
38	0	0	0	0	0	0	78	34	18	119	0	145	0	1	0	14	409
40	0	0	0	184	0	26	0	42	0	0	0	0	66	0	0	0	318
50	0	0	0	0	0	0	0	44	0	200	0	173	0	0	0	135	552
BAR Total by year/ by month	0	112	0	245	0	65	78	193	56	556	486	479	66	36	0	149	2521

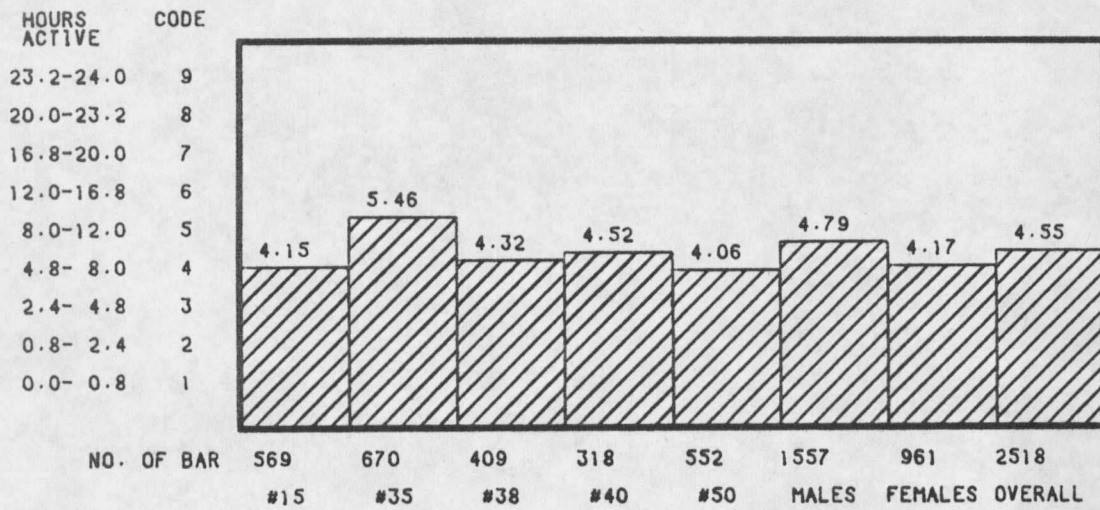


Figure 4. Comparison of the yearly average (spring-fall) activity levels for five individual grizzlies and both sexes, 1979-1980. Activity is converted from code to the average hourly activity per day. Bear activity records equal (BAR).

Table 5. Analysis of variation in the activity level of grizzly bears in the Yellowstone ecosystem with respect to time of year, time of day, differences among bears, reproductive state, lunar phase, and weather related factors, 1979-1980.

Source of Variation	d.f.	M.S.	F	Significance (p-value)
Month	7	402.437	59.975	0.000
Half hour	47	130.443	19.440	0.000
Bear	4	136.087	20.281	0.000
Weather	32	41.93	6.250	0.000
Temperature	8	124.171	18.510	0.000
Precipitation (amount)	7	19.351	2.884	0.006
Precipitation (type)	8	10.034	1.495	0.153
Relative humidity	8	15.992	2.383	0.015
Wind	1	4.766	0.710	0.399
Reproductive state	4	62.086	9.253	0.000
Lunar phase	5	22.075	3.290	0.006
Residual	2337	6.710		

Table 6. Analysis of variation in the probability of activity of grizzly bears in the Yellowstone ecosystem with respect to time of year, time of day, differences among bears, reproductive state, lunar phase, and weather related factors, 1979-1980.

Source of Variation	d.f.	M.S.	F	Significance (p-value)
Month	7	2.516	13.908	0.000
Half hour	47	2.718	15.020	0.000
Bear	4	1.481	8.187	0.000
Weather	32	0.856	4.732	0.000
Temperature	8	2.746	15.180	0.000
Precipitation (amount)	7	0.205	1.133	0.339
Precipitation (type)	8	0.137	0.757	0.643
Relative humidity	8	0.323	1.786	0.075
Wind	1	0.311	1.719	0.190
Reproductive state	4	1.320	7.297	0.000
Lunar phase	5	0.385	2.127	0.059
Residual	2337	0.181		

A first order (no interaction) least squares analysis of variance showed that each of the following factors explained a significant portion of the total variation in both the probability and level of activity (Tables 5 and 6).

1. month
2. hour
3. bear
4. combined weather related factors (including temperature, relative humidity, and precipitation type and amount)
5. reproductive state
6. lunar phase

The significance level for lunar phase was $p \leq .06$ and for all of the other factors $p \leq .001$.

Individually most of these factors were also found to be significantly related to both the level and probability of activity of grizzly bears ($p < .001$ as discussed separately).

Temperature

An analysis of variance test revealed that even after time of day and month were taken into account, temperature explained a significant portion of the variation in activity (see Tables 5 and 6, $p < .001$).

Considering only temperature and the measures of activity it was found that activity was significantly different ($p < .001$) over at least one temperature grouping. A test for a linear effect proved non-significant for the activity level while the linear effect on the

probability of activity was significant ($p \leq .223$ and $p \leq .018$, respectively). The non-linear effect was found to be significant for both measures of activity which suggests that there was a pattern but it was not strongly linear ($p < .001$).

As shown in Figure 5, on a yearly average activity was very low for temperatures below -11°C (12°F) or at temperatures above 22°C (72°F). The highest level of activity was recorded for temperatures in the $5.6 - 11^{\circ}\text{C}$ ($42 - 52^{\circ}\text{F}$) range. Activity was virtually identical for temperatures from -11°C to 5.6°C ($12 - 42^{\circ}\text{F}$) and for temperatures between 11°C and 16.7°C (52°F and 62°F) dropping off apparently linearly above this range to no recordings of activity above 27.8°C (82°F). In the spring a temperature increase was associated with an increase in activity up to 5.6°C (42°F) where activity began to decline (Figure 6). Activity thus was highest at temperatures above freezing, but below 5.6°C . A direct relationship was seen between temperature and activity during the summer where activity increased as temperature increased until 11°C (52°F) above which activity linearly declined (Figure 7). In the fall temperature and activity did not appear related at temperatures between -11°C and 5.6°C ($12 - 42^{\circ}\text{F}$); however, above 5.6°C activity increased (Figure 8). Very little data were available for temperatures above 11°C (52°F) since temperature during the autumn rarely exceeded this. Virtually no activity was recorded during the fall at temperatures below -11°C (12°F).

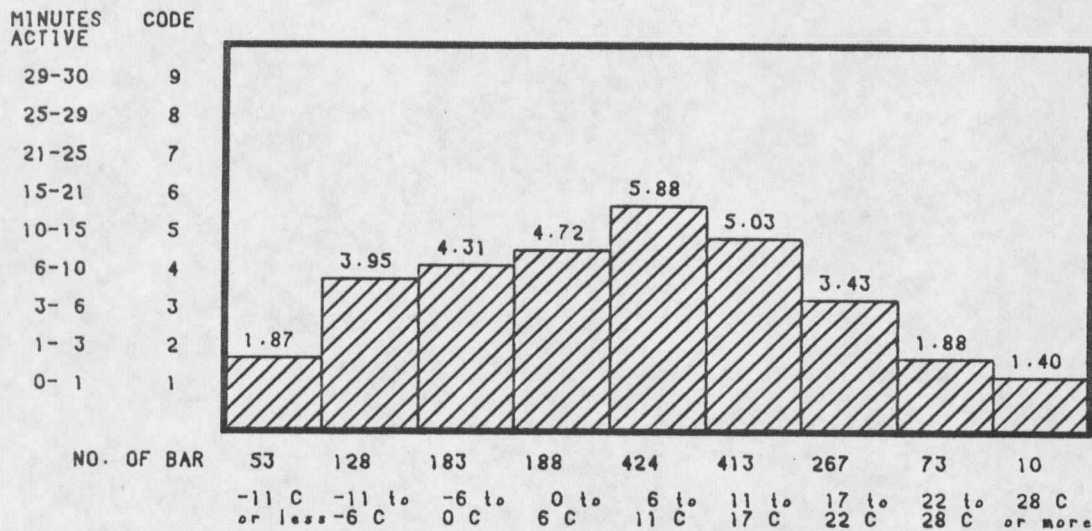


Figure 5. Relationship between temperature (in C) and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during 1979 and 1980 are included.

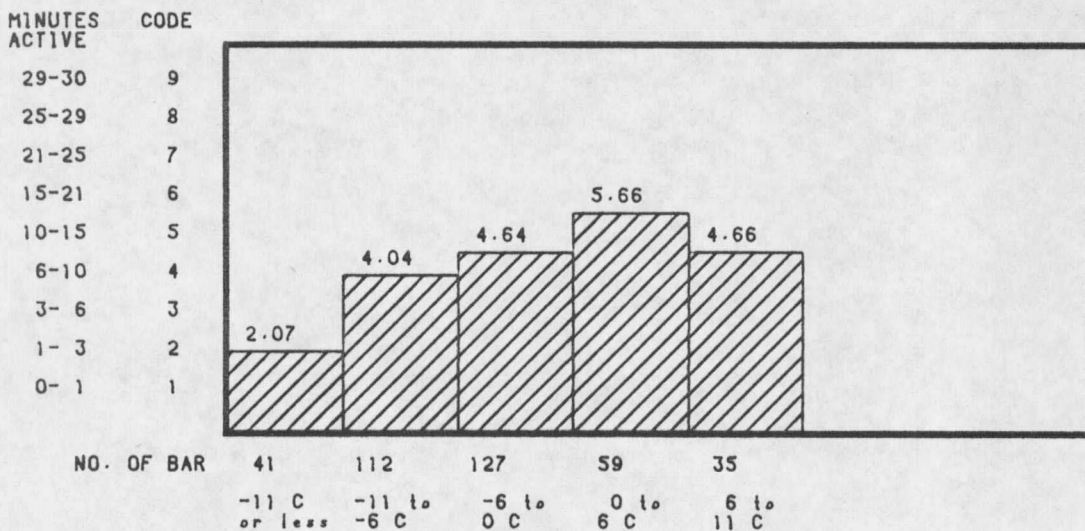


Figure 6. Relationship between temperature (in C) in the spring and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during the spring of 1979 and 1980 are included.

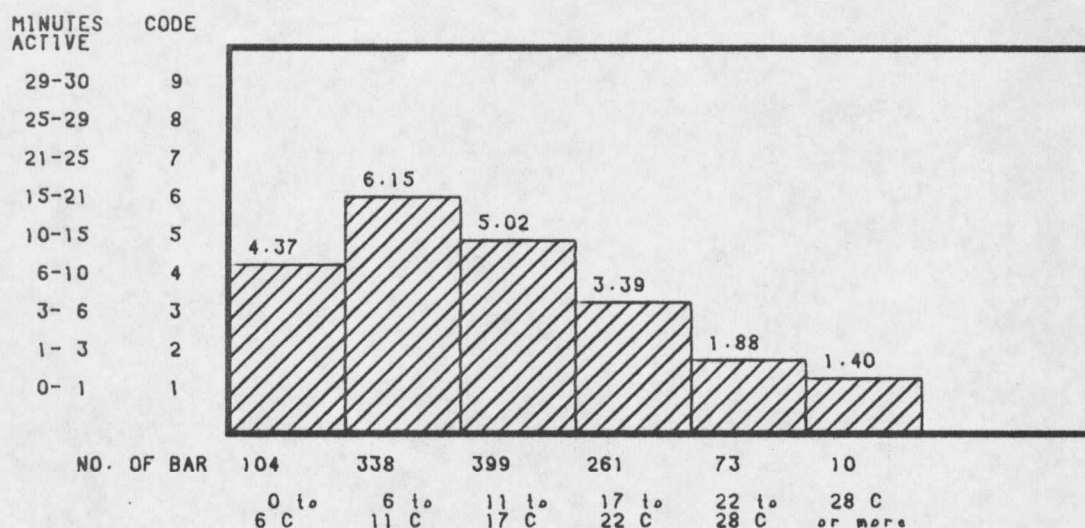


Figure 7. Relationship between temperature (in C) in the summer and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each temperature range during the summer of 1979 and 1980 are included.

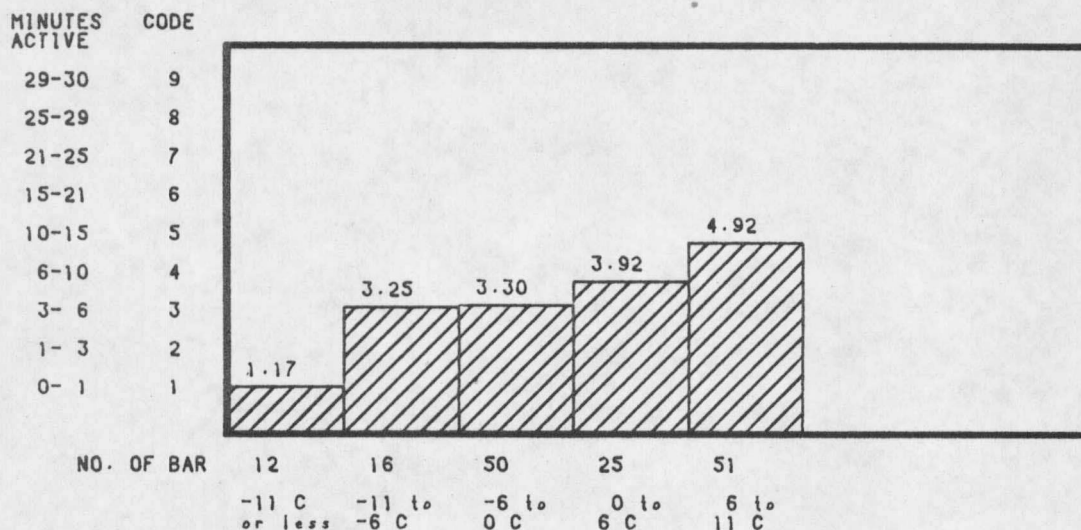


Figure 8. Relationship between temperature (in C) in the fall and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All activity records (BAR) within each temperature range during the fall of 1979 and 1980 are included.

Relative Humidity

Changes in relative humidity were found to be significantly related to both the probability and level of activity of grizzlies ($p < .001$). There was found to be a linear effect as well as a non-linear effect which possibly indicates that the pattern present has a linear trend, but also deviations from linearity ($p < .001$ and $p \leq .004$, respectively).

The pattern exhibited in Figure 9 suggests that as relative humidity increases, the activity of grizzlies increases until the humidity reaches the 95% level above which activity diminishes slightly. This is about the point where actual precipitation occurs.

Increased relative humidity measures have been associated with an increase in the ability of the olfactory senses (Picton, personal communication). Since grizzlies are known to have a highly developed sense of olfaction, it was hypothesized that they may feed and therefore be most active during periods of high relative humidity. To consider this hypothesis, changes in relative humidity per half hour time block were plotted against changes in the activity measures. It appeared from this visual comparison that grizzlies may, in fact, feed during time periods in which they can more efficiently locate food sources.

Types of Precipitation or Lack of It

The type of precipitation or lack of it was found to be significantly related to both activity measures ($p < .001$). It appears from Figure 10 that hail had quite a dampening effect on their activity.

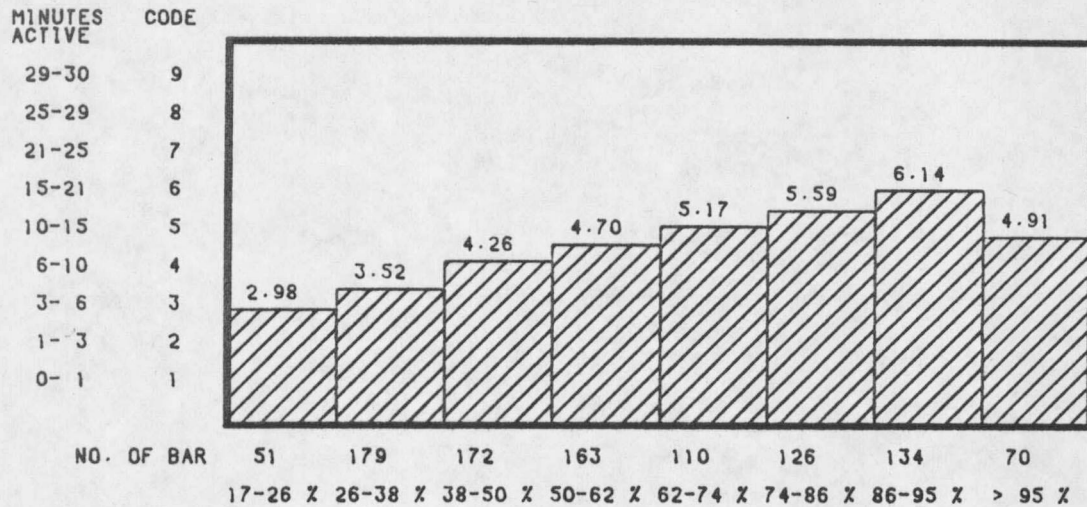


Figure 9. Relationship between percent relative humidity and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) within each relative humidity range during 1979 and 1980 are included.

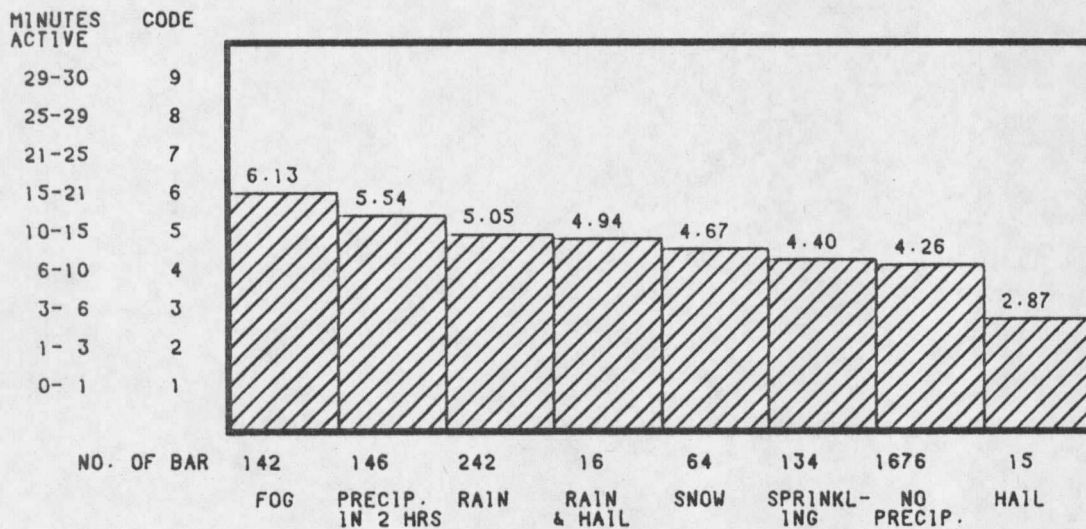


Figure 10. Relationship between type of precipitation and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) obtained within each precipitation type during 1979 and 1980 are included.

Bears were active slightly less than average when there was no precipitation and were active slightly more than the average levels when there was precipitation in the form of rain. The highest activity recordings occurred when there was fog and to a lesser degree when rain had fallen within two hours.

Amount of Precipitation

The amount of precipitation was found to explain a significant portion of the total variation in the level of activity ($p=.006$, Table 5) when all other factors were considered. When only the amount of precipitation was considered, it was found that both measures of activity were significantly different over the precipitation categories. For probability of activity $p<.001$ and $p\leq.004$ for the average activity level. Activity was greatest when the daily precipitation was in the 0.16 - 0.6/cm range (Figure 11). Bears were less active than average when no precipitation had fallen during a day, but least active when more than 1.4 cm inches of precipitation occurred during a day. A test metric for linearity proved non-significant for the level of activity ($p=.4368$) and the probability of activity ($p=.3987$) however, the test for non-linearity proved significant ($p<.001$ and $p<.003$, respectively). The non-linear pattern seemed to be that activity increased linearly as the amount of precipitation increased until 0.61 cm (.24 in) of precipitation had fallen, above which activity declined linearly.

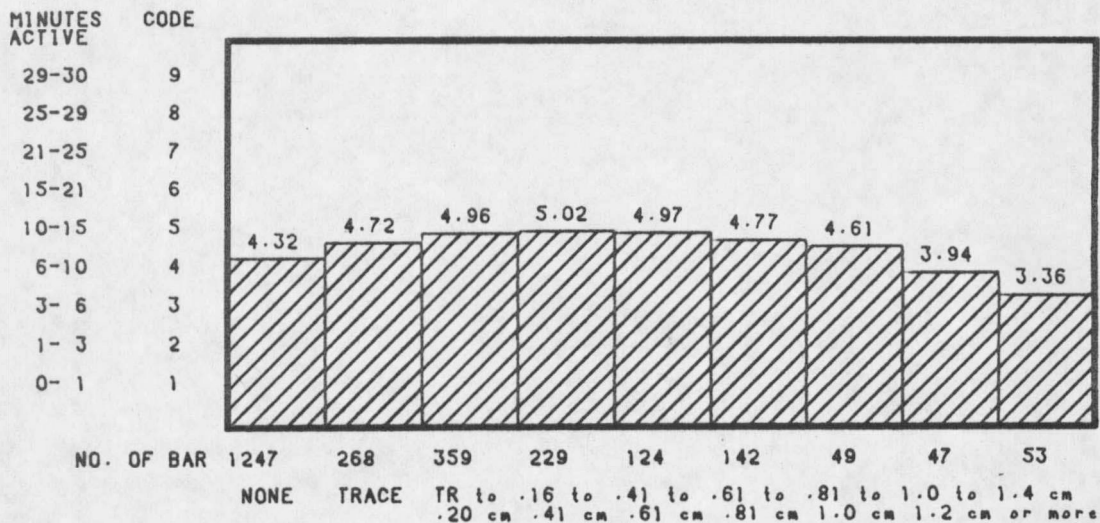


Figure 11. Relationship between amount of precipitation (in cm) and the average activity level (converted from code to minutes active per half hour) of grizzly bears. All bear activity records (BAR) obtained within each precipitation range during 1979 and 1980 are included.

Wind

Only two categories of wind speeds were recorded, slight to no wind and high winds.

They did not explain a significant portion of the total variation in activity ($p \leq .399$ for activity level and $p = .190$ for probability of activity) among bears having considered other factors nor were there significant differences for the activity level ($p \leq .165$) or the probability of activity ($p \leq .676$) between these two wind speeds.

Throughout the study, bears consistently showed uneasiness during bedding periods on days with strong winds. The increase of these quick pulse mode changes did not increase the actual minutes active per BAR much and therefore did not affect the activity levels much either. The fact that strong winds did not significantly affect the

probability or activity levels is correct, however, since slight uneasiness is not actual activity.

Lunar Phase

Lunar phases were found to explain a significant ($p \leq .006$) portion of the variance in the level of activity (for probability of activity the significance was $p < .060$). It also proved to have a significant effect upon both the probability of activity ($p \leq .042$) and the activity level ($p \leq .022$) when no other factors were considered. Bears were least active during the night of a full moon and most active during the week centered on the new moon (excluding the night of the new moon (Figure 12). Bears were therefore most active under intermediate light levels of the moon.

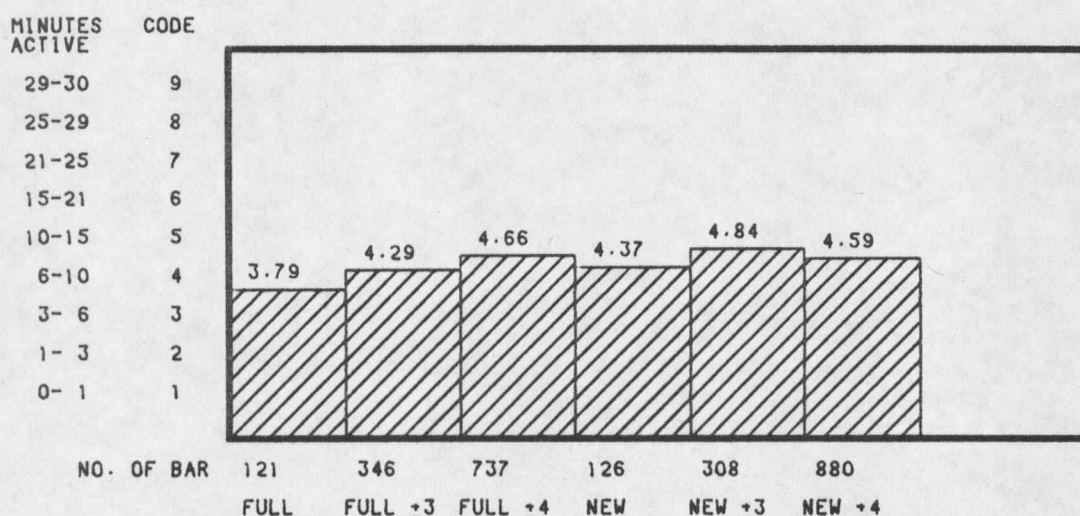


Figure 12. Relationship between lunar phase and the average activity level (converted from code to the average number of minutes active per half hour time block) of grizzly bears. All bear activity records (BAR) obtained within each lunar phase during 1979 and 1980 are included.

A bear's eyes possess many cones as well as a tapetum and enough rods for reasonable visual acuity (Cloudsley-Thompson; 1961). Vision, though relatively poor, does not force them into a certain activity pattern by time of day.

Reproductive Status

When considering all factors reproductive status was found to explain a significant portion of the variation in activity among grizzlies (Tables 5 and 6). The reproductive status was also found to be significantly related ($p < .001$) to both the probability and level of their activity when its effect was considered alone. The average level of activity (coded) was greatest for reproductively available grizzlies during the peak (June 1 - June 30) breeding period. This level, however, was only slightly higher than the activity level for a bear traveling with a mate, during periods other than this assumed breeding season (Figure 13). The probability of activity, however, was greatest for grizzlies traveling with a mate during periods before the peak breeding season (June 1 - June 30), though this probability was only very slightly higher than that for this period. This could be an indicator of an earlier or extended breeding season for the study years or for non-congregating populations. Also, it may indicate that the pairing phase, and pre- and postcopulatory behavior may extend farther beyond the breeding season, with "mates" at present being harder to locate (as discussed later under reproductive behavior). Bears traveling alone exhibited about the average activity levels and probabilities while females without cubs exhibited below

average activity levels and probabilities. Females with cubs had the lowest activity recordings.

Activity Patterns

Seasonal Effects on Activity

There was a significant difference in the average monthly levels and probability of activity of the grizzlies ($p < .001$). Season also had a significant effect on both activity measures ($p < .001$). They were least active in the two months prior to denning (September and October) and during March shortly after emerging from their dens (Figure 14). The average daily activity level for these months was about 2.4 to 4.8 hours.

May appeared to be the month when the bears were most active. However, the level was unrealistically high due to the fact that a large portion of the few BAR's (bear activity records) taken during this month occurred during time blocks when the probability of activity is very high. During the summer months, the activity level was high and fairly constant at anywhere from 8 to 12 hours of activity during any 24 hour period.

When the months were grouped into seasons, the average daily activity levels were also significantly different for the spring or summer compared to fall where the levels were at about 8.8, and 2.4 minimum activity hours respectively (Figure 15).

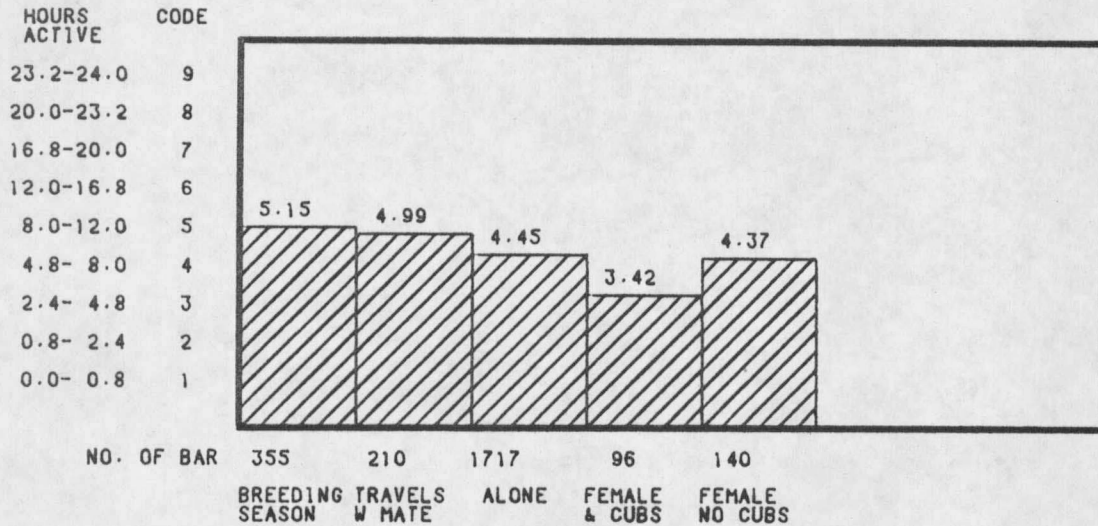


Figure 13. Relationship between reproductive state and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained for bears within each reproductive state during 1979 and 1980 are included.

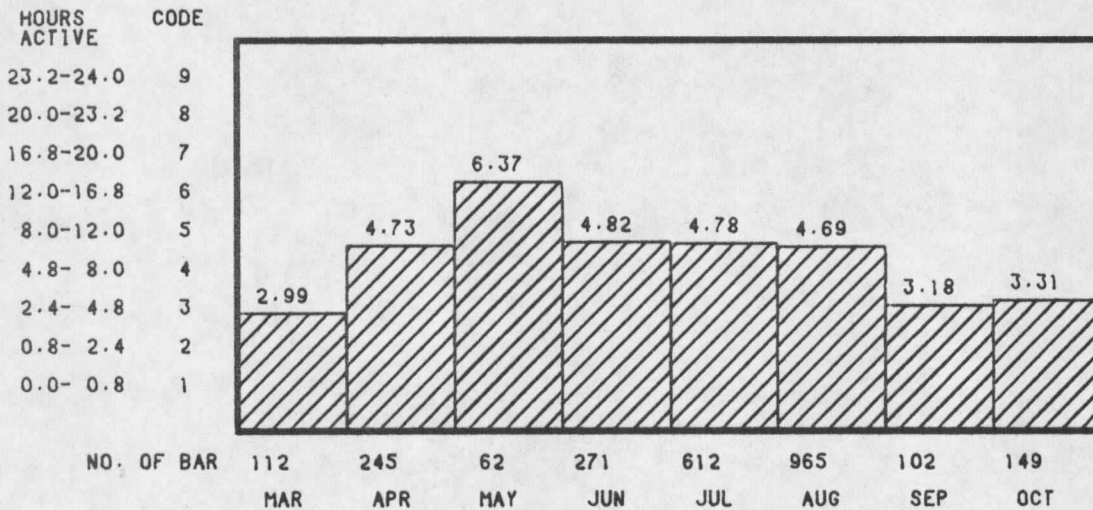


Figure 14. Relationship between time of year (month) and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained within each month during 1979 and 1980 are included.

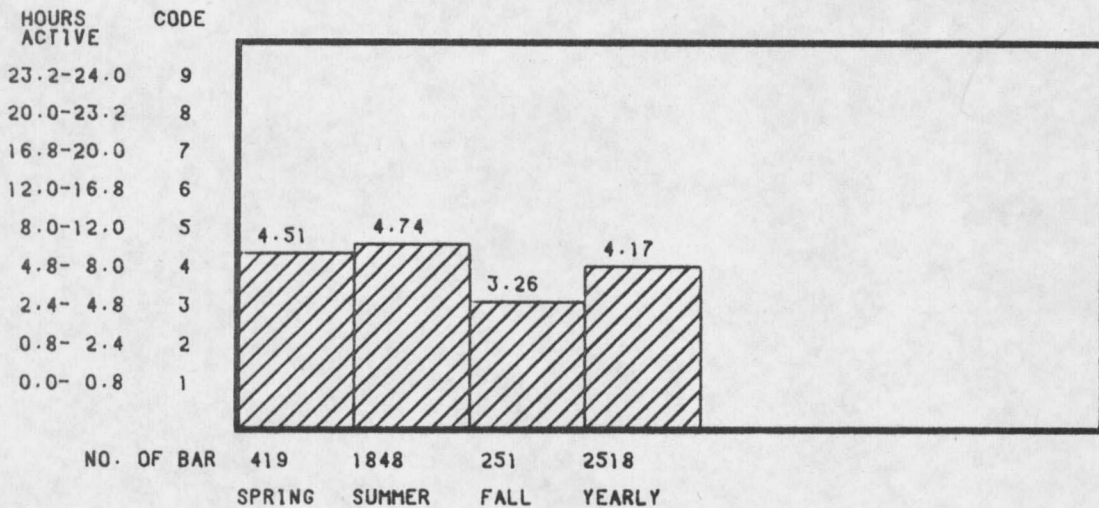


Figure 15. Relationship between time of year (season) and the average activity level (converted from code to hours active per day) of grizzly bears. All bear activity records (BAR) obtained within each season during 1979 and 1980 are included.

Spring

During the spring, grizzlies tended to be somewhat crepuscular especially at dusk and more diurnal than during summer (Figures 16 and 17). There were two major peaks in activity, the most distinct occurring at 0630 and one at 2000 while minor peaks occurred at 0030 and 1230. The lowest level of activity was recorded at 0330, while the least active period during the daylight hours was noted at 1400. Although the average activity level during spring was fairly high (Figure 15), one can see in Figure 16 that there was not as distinct of pattern of activity as exhibited during summer, but rather low to intermediate levels of activity occurring in most of the time blocks.

Minutes Active	Code
29 - 30	9
25 - 29	8
21 - 25	7
15 - 21	6
10 - 15	5
6 - 10	4
3 - 6	3
1 - 3	2
0 - 1	1

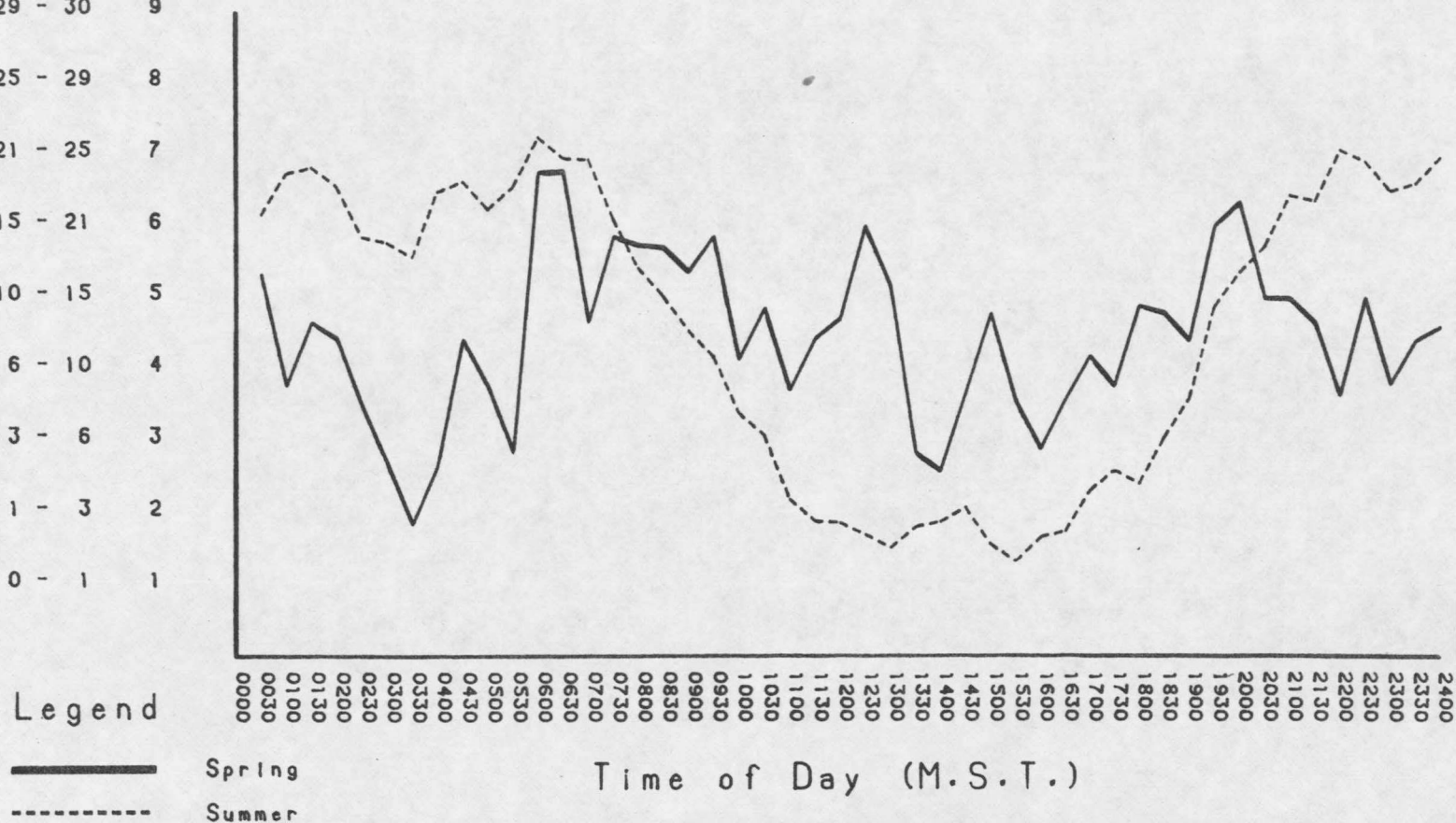


Figure 16. Seasonal comparison (summer vs. spring) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block. All bears combined.

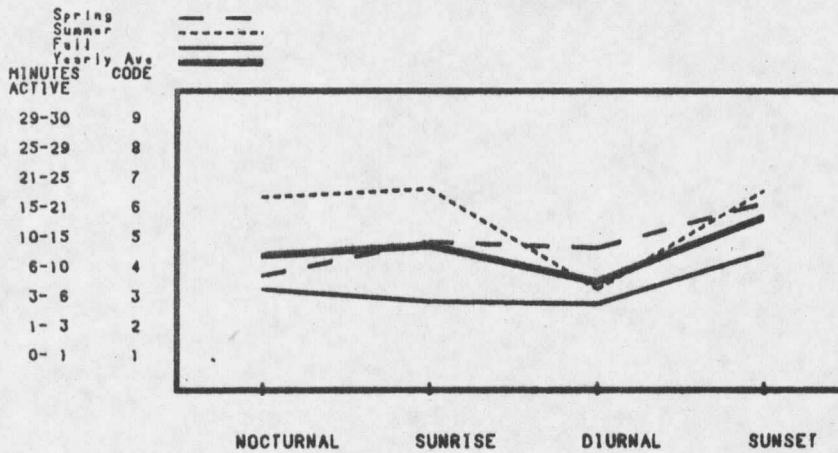


Figure 17. Relationship between the average activity level (in minutes active per half hour time block) of grizzly bears and nocturnal, diurnal and crepuscular periods, 1979-1980. All bears combined.

Summer

In the summer grizzlies were nocturnal with crepuscular activity peaks (Figures 16 and 17). Grizzlies were generally active throughout the night with a minor lull in activity around 0330 and peaking around 0600. From here activity quickly declined with virtually no activity recordings between 1030 and 1830, apart from slight head movements or a change in position of the bear in its bed. Pearson (1975) noted that grizzlies would sleep soundly during the day for periods (i.e. total inactivity) followed by periods of drowsy activity such as rolling, scratching, and testing the wind. This study indicated similar findings with periods of total inactivity ranging from several minutes to several hours. After about 1830 activity steadily increased peaking at 2200.

Fall

The fall activity pattern appeared very erratic due to the fact that most of the data was based on grizzlies using animal protein (elk and bison) as a food source. The fall activity patterns (Figures 18 and 19) suggested that grizzlies are crepuscular during this season, being much more active at dusk than any other period (Figure 17). Minor peaks in activity occurred at 0800 and 2030 while the greatest level of activity occurred at 1430. Aside from these peaks, activity was generally low throughout the night and daylight hours. It was noted in late August and early September of 1980 that a large grasshopper population was present. The cool evening and morning temperatures made the insects sluggish and easily captured by grizzlies during periods when grizzlies were highly active. A high abundance of grasshoppers was noted in scats at this time. These observations are consistent with those of A. Murie made in Yellowstone (Schullery, 1980).

Yearly Average

The yearly average activity pattern of grizzlies resembled the nocturnal pattern of summer even when each season was given equal weight, regardless of the number of BAR in each (Figures 18 and 20). This is especially true considering the fact that an average of three to six minutes of activity per half hour time block (i.e., a code of 3 or lower) is considered inactivity. Based on nocturnal, diurnal and crepuscular periods, grizzlies were somewhat nocturnal with crepuscular activity peaks although this pattern was not as distinct as

Minutes Code

Active

29 - 30 9

25 - 29 8

21 - 25 7

15 - 21 6

10 - 15 5

6 - 10 4

3 - 6 3

1 - 3 2

0 - 1 1

Legend

———— Summer

- - - - - Fall

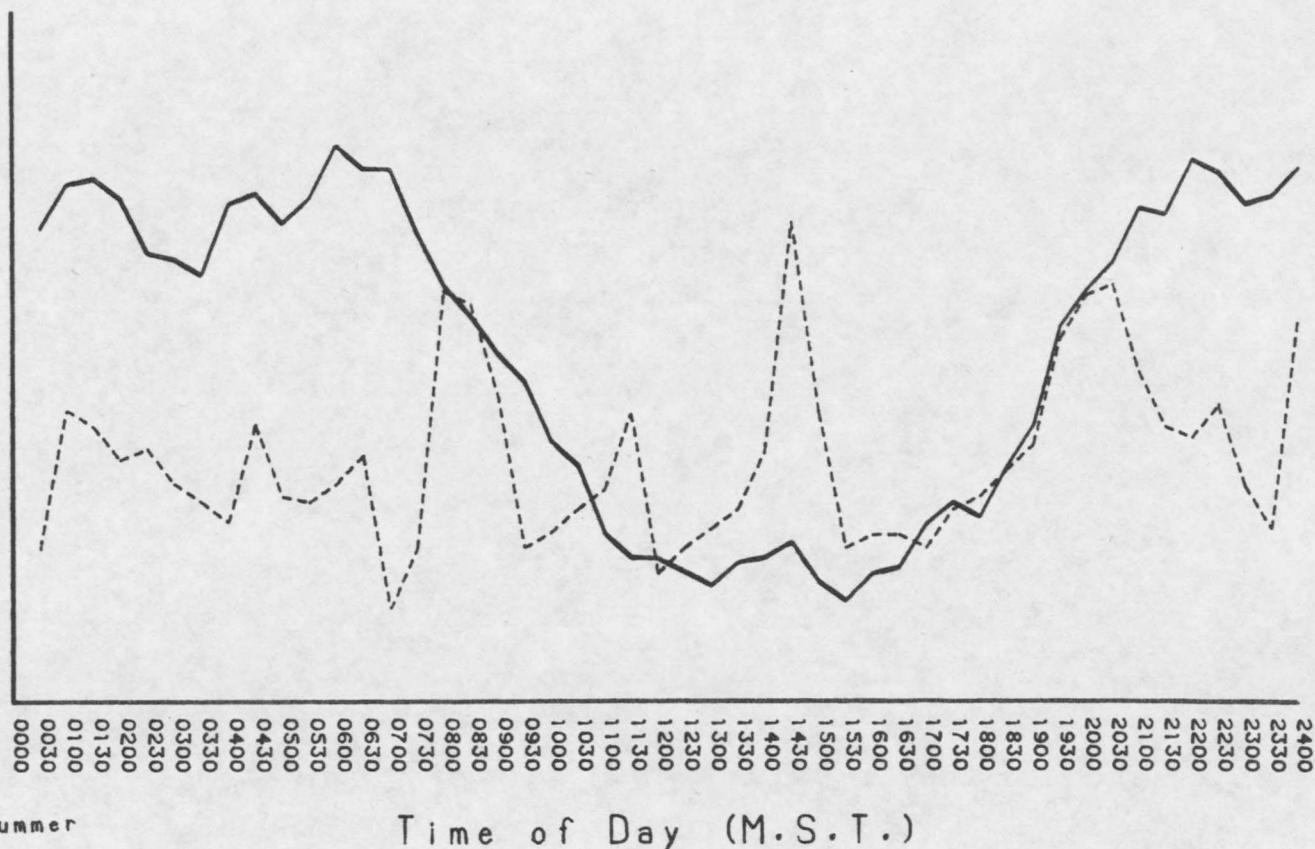


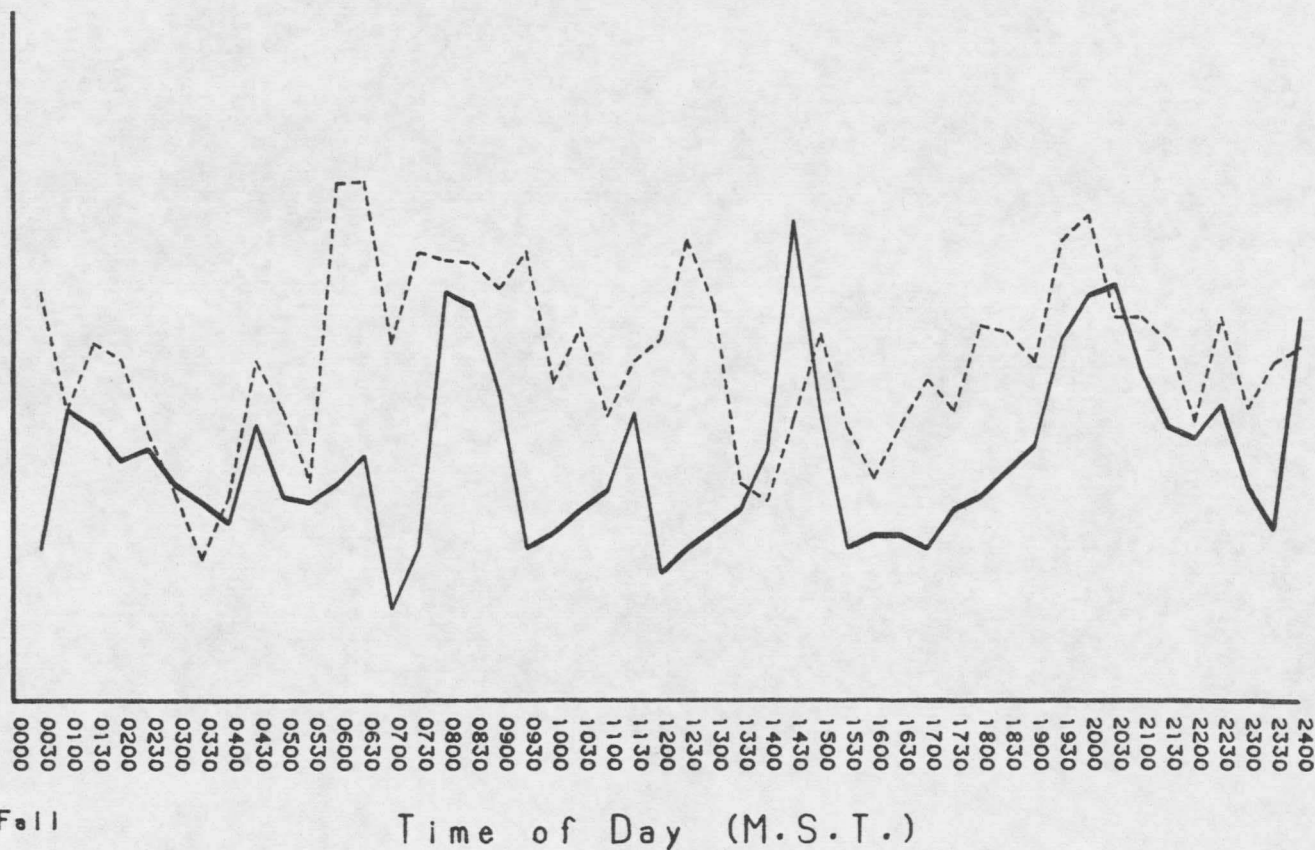
Figure 18. Seasonal comparison (summer vs. fall) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined.

Minutes Active	Code
29 - 30	9
25 - 29	8
21 - 25	7
15 - 21	6
10 - 15	5
6 - 10	4
3 - 6	3
1 - 3	2
0 - 1	1

Legend

———— Fall

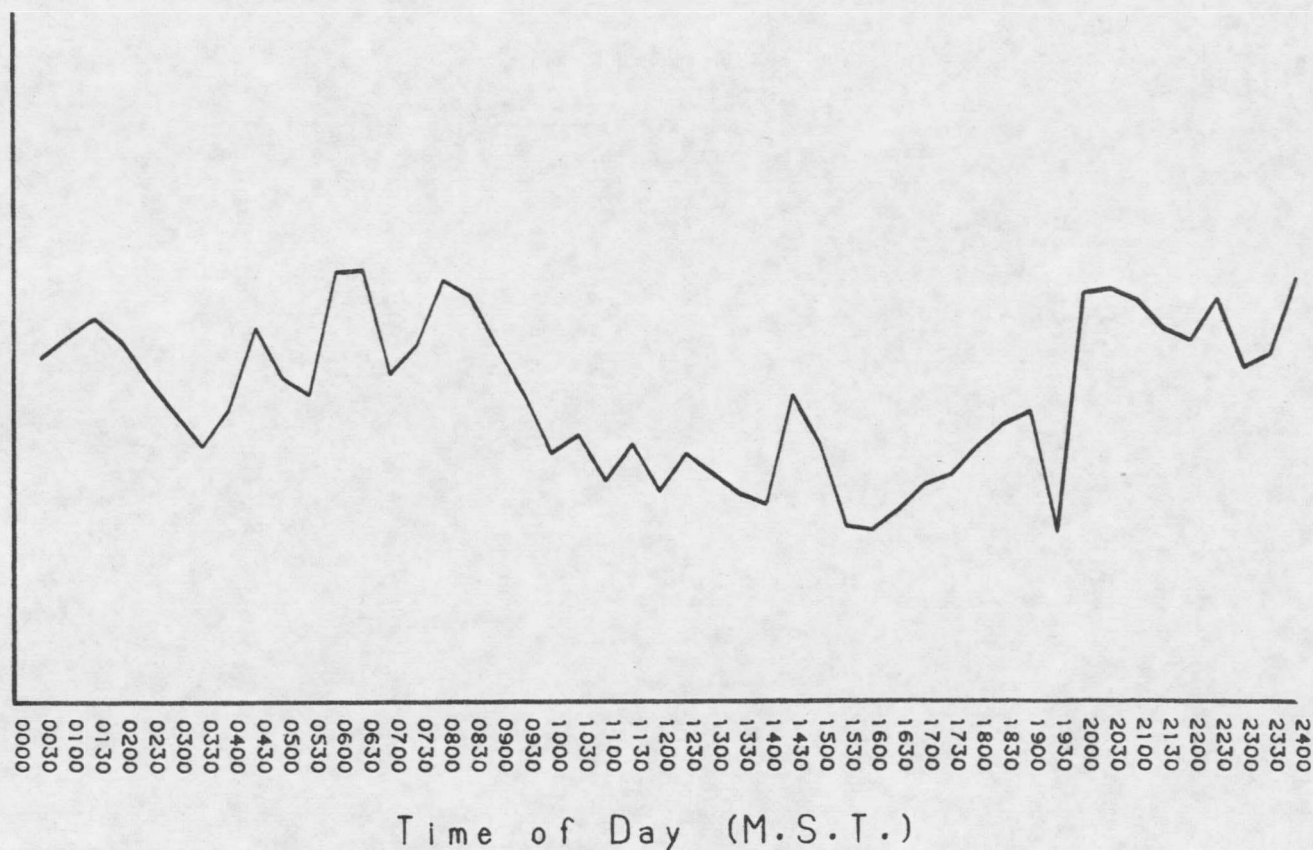
----- Spring



-44-

Figure 19. Seasonal comparison (fall vs. spring) of the activity patterns of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined.

Minutes Active	Code
29 - 30	9
25 - 29	8
21 - 25	7
15 - 21	6
10 - 15	5
6 - 10	4
3 - 6	3
1 - 3	2
0 - 1	1



-45-

Figure 20. Yearly average (spring-fall) activity pattern of grizzly bears during 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). All bears combined.

the one exhibited during the summer (Figure 17). The diurnal activity level was almost identical for the yearly average when compared to summer. Bears were generally nocturnal with a crepuscular activity peak at 0630 and another peak at 2400. A minor lull in nocturnal activity was noted once again at 0330. Again very little activity was recorded between about 1030 and 1830, although often times head movement or a slight change in the resting position of a bear occurred at 1430. Similar restlessness was recorded for all seasons at about this time (1430 - 1500). Month and season were found to have a significant effect on hourly activity ($P < .001$; see Tables 5 and 6).

Individual Bear Activity Patterns (Daily Routines)

Four of the five study bears were generally nocturnal to crepuscular with very little diurnal activity except during the spring season (Figure 21). Despite the scanty data, Bear 40 appeared to be diurnal to crepuscular with very little nocturnal activity except during the summer (Figure 22). He appeared to be most active during late morning to mid-day and again during early evening.

Yearly Average (Spring-Fall) Activity Patterns of "Nocturnal Bears"

The four nocturnal bears generally became inactive and presumably bedded during most of the mid-day hours and were active (feeding or traveling) from the evening through late morning hours. These bears typically bedded down between 0830 - 1030 hours and remained bedded and virtually inactive until about 1800 - 1900 hours, when the activity period generally began. The yearly (spring-fall) average

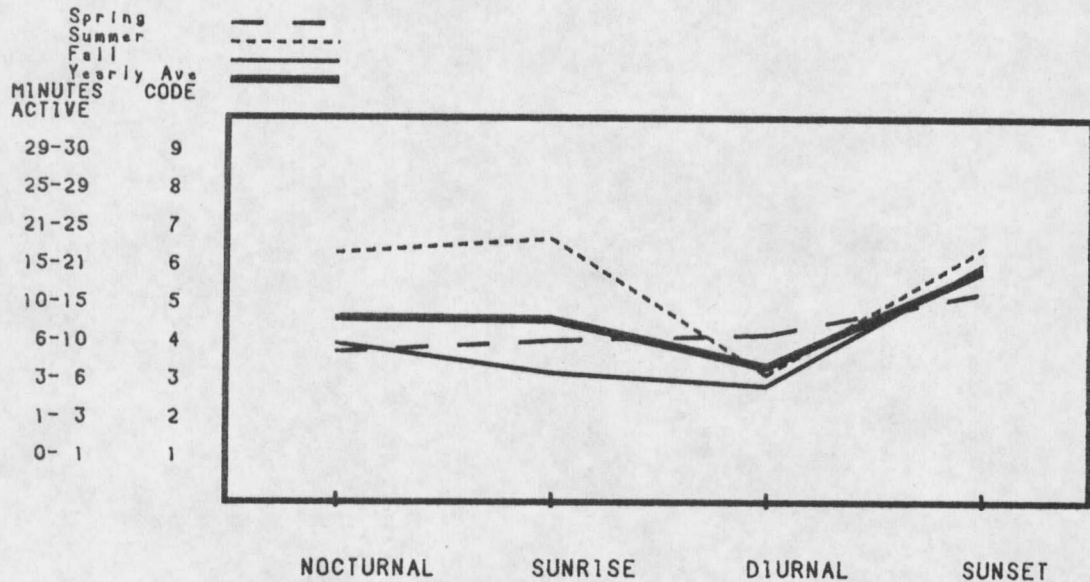


Figure 21. Relationship between the average activity level of the four "nocturnal bears" combined and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.

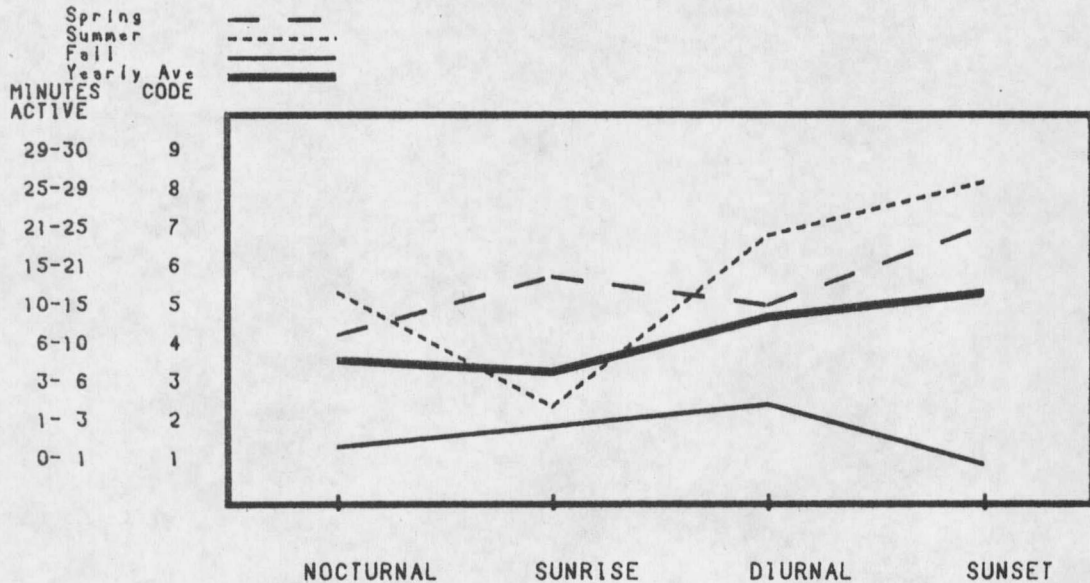


Figure 22. Relationship between the average activity level of Bear 40 (the "diurnal study bear") and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.

activity patterns of "nocturnal bears" were remarkably similar (Figures 23-24). Nocturnal, diurnal and crepuscular activity, as well as the seasonal pattern changes of the activity were also very similar for the four "nocturnal bears" (Figures 25-28). This is especially true considering the wide variation in the seasonal distribution of bear activity records (BAR) between bears (Table 7). Usually within 30 minutes to an hour before a bear bedded down, a "winding down" or decreased amount of activity was noticed in the signals received. These animals seemed to spend much of their active feeding cycles within open parks, meadows, and ecotonal areas but where a greater quantity and diversity of known bear foods occur. They were quick to leave the open areas before or soon after first light. After entering the timber, they would remain active for an hour or two while traveling and/or foraging to the day bed.

Day beds normally were located within dense stands of timber, frequently within downfall. The most common day bed encountered was typically a relatively deep-to-shallow, scooped-out, unlined depression slightly over 1 m long by 1/2 m wide. These were usually less than 1 m from the base of a large tree and often beside fallen timber forming natural shelters. Similar results were noted by the IGBS for day beds throughout the Yellowstone system (Knight et al. 1978, Blanchard 1980).

During the mid-day bedding terms, long periods of a steady mode were interrupted by changes in mode or an occasional erratic signal. These were sometimes hours apart and presumed to indicate that the bear had changed positions in its bed or had risen to stretch, then

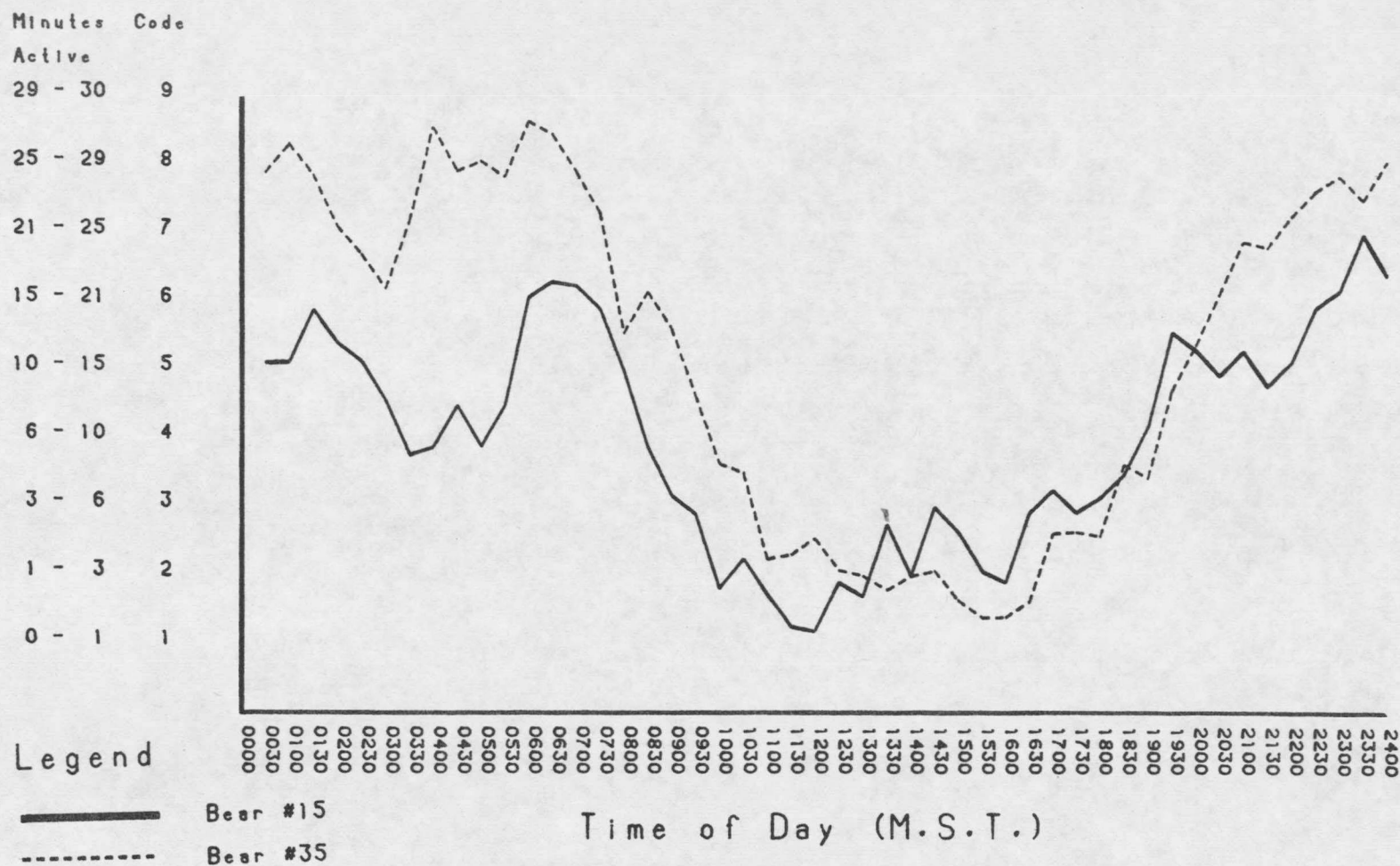


Figure 23. Comparison of the yearly average (spring-fall) activity patterns of Bear 15 and Bear 35, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted.

Minutes Code

Active

29 - 30 9

25 - 29 8

21 - 25 7

15 - 21 6

10 - 15 5

6 - 10 4

3 - 6 3

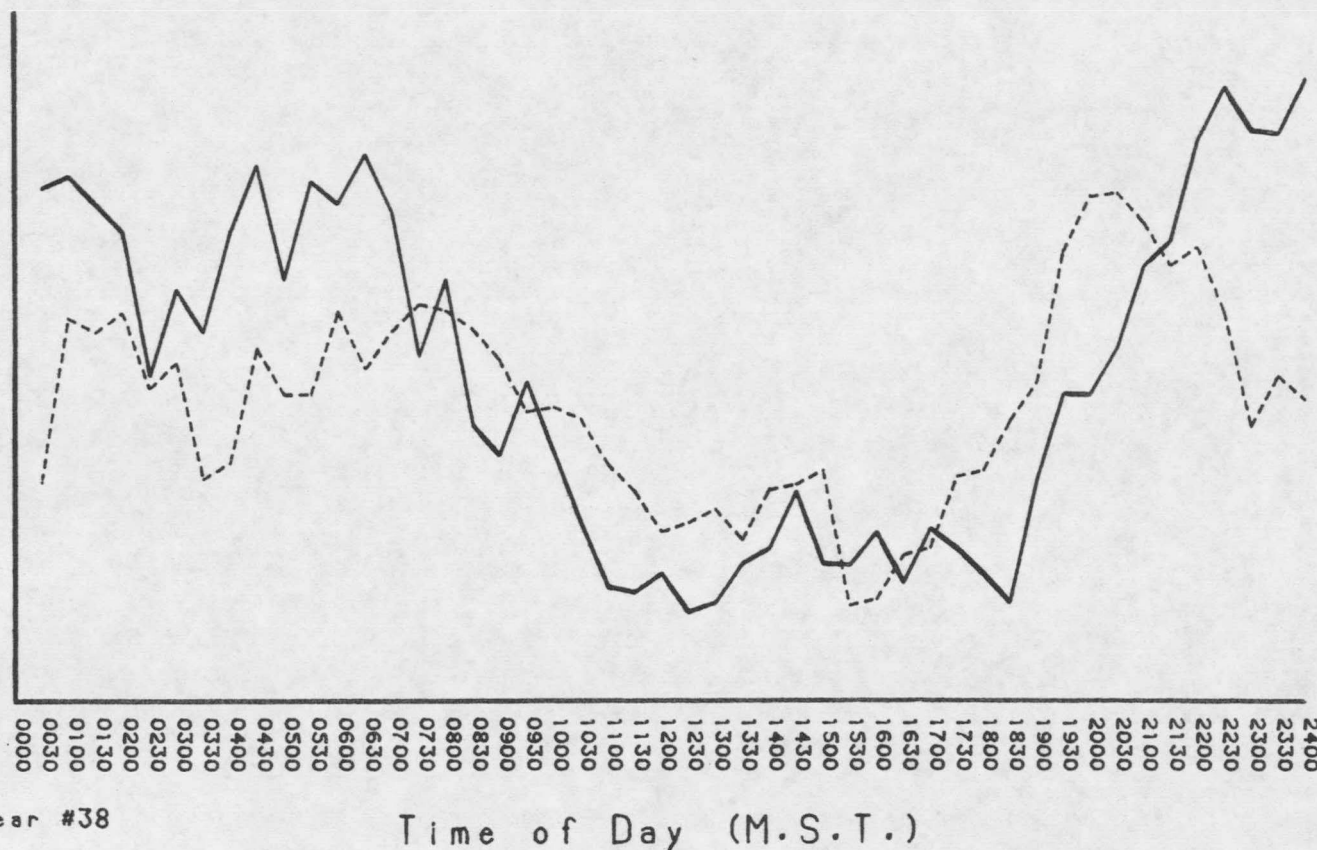
1 - 3 2

0 - 1 1

Legend

— Bear #38

- - - Bear #50



-50-

Figure 24. Comparison of the yearly average (spring-fall) activity patterns of Bear 38 and Bear 50, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted.

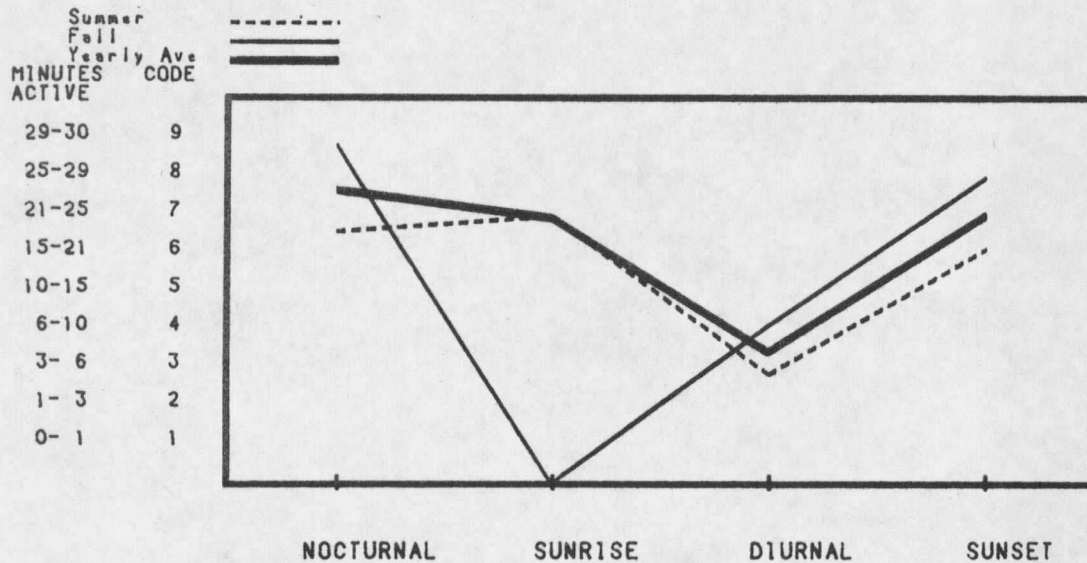


Figure 25. Relationship between the average activity level of Bear 38 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block. Note that the zero bear activity records obtained for sunrise during fall (see Table 7) is labeled as zero activity.

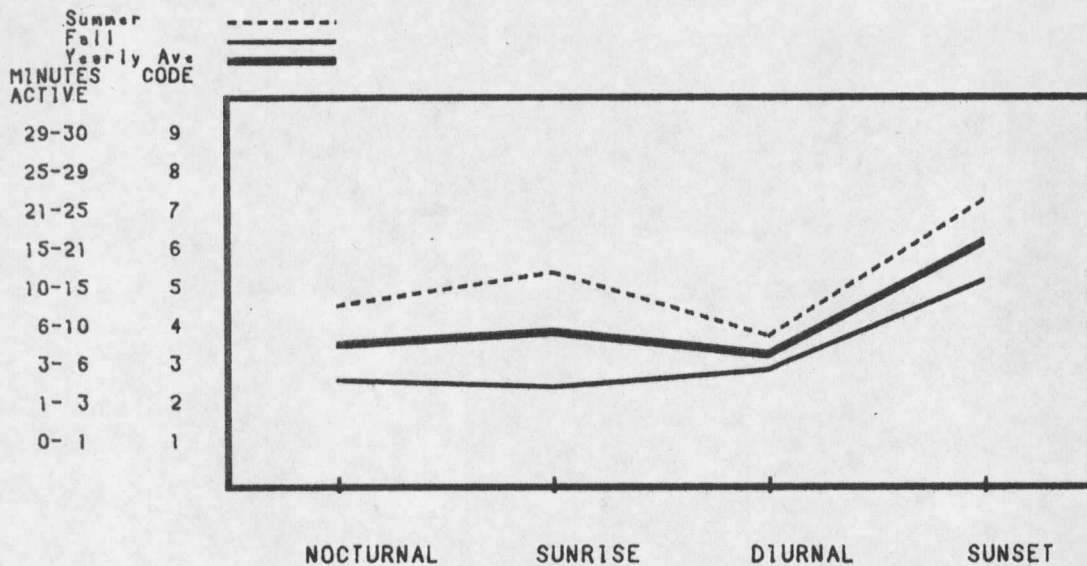


Figure 26. Relationship between the average activity level of Bear 50 and nocturnal, diurnal and crepuscular periods, 1980. The activity level is shown in minutes active per half hour time block.

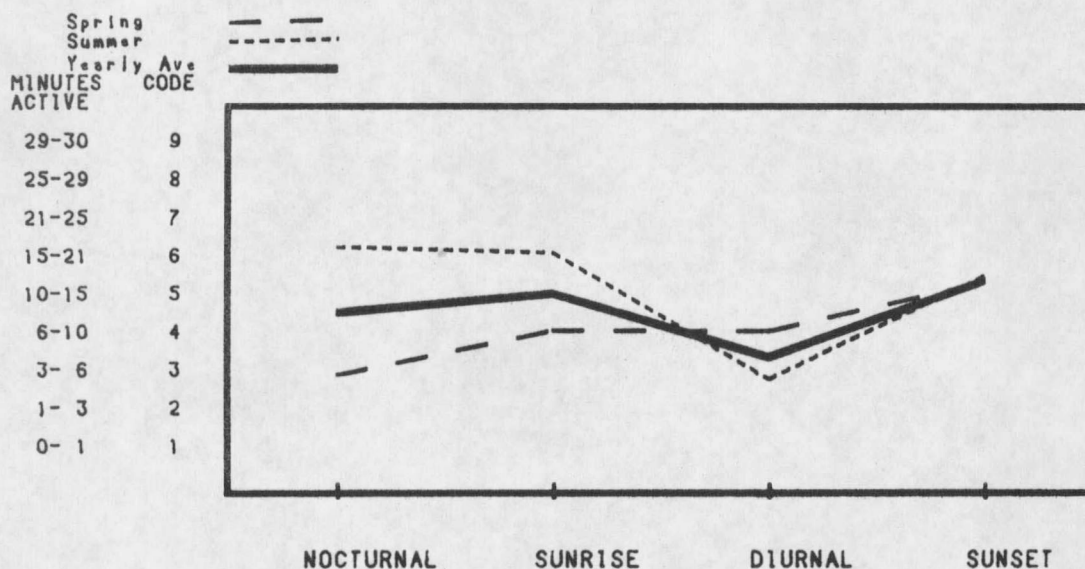


Figure 27. Relationship between the average activity level of Bear 15 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.

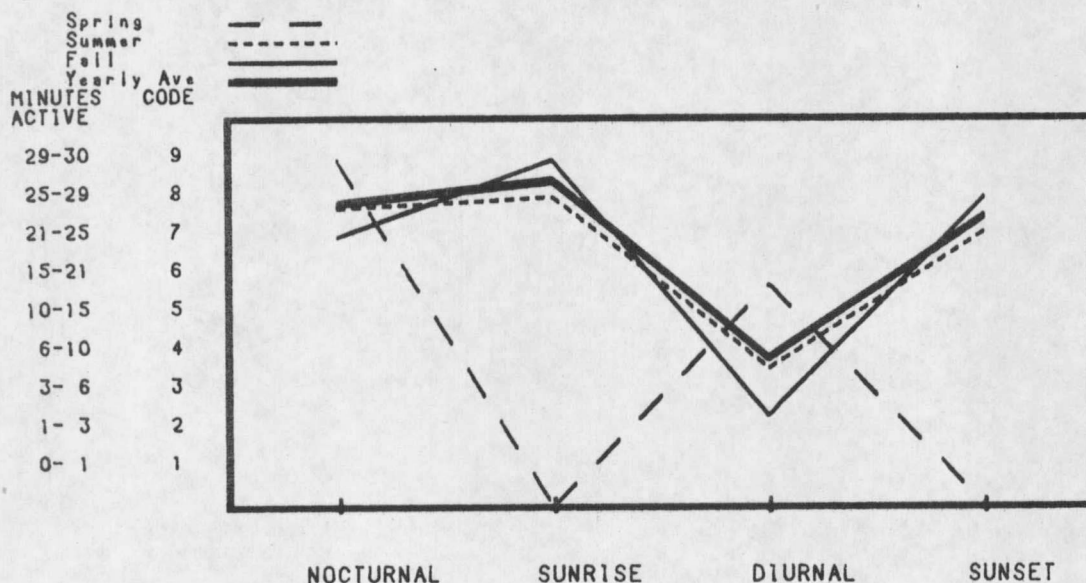


Figure 28. Relationship between the average activity level of Bear 35 and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block. Note that zero bear activity records obtained for sunrise and sunset during spring (see Table 7) are labeled as zero activity.

Table 7. The distribution of bear activity records (BAR) broken down by bear, season, and nocturnal, diurnal and crepuscular periods.

Bear Number	Spring					Summer					Fall				
	Noct.	Sunr.	Diur.	Suns.	Spring Total	Noct.	Sunr.	Diur.	Suns.	Summer Total	Noct.	Sunr.	Diur.	Suns.	Fall Total
15	84	9	87	12	192	121	15	220	21	377	0	0	0	0	0
35	5	0	12	0	17	212	30	342	34	618	21	1	11	2	35
38	0	0	0	0	0	112	15	247	20	394	6	0	8	1	15
40	79	8	112	11	210	15	2	22	3	42	34	3	25	4	66
50	0	0	0	0	0	142	20	236	19	417	63	7	59	6	135
Sum Total	168	17	211	23	419	602	82	1,067	97	1,848	124	11	103	13	251

lay back down to rest. Similar to the "winding down" period mentioned earlier, there ordinarily was a "winding up" interval beginning from 1/2 to 1 hour prior to departure from the bed site. This interval was characterized by copious, erratic interruptions of the steady mode.

The activity period began when a constant erratic signal was heard along with a change in the direction of the bear from the observer, indicating movement and departure from the day bed.

It was not uncommon for the active cycle to be broken once or twice by short periods (up to 1 hour) of steady mode. These periods were resting periods, referred to as night bedding. It was more common for night beds to be used by Bear 15 and Bear 50 than by the other two nocturnal bears.

Activity Patterns of a Diurnal Bear

Meager data were obtained for Bear 40. His classification as a diurnal bear was based on instances that involved aerial flights in addition to ground work. Four instances occurred during the late to mid-morning hours in which Bear 40's location was instantly radioed to the ground. I immediately traveled to the location only to find this bear absent or at an entirely different location. These aerial locations were at times when the other three bears were never found to move to any extent. These instances, coupled with data from ground observations, led to the deduction that this particular animal had an activity cycle which differed significantly from the nocturnal bears studied. On a yearly basis he appeared to be most active from about

0600 to 1300 hours, a time period when the other bears became totally inactive. His activity level peaked at about 0930 with two lesser crepuscular peaks occurring at 0630 and 2000 (Figure 29). He was very inactive between 1400 and 1800 and exhibited a fairly low level of activity throughout the night except at midnight where activity increased somewhat. On the yearly average he was more diurnal and less nocturnal than the other bears (Figures 21-24 and 29).

Observations during the late evening and early morning hours revealed that Bear 40 was resting and most probably bedded at time intervals in which the other bears were moving and/or feeding. A gradual increase in restlessness, or the "winding up" period, was also observed before the onset of activity. Longer spans of uninterrupted steady modes were noticed during Bear 40's resting periods when compared to the other study bears. This could be an individual trait but was probably a result of sample size, field conditions at the time, or simply a tired bear, etc.

Human-Related Disturbance

There were seven observations where a bear was known to immediately flee from the area because of scenting the observers. These bears traveled several to many kilometers before stopping for any length of time.

Three instances occurred where a study bear traveled towards the observers during the night while unaware of their presence, discovered their presence by scent, circled the observers within 45 - 75 m, then quickly left the vicinity, and again did not stop for any length of

Minutes Code

Active

29 - 30 9

25 - 29 8

21 - 25 7

15 - 21 6

10 - 15 5

6 - 10 4

3 - 6 3

1 - 3 2

0 - 1 1

Legend

—————

Bear #40

- - - - -

All Others

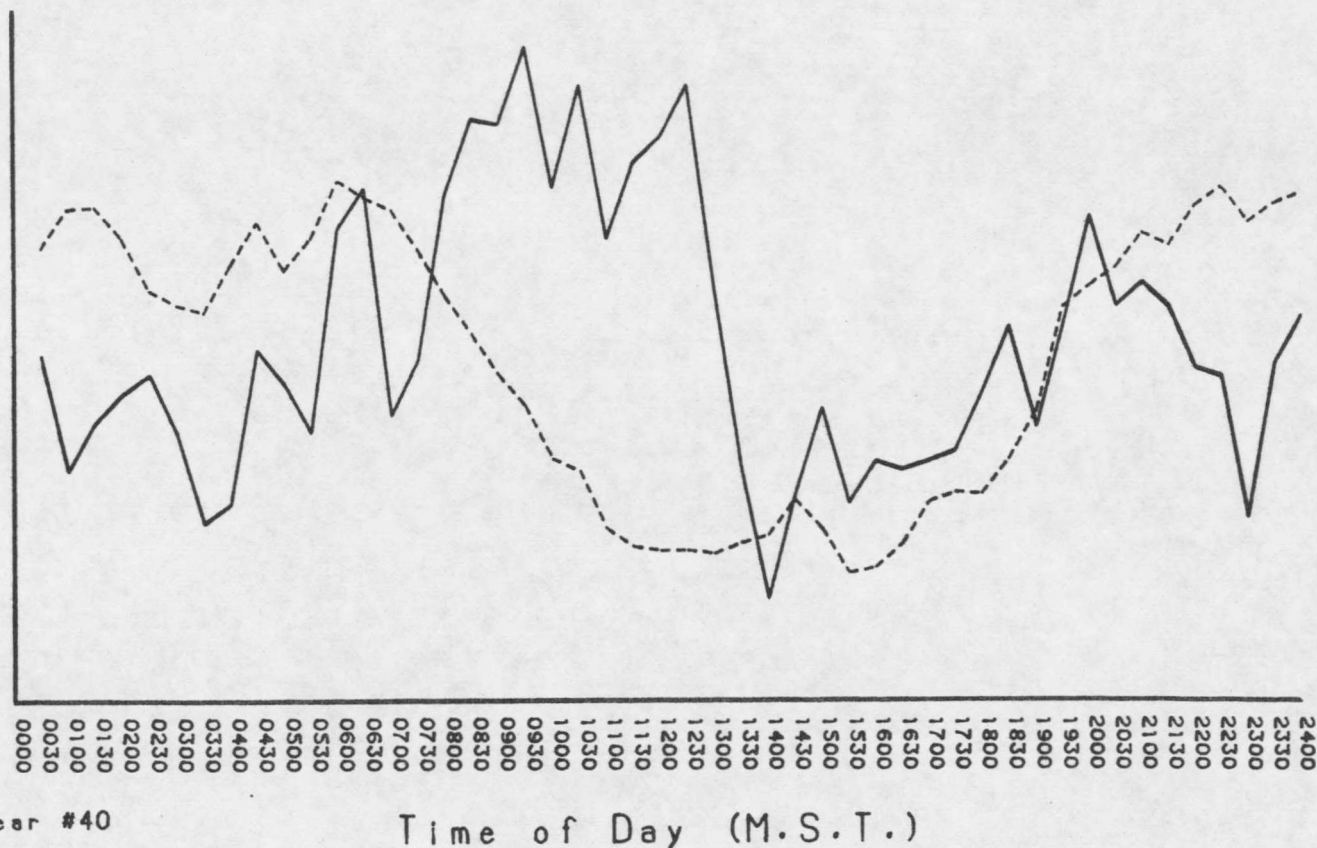


Figure 29. Comparison of the yearly average (spring-fall) activity patterns of Bear 40 and the other four study bears combined, 1979-1980. Points indicate the average number of minutes active per half hour time block (activity level). Seasonally non-weighted.

time until several kilometers away. In these instances, this circling behavior was only discovered with the aid of radio telemetry and verified with tracks. Data from human induced alterations on grizzly behavior was not used in the analysis of activity measures nor activity patterns. In all other observations the bears appeared unaware of our presence, and uniform activity patterns suggested that our impact on the activities of grizzlies was negligible.

Predation and the Use of Carrion

Of the 13 carcasses I inspected that were known to be fed upon by grizzlies, six were known to have been killed by the bear(s), two were known to be carrion, and the causes of death for the remaining five were undetermined. Two bull moose and two bull elk were killed when in excellent physical condition, indicated by femur marrow fat contents of approximately 90%, while one bull elk killed on 31 March 1980 had a femur fat marrow content of about 50%. Therefore, this bull elk was in poor condition and entering the first stages of emaciation (Cheatum 1949).

There were 24 observations of grizzlies feeding on different carcasses made during IGBS aerial radio tracking flights for 1979 and 1980. I inspected three of these carcasses, in addition to 10 other carcasses known to be fed upon by grizzlies which were located and examined from the ground. The approximate time of death for 21 of these 34 carcasses occurred from March to the end of May, while 10 of the remaining 13 died during a period from 1 August to the end of October.

All of the study bears were observed using carrion, and three were known to prey on elk. Of the 13 carcasses inspected and known to be fed upon by grizzlies, four out of the five study bears were involved in nine instances of feeding on different carcasses (one instance equals a study bear feeding upon a carcass). Study bears were involved in nine of the IGBS aerial observations of carcass use.

Observations by IGBS members and by this study indicate that Bears 15, 38 and 50 were all adept at preying on elk and did not restrict themselves to the use of carrion (Table 7).

Behavior of Grizzlies Using Carcasses as a Food Source

Grizzlies using carcasses as a food source were significantly less active ($p < .001$) than bears using other food sources. Generally they were much less active nocturnally and at sunrise, but about equally active at sunset (Figures 30-32). Diurnal activity, though averaging the same level as for grizzlies using other food sources, reached a fairly high peak at about 1400 hrs and troughs lower than the norm for late morning or early evening time blocks. Activity in general was more sporadic forming a less defined pattern (Figure 32).

Of the eight carcasses examined which were known to have been fed upon by a study bear, seven of them were either found by the bear, killed and/or dragged by the bear to sites within the canopy cover of timber. The one carcass (domestic cow) fed upon in the open was dragged to the site by the rancher, while the only other carcass that was partially fed upon in the open (10 m from the timber and within a

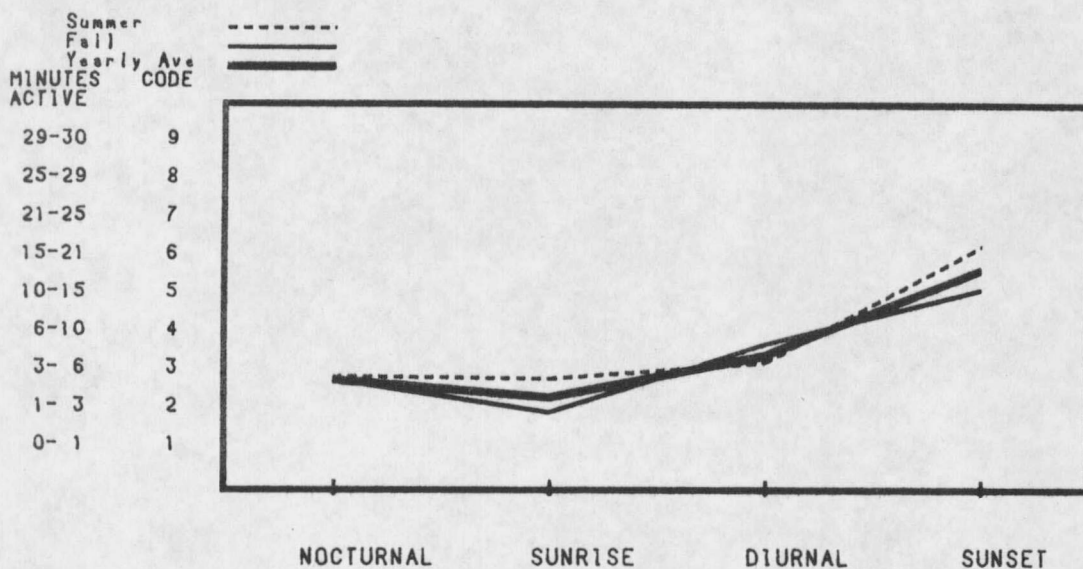


Figure 30. Relationship between the average activity level of grizzlies using a carcass as a food source and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.

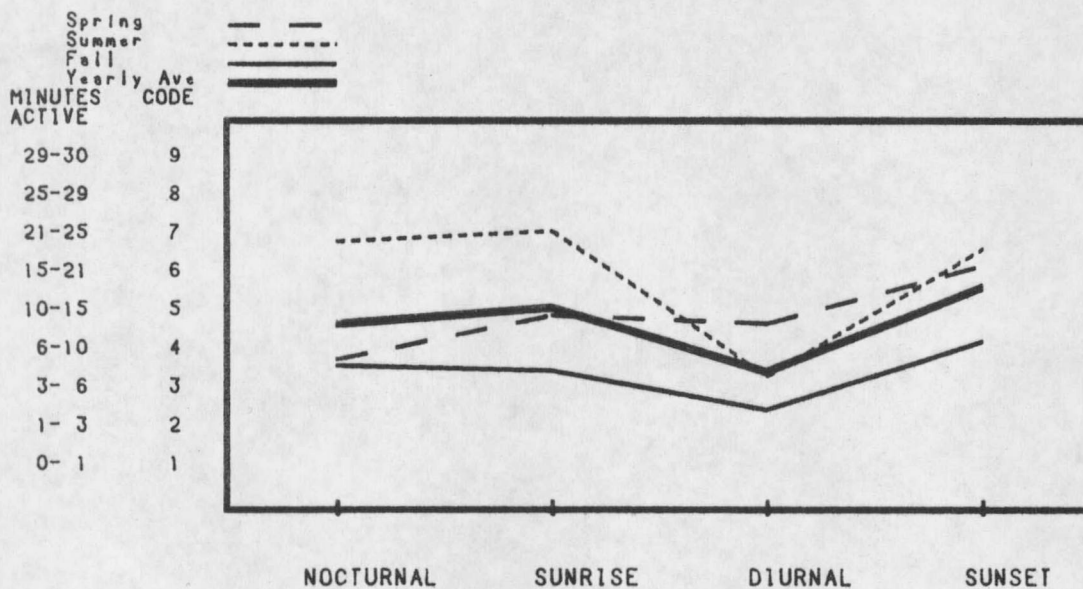


Figure 31. Relationship between the average activity level of grizzlies using food sources other than a carcass and nocturnal, diurnal and crepuscular periods, 1979-1980. The activity level is shown in minutes active per half hour time block.

Minutes Active	Code
29 - 30	9
25 - 29	8
21 - 25	7
15 - 21	6
10 - 15	5
6 - 10	4
3 - 6	3
1 - 3	2
0 - 1	1

Legend

— Not Feeding
 - - - - - Feeding on Carcass

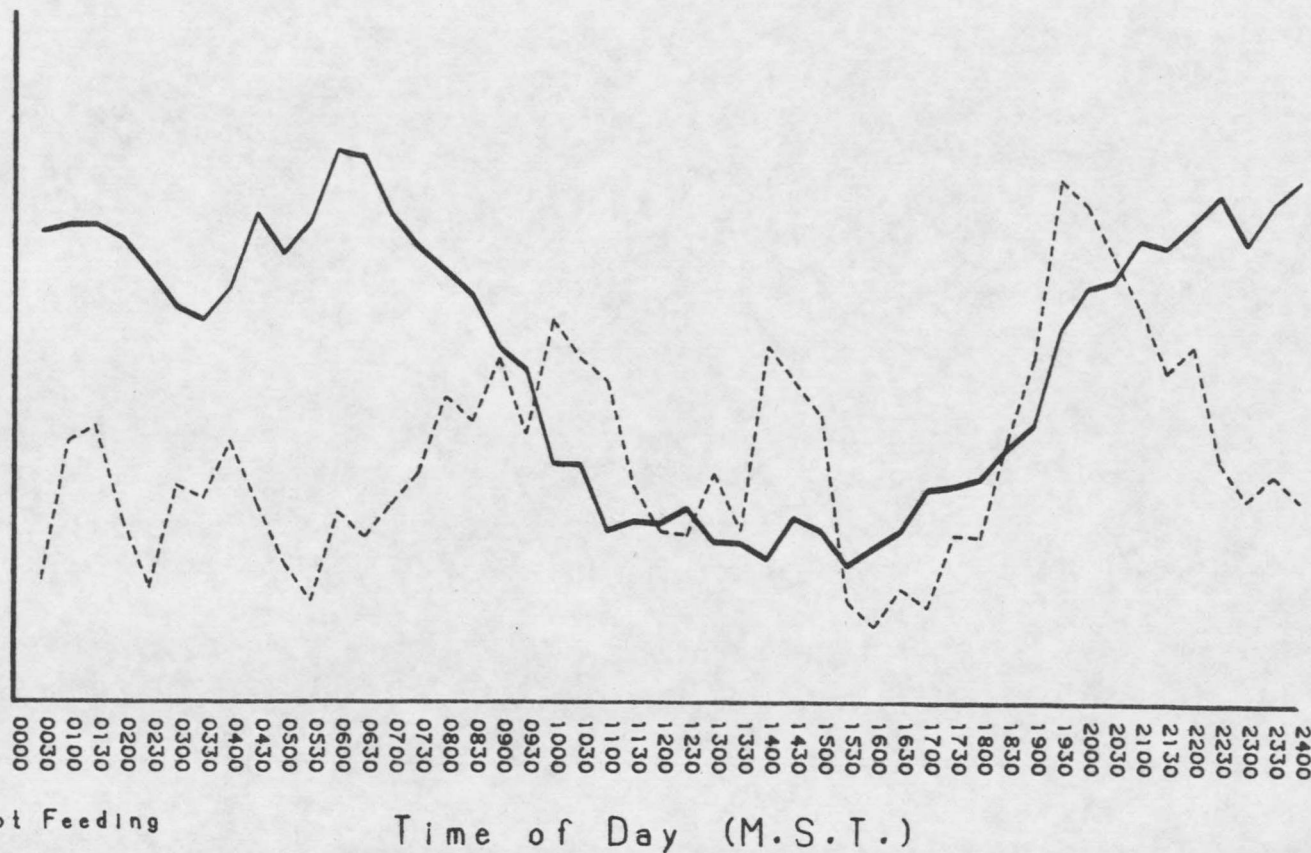


Figure 32. Comparison of the average activity patterns of grizzlies using a carcass as a food source and those using other food sources (not feeding), 1979-1980. Points indicate the average number of minutes active per half hour time block.

small 50 m² clearing) was later dragged by Bear 38 and her three yearlings to a site 15 meters inside the timber canopy (15 m from an opening), therefore in calculating the mean distance (for nine locations) from an opening, both of these locations were entered in. The mean distance from an opening for these nine feed-site locations was 27.5 m with a range from 5 m inside the timber to 140 m from the nearest opening (not including the site 10 m from the edge of timber).

Beds associated with carcasses differed somewhat from beds found at other sites in that they were generally scooped out deeper and appeared to be used several to many times.

Twenty-one of twenty-two bear beds found that were associated with a carcass were within 50 m of the carcass. The mean distance from the carcass for these 21 beds was 36 m. The mean distance for all 22 beds was 39 m (5 m - 110 m) from the carcass. Many times sites were found near a carcass (that was fed on by one of the study bears) that appeared to be bed sites though not typically scooped out. These probable bed sites were not included in the calculations of mean distances. When there was snow cover on the ground, bears were known to bed in the snow close to a carcass but many of these were not identified because of snow melt and/or disturbances by the bears and scavengers before the sites were investigated. On occasions a bear using a carcass was known to have bedded at approximately 500 m from the carcass, but no bed was ever found.

In my observations the carcass was typically covered with soil, vegetation and other debris sometimes forming a large mound (six out of the nine carcasses known to have been fed upon by a grizzly and

classified as either buried or not had at least been partially covered and three were known to have been covered with large mounds of soil).

Two of the three non-buried carcasses were near human disturbances (one 500 m from a ranch house and one 80 m from a road) which could explain their uncovered condition. This behavior may be a physical deterrent to avian and other small scavengers as well as an aid in diminishing the drift of odors which could attract other bears. The abundance of other bears, coyotes and other scavengers in the area appeared to determine the proximity of beds to a guarded carcass.

DISCUSSION

Amstrup and Beecham (1976) found that black bears in Idaho were more nocturnal, less diurnal, and less active in the early spring and late fall when compared to summer while Garshelis and Pelton (1980) reported similar results for black bears in Great Smoky Mountains National Park. Sizemore (1980) found that grizzlies near the South Fork of the Flathead River were more active during the night than during the day for the spring-summer period. No significant difference was found between day versus night activity during the summer-fall period. All of his bears were found to be active during all hours of the day. The activity of the summer-fall period was greater than the activity of the spring-summer period. Pearson (1975) determined activity patterns of grizzlies by direct observation during the daylight hours and the incidence of trap disturbances after dark. He found that activity was moderately high in the early morning, interrupted only by short rest periods. From approximately 1100 hours to 1500 hours activity dropped particularly during late autumn. Activity increased in the late afternoon and reached a peak at dusk. Trap disturbances were considerably greater after dark than during the daylight hours indicating that the markedly increased activity observed at dusk remained high for at least part of the night.

In contrast, this study suggested that although grizzlies were less active during the fall and spring, they were less nocturnal and

more diurnal than during the summer. Barnes and Bray (1967) working on black bears in Yellowstone National Park found that some bears were chiefly diurnal while some were nocturnal. This study indicated that on a yearly average grizzlies were nocturnal with crepuscular activity peaks. If the same seasonal changes in activity patterns as found by Amstrup and Beecham (1976), Garshelis and Pelton (1980) occur in the black bear population within the Yellowstone ecosystem, then a possible species niche separation is afforded the two species of bears present, for space by time of day. Possibly, black bears are forced to use certain activity periods due to social pressure as described for Peromyscus maniculatus by Farr and Andrews (1978), though in this case dominance would involve one species over another.

The pattern of black bear activity found by other authors is supported by trap capture and disturbance data gathered during the summer of 1981. Black bears within the Yellowstone ecosystem appear to be predominantly diurnal during the summer months, while grizzlies mimicked the nocturnal behavior revealed in radio tracking data. Three trap disturbances and thirteen captures of black bears during the summer months were known to occur during the diurnal (dawn to dusk) period while only two captures were known to occur during the nocturnal (dusk to dawn) period. Four other captures were thought to occur diurnally while for one capture the period was not known. In contrast 21 grizzly captures and two disturbances were known to occur during the dusk to dawn period and the three remaining captures were thought to occur nocturnally as well.

Two possible factors causing grizzlies to avoid open areas during the daylight hours of summer are probably the need for seclusion as well as the need for shade. Jonkel (1980) has noted that the heavy fur and dark-colored underfur could cause a temperature problem due to heat absorption under direct sunlight. Grizzlies foraging in the high, cool, secluded alpine zones may remain active in the openings for a longer period than bears using areas such as those most frequented by the study bears.

Food habits and availability also have a major influence on the patterns and duration of activity as well as the timing of activity peaks. There appear to be differences in the activity patterns among the study bears. These may be real or they may reflect differences in the time blocks and seasonal location that bear activity records (BAR) were taken for the individual bears, feeding habits, reproductive status, sex and age as well as peculiarities of individuals.

The two activity measures considered (activity level and probability of activity) gave remarkably similar results. Therefore, it appears that changes in total activity level don't result in changes in the distribution of activity across the variables. This possibly suggests that the activity pattern is wired into the animal rather than the environment, but the activity level is environmentally controlled (Picton, personal comm.).

The tendency for Bear 40's yearly activity pattern to display a diurnal to crepuscular rhythm (Figures 22 and 29), probably has much to do with the fact that the only months that he was monitored was April, May, June, and September (Table 3), with only 13 percent of

his 318 BAR occurring during June. Data from his 66 September BAR, however, indicated that he was active throughout much of the daylight hours and inactive throughout the night. The scant data on this bear for any one season, however, make conclusions very speculative.

Sizemore (1980) also had a male grizzly that displayed a peculiar activity pattern when compared to his other study bears in that it moved at all hours of the day and night during each season. An intra-specific social dominance, time territory mechanism as described by Farr and Andrews (1978), is a possible explanation for Bear 40's seemingly peculiar activity pattern.

Most of the data obtained for the months of August and September were based on one grizzly (Bear 50) feeding on an animal food source (elk and bison carcasses), which would decrease the overall probabilities of activity during these months and alter the daily rhythm. Data, however, suggest that such feeding habits are not uncommon during these months and the pattern thus, may still reflect an average seasonal activity pattern for many individual grizzlies within the Yellowstone ecosystem.

The activity patterns, use of preferred travel routes, feeding sites, and bedding areas by grizzly bears in the study area suggest that grizzly-human encounters could be reduced if certain precautions are taken.

Blanchard (1978) found that a high value was placed on the existence of grizzlies in her study area based on the response of registered recreationists. Since few hikers left the trails, the majority

of grizzly-human encounters occurred while the recreationist was on the trail.

My observations indicated that grizzlies frequent trails. In the Gneiss Creek area the trails were used almost nightly by grizzlies, however, the activity pattern exhibited by grizzly bears in the Yellowstone ecosystem was highly related to time of day. Activity was almost restricted to a period from dusk to daylight. With yearly and summer activity peaks both occurring at 0600 hours, grizzly-human encounters might be reduced substantially if hikers restricted their use of trails to a time period from about 1030 to 1800 hours. If a trail leads into the wind and/or visibility is poor, extra caution (Jonkel 1980), should be taken if one must hike at all.

In the four instances when the study bears were surprised at close quarters (within 100 m) by the observers, they always reacted by fleeing and always traveled from 3.2 km (2 mi) to many kilometers before stopping and remaining in an area. This indicates that grizzlies may avoid human activity and may react to disturbances at close quarters by moving elsewhere. This implies that with ever increasing numbers of people using "critical" bear habitat, the numbers of places where the bears can retreat will continually shrink and grizzly-human encounters will inevitably increase. Management policies limiting human use of certain areas seem to be of major importance for the grizzly's future. The closure to human use of grizzly bear congregation sites, as found along Flat Mountain Arm during the spawning run of cutthroat trout, (Salmo clarki) also seems to be a wise choice for allocation of space for bears and humans.

Field observations indicated that grizzlies may have preferred bedding areas often within dense stands of timber. Hiking through dense timber during the daylight hours would greatly increase the chances of a grizzly-human encounter (of surprising a grizzly in its day bed). To lessen future grizzly-human encounters, any grizzly bear use areas should be avoided when constructing trails, campsites, campgrounds, or other human recreational areas (Jonkel 1980).

Rogers (1976) reported that food availability greatly influenced the reproductive success of black bears in Minnesota. He theorized that if black bear energy reserves were low in autumn, the fertilized ova is not implanted during November or December. Picton (1978) noted that during autumns with much snowfall, the availability of grass, sedges, and pine nuts would be affected. During autumns with heavy snowfall, predation may thus be an important adjunct in supplying needed energy reserves.

Craighead and Craighead (1972) and Cole (1972) noted that carrion is of importance from March to May. Mealey (1975) suggested that animal material as food (mainly elk) is limited during the pre-growing season and that competition among grizzlies during this time may have a regulatory consequence for the grizzly population. However, if grizzlies become effective predators on ungulates such a regulatory effect would be dampened to some degree. Deep snow and certain snow conditions during this interval would improve the chances of such a situation occurring. My observations (Appendix A) indicate that grizzlies only have one-fifth the weight loading on the foot of ungulates. The regulatory mechanism would still be in operation, but effective

predation after mild winters when carrion is scarce, would dampen the oscillations of bear numbers thus ensuring more stable population numbers.

Cole (1972) noted that accumulations of snow that kept elk on limited areas coupled with "wintry" weather extending into May prolonged stresses on elk herds and increased their vulnerability to predation by grizzlies. He felt that grizzlies could be highly cursorial predators at times. His study also concluded that competitive scavenging and predation on elk by grizzlies was a natural adjunct to the regulation of elk numbers, but was not of major importance in the regulation.

Two of the Park's major predators on ungulate herds -- the wolf and the mountain lion -- were eradicated in the past for the most part. An ecosystem with fewer major predators, but increased malnutrition and starvation of ungulates would lead to a greater quantity of carrion left for the bears. Most ungulate deaths due to starvation (in Yellowstone National Park) occur from March to May (Houston 1978). Grizzlies emerging from their dens in late March and April would maximize finding carrion before the smaller scavengers located and devoured them. Houston (1978) found that an ungulate carcass was often devoured by coyotes and avian scavengers within 24 to 48 hours of the time it died or was killed. Thus emergence from the den may be keyed to the months when carrion is most available. "Walking carrion" numbers are also highest during this spring period. Craighead

(1979) reported that the sight of an ungulate incapacitated or struggling in deep snow, may arouse a grizzly's predatory instinct, but it could also be considered optimal foraging.

Most research has, however, indicated that predation on ungulates by grizzlies is an exception rather than a common occurrence. Observations during this study, however, indicate that predation on ungulates by grizzlies in the Yellowstone ecosystem may be much more prevalent than reported in the past. For a period in the spring, shortly after emergence from the den, I believe that predation, along with the use of carrion and white bark pine nut caches, are by far the most important food sources or nearly the sole food sources for certain individuals during certain years as indicated for Bear 15 and Bear 38. Actual predation on healthy ungulates during the fall may also be highly underrated in the literature.

Pearson (1975) stated that the grizzly is an opportunistic omnivore and although they have the capability of utilizing any food item, they concentrate on those that occur in quantities, sufficient for energetic input needs. The availability of large ungulates within the Yellowstone ecosystem not only supplies another potential food source for grizzlies through carrion, but also increases the probability that predation by grizzlies will occur. Houston (1978) noted that the elk population had increased in the Park from about 5,000 animals in 1968 to about 12,000-15,000 in 1976 since the end of the elk culling program.

There may be a real behavioral difference between the Yellowstone grizzly bear population and grizzly bear populations in other areas

because of this availability, just as the availability of spawning salmon in areas of Alaska make fishing a much more prevalent activity and food source than within the Yellowstone ecosystem.

Measures that benefit elk and other ungulates within the Park should in turn, benefit the grizzly. However, if the numbers of these ungulates becomes too large, heavy competition with bears for succulent forbs and grasses may occur (Graham 1978). The over-winter loss of ungulates from natural causes and due to natural regulation policies should not be considered a waste, as noted by Houston (1978), since these losses benefit the grizzly bear as well as other scavengers and insectivores. An overpopulation of ungulates would, however, result in a crash in the food base for grizzlies if a long term crash in ungulate numbers occurred due to range deterioration.

The frequent shifting to different bio-centers for the study bears without an apparent relationship to the type, quantity, quality or distribution of bear foods present may be related to exploratory movements or the foraging strategy of grizzly bears in the Yellowstone ecosystem. However, the IGBS has also noted particular individuals using a certain area during the same time period in consecutive years. The nutritive values of sections of habitat change occasionally as well as from year to year, and through exploration a bear should gain familiarity, thus better efficiency in exploiting the environment in the long run (Altmann and Altmann 1970, Armstrup and Beecham 1976). Shifts to other bio-centers may also be related to food items of seemingly minor importance due to infrequent occurrence or quantities

present in the diet of grizzlies but which are of essential nutritive value.

All the home ranges for the male study bears were greater in size than those for the females. During the breeding season, reproductively available female grizzlies in theory would amount to only about 1/3 of the adult female population, since the other 2/3 will be occupied with cubs of the year or yearlings. For males, minimal home range sizes may be determined by nutritional needs and habitat characteristics; however, for these males to be a reproductive success it is to their advantage to range over larger areas and have ranges that overlap those of many female bears. The size of an adult female home range should only be large enough to assure self-maintenance of the female and her young.

Although grizzlies use a wide variety of habitat types, they appear to select certain types (Blanchard 1978). Therefore, it is advantageous for their ranges to overlap in order that they can exploit their environment to the fullest. This is especially important during years when food productivity fluctuates (Pearson 1975). Grizzlies are omnivorous, within the Yellowstone ecosystem. Mealey (1975) found that vegetation represented 93.1% of the total importance value in the diet of grizzlies in the Yellowstone ecosystem. The digestive physiology of the grizzly was found to be adapted to a highly herbivorous diet, but these adaptations were found not to impair the ability to assimilate animal food material very efficiently.

Many bear-clawed trees were observed on the study area, and these are thought by some people to represent territorial markings by bears. These were observed mainly along traditional travel routes for grizzlies and in areas known to be used by numerous grizzlies of both sexes. Therefore, since territoriality was not found to be the rule, some tree markings may be the result of a sort of exercise to train and stretch muscles. Elgmork (1978) felt this was the explanation for the tree climbing activity he reported for brown bears in Norway shortly after the bears had left their dens.

Hornocker (1969) found that olfactory and visual marks served to facilitate avoidance between mountain lions. These markings, though not serving as territorial markings in the sense of defended territories, may also assist the avoidance reaction among grizzlies.

LITERATURE CITED

LITERATURE CITED

- Altmann, S. A., and J. Altmann. 1970. Baboon ecology: African field research. University of Chicago Press, Chicago. 220 pp.
- Amstrup, S. and J. Beecham. 1976. Activity patterns of radio-collared black bears in Idaho. J. Wildl. Manage. 40(2): 340-348.
- Barnes, V. G. and O. E. Bray. 1967. Population characteristics and activities of black bears in Yellowstone National Park. Final Report, Colorado Wildl. Res. Unit, Colorado State Univ. Fort Collins. 199 pp.
- Blanchard, B. 1978. Grizzly bear distribution in relation to habitat areas and recreational use: Cabin Creek - Hilgard Mountains. M.S. Thesis, Montana State Univ., Bozeman. 75 pp.
- Blanchard, B. 1980. Grizzly bear - timber relationships in the Yellowstone area. 5th Int. Conf. on Bear Res. and Manage. (In press)
- Cheatum, E. L. 1949. Bone marrow as an index of malnutrition in deer. New York State Conserv. 3(5):19-22.
- Chester, J. M. 1976. Human wildlife interactions in the Gallatin Range, Yellowstone National Park, 1973-1974. M.S. Thesis, Montana State Univ., Bozeman. 114 pp.
- Chittenden, H. M. 1949. Yellowstone National Park, Historical and Descriptive. Stanford Univ. Press, Palo Alto, CA. 286 pp.
- Cloudsley, J. and L. Thompson. 1961. Rhythmic activity in animal physiology and behavior. Academic Press. New York. 236 pp.
- Cole, G. F. 1972. Grizzly bear-elk relationships in Yellowstone National Park. J. Wildl. Manage. 36(2): 556-561.
- Craighead, F. C., Jr. 1968. Radio-tracking of grizzly bears in Yellowstone National Park, Wyoming. In Nat. Geog. Soc. Res. Rpts., 1963 Projects. Washington, D.C.: 59-67.
- Craighead, F. C., Jr. and J. J. Craighead. 1972. Grizzly bear prehibernation and denning activities as determined by radio tracking. Wildl. Monogr. 32. 35 pp.

- Craighead, F. C., Jr. 1979. Track of the grizzly. Sierra Club Books, San Francisco. 261 pp.
- Craighead, J. J., J. R. Varney, and F. C. Craighead. 1974. A population analysis of the Yellowstone grizzly bears. Montana For. and Conserv. Exp. Stn. Bull. 40. Univ. of Montana, Missoula. 20 pp.
- Craighead, J. J., M. G. Hornocker and F. C. Craighead, Jr. 1969. Reproductive biology of young female grizzly bears. J. Reprod. Fert. Suppl. 6: 447-475.
- Despain, D. G. 1973. Major vegetation zones of Yellowstone National Park. Yellowstone Nat. Park Info. Paper No. 10. 4 pp.
- Elgmork, K., O. Brekke, R. Selboe and S. Unander. 1978. Post-hibernation activity and habitat selection in a small remnant brown bear population (Ursus arctos L.) in southern Norway. Viltrevy (Swedish Wildlife): 10(5): 113-144.
- Farr, L., and R.V. Andrews. 1978. Rank-associated desynchronization of metabolic and activity rhythms of (Peromyscus maniculatus) in response to social pressure. Comp. Biochem. and Physiol. 61(A): 539-542.
- Fisher, W. A. 1960. Yellowstone's living geology. Yellowstone Library and Museum Assoc., Yellowstone Natl. Park, Wyoming. 62 pp.
- Garshelis, D. L. and M. R. Pelton. 1980. Activity of black bears in the Great Smoky Mountains National Park. J. Mammal., 61(1): 8-19.
- Graham, D. C. 1978. Grizzly bear distribution, use of habitats, food habits and habitat characterization in Pelican and Hayden Valleys, Yellowstone National Park. M.S. Thesis, Montana State Univ., Bozeman. 88 pp.
- Herrero, S. and D. Hamer. 1977. Courtship and copulation of a pair of grizzly bears, with comments on reproductive plasticity and strategy. J. Mammal. 58(3): 441-444.
- Hornocker, M. G. 1962. Population characteristics and social and reproductive behavior of the grizzly bear in Yellowstone National Park. M.S. Thesis. Univ. of Montana, Missoula. 94 pp.
- _____. 1969. Winter territoriality in mountain lions. J. Wildl. Manage. 33(3): 457-464.
- Houston, D. B. 1978. Elk as winter-spring food for carnivores in northern Yellowstone National Park. J. Appl. Ecol. 15: 653-661.

- Jonkel, C. J. 1980. Black, brown (grizzly), and polar bears. Big game of North America, Ecol. and Manage. Stackpole Books, Harrisburg, PA. 494 pp.
- Keefer, W. R. 1972. The geologic story of Yellowstone National Park. Geologic Survey Bulletin 1347. 92 pp.
- Kelsall, J. P. 1969. Structural adaptations of moose and deer for snow. J. Mammal. 50: 302-310.
- Kelsall, J. P. 1971. Studies of the physical adaptation of big game for snow. Snow and Ice In Relation to Wildl. and Recreation. Symp. Iowa State Univ., Ames. 146 pp.
- Kendall, K. C. 1981. Bear use of pine nuts. M.S. Thesis, Montana State Univ., Bozeman. 27 pp.
- Knight, R., J. Basile, K. Greer, S. Judd, L. Oldenburg and L. Roop. 1975. Annual report, 1974. Interagency Grizzly Bear Study Team, USDI National Park Service. 60 pp.
- _____, _____, _____, _____, _____. 1978. Yellowstone grizzly bear investigations. Annual report of the Interagency Study Team, 1977, USDI-National Park Service. 107 pp.
- Knight, R., B. Blanchard, K. Kendall, and L. Oldenburg, eds. 1980. Yellowstone grizzly bear investigations. Report of the Interagency Study Team, 1978 and 1979. USDI-National Park Service. 91 pp.
- Knight, R. and S. Judd. 1980. Grizzly bears that kill livestock. 5th Int. Conf. on Bear Res. and Manage. (In press).
- Mealey, S. P. 1975. The natural food habits of free-ranging grizzly bears in Yellowstone National Park, 1973-74. M.S. Thesis, Montana State Univ., Bozeman. 158 pp.
- _____. 1980. The natural food habits of grizzly bears in Yellowstone National Park, 1973-74. Proc. 4th Int. Conf. on Bear Res. and Manage. Ser. No. 3: 281-292.
- Murie, A. M. 1944. The Wolves of Mount McKinley. Fauna Nat. Pks U.S. No. 5, 238.
- Murie, A. 1948. Cattle on a grizzly bear range. J. Wildl. Manage. 12(1): 57-72.

- Mundy, K. and D. Flook. 1965. Notes on the mating activity of grizzly and black bears. J. Mammal. 45: 637-638.
- Pearson, A. M. 1975. The northern interior grizzly bear (Ursus arctos L.) Canadian Wildl. Ser. Rep. Series 34, Ottawa. 86 pp.
- Picton, H. D. 1978. Climate and reproduction of grizzly bears in Yellowstone National Park. Nature. 274: 888-889.
- Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. N. Am. Wildl. and Nat. Res. Conf. 41: 431-438.
- Schullery, P. 1980. The bears of Yellowstone. Yellowstone Library and Museum Assoc., Yellowstone Natl. Park, WY. 176 pp.
- Sizemore, D. L. 1980. Foraging strategies of the grizzly bear as related to its ecological energetics. M.S. Thesis, Univ. of Montana, Missoula. 67 pp.
- Sparrowe, R. D. 1968. Sexual behavior of grizzly bears. Amer. Midland Nat. 80: 570-572.
- Stickel, L. F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal. 35(1): 1-15.
- Tinbergen, N. 1953. Social behavior in animals. Methuen and Co., Ltd., London; John Wiley and Sons, Inc., N.Y. 150 pp.
- U.S. Department of Commerce. Natl. Oceanic Atmos. Admin. Envir. (NOAA). Climatological Data for Montana 1979-1980.
- U.S. Weather Bureau. Climatological data summaries for Montana. 1940-1969. GPO, Washington, D.C.

APPENDICES

APPENDIX A

DATA CONCERNING PREDATION AND THE USE OF CARRION,
TREE CLIMBING, AND REPRODUCTIVE BEHAVIOR

PREDATION AND THE USE OF CARRION

A Morphological Characteristic of Grizzlies That is Advantageous for Snow Travel

Grizzlies often travel extensively on deep snowpack after emerging from their dens in the spring. Visual observations of traveling bears and ungulates along with the inspection of tracks revealed a great difference in the ease of travel for bears as compared to artiodactyls during periods of accumulated snow. In the soft snow of early spring, moose and elk were observed sinking to chest height in snow, relying on the exhaustive process of plowing or bounding which quickly uses up dwindling energy reserves. Bears typically sank only slightly deeper than we did traveling on snowshoes, although we were weighted down with approximately 34 kg (75 lb) backpacks. Had we been merely on foot (without snowshoes or our backpacks), travel for any distance would have been unreasonably difficult to impossible.

A useful method to compare the relative adaptation of various species for traveling in snow is by comparing their weight-load-on-track measurements (Kelsall 1969, Kelsall 1971). The depth to which an animal sinks into snow depends upon the methods of locomotion, the weight-load-on-track, and the density, depth and hardness of the snow. If two species have comparable weight-loads-on-tracks, the species with a greater chest height would have the advantage over the other in deep, soft snow (Kelsall 1969). Animals that have lesser chest

heights may be compensated for by their having smaller weight-loadings and thus have the advantage in crusted, denser snow where they can walk on top of the snow surface (Kelsall 1971).

Kelsall (1971) compared foot loadings of male ungulates 4 1/2 years old and over for four species.

The results listed in Table 8 indicate that the five study bears (and probably most grizzlies within the Yellowstone ecosystem) are better adapted to traveling in snow with weight-on-load-on-track measurements of about 1/5 or less than that of elk, moose and bison. This would be particularly advantageous in dense snow with hard crusted layers. This allows for ease in roaming vast areas in search of carrion or in capturing weakened prey species during the early post-denning phase when accumulations of snow are great. A person traveling without snowshoes has a disadvantage (with a walking weight loading of about 340 gm/cm^2) compared to a traveling bear (196 gm/cm^2 for the study bears). A person on snowshoes, however, has the advantage over a grizzly even when carrying a heavy (34 kg) backpack with a weight loading of about 61 gm/cm^2 (traveling). Even a very large bear, such as Bear 9 (an adult male instrumented by IGBS members, but not one of my study bears, that had a 324 kg fall weight), has an advantage in snow because of smaller traveling weight loadings (248 gm/cm^2 fall estimate) over a human without snowshoes or ungulates such as elk.

A bull elk that Bear 38 killed was located in a small (40 meters wide by 60 meters long) southeast facing Park at midslope at an elevation of 2097 meters. At this site on the date the bear(s) made the

Table 8. Estimates of track area, standing weight-load-on-track (in gm/cm²), and traveling weight-load-on-track (for careful travel; one foot off the ground) for 6 grizzlies, a human (with and without snowshoes and/or 34 kg backpack), and 4 species of ungulates (4 1/2 years old and over) from Kelsall's (1969, 1971) works.

Species and Description	Track Area of Front Feet (cm ²)	Track Area of Hind Feet (cm ²)	Total Track Area (cm ²)	Estimated Spring Wt. kg lbs.	Standing Wt. Load (gm/cm ²)	Traveling Wt. Load (gm/cm ²)
Griz. Bear 40	478	426	904	124 275	138	184
Griz. Bear 50	402	376	778	109 240	140	186
Griz. Bear 35	578	524	1102	158 350	144	192
Griz. Bear 38	535	486	1021	158 350	155	207
Griz. Bear 15	608	546	1154	181 400	157	209
Mean of the 5 Study Bears	520	472	992	146 323	147	196
Griz. Bear 9 (Spring Wt.)	730	668	1398	260 575	186	248
Griz. Bear 9 (Fall Wt.)	730	668	1398	324 715	231	308
Human (Size 10 1/2 Hiking Boot (no Backpack))	---	(one boot) 253	506	86 190	170	340
Human (Size 10 1/2 Hiking Boot with Backpack)	---	(one boot) 253	506	120 265	237	474
Human (with Snowshoes no Backpack)	---	(one snowshoe) 1959	3918	86 190	22	44
Human (with Snowshoes and Backpack)	---	(one snowshoe) 1959	3918	120 265	31	61
Elk (Females, Kelsall 1969)	99	94	193	261 577	676	907*
Moose (Males Kelsall [1969])	---	---	(Hoof Area Only) 499	455 1005	922	1235*

Table 8. Continued

Species and Description	Track Area of Front Feet (cm ²)	Track Area of Hind Feet (cm ²)	Total Track Area (cm ²)	Estimated Spring Wt.		Standing Wt. Load (gm/cm ²)	Traveling Wt. Load (gm/cm ²)
				kg	lbs.		
Moose (Males Kelsall 1971)	---	---	---	--	---	710	951*
Elk (Males)	---	---	---	--	---	780	1045*
Bison (Males Kelsall 1971)	---	---	---	--	---	910	1219*

* = Traveling Weight-Load-On-Track estimates using Kelsall's (1969, 1971) Standing Weight-Load-On-Track estimates.

- = No data or not applicable.

kill, the snow depth had been judged to be about 90-110 cm deep. Kelsall (1969) noted that snow depths of about 30 percent less than chest heights of ungulates, severely hinder their travel. Kelsall (1971) found that the mean chest height for male elk 4 1/2 years old and over was about 89 cm. Typical snow depths in the area of the kill was about 110 cm which would greatly hinder travel for elk allowing them to sink to chest heights.

Predation

Knight and Judd (1980) reported that certain grizzlies learn to prey on domestic livestock whereas others never become such problem makers. Knight (1977) has also noted that certain grizzlies become adept at preying on elk even during the summer months. Bear 6 was observed guarding elk she had killed on several occasions during the summer of 1977. Mealey (1975) reported on the predation of a mature (7-9 year old) bull elk by a grizzly during the breeding period for elk. Bear 50 also provides an example of an individual with predatory ability.

From 18 July 1980 to 19 August 1980 Bear 50 appeared to have lost at least 23-27 kg (50-60 lbs), was very gaunt, and looked to be in very poor physical condition. This observation was made after she had finished consuming a large bull elk, but the reason for her loss of condition was unknown. She was not sighted nor monitored from the ground for nearly two months until early in October when she was found to be feeding on whitebark pine nuts and a bull elk she had killed.

A sighting of her on 14 October 1980 indicated that she was in excellent physical condition having gained in excess of 45 kg (100 lbs). Her large gain in weight along with her growth of a thick winter coat made her not even resemble the bear we sighted two months earlier. Both Jonkel (1980) and Knight (personal communication) have noted the capability of grizzlies to gain weight at the rate of several pounds per day if they have a good supply of nutritious food. It's believed that she had been very successful at preying on ungulates during this interval. She had displayed her efficiency at preying on elk before the rutting season of elk and it is assumed that her efficiency would have increased during the rut (September to early October) since these ungulates become increasingly less wary as the rut peaks:

Bear 50 was known to be using whitebark pine nuts heavily during the early part of October, even during a 7-9 day period when she had an elk kill nearby. The possession of this elk, thus did not preclude other foraging activities which is consistent with Mealey's (1975) findings. Both pine nuts and elk meat are highly nutritious with protein contents at 11.9 percent and 88.2 percent, respectively, and respective digestibilities of 73.6 percent and 78.1 percent (Mealey 1975).

Behavior of Grizzlies Using Carcasses as a Food Source

Grizzlies using carcasses typically drag them into the timber and bed fairly close to the carcass. Six of the nine carcasses classified as being cached or not, were covered with dirt, vegetation and debris. Knight (1977) and Hoskins (personal communication) reported

that one adult male (Bear 19) killed two elk and went to the trouble of burying the remains in a large rectangular hole (2 m in width by 3.5 m in length) approximately 1 m deep. He also buried parts of a bison carcass in a similar hole. Knight (1977) observed an adult female grizzly (Bear 6) covering an elk carcass with soil and vegetation and within 100 yards of her were another female grizzly with three yearlings and a lone grizzly. Two days later she was observed still in possession of the carcass, but lame in the left front foot. She was believed to have actively defended the kill against the other bears. This caching behavior is not a common technique for the black bear as it is for the grizzly (Schullery 1980; Knight, personal communication).

The Caching of Carcasses

It was noted earlier that both Bear 50 and Bear 15 were known to have cached carcasses and left the vicinity for up to four days (in Bear 50's case). No direct evidence was available to indicate why they had left their caches. My observations as well as those of IGBS trapping crew members do not support the idea that grizzlies prefer putrid meat. Putrid meat, though much easier to detect and locate, for a bear, is not always chosen over fresh meat when both are offered at a trapping site. The bears tend to be individualistic, however, some do seem to prefer meat when numerous maggots are also present as do many scavengers. I do not think that the caching behavior (caching a carcass then leaving for up to four days) displayed by Number 50 and Number 14 was due to a preference for aged meat. In these cases

I feel that an easy opportunity arose for preying on elk and the bears, though fairly satiated, took advantage of it, killing, then caching it for later use.

Tree Climbing

It is generally assumed that an adult grizzly cannot climb trees unless ladder-like limbs enable it to do so. However, claw marks and a trail of grizzly hair indicated in four instances that grizzlies climbed trees without ladder-like limbs in order to obtain or in attempts to obtain meat which had been hung from a tree as an attractant to IGBS trapping sites. The climbs ranged from 3 to 12 m in height (mean = 8 m) and the trees varied in size from 25 cm to 2 m d.b.h. The claw marks indicated that on the smaller diameter trees the bears grasped the side of the tree opposite their body with the front claws while clawing and pushing with their hind legs on the side of the tree that their body was oriented.

Reproductive Behavior

Pair Bonding

My observations indicate that pair bonds between "mates" may last as long as two months or more. On 23 April 1980, a smaller set of grizzly tracks (115-120-mm-wide front track) accompanying Bear 40 indicated he had probably paired with a female. These bears were sighted on 24 April 1980, confirming that they were, in fact, together. From the date of this sighting until the date that Bear 50 was first captured on 15 May 1980, evidence indicated that No. 40 was

still paired with the same female (with 115-mm-wide front tracks). Bear 50 was found to have front feet that were also 115 mm wide, and the descriptive size and coloring of the unmarked bear (based on two sightings) also matched that of Bear 50; therefore, it is believed that she is the female he originally paired with. On 21 May 1980 Bears 40 and 50 were located together during the first radio-tracking flight made after No. 50's capture. From this time until 17 June 1980, these bears were known to be paired with only a single 1- to 2-day split-up. Neither bear was located again by air or on the ground until 1 July 1980 when the bears were about 8.7 km apart. Therefore, the pair bond was broken sometime between 17 June 1980 and 1 July 1980. This breeding pair were bonded at least 56 days.

The only other pair bonding I observed for the study bears during the two field seasons was for Bear 35. We found tracks of a smaller bear with No. 35 on 7 July 1980, and the next day we sighted him with a smaller (approximately 113 kg) smokey gray-colored female with frosty blond grizzling traveling to their day beds. Neither the beginning nor duration of this pair bond was known.

Based on IGBS aerial flight data (Tables 9 and 10), May was the month when the most "possible breeding pair" observations were made during both 1979 and 1980, with seven and 10 observations, respectively. In 1979, six of the seven observations were made during the first 10 days of May, while in 1980 all 10 observations occurred between 12 and 22 May. During 1979, no observations were made in the month of June, which is usually considered the month when the rut peaks. Two observations were made in July, while the earliest and

Table 9. IGBS aerial flight data on possible breeding pairs of grizzlies sighted or located (radio) together during 1979.

Male Bear No. or Approx. ¹ Weight	Female Bear No. or Approx. Weight ¹	Date 1979	Location
UM 500 lb. grizzly	12	April 16	North of Witch Creek near a moose kill. Bear 12's 2-year old not seen in the area.
36 UM grizzly	UM approx. 275 lb. 26	April 27 May 3	Beaverdam Creek On NW ridge of Prospect Peak
2 UM grizzlies, one larger, one the same size as Bear 26	26	May 7	Carcass of an elk east of Prospect Peak
UM large griz- zly	21	May 7	On ridge between Hoodo Creek and Lodgepole Creek
14 40	12 UM larger grizzly	May 7 May 10	NW of Heart Lake On elk carcass on Alum Creek
2 UM grizzlies	26	May 10	On elk carcass east of Prospect Peak
1 UM grizzly	26	May 21	On Prospect Peak asleep on top on a snowbank
22 22	UM approx. 300 lb. 3 UM grizzlies all about 400 lbs.	July 16 August 17	Bear Creek In meadow on Jones/ Bear Creek ridge
2 UM grizzlies, one about 375 lbs. other bear about 225 lbs.	26	August 29	West of Prospect Peak
1 UM grizzly, 300-350 lbs.	1 UM grizzly about 125-200 lbs.	October 11	Woody Creek
15	38	August 10- 13, 1978 ²	Fir Ridge Mt.

¹UM = Unmarked

²1978 observation on Bear 15 and Bear 38

Table 10. IGBS aerial flight data on possible breeding pairs of grizzlies sighted or located (radio) together during 1980.

Male Bear No. Approximate Weight ¹	Female Bear No. or Approx. Weight ¹	Aerial Flight Date	Location
40	UM smaller bear (No. 50?)	April 28	Rabbit Creek
UM 450 lb. bear	26	May 12	NE of Prospect Peak
UM 450 lb. bear	26	May 15	Lower Blacktail Crk
51	26	May 21	Between Folsom and Prospect Peak
UM 500-530 lbs.	UM approx. 175	May 21	On eastern ridge of Prospect Peak
?Tracks in snow of another adult bear with Bear 8	8	May 21	West side of Thun- derer
40	50	May 21	East of Arnica Crk
40	50	May 27	
UM 250 lb.	12	May 27	Flat Mtn Arm Crk
UM 500 lb.	UM 300 lb. griz- zly	May 22	South of Crescent Hill
UM 450 lb.	UM 300 lb. griz- zly	May 22	In Cache Lake
40	50	June 9	One mile north of Beach Lake
51	UM 350 lb. griz- zly	June 12	.75 km west of Blacktail Creek
40	50	June 17	Sentinel Creek
UM 350 lb. grizzly	UM 300 lb. griz- zly	June 24	Carnelian Creek
1 ²	21	Sept. 2	Papoose Ridge
35 ²	UM 250 lb.	July 8	.75 km NE of Whits Lake
40 ²	50	April 26- June 17	Traveling together within their annual use ranges

¹UM = Unmarked

² = Ground observation

latest observation dates for observed "possible grizzly mated pairs" were 16 April and 11 October 1979, respectively. During 1980 there were no aerial observations made in July, while one ground observation was made during this month, but there were four made during June. The earliest and latest dates when such aerial observations were made during 1980 were 28 April and 2 September, respectively.

Actual mating activity was observed between Bear 40 and Bear 50 on 12 June 1980. Copulatory as well as non-copulatory mounts were followed by short interims of rest and/or grazing as described in detail in the case histories (Appendix C).

Reproductive Biology

Craighead, Hornocker and Craighead (1969) stated that precopulatory behavior was observed as early as 14th May and postcopulatory behavior as late as 15 July, however, 80 percent of all copulations occurred in June. Craighead (1979) stated that it was essential to grizzlies that the males meet and mate with females during the two to three week period that the females are in estrus (psychologically and physiologically receptive to copulation with males). The bears congregating (at dumps) in early spring as they had done for 80 years previously, would help assure that nearly all females in estrus would be bred.

Many observers have reported on the mating and copulation between grizzly bears (Murie 1944; Hornocker 1962; Mundy and Flook 1965; Sparrow 1968; Craighead 1969; Pearson 1975, and Herrero and Hamer

1977). Compiling these works one learns that grizzlies may be promiscuous coming together for only a few hours to copulate and then part (Hornocker 1962), or they may form pair bonds lasting up to 23 days (Murie 1944). My observations show that pair bonds between "mates" may last as long as two months or more.

Observations during this study seem to indicate that individuals or populations of grizzlies that do not congregate (where food is readily obtainable, for instance), may exhibit a different pattern of breeding behavior than that observed by Hornocker (1962).

Due to closure of the dumps since the Craighead (1972) and Hornocker (1962) studies, most of the major congregations of bears no longer occur outside of the June - August concentration of bears fishing a few tributaries of Yellowstone Lake. Large berry crops are rare in the Yellowstone ecosystem so typical summer to fall concentrations in such areas are also highly limited.

From May 21 to July 16, Pearson (1975) made 12 observations of male-female associations where the male displayed sexually aggressive behavior. By examining grizzlies killed by sport hunters spermatozoa were found in the testes of males as early and late as May 22 and August 23, respectively. Follicular development within the ovaries of females had commenced as early as May 16 and the vulva showed some swelling by May 25. During June and early July the height of the breeding season occurred. Although the culmination of breeding was not clearly defined, vulvar swelling was much reduced by August 4 and by August 14 no follicular activity was observed in the ovaries. These findings agree closely with evidence found during this study

and seem to indicate that although the peak of the breeding season occurs from June to mid July, male-female associations and/or mating may span from May to early September. With the phenomena of delayed implantation found among the ursids, such a wide span for dates of conception would have little or no effect upon the critical timing for development and birth of cubs. The survival value of this physiological mechanism for an animal that must nourish the fetuses and suckle young while fasting for about six months has been reported by Craighead (1979).

A mechanism for increasing the odds of males and females meeting would be a behavioral pattern where males and females paired up upon early spring meetings and once they have determined that one another are a good genetic investment, a lengthy pair bond is formed until the female has gone through her estrus cycle and was bred. It is assumed, however, that this behavior is inherent in the grizzly population and need not depend upon a behavioral change. Although some grizzlies within the Yellowstone population are thought to be promiscuous or form very loose and/or short-term pair bonds, some individuals are known to form lengthy pair bonds. This lengthy pair bond would seem more beneficial (for non-congregating grizzly populations) since mates would be harder to find and should be defended from a surplus of males (Herrero and Hamer 1977).

Fighting

Bear 15 was known to have fought Bear 20 on 13 May 1980 and since no carcass was found in the vicinity and the sterile understory held little bear foods, it was not likely that this aggressive behavior

was due to competition for food. Possibly the fight occurred because of a violation of one of these male's critical distance as described by Pearson (1975) since the breeding season would be beginning to break down their avoidance reactions. It is unknown whether either male had been with or was following a female at the time of the fight, but a fight over a female seems likely since this occurred during May, the month during which the most breeding pairs were observed.

Fighting among individuals within a population is reduced by the development of a dominance hierarchy which relates to the survival of individuals as well as the species (Tinbergen 1953). Hornocker (1962) reported that most of his observations on fighting and aggression were related to competition for food or among males during the breeding season. He also found that aggressive males were generally the successors when competing for females in estrus.

Three of the adult male dominance classes (aggressive, defensive, and cautious) described by Hornocker (1962) varied as to specific reproductive behavior. However, none of the males in these classes were observed to defend a certain female although some appeared to be paired with a single female for periods up to several days. The dominant male in each of the three years of his study and a single subdominant male were the only males observed to defend a particular female. At congregation sites where his study occurred, the chances of a male losing his "mate" to another male would be greatly enhanced; thus, polygamy should be favored under these conditions.

An avoidance reaction described by Pearson (1975) now appears to be the mechanism whereby grizzlies within the Yellowstone population

reduce fighting. The dominance hierarchy as described by Hornocker (1962) probably has broken down for the most part since frequent meetings by bears, as would have occurred in a dump situation are needed to keep such a mechanism going.

The Family Unit

During the spring of 1979, No. 38 came out of her den in mid-April and had three male offspring which were probably sired by Bear 15 since these two bears were known to be paired for a short period during mid-August of the previous summer.

Observations of No. 38 during the summer of 1979 indicated that she was a "good mother", keeping close watch on her three cubs. Observations of this family unit indicated that the largest of the cubs was more aggressive and ranged farther from his mother than the other two cubs. Bed sites inspected that were used by this family group also indicated that one of the cubs was more of a loner, for one cub bed was found on several occasions as much as 25 m from the other three beds, which were always located less than 1 m from one another. The group denned together during late November 1979 and left their den sometime between 19-24 March 1980.

In June 1980 the two smaller yearlings (Bears 54 and 55) were instrumented with expandable radio collars designed for young bears (Knight 1980), while the larger, more solitary yearling was not recaptured.

It is not known when Bear 38 separated from her three yearlings. After her capture and release (on 11 June), an aerial flight was made on 16 June 1980 and they were no longer together.

This split-up of Bear 38 with her family in 1980 may have been triggered by the onset of rutting activity since it occurred about 11 June and lasted until approximately 22 July when Bear 54 had reunited with No. 38. This breakup coincided with the time period when grizzly bear breeding activity is high; however, Bear 38 did not have offspring the following year. Female grizzlies are known to breed occasionally after the weaning of yearlings (Craighead, Hornocker and Craighead 1969, Knight, personal communication).

The three yearlings remained together for only about a week or two, then separated. Bears 54 and 55 reunited by 11 July 1980. The aggressive sibling apparently did not reunite with his family. Nos. 54 and 55 remained in the company of one another until about 22 July when Bear 55 had split with Bear 54 and reunited with No. 38. By 25 July Bears 54 and 55 were traveling together once again while their mother was alone. After this, Bears 54 and 55 remained together but apart from their mother until about 7 August when Bear 54 rejoined his mother for several days only to part from her once more and join Bear 55. These two bears then remained together but apart from their mother until about 7 October when Bear 54 and Bear 55 could no longer be located due to the loss and failure of their collars, respectively. The third yearling had not been sighted in the company of his brothers since 16 June and was thought to be traveling alone. Bears 54 and 55 were thought to have denned together.

The reuniting of Bear 38 with one or more of her siblings from time to time probably occurred after she had ceased entering estrus and probably resulted from a weak, but somewhat tolerant bond between her and her offspring during this interval.

The split-up of Bears 54 and 55 from their more solitary sibling (G-9) probably was due to the individualistic behavior witnessed for this yearling male.

APPENDIX B

AERIAL MONITORING HISTORY FIGURE AND CARCASS USE TABLES

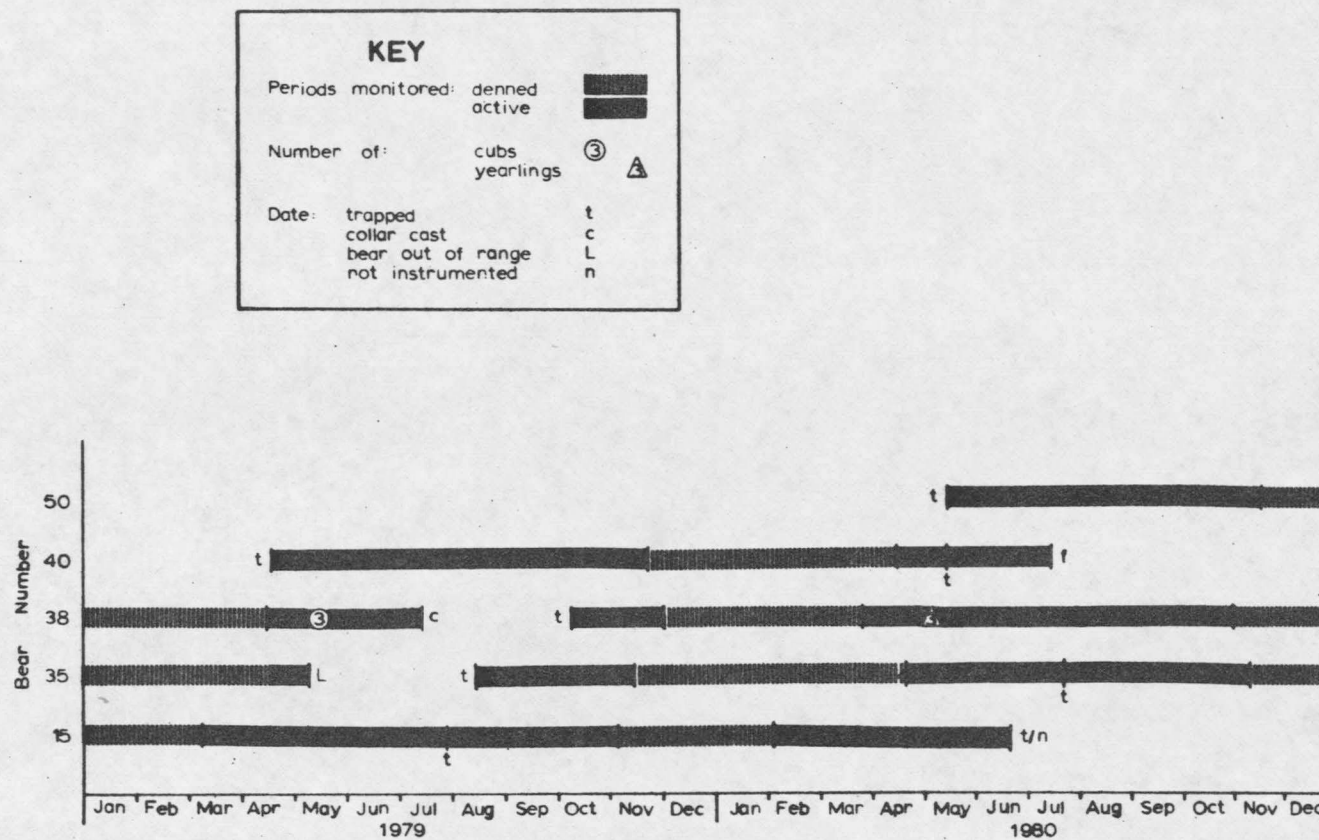


Figure 33. Aerial monitoring histories of the five study bears during 1979 and 1980.

Table 11. Summary for carcasses inspected and known to be fed upon by grizzlies during 1979 and 1980.
Classes of femur marrow according to Cheatum (1949).

Bear No.	Species and Description of Carcass Species	Sex	Evidence of Kill or Carrion	Age of Animal at Death	Class of Femur Marrow	Approximate Date of Death of Animal	Distance (in meters) of Carcass to Opening(0) or Timber(t)	Carcass Buried (Cached)	Location (drainage) of Carcass	Number of Bear Beds Found at Carcass	Distance (in meters) of Bed(s) to Carcass or Range
38 + (Yrlgs)	Elk	M	Kill	4	5	March 31, 1980	10 m to (T) then drug to 15 m to (0)	Yes (Partial)	Gneiss Creek YNP	7 & (SB) 1 & (SB)	50 (all) 40
38 + (Yrlgs)	Elk	F	UK	3	UD	Early to Mid-March (1980)	5 m to (0)	Yes (Partial)	Gneiss Creek YNP		
15	Elk	M	Kill	UK	UK	April 3, 1980	20 m to (0)	UK	Gneiss Creek YNP	UK	UK
35, 38 54, 55	Beef Cattle	UK	Carrion (killed by lightning)	UD	UD	July 1, 1980	In Open	No (near ranch house)	Grayling Creek	0--near ranch house	UK
50	Elk	M	Kill	6 1/2	1	August 12, 1980	8 m to (0)	Yes (Partial)	Firehole River YNP	4	5 - 40
50	Elk	M	Kill	4 1/2	1	September 29, 1980	140 m to (0)	Yes	Delacy Creek YNP	9	15 - 110
50	Bison	M	UK	7-11	5	October 18, 1980	20 m to (0)	No	Tangled Creek YNP	UK	UK
50	Elk	M	Carrion (road kill)	UD	UD	October 24, 1980	10 m to (0)	No Near road)	Firehole River YNP	0--carcass near road	UK

Table 11. Continued

Bear No.	Species and Description of Carcass		Evidence of Kill or Carrion	Age of Animal at Death	Class of Femur Marrow	Approximate Date of Death of Animal	Distance (in meters) of Carcass to Opening(O) or Timber(T)	Carcass Buried (Cached)	Location (drainage) of Carcass	Number of Bear Beds Found at Carcass	Distance (in meters) of Bed(s) to Carcass or Range
51	Moose	M	Kill	7	1	October 1-24, 1980	30 m to (O)	Yes	Cascade Creek YNP	UK	UK
51	Moose	M	Kill	9	1	October 1-24, 1980	30 m to (O)	Yes	Cascade Creek YNP	UK	UK
10?	Elk	UK	UK	8	1	May-June 1980	100 m to (O)	UK	Republic Creek	UK	UK
42	Bison	UK	UD	UD	UD	June 11, 1980	UK	UK	NW Edge of Hayden Valley	UK	UK
41	Elk	UK	UD	UD	UD	August 1, 1979	UK	UK	Antelope Creek	UK	UK

* UD = Undetermined
 UK = Unknown
 (SB) = Snow beds

Table 12. Summary of IGBS aerial observations of grizzlies feeding on carcasses during 1979.

Bear No. or Approximate Weight	Species of Carcass	Carriion or Kill	1979 Flight Date	Meters From Timbers Edge	Location
15	Elk	UK	March 10	UK (in open)	South of Gneiss Creek
36	UK carcass	UK	March 16	At timbers edge	At mouth of Beaverdam Creek
15	Elk	UK	March 20	At timbers edge	On southern bank of Gneiss Creek
UM 350 lb grizzly	Elk	UK	March 23	75 m (in open)	Southeast Arm
15	Elk	UK	March 23	500 m (in open)	Richards Creek
12 and an UM 500 lb grizzly	UK carcass	UK	April 16	UK (in timber)	North of Witch Creek
40	Elk?	Kill?	April 27	UK	Mez Perce Creek drainage
26 and two UM grizzlies. One larger, Bear 26 and one the same size as Bear 26.	Elk	UK	May 7	UK	East of Prospect Peak
32	Elk	UK	May 7	UK	Phlox Creek
6 and cubs	Elk?	Kill?	May 7	UK	Surprize Creek
40 and an UM, larger, darker grizzly	Elk	UK	May 10	20 m (in timber)	Alum Creek
26 and 2 UM grizzlies, one larger than Bear 26 and one same size as #26	Elk	UK	May 10	UK	East of Prospect Peak. Same elk carcass as observed on May 7.
26	Elk		June 4	In meadow	Pursuing elk in a sage meadow on Blacktail Plateau near Lupine Creek
42	Elk	Kill?	October 3	UK. At edge of small pond.	West of Magpie Creek

UK = Unknown.

UM = Unmarked.

Table 13. Summary of IGBS aerial observations of grizzlies feeding on carcasses during 1980.

Bear No. or Approximate Weight	Species of Carcass	Carriion or Kill	1980 Flight Date	Meters From Timbers Edge	Location
*38	Elk	UK	March 24	5 m (in timber)	Gneiss Creek
*38	Elk	UK	March 26	5 m (in timber)	Gneiss Creek (same carcass and location)
*38	Elk	Kill	April 3	5 m (in open)	Gneiss Creek
15	Elk	Kill	April 3	20 m (in timber)	Near head of Gneiss Creek NE of
One UM female grizzly, approx. 250 lbs with 3 youn (175-200 lbs each)	Elk-- also 2 elk carcasses up the ridge from the bears	UK	April 21	At timbers edge	Mt. Washburn just above canyon rim
32	Elk?	UK	April 21	At timbers edge	SE of Hawks Rest
UM grizzly, approx. 500-550 lbs	Elk	UK	April 24	UK	On NE ridge of Mt. Washburn; elk carcass observed on April 21, 1980 gone
35	Moose	UK	April 28	5 m (in open)	1-1 1/2 miles from the head of Grayling Creek
2 UM grizzlies; 200 lbs each	Elk	UK	May 21	250 m (in open)	E of Geode Creek
*42	Bison	UK	June 25	UK	NW edge of Hayden Valley
			July 28		
49	Gut pile from hunter killed elk	Carriion	October 20	UK	Pass Creek
36	Elk	Kill	October 20	30 m (in timber)	Trappers Creek

UK = Unknown

UM = Unmarked

*Inspected on ground

APPENDIX C

CASE HISTORIES

ACTIVITY PATTERNS

Walking Lethargy

Shortly after emerging from their dens, many bears have been reported lying next to or near the vicinity of their dens for a considerable period of time, often for as long as 1 or 2 weeks (R. Knight, D. Stradley, R. Stradley, personal communication).

Case History 1

The only bear extensively monitored soon after emergence from the den was No. 15. On an aerial flight on 5 February 1980, tracks observed indicated that he had been out of his den and then had re-entered. He had emerged early in the past and had left his den without returning about 5 March 1980 or earlier. The first period in which he was monitored after this emergence was 19-23 March 1980. During this period he was very inactive spending approximately 19 to 22 hours of each day resting.

He was bedded at the edge of the timber in a deeply snow-covered willow bottom of Gneiss Creek for several days before we accidentally disturbed him. He then traveled approximately 4.5 km (3.25 mi) and once again bedded down.

We checked his bed site and found three day beds. These day beds along with others encountered in March and April were peculiar in several ways in that they were located in fairly exposed sites in the

willow bottom. In several of the beds that No. 15 was frightened from, 10% of a grizzly would be observable for up to 150 m. It is possible that during these spring months bed sites are chosen which are exposed to more solar heat. The tracks leading to the set of day beds indicated that Bear 15 had been at the site for at least 2 days, but no scats were found at the site. After backtracking the trail leading to the bed site for about 3 km, we still did not find any scats or evidence of feeding.

After moving to the new site and bedding down, Bear 15 was known to have remained at the new location for at least 2 days. He again had been active for about two hours out of each day and apparently was not feeding but continued to rest.

This observation as well as those gained from following the tracks of other individuals during this early post denning period, seem to indicate that early emergers may be out of their dens, but remain fairly inactive and may not eat much for a period. This walking lethargic state may be physiologically readying the digestive tract for a major change from its resting state. Observations of later emergers such as Bear 38 indicate that if carrion is located shortly after emergence, the bear (or bears) may bed near the carcass guarding it and consuming small quantities of meat. These later emergers appear to begin feeding normally soon thereafter.

Human-Related Disturbances

Human Disturbances: Backpackers, fishermen, etc. -- Findings by the IGBS have shown that grizzlies at times live near human habitation

and interference. While locating radio-collared bears during aerial flights, members of the IGBS have frequently located grizzlies within several hundred meters of hikers, fishermen, etc., without apparent conflicts with the bears. Observations of this kind were made on Bears 15 and 38.

During this study bears were followed at a distance that would give a strong, clear signal. This signal depends a great deal on topography, climatic conditions, and distance from the bear. In order to obtain the "typical" daily routine, care was taken not to disturb the bear. Despite precautions, there were times when the bear being monitored was aware of human intrusion.

Case History 1

One such occasion was on July 28, 1979 at 1959 hours when Bear 15 was accidentally met in dense lodgepole pine. He had been up and moving for about 20 minutes and when surprised, his reaction to human presence was immediate flight. His flight distance was judged to be about 50 meters. At 2057, slightly less than 1 hour later, his signal was lost. His apparent reaction to disturbance this time was to leave the area. The next day he was located about 7.2 km (4.5 miles) east of the area he was jumped.

Case History 2

On the evening of July 31, 1979 through the early morning hours of August 1, Bear 15 was being monitored from a distance of roughly $\frac{1}{2}$ to 1 km ($\frac{1}{4}$ to $\frac{1}{2}$ mile) with timber separating him from the observer. At 1851 hours he became active. By 2015 he had traveled a half circle

around the observer and was judged to be within 200 meters. By 2200 this bear had slowly approached to an estimated 50 meters (later confirmed by tracks) from the monitor and had completed a full circle. No sound had been heard up until this point, then a few branches were heard cracking. A whistle from the observer brought a deep rolling growl from Bear 15. The monitoring station was then relocated on the branch of a large tree. Bear 15 remained in the immediate area for a few hours, then began traveling fairly rapidly in a northerly direction until contact was lost at 0242. This bear had not been sighted due to the timber and darkness, but tracks were found within 50 yards of camp the next morning. He had not acted aggressively and it was felt that he had been headed in my direction, became aware of my presence, and had circled out of curiosity. This circling behavior probably happens much more often than we realize. An aerial location of Bear 15 on the morning of August 1 at 1112 hours put the bear approximately 10 miles north and slightly west from the encounter site. Thus, it appeared as though this bear was feeding and intended to move in one direction, encountered human intrusion, checked out the situation, and then reacted by hightailing it in an opposite direction.

Case History 3

Bear 15 tightly circled two observers (who were situated in a truck) on another occasion. Again, it was probable that we had coincidentally been in the bear's line of travel.

GB 15 killed and ate Roger May on June 24, 1983. (This bear was completed on May 18, 1983). Roger May died in the Rainbow Point Campground Gallatin N.F. after being pulled out of his tent. In one hour, 70 lbs was eaten. GB 15 was trapped & had May's hair in his fecal material & was destroyed.

Case History 4

On June 21, 1979 while trying to get a better location on Bear 38, I noted that she became active at an early time (1600 hrs). She had been bedded with her three cubs in the thick lodgepole pine and had become active early due to the noise we made moving through the timber less than 200 meters away. Her apparent reaction was to lead her cubs from danger since she probably did not feel cornered. Within an hour she had moved over a ridge and into a drainage several miles (km) away.

Case History 5

On 19 August 1980, while observing Bear 50 finish the remains of a bull elk carcass, a shift in wind direction caused her to depart the site. A co-worker and I were situated behind some fallen trees 200 m downwind of her and the carcass. She had been at the site for nearly 20 minutes and a steady breeze of about 4.8 km per hour (3 mph) was bringing the heavy smell of putrified meat to us, assuring us that wind conditions as such, she would be unable to detect us. A sudden switch in wind direction towards the bear, then back to us, caused her to run off at full speed into the nearby timber. Even with the overpowering smell of the elk carcass by her, she was able to detect and react to merely a faint wisp of human scent. Shortly after her rapid departure from the site of the carcass, she stopped running and remained fairly inactive for about 15 minutes (at about 500 m from the carcass). After no further wind changes to confirm our presence or whereabouts, she slowly traveled off and bedded about 1.6 km (1 mi).

from the carcass. She returned to the carcass about 8 hours later, but had reacted by fleeing to even a hint of human scent.

Case History 6

About 16.1 km (10 mi) north of West Yellowstone, 50 m north of the Highway 191 crossing of Grayling Creek and within 20 m of the highway lay a large (7 m wide by 10 m long) pool of coagulated animal renderings and water. These coagulated renderings were inadvertently dumped during the crash (turn over) of a tank truck carrying heated animal renderings in July 1978. Due to the Gallatin National Forest's (GNF) concerns for grizzly bears and water quality, cleanup operations began immediately. The owner of the truck buried most of the material to their (GNF) satisfaction and the effort appeared successful since no apparent problems with grizzlies occurred during 1978 or 1979 (Puchlerz, personal communication).

This spill was located along a traditional travel route for grizzly, and during the summer of 1980 there was considerable grizzly bear activity at the site especially in terms of digging up the coagulated renderings.

Fresh seepage from Grayling Creek kept the area greasy and mucky. Fresh tracks nearly every morning that the site was checked indicated that this site was visited almost nightly by grizzly and black bears. Bears would walk through and roll in, as well as eat the renderings which were thoroughly mixed with sand and soil. It became almost a mini-congregation site, so frequented by Bears 15, 35, 38 and her yearlings (Bears 54 and 55) as well as many unmarked grizzly and black

bear that it became an area with a high potential for creating grizzly bear mortalities the chance of a roadkill was greatly increased by the concentrated and sustained use of the site. Greasy bear tracks staining the highway caused from bears first stepping in the renderings, then crossing the highway, attested to the very frequent crossings of the highway at this site. On several occasions during the summer of 1980, as many as six bear crossings (one bear crossing the highway equals one bear crossing) were known to occur in this small 300 m section of highway during the course of an evening and the early morning hours.

I did not discover the site until July 8, 1980, after monitoring No. 35 at the site during the early morning hours and previous night. We were monitoring his signal from the highway's edge (in the truck) for nearly 2½ hours when we heard him walking in what sounded like gumbo mud (later found to be the renderings), and lapping up water (later found to be the greasy water), not 30 m from us. Due to darkness and the fog, we were unable to sight him. During the 2 hours and 45 minutes that we monitored his signal from this location, we counted the number of speeding motorists passing by. Some vehicles zipped by at speeds estimated to be in excess of 105 km (65 mph) which would make stopping to avoid an animal (possibly a grizzly) nearly impossible. During this interval (0130 hours to 0415 hours), 14 semi-trailer trucks and 8 passenger vehicles passed. This was thought to be a time period when traffic would be minimal.

Concerned for the risk to grizzlies, we contacted GNF biologist Tom Puchlerz and informed him of the recent use of the site. He

informed us of the history and cause of the greasy material. Due to his greatly appreciated cooperation, solutions to cleanup of the area were proposed and applied. The area was treated with San-X, a bacterial decomposing agent, which was followed by covering it with about 1 foot (1/3 m) of gravel. This was a cooperative effort between the State Highway Department and the Forest Service. Soon after treatment, grizzly bear use of the area was again evident. On 9 November 1980 an unmarked adult male grizzly was killed by a vehicle at the site.

It became apparent that total removal of the spill was the only solution. Nothing could be done in November due to frozen ground conditions, and wet ground conditions in the spring postponed the job until July 1981.

The State Highway Department, found to have responsibility over the spill, removed 150 cubic yards of material which was hauled to the West Yellowstone landfill. This was a costly job requiring a frontend loader, dump trucks, and replacement soil. The final cleanup was completed on 17 July 1981 (Puchlerz, personal communication).

Due to the concern and cooperation among different agencies, the potential of the site for creating more grizzly bear mortalities was drastically reduced.

Case History 7

The reactions of study bears to small aircraft buzzing overhead was observed a number of times. The usual reaction of a bedded bear to an airplane circling overhead was to raise its head and look up at

it, although at times the plane was ignored. Very few flight reactions were observed.

Case History 8

At times grizzlies cross fairly busy highways or are located close to one while bedded, feeding, or moving. Occasionally the bears are hit and killed by cars. On June 19, 1979 Bear 38 was located bedded in a willow patch along Grayling Creek, within 100 yards of Highway 191. Every time a semi-truck passed, the signal would become erratic. The time interval involved was during a period Bear 38 normally would become active. However, she was still not active by 2130 when we left the area. Evidently the loud highway noises disturbed Bear 38 to some degree. By daylight the next morning she and her family were several miles removed from their willow bed site. Perhaps she had chosen this bed site at a time when highway noise was at a minimum.

REPRODUCTIVE BEHAVIOR

Copulatory Behavior

Case History 1

On 12 June 1980 Number 40 was sighted following 15 meters behind Number 50 with his neck arched, head held low, and walking in a swaggering stiff-legged gait as reported by Hornocker (1962). However, neither the reported frequent urination on the hind legs and belly, nor exuberant salivation were witnessed during the three hour period that this male was observed. Bear 50 laid down, rolled over on her back and allowed Number 40 to walk up to her. He then smelled her genital region, bowed his neck, pounced on her with his forefeet, then bit and mouthed about her ears, muzzle and neck. Both bears groaned and roared softly, then she suddenly jumped to her feet, faced Number 40 and shunned his attempts to mount or nuzzle her. The two bears then began grazing.

Bear 40 was observed actually mounting #50 eight different times, but only during three of these occasions did actual copulation take place. Mounting and copulation occurred while both bears were standing. The duration of copulation ranged from five minutes to eight minutes averaging six minutes for the three cases. There did not appear to be a copulatory tie as found in canids.

On the three occasions that actual copulation took place, Bear 40 intermittently bit Bear 50's neck and ears. He would rest his head

on her back, neck, or press it against hers as observed for black bears by Bacon and Burghardt (1974). He was in an arched position with his forepaws grasping her lower abdomen or pelvic area. Pelvic thrusts and some circular movements were observed during these three copulatory mounts as described by Bacon and Burghardt (1974). These pelvic thrusts were the main criteria in which we separated the copulatory versus non-copulatory mounts. Bear 50 walked about while Bear 40 remained standing, motionless for up to one minute.

The duration of the non-copulatory mounts ranged from several seconds to about 10 minutes. During these instances Bear 40 would rest on Number 50 in the fashion described for copulatory mounts.

Several times Number 50 wasn't receptive to Number 40, and prior to, or shortly after his mounting she would collapse to a prone position ceasing his attempts. One instance was observed where Number 40 mounted Number 50 and was able to lock his forefeet beneath her abdominal region in typical fashion. She, however, proceeded to run away causing him to slide back, still locked about her lower pelvic region. Continued running by Number 50 caused Bear 40 to slide back still further until his forepaws were locked slightly above her ankles. She dragged him in wheelbarrow like fashion for approximately 40 meters before breaking free and returning to her grazing. He then proceeded to graze also.

On one attempted mount Number 40 bit at Bear 50's neck and she became angry and whirled around growling and snapping at him.

On some occasions Number 50 appeared coy yet would allow Bear 40 to mount her while other times he had to chase her before mounting.

These bears were observed a number of times rolling around and wrestling. One such time Number 50 was laying on her back with Bear 40 straddled over her, biting at her neck. Apparently he got too rough or bit too hard for she began growling and slapping him in the side of the head with her left front paw, while he continued biting at her neck. This episode lasted nearly one and one-half minutes.

Short 5 minute to 10 minute interims of rest were also observed. The bears would lay together, and he would have his head rested on her and frequently have a leg resting over her as well. Several times during interims of rest, Bear 50 would roll on to her back sticking her hind quarters in Number 40's face. He would then respond by sniffing and licking her genital region and either a playful wrestling bout would be engaged and/or both bears would jump to their feet and Number 40 would mount or attempt to mount Bear 50. In the course of one intimate resting phase, Bear 40 appeared to be sleeping, while Number 50 began grazing in an arc about her while lying in a prone position.

Numerous times while the two bears were lying together, and interrupting some grazing periods, Bear 50 would sit up, buttocks on the ground, head held upright and all four feet in the air, as if she was in a rocking chair. It was an uncomfortable looking and clown-like position in which a slight push would topple her backwards. She would sit this way for up to a minute until Bear 40 stood up or quit grazing whichever the case be, and came over to her. The position seemed to be somewhat sexually stimulating to Bear 40. Upon his approach she usually would roll back on to her feet and start grazing.

This half-sitting, half-lying position was described by Craighead (1979) as the nursing position of a female with cubs.

While following these two bears in April (6 weeks previously), indentations were found in the snow on several occasions which were made by a bear sitting in a similar position.

Fighting and Aggression

In the struggle for mates or dominance, substantial scars and wounds on the bodies (especially the head and neck) of Bear 15 and other males are evidence of the severe fights that occur from time to time (Hornocker 1962, Craighead 1979, Knight Personal Communication).

Case History 1

Severe fights also occur at times other than the peak breeding period. On May 12, 1980 we were monitoring Bear 15. He had been inactive until 1735 when a signal change indicated that he probably had awakened but was inactive. At 1841 it became apparent that he was beginning to travel rapidly.

After traveling about 10 km during the first 45 minutes, he slowed his pace. At 2040 he stopped traveling but remained active, presumably feeding.

At 0145 on May 13, 1980 the pulse mode was changing rapidly to a degree that we had rarely witnessed. The exceedingly erratic signal changed abruptly to a constant slow mode at 0151. After nearly four continuous hours of monitoring completely void of any changes in the

pulse mode, we were confident that his collar had either been cast or the motion sensitive mercury switch had become non-functional. The signal was further monitored for any change in direction as a check for a switch malfunction. Monitoring was ceased on May 14 at 0131 since neither a change in direction nor pulse mode was observed.

On May 14, we found the cast collar and evidence of a brutal fight. The rot-prone canvas strips used to make fitted collars a temporary item on bears had been torn through causing the collar to drop off. Marks caused by canines were visible on the collar.

Large clumps of saliva-saturated grizzly hair (apparently pulled out by the mouths of the contenders) were scattered about the area. These fist-sized clumps were estimated to have a loose volume of over 25L.

The sterile understory of the mature lodgepole pine stand also was disturbed. Duff, clumps of dirt and small (6 cm-15 cm diameter) logs and blow downs were scattered about. Flecks and puddles (.5 cm-20 cm diameter) of blood were found in the duff and upon logs. The front track of a large grizzly was perfectly stamped on a log with blood. Hair and blood covered the sharp angled breaks of branches in an area of tangled deadfall about 75 meters from the cast collar. At this site, the end of a fallen tree was freshly broken (10 cm diameter at the break), covered with hair, and received bites from the jaws of one of the contenders (2½ cm deep indentions from canine teeth).

Within 50 meters from this site of tangled deadfall was the blood and hair smeared trunk of a 30 cm d.b.h. lodgepole pine tree. It appeared that one of the bears had been pinned up against the tree smearing blood and hair to a height of 1.5 meters.

A metal eartag which was at first thought to be Number 15's, and part of a red plastic eartag were found at the site. It was later determined by these numbered tags that they had both been torn from the ears of Bear 20. Bear 20 was a large 7 year old male that had not carried a functional collar or been observed since September 1977.

Bear 14 was recaptured on June 18, 1980 and was found to have numerous fresh wounds presumably from his fight with Number 20. It is unknown whether either male had been with or was following a female at the time of the fight.

Predation, Caching and Related Behavior

Case History 1

During an aerial radio tracking flight, tracks and a large blood trail indicated that Bear 15 had killed an elk on the morning of 3 April 1980. During previous years he was also known to prey on elk in the spring (Knight, personal communication). He was also observed using three elk carcasses in March 1979.

Case History 2

After No. 38 left her den in late March 1980 and until about 25 April 1980, she was known to have killed one bull elk, had eaten a

cow whose cause of death was undetermined, and was suspected of using another carcass (based on her lack of movement for at least 1 week during late April). The single account of known predation by this bear was partially witnessed on 31 March 1980 at about 1500 hours. We had observed No. 38 and her three yearlings leave the feeding site of a cow elk carcass that they had just finished consuming in the Gneiss Creek drainage. The numerous bear tracks in the creek bottom indicated that this family group had probably been using this area (about a 2 km area surrounding this cow elk carcass) ever since leaving their den (some time between 19-24 March 1980). They had been walking along the bank and in the waters of Gneiss Creek, then started climbing the ridge to our east (500 m away). It was fairly steep and the yearlings were playing. They would run uphill, turn around, tuck into a ball, and somersault down the hill for 30 meters or more.

It amazed us as to the ease in which these four bears traveled through the snow since snow conditions were very poor for walking (without snowshoes we would sink up past our waists). Elk tracks were fairly numerous and they revealed that these ungulates were breaking through the crusted snow layer and sinking to chest height. Bear 38 was sinking in only about 30 cm until once, when she broke through the crust and fell on her side.

The yearlings began grabbing one another by the scruff of the neck and shaking their heads. Bear 38 was further up the ridge when she stopped and began sniffing the air. She appeared to have caught

the scent of something that interested her, for she turned and beelineed it angling downhill and towards the ridge we were viewing them from. She was picking up pace and sniffing the air as she went. The yearlings were now about 125 meters behind her but they raced to catch up with her. Her straight and rapid course was taking her up the ridge we were on and towards the site we had cached our backpacks and equipment. We felt we had better leave before the bears learned of our presence and possibly be frightened from the area. When we reached a point about 100 meters from our equipment the receiver indicated the bears were very close and in the timbered gully to our east. We then heard timber cracking, the sounds of animals running in snow, and a bear bawl approximately 100 meters away. We felt the bears might soon appear so we climbed some aspen trees. From our position in the trees we heard a bull elk bugle then grunt, then heard Bear 38 bawl. The elk made a bugle-like noise then bellowed frantically which was followed by the bears bawling again. For a period of about ten minutes we heard one or more of the bears bawl every minute or so. Then it became quiet so we retrieved our packs and equipment and traveled to a vantage from which to monitor her signal.

By April 3, 1980 Bear 38 had not moved from her location in the gully below us, but due to timber we were unable to see her or a carcass. At 0955 hours on April 3, 1980 an IGBS aerial survey sighted Number 38 and her three yearlings on an elk carcass. This confirmed our belief that she had preyed on an elk. We returned to the site on April 10, 1980 to examine the elk carcass and feeding site.

After examining the site and the old badly melted tracks in the snow, we became convinced that Number 38 and her yearlings had overtaken and killed the four year old bull elk (judged by tooth wear and replacement) that was ploughing through chest deep snow. The neck of this bull had been broken several vertebrae posterior to the axis. The marrow from a femur of this elk indicated it to be in poor physical condition at the time of death with approximately a 50 percent femur marrow fat content.

Case History 3

Bear 50 was known to prey on elk throughout the pre-rut period of elk and for a time after the rut (she was not monitored during the breeding season of elk), and was efficient at seeking out carrion. Within these periods (about 1-1½ months) during 1980, she was known to kill and eat two bull elk, eat a bison with an undetermined cause of death, and partially eat another road-killed bull elk.

Of the two clear cases of predation, she killed a large seven-point bull elk around 12 August 1980. The neck was broken at the third cervical vertebrae. It appeared that a struggle had occurred at this site. An area about 3 m long by 15 m wide at the edge of the timber was torn up, trampled, and full of elk and bear tracks. The carcass was about 10 m west of this site. To the southeast was a clearly defined path of churned ground and broken branches for about 35 m. Elk hair, bear hair, splattered blood, antler scars on the trees, and broken limbs along the path indicated that death was not immediate for this large, 6½ year old, seven-point antlered bull elk.

This elk was determined to be in excellent physical condition at time of death.

Case History 4

Bear 50 again killed a five-point antlered elk about 29 September 1980, breaking the neck of this bull near the shoulders. Numerous canine marks about the face, neck and ears (which had nearly been chewed off) were hemorrhaged beneath the skin, indicating they were inflicted before the death of the animal (Murie 1948). The area surrounding the buried elk had several places where the ground was churned from elk hooves. This elk was determined to be $4\frac{1}{2}$ years old and was found to be in excellent condition at time of death.

Case History 5

Evidence also indicated that Bear 51 (a very large male grizzly, but not one of my study bears) killed, buried, and consumed the two bull moose carcasses we investigated at the same site. One of these bulls had a broken neck, while the other's skull was partially crushed (the nasals and part of the frontal bones were caved in, apparently due to a blow to this region). Both of these moose were in excellent condition at time of death, one being 7 years old and the other 9 years old. Evidence at the site also suggested that a struggle had occurred.

Carcass Caching

Six of the eight carcasses we examined which were known to have been fed upon by a grizzly and classified as either buried or not were

covered or showed signs of having been covered with soil (this does not include a lightning killed steer which was dragged by the rancher into a large sagebrush covered opening).

Case History 1

An elk carcass and a bison carcass fed upon by Number 50 showed no signs of having been covered, however, she covered one bull elk that she killed with soil in excess of 50 cm deep. This carcass was left unguarded, but cached for later use.

In this case Number 50 had been located by plane several times within a small area near Chickadee Lake and had remained there for about nine days.

Her activity pattern had been typical of that displayed by a bear feeding on a carcass so we began searching the area shortly after her departure. A five-point bull elk (on October 8, 1980) that she had recently killed (within 4-5 days) and buried with a large mound of soil (approximately 1 meter high by 3 meters wide by 4 meters long) was found. She had only eaten about one-third of the elk, but fresh whitebark pine nut scats were very numerous (29 out of 40 scats found were whitebark pine nut scats, 6 consisted of sand and dirt, and only 5 were meat scats) near the carcass. Disturbed squirrel middens also abundant nearby, indicated she had been using the nuts as her primary food source for the past eleven days or more.

She did not return to the vicinity of the carcass until four days after her departure. Upon her return she began to consume mostly, or solely, meat from her cache.

Case History 2

Bear 15 also exhibited caching behavior. On April 3, 1980, Bear 15 was observed by Knight (personal communication) dragging a freshly killed bull elk (blood trail in the snow leading from the kill site to the timber) to the timber's edge. Bear 15 had left the carcass and we located him about 3½ km from the approximate location of his kill. He did not return to his kill during the two days we monitored him.

Tree Climbing

It is generally assumed that an adult grizzly cannot climb trees unless ladder-like limbs enable it to do so. Several instances during this study indicate that although not nearly as adept as the black bear at climbing, grizzlies will climb with sufficient motivation.

Case History 1.

Decaying meat hung from a tree as an attractant to IGBS trapping sites provided motivation. Under such circumstances claw marks and a trail of hair indicated an adult grizzly climbed 11 meters up into a large whitebark pine tree and crawled out onto the limb from which the bait was hung. The 19 cm (diameter at the break) live limb broke bringing the bear and bait to the ground, where the bear ate the bait.

Case History 2

Signs indicated that a grizzly (thought to be Number 60, a three-year-old female) climbed up 6 meters in the same tree onto a slanting limb tearing much of the bark off the tree on her way. She then

leaped outward (approximately 3 meters) off the limb onto a pork-filled burlap sack, tearing the sack and dumping the meat to the ground where she ate the meat. This tree, though more suitable to climbing than many, still required that a bear grasped and pulled with its claws in order to climb (in black bear style).

Case History 3

Another grizzly (possibly Bear 1) climbed approximately 12 meters up into a large Douglas Fir, but was unable to get the bait hung on a rope between this tree and another.

Case History 4

A large grizzly (Bear 61) climbed approximately 3 meters up a limbless 25 cm d.b.h. lodgepole pine tree. This bear was able to leap out (from his position in the tree) about 2 meters and apparently snag a bait-filled burlap sack (hung from a pole between two trees) with his claws ripping it open on his way to the ground. The encased beef hind quarters dropped to the ground and was then eaten. Deep claw scars and hair in the tree to a height the bear climbed attested to the actual climbing. This bear was known to have exceedingly curved claws for a grizzly which may account for his superior ability at climbing.

Case History 5

A large (2 meter d.b.h.) limbless, slick trunked, rather vertical whitebark pine tree bore many grizzly claw marks. The bait which hung about 5-6 meters high and 2 meters out from the trunk was unobtainable

by climbing. An apparently frustrated grizzly chewed several small (11 cm d.b.h.) nearby trees in half as well as large chunks from a tree, 20 cm below the point that the rope anchoring the hanging bait was tied.

The Trailing of a Family Group by a Male Grizzly

Case History 1

Females with cubs avoid adult males since they may kill and devour a cub (Knight, personal communication). This does not mean that a female with cubs will never be found near an adult male, since she could be unaware of his presence. This appeared to be the case on the morning of August 7, 1979. A large, dark-colored female grizzly with three young were sighted in an open meadow and observed from 0635 until around 0745. During this time Bear 15 was located nearby but not observed. He seemed to be skirting the timber edge within a hundred meters of this family group. The family group appeared unaware of another bear. The mother busily dug large (1-2 m²) holes, occasionally pouncing on rodents and eating food caches. The cubs were chasing one another and playing. They ranged as far as 75-1000 meters from their mother, seemingly unaware of Bear 15. As the family crossed the creek, climbed the hillside and disappeared into the timber, Bear 15 seemed to still be in close pursuit. He moved further into the timber where the female and cubs had disappeared and then bedded down around 0909. At 1835 the family unit was resighted in a nearby meadow about 20 minutes after Bear 15 became active. The family gradually left this general area. That evening the cubs stayed

much closer to their mother although she still did not act disturbed. Based on their coloration, their location, and the size of the female and each cub, this group could well have been Bear 38 and her young. She had cast her radio collar, thus eliminating positive identification.

Reaction to Weather Conditions

Case History 1

On August 8, 1979 Bear 15 was monitored throughout a storm consisting of strong wind and rain. This bear was very restless during his inactive period. At times strong gusts of wind estimated at 80 km/hr (50 mph) caused his mode to jump from a steady to very erratic mode. The entire day was windy and this bear seemed nervous and did not rest soundly for any long periods of time. The rain may have also added to his uneasiness. Days with strong gusty winds consistently made bears uneasy during resting periods.

Case History 2

During an August 24, 1979 hail storm, the signals of Bears 15 and 35 were monitored from start to finish of the outburst. This shower of 1.8 cm (3/4 inch) diameter pellets lasted about 10 minutes. Before the storm both bears were active. When the storm started, both animals remained in the erratic mode for several minutes, then switched to steady modes until the hail quit falling. The bears probably searched for sheltered beds, found them, layed down, and buried their heads (fast modes for both bears signified "heads down") until

the storm changed to rain. At the onset of this rain the two became active once again. Contact with both bears was lost early morning of the 25th. Hail storms were found to invariably reduce the activity levels of bears.

Bart eventually moved to Alaska where he enjoyed hunting and fishing and making his own recurve bows. He became involved in the Siberian Tiger Preservation efforts in Russia for many years.

On September 14, 2004, Bart was killed by a grizzly while moose hunting in the Yukon.

Bart's friends and family cherish his memory.

- RF

MONTANA STATE UNIVERSITY LIBRARIES



3 1762 10059237 5