AN ABSTRACT OF THE THESIS OF

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Behavior of grizzly bears (Ursus arctos) toward people was studied by examining hikers' reports of grizzly bear observations and by intensively observing grizzlies in an area of Glacier National Park that was heavily used by day-hikers. Of concern were the apparent habituation of grizzly bears to people in the study area, the increasing rate of human injuries by grizzly bears in the park, and the increased involvement of lone adult and subadult bears in injuries to hikers. Associations between environmental circumstances, including the presence and behavior of people, and grizzly bears' behavior were evaluated. Human use of the study area was associated primarily with season and weather. Numbers of grizzly bears observed were also associated with season as it reflected patterns of habitat use. Behavior of grizzly bears was associated primarily with the level of human activity, the presence of bear-bells, and the climatic circumstances under which the bears were seen. Although grizzly bears' fear response toward people appeared to habituate, they maintained a degree of vigilance that was related to conditions affecting the ease of scent perception. Charges, which have been associated

with hiker injuries, involved only people who did not have bear-bells. Charges occurred primarily along trails that received little human use although grizzly bears were also startled by hikers on trails with high levels of human use. Evidence indicated that habituation of grizzly bears' fear response did not lead to the increasing trend in the rate of human injuries. On the contrary, habituation may contribute to a reduction in the rate of injuries that result from fear-induced aggression. A possible mechanism for the increased rate of injuries is presented. Other types of aggression relevant to danger of human injury by grizzly bears are discussed.

INTERACTIONS BETWEEN GRIZZLY BEARS AND HIKERS IN GLACIER NATIONAL PARK, MONTANA

by

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INTERACTIONS BETWEEN GRIZZLY BEARS AND HIKERS IN GLACIER NATIONAL PARK, MONTANA

INTRODUCTION

Understanding the behavior of grizzly bears (Ursus arctos) is critical to the management of areas where people and grizzly bears come into contact. Grizzly bears are a threatened species, yet they can present a hazard to people who visit areas that they inhabit. It is therefore essential to understand grizzlies' behavioral and ecological responses to human activities as well as the subtle, but potentially serious, influences that people have on grizzly bear populations in refuge areas. This study represents a step toward that goal.

Behavioral Ecology

The behavior of present-day grizzly bears is closely tied to their evolutionary history. The ancestor of all bears was the omnivorous etruscan bear (U. etruscus) which inhabited the forests of Asia about 2 million years ago. During the warm interglacial periods of the Ice Age, retreating ice sheets left vast areas of treeless vegetation. Evolution of bears that used the new resource gave rise to the cave bear (U. spelaeus) in Europe and the brown bear (U. arctos) in Asia. The brown bear was a forest-adapted species that was also adapted to venture into open tundra areas when they were most productive (Herrero 1972, 1978; Bunnell and Tait 1978). Brown bears crossed the Bering land bridge about 10,000 years ago and spread throughout northern and western North America. Two subspecies

are generally recognized in North America: the most numerous is the grizzly bear (Rausch 1963).

Although grizzly bears commonly use forested areas for food and cover, research has consistently supported the importance of open areas as sources of food. Temporary elimination of forest canopy, as by fire or snowslide, often creates superior habitat. Mealey et al. (1977) rated avalanche chutes, stream bottoms, wet meadows, and burns as the types of vegetation that were generally highest in food-producing value. However, every major type of vegetation identified by Mealey et al. (1977) was used by grizzly bears at some time of the year for food, cover, or both. More than one vegetation type is used during any season, and grizzly bears are most consistently observed in areas of the greatest vegetation diversity (Shaffer 1968, Martinka 1976, Mealey et al. 1977).

In most areas, a grizzly bear's home range consists of several seasonal home ranges that may be separated by as much as 50 km. Within a seasonal home range, a bear spends most of its time in small, intensively used activity areas. Bears' movements between and within seasonal home ranges are influenced primarily by the quality, availability, and distribution of food (Berns and Hensel 1972; Craighead and Craighead 1972a; Mundy and Flook 1973; Pearson 1975; Herrero 1978; Russell, R. H., et al., unpubl. annu. rep., Can. Wildl. Serv., Edmonton, 1978; Hamer, D., et al., unpubl. annu. rep., Parks Canada, 1979).

Home ranges of grizzly bears are so large and disjunct that their defense as territories is not feasible. Food resources are

patchy and unpredictable, and because grizzly bear populations are apparently not directly food-limited, defense of feeding territories is of no advantage (Geist 1974, Bunnell and Tait 1978). Instead of a geographic territory, a grizzly maintains, through mutual intolerance of other bears as well as aggressive defense, an individual space that centers on the bear as it moves about its home range. The extent of the individual distance and the bear's response to its violation vary with the individual, the situation, and the season. Females with cubs may actively defend individual distances of several hundred meters (Herrero 1970:595).

Because of their long period of hibernation, bears must obtain high-quality food in excess of their summertime maintenance requirements. Although grizzly bears are primarily herbivorous, they are opportunistic feeders and will scavenge or prey on almost any available food, including ground squirrels (Spermophilus spp.), ungulates, carrion, and garbage. Grizzlies generally select the most protein-rich vegetation or animal matter that is available at a given time and, in some areas, depend upon occasional surpluses of feed rich in protein or energy, such as nuts, fish, or berries (Cole 1972a; Martinka 1972; Hamer, D., et al., unpubl. annu. rep., Parks Canada, 1977; Kendall 1980; Mealey 1980).

The grizzly bear is a long-lived species that depends upon relatively short-lived, early-successional plant communities. Within these communities, food production is patchy and unpredictable. Thorpe(1966) stated that it is possible for learning in higher mammals to occur solely as a result of motivation by an "exploration

drive" or curiosity, a general tendency of the individual to explore the environment and learn its characteristics without immediate reward. Bacon (1980) stated that black bears (Ursus americanus) exhibit intense curiosity. Curiosity probably aids a bear in discovering the most productive food sources and thus enhances nutrition and reproduction.

Herrero (1978) hypothesized that because grizzly bears generally inhabit sparsely treed vegetation types, cubs cannot depend on climbing trees, as black bear cubs do, for escape from potential predators, such as wolves (Canis lupus) and other bears. Instead, their survival depends on protection by their mother. A sudden burst of violence by the mother toward a perceived threat effectively discourages the threat and permits the mother to return quickly to the cubs to protect them from other dangers. Explosive displays of aggression were thus selected for as grizzlies adapted to the open areas that provided rich new sources of food.

As an alternative to overt aggression, females may defend their young through avoidance of bears that may constitute a threat, although findings have conflicted. Pearson (1975) and Russell et al. (unpubl. annu. rep., 1978) found that females with cubs were relatively sedentary, seeking out rugged and isolated areas and avoiding contact with other grizzlies. Their smaller foraging range was attributed to the smaller body size of females than of males. On the other hand, Hamer et al. (unpubl. annu. rep., 1979) found that the home ranges of females with cubs were larger than those of lone adult females and attributed the larger home range size to the

greater requirements of a family over those of a lone bear. Reproduction at an earlier age, shortening of the breeding interval, and increased litter size can enhance the lifetime reproduction of female bears; all of these factors are under strong nutritional control (Bunnell and Tait 1978), favoring strategies that ensure access to dependable food sources. Whether this results in a smaller home range depends upon the quality, abundance, and distribution of food resources and upon the relative benefit obtained in terms of reduced contact with other, potentially threatening bears in exchange for the limitation of food resources in a restricted home range.

There is substantial evidence of intraspecific killing and cannibalism by adult male bears. Troyer and Hensel (1962) described 4 instances of cannibalism and stated that cannibalism, usually involving large males and small cubs, was more prevalent during the breeding season, when males were especially aggressive. Numerous instances of predation by adult males on cubs have been recorded by other investigators, especially in areas of high population density such as feeding aggregations (Herrero 1972:230, Craighead et al. 1976:355, Glenn et al. 1976:387). Reynolds et al. (1976:408) reported a large bear feeding on the carcass of a female and yearling in a den, although it was not known whether the large bear killed them or found them already dead.

In addition to protection from predation, cubs benefit from their long association with their mother by learning about their physical and social environment, lessons that may be critical to

their future survival. The young bears imitate certain learned behavior patterns of their mothers, become familiar with features of their environment, develop their ability to locate and obtain food, and learn to recognize and avoid dangers (Geist 1971:417, Pearson 1975). Species that exploit a variety of food resources must have the ability to learn which of a wide number of objects are edible. For such species, the ability to learn by observation is advantageous in terms of energy, time, and risk (Thorpe 1966, Weigl and Hanson 1980). Russell et al. (unpubl. annu. rep., 1978) discussed their observations of 3 young bears whose mother had died early in their first summer, before buffaloberries (Shepherdia canadensis) had ripened. Although buffaloberries were a major food used by grizzly bears in the area, these young bears made little use of them during the next 1.5 years.

When cubs are weaned, at approximately 2.5 years of age, they can no longer depend on the protection of their mother and, for the next several years, they experience the highest mortality rates of any age-group. Intraspecific intolerance resulting in dispersal and/or death of juvenile bears interacts with the nutritionally mediated reproduction to determine grizzly bear population levels (Stokes 1970; Martinka 1974, 1976; Kemp 1976; McCullough 1978; Nagy, J. A., and R. A. Russell, unpubl. annu. rep., Can. Wildl. Serv., Edmonton, 1978). Activity areas of adults of the same sex are generally mutually exclusive, and juveniles avoiding contact with adults are relegated to marginal habitat, where their chances of survival and successful reproduction are minimal. Dispersal of juveniles is

believed to be induced primarily by adult males, which pose a serious threat to juveniles not under their mothers' protection. Several instances have been recorded in which a subadult was killed by another bear (Pearson 1972:34; Egbert and Stokes 1976:48; Russell, R. A., et al., unpubl. annu. rep., 1978:83). Kemp (1976) reported a 118% increase in a black bear population within 2 years following removal of virtually all adult males from the population. The increase occurred primarily among subadults and was attributed to ingress of juveniles from adjacent areas, reduced egress, and perhaps increased survival of juveniles.

Habituation

Under most circumstances, grizzly bears' mutual intolerance, great mobility, and curiosity enable them to discover new sources of food in their relatively unstable environment. When food supplies become locally abundant, however, their intolerance of each other diminishes, allowing a number of bears to use the abundant resource (Hornocker 1962, Craighead and Craighead 1972b, Stonorov and Stokes 1972, Egbert and Stokes 1976, Martinka 1976, Herrero 1978, Singer 1978). Improved nutrition gives selective advantage to the ability of bears to habituate to other bears as an adaptation to a short-term environmental change.

Habituation is defined as a long-term decrease in frequency or magnitude of a response as a result of repeated stimulation. It is considered as perhaps the simplest form of learning: learning not to respond to a stimulus that is of no significance to the organism

(Thorpe 1966, Peeke 1969, Peeke and Peeke 1970, Kimmel 1973, Thompson and Glanzman 1976). Habituation is stimulus-specific. Klein et al. (1976) presented a male Siamese fighting fish (Betta splendens) in a protective glass tube to a territorial male and observed a decline in the territorial male's aggressive response with successive presentations. When a different male was presented, the territorial male again responded aggressively. Such stimulus-specificity differentiates habituation to a stimulus from fatigue of a response. For a decline in response to be considered habituation, reduced sensitivity of the receptor organ must also be ruled out (Peeke 1969).

The rate and persistence of habituation are influenced by the frequency and intensity of the stimulus and the number of times it is presented. A weaker stimulus leads to more rapid and complete habituation, and habituation proceeds more rapidly with spaced than massed presentations (Russell 1967, Petrinovich 1973, Thompson et al. 1973). When a stimulus is withheld, the response eventually recovers, or "dishabituates" (Petrinovich 1973, Thompson et al. 1973). Recovery of the response, as well as habituation, is also influenced by conditions of exposure to the stimulus. Habituation brought about by multiple, longer-duration exposures to the stimulus is more resistant to recovery, whereas recovery is more rapid when habituation is accomplished by a few short-duration exposures or by multiple exposures with only brief intervals between exposures (Peeke et al. 1971, Peeke and Peeke 1973, Petrinovich 1973). In instances in which the response does recover, subsequent habituation upon exposure to the stimulus occurs more readily (Peeke 1969, Petrinovich 1973, Thompson

et al. 1973).

Associated with habituation is a phenomenon termed sensitization, an increase in the organism's response which frequently precedes the decline with habituation (Thompson et al. 1973, Peeke et al. 1979a). Thompson et al. (1973) stated that habituation and sensitization are physiologically independent processes, but that the net outcome of their behavioral interaction is the response observed with repeated stimulation. Peeke et al. (1979b) found that greater stimulus intensity, such as size of an intruder, elicits sensitization. Also, if a stimulus has strong consequences, repetition of it will result in sensitization (Thompson et al. 1973).

The components of a behavior, such as "aggressive behavior," do not habituate at the same rate (Peeke and Peeke 1970, Peeke et al. 1971). The more vigorous components of a response often wane first, followed to a less complete degree by the less vigorous components, such as orientation (Russell 1967, Peeke and Peeke 1973). In territorial male Siamese fighting fish, convict cichlids (Cichlasoma nigrofasciatum), and 3-spined sticklebacks (Gasterosteus aculeatus), aggressive charges habituated at a different rate than bites. The rate at which each behavioral component habituated depended upon the frequency and length of exposure to the stimulus as well as the context in which it occurred (Peeke 1969, Peeke and Peeke 1970, Peeke et al. 1971, Klein et al. 1976). Wyers et al. (1973) suggested that particular components of a stimulus may relate more strongly to different facets of the response.

As suggested for grizzly bears, the ability to habituate has

evolved in response to environmental pressures. Peeke et al. (1971) and Peeke (1973) suggested that habituation is involved in suppression of hostilities between individuals with adjacent territories, while still allowing them to drive off unfamiliar intruders. Implicit in this is an ability to recognize individuals, whether by appearance, behavioral, or situational cues. Hinde (1954) found that although chaffinches (Fringilla coelebs) are sometimes killed by owls, their response to owls is subject to habituation. This finding led Melzack (1961) to examine the adaptiveness of habituation. He found that although the initial fear behavior of ducks toward hawks tended to disappear with increased experience, the ducks continued to show vigilant behavior toward hawks. The ducks did not lose their capacity to respond, but responded in a more organized, less disruptive way. Wyers et al. (1973) suggested that habituation resulted in an increased capacity to integrate information about the stimulus. With habituation, there may be less interference with the process of learning to discriminate among specific stimuli or of incorporating the stimulus into what the organism perceives as its general environment (Russell 1967, Peeke and Peeke 1973).

Interactions With People

Primitive people inhabiting grizzly bear range lived in a state of uneasy equilibrium with the bear. Grizzlies had little to fear from people and took advantage of opportunities to raid cached food and occasionally to prey on people themselves (Hanna 1978). Schneider (1977:13) told of a Jesuit priest in the Northwest who

wrote of "Indians who live on raw fish and who 'in turn are eaten by bears of frightful size, all red, and with prodigiously long claws.'" It is clear that grizzly bears had no "natural" fear of people.

The balance of power shifted with the introduction of firearms. Conflicts between grizzly bears and early explorers were exacerbated by the frequent choice by frontiersmen to travel along river bottoms, which were preferred grizzly bear habitat. People who confronted grizzly bears found that they were formidable opponents and difficult, though not impossible, to kill. At least 43 grizzlies were killed by the Lewis and Clark expedition (Schneider 1977:15). As stories of encounters were told and retold, the grizzly's reputation for ferocity grew, and some people viewed the existence of grizzly bears as a challenge to see who would rule the West (Schneider 1977).

McCracken (1955) stated that the factor contributing most to the destruction of the grizzly was the introduction of livestock into open ranges west of the Great Plains. Grizzly bears became known as cattle-killers and were viewed as an obstacle to the profitability of the livestock industry. Storer and Tevis (1955:43) wrote that as settlement proceeded and grizzly bears were intensively hunted, they became more wary and more nocturnal. Their statement implies that bears learned to avoid people, but it is more likely that the avoidance resulted from intensive selection against bears that ventured near people, accompanied by a severe reduction in grizzly bear numbers. The only grizzlies that survived were ones that inhabited the most remote areas and were extremely secretive. Today it is estimated that 26,000-30,000 grizzly bears remain in North America

(Cowan 1972:350). In the contiguous United States, fewer than 1,000 grizzly bears exist in the mountainous parks and wildernesses of the northern Rocky Mountains, and half of them, those in the Yellowstone ecosystem, are isolated from other populations (Cowan 1972). The grizzly bear was designated a threatened species in 1975 (Jacobsen 1980).

National parks in the United States that are inhabited by grizzly bears are legally obligated to preserve naturally regulated populations of the bears. Although grizzly bears are considered a valuable resource, this obligation has presented a difficult challenge since the bears can present a hazard to the safety of people who visit the parks (Glacier National Park 1981). Injuries to people by grizzly bears in national parks have primarily involved (1) campers who were confronted by grizzly bears that had learned to associate human presence with food availability, and (2) hikers who surprised females with young and were perceived as a threat, charged, and injured (Herrero 1970, 1976; Mundy and Flook 1973).

People's food and garbage are a very attractive food resource for grizzly bears, and where it has been available to the bears, their opportunistic feeding habits have brought them into conflict with people. Ninety-five percent of the injuries by grizzly bears in Yellowstone National Park during 1930-69 took place in campgrounds, several of which were located in choice grizzly bear habitat (Herrero 1970:596, Cole 1972b:281). People's food was a factor in at least 6 of the 10 injuries to campers in Glacier National Park (Glacier National Park records). Merrill (1978) found that backcountry

campsites with larger party limits and greater deterioration had a greater frequency of encounters between black and grizzly bears and people. Campers whose own food is unavailable to bears may be attacked because, in the past, a bear learned to associate food with the presence of people. Refuse left by one camper may thus predispose future campers to injury (Herrero 1970).

Females with young were involved in at least 74% of the 38 injuries to hikers in North American national parks prior to 1974, even though they comprise only 16-20% of grizzly bear populations (calculated from Craighead et al. 1974:7; Martinka 1974:24, 1976:150; Herrero 1976:124). Sudden surprise was an important factor in these incidents, and in all of the attacks, the hikers were not actively making noise (Herrero 1970, 1976).

In recent years, charges by lone adult and subadult grizzly bears have also resulted in injuries to hikers in Glacier National Park. At the same time, an increasing rate of human injury by grizzly bears (Martinka 1982) and an apparent reduction in grizzly bears' wariness of people (McArthur 1980) were noted and caused concern for park managers (Glacier National Park 1981). Although no information existed concerning the causes of or relationships among these developments, a cause-and-effect relationship became generally accepted—that the increased number of hiker injuries was a direct result of bears' loss of their fear of people (Gjelten 1980, Schneider 1980, Kittredge 1982). Schneider (1980:40) stated that "the solution is, of course, to maintain—or in some cases reinstate—this fear without mortally wounding the grizzly." This conclusion is

speculation which is not based on scientific evidence. Because human injuries and fatalities caused by grizzly bears in Glacier National Park result in increased public sentiment that grizzly bears should be eradicated from the park because they pose an unacceptable danger to people (Kemsley 1978), it is critical that the rate of human injuries be reduced to the lowest level possible. Speculation is not an adequate foundation for management policies that will influence the survival of a population.

Examination of grizzly bear sighting reports in Glacier National Park showed that grizzly bears' behavior toward people in an area heavily used by people differed from their behavior in the rest of the park (McArthur 1980). The proportion of deliberate approaches and "neutral" responses, in which the bear continued its previous activity in spite of close proximity of people, was greater in the area heavily used by people. Although a midsummer increase in such behavior occurred in both the heavy-use area and the rest of the park, the behavior was reported at a consistently greater rate in the heavily used area throughout the summer and was believed to reflect long-term habituation of grizzly bears to people. Habituation to people was considered a manifestation of an ability that is adaptive for grizzly bears in their natural environment.

This study was conducted to examine in detail the responses of grizzly bears to people in an area heavily used by people and to explore implications of the bears' behavior in terms of human safety. Specific objectives were to (1) examine the temporal and spatial distribution of grizzly bear activity and human activity in an area

that was heavily used by people, (2) examine the characteristics of interactions between grizzly bears and hikers, and (3) test the hypothesis that the behavior of grizzly bears in areas heavily used by people is different from their behavior in areas that receive less human use.

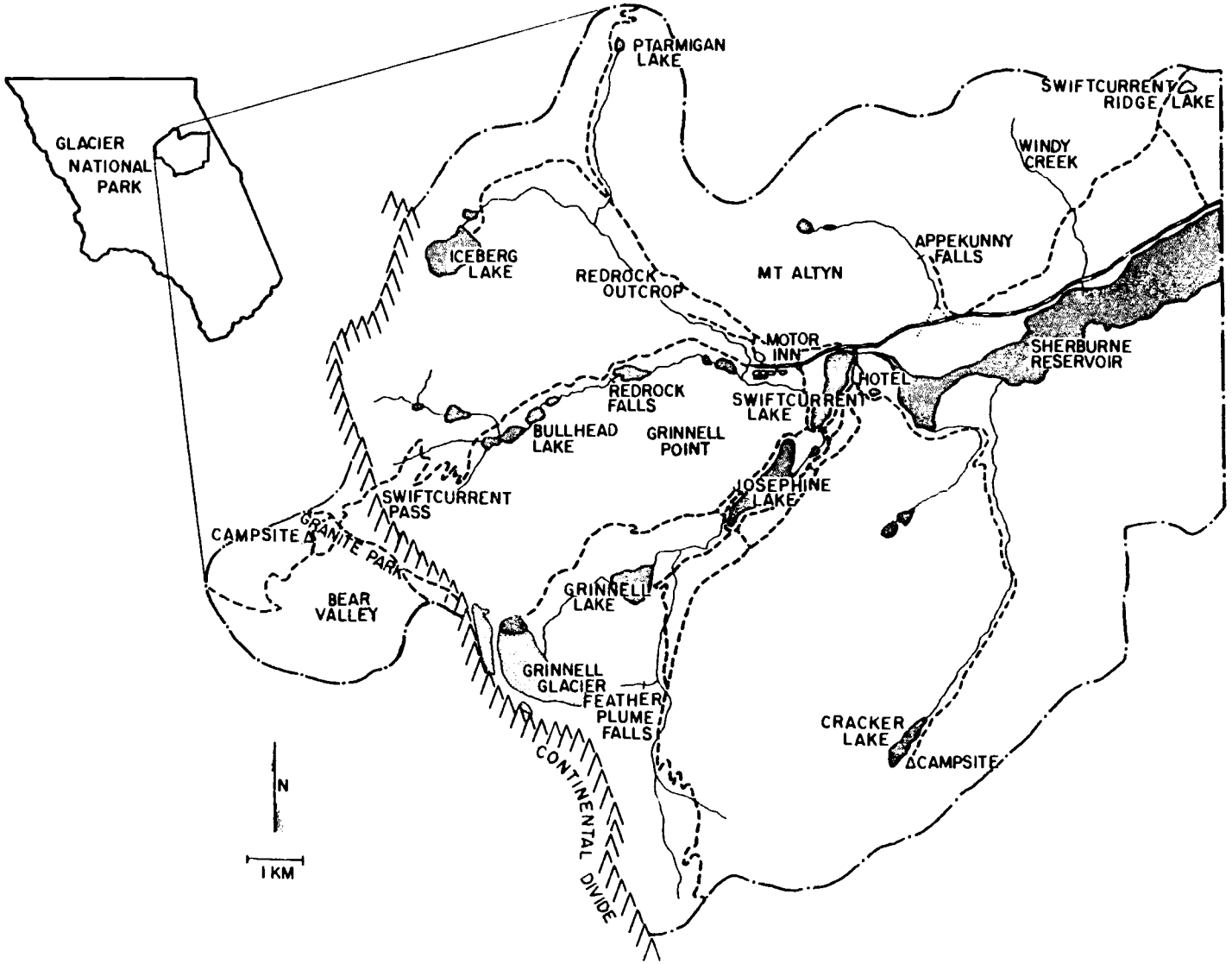
STUDY AREA

Glacier National Park is a 4,100-km^2 area of rugged mountains adjacent to the Canadian border in northwestern Montana. Research was conducted in the 154-km^2 area of Many Glacier and Granite Park in the east-central portion of the park (Fig. 1). Climate in the study area is continental. Freezing temperatures can occur in any month, and thunderstorms occur frequently during summer. Elevations range from 1,460 m to 3,050 m. The topography, shaped by alpine glaciation, is characterized by long, narrow, steep-walled valleys. Common habitat types include subalpine fir (Abies lasiocarpa)/ bedstraw (Galium triflorum)(Abla/Gatr), subalpine fir/beadlily (Clintonia uniflora) - beadlily phase (Abla/Clun-Clun), subalpine fir/ beargrass (Xerophyllum tenax) - globe huckleberry (Vaccinium globulare) phase (Abla/Xete-Vagl), and subalpine fir/woodrush (Luzula hitchcockii) - whortleberry (V. scoparium) phase (Abla/Luhi-Vasc)(Pfister et al. 1977). Early-successional stages are common due to a wildfire that burned west of Many Glacier Hotel in 1936, a wildfire in the Granite Park area in 1967, and annual spring snowslides.

The 2 backcountry campsites in the study area are located at Cracker Lake and Granite Park, with designated capacities of 2 and 4 parties (maximum of 4 people per party) per night, respectively. Trail length in the study area totals 80 km; all except the Swiftcurrent Ridge Lake and Sherburne cutoff trails are used primarily by day-hikers (Appendix 1). The only trail crossing the Continental Divide from Many Glacier is the Swiftcurrent Pass trail. Granite

Fig. 1. Map of the study area, Many Glacier/Granite Park, Glacier National Park.

Fig. 1.


PTARMIGAN LAKE
GLACIER NATIONAL PARK
SWIFTCURRENT RIDGE
LAKE
WINDY CREEK
ICEBERG LAKE
REDROCK OUTCROP
MT ALTYN
APPEKUNNY FALLS
MOTOR INN
SHERBURNE RESERVOIR
HOTEL
REDROCK FALLS
SWIFTCURRENT LAKE
BULLHEAD LAKE
GRINNELL POINT
JOSEPHINE LAKE
SWIFTCURRENT PASS
CAMPSITE
GRANITE PARK
BEAR VALLEY
GRINNELL LAKE
GRINNELL GLACIER
FEATHER PLUME FALLS
CRACKER LAKE
CAMPSITE
CONTINENTAL DIVIDE
N
1 KM

Park chalet is located 1.5 km west of Swiftcurrent Pass, at the intersection of the Swiftcurrent Pass, Highline, and Loop trails and a trail to the north used primarily by backpackers. The chalet provides overnight accommodations and meals for a maximum of 48 guests, as well as the staff, per night. Granite Park campsite and a patrol cabin, used by National Park Service rangers and trail crews, are located in the vicinity of the chalet. Approximately 1 km southeast of the chalet, and 160 m lower in elevation, is a bench that has been informally named Bear Valley because grizzly bears there may frequently be seen from the chalet. Drainage in Bear Valley is poor, and there are 2 ponds, a meandering creek, and a marshy area. Tree cover consists primarily of scattered subalpine fir.

Major visitor facilities are located at the confluence of Grinnell, Iceberg/Ptarmigan, and Swiftcurrent valleys. On the east shore of Swiftcurrent Lake are Many Glacier Hotel, a horse concession, and a boat concession whose boats take passengers on a tour across Swiftcurrent and Josephine lakes. West of Swiftcurrent Lake are a picnic area, Many Glacier Ranger Station, Many Glacier Campground, and Swiftcurrent Motor Inn, including a cafe and a store. The self-guiding Swiftcurrent Nature Trail (SNT) encircles Swiftcurrent Lake, with trailheads at the picnic area and Many Glacier Hotel.

METHODS

Research was conducted from 3 June through 15 September 1980 and from 14 June through 22 September 1981. Weather information recorded every day at Many Glacier Ranger Station included maximum and minimum temperature, weather type (amount of cloud cover or occurrence of precipitation), and occurrence of lightning. Changes in temperature were evaluated by subtracting the maximum temperature of the previous day from that of the present day. This measure will be referred to as "change in temperature."

Daily information on visitor use of the study area was obtained through the use of an infrared-beam traffic counter set up for alternating 9-day periods near the Swiftcurrent Pass and Iceberg/Ptarmigan trailheads. Two additional traffic counters were placed at each end of Swiftcurrent Nature Trail in 1980. Traffic counters provided minimum counts of people using the trails since people traveling abreast or adults carrying children were counted as single individuals. Records were also obtained on the number of passengers on the concession boat tours and on the numbers of campers at Cracker Lake and Granite Park backcountry campsites each day.

Canonical correlation analysis was used to evaluate the association of seasonal and weather variables with visitor use of trails, tour boats, and backcountry campsites. The aim of canonical correlation analysis is to explain as much as possible of the variation in one set of variables (here, the visitor-use variables) from a second set of variables (the environmental variables). Canonical correlation

analysis derives a linear combination from each set of variables in such a way that the pair of linear combinations have the highest correlation possible. A second canonical variate, or pair of linear combinations, is then derived to account for as much as possible of the remaining correlation between the 2 sets of variables. A canonical variate can be interpreted by its correlation with the original variables (its factor structure). Correlations of ≤ 0.30 were considered important. The canonical correlation coefficient (R_c^2) is the variation in the visitor-use variate that is explained by the associated environmental variate. Significance of canonical correlation coefficients was estimated using X^2 tests, though they are not a strict test of significance in canonical correlation analysis. Redundancy of each canonical variate is the variation in all visitor-use variables that was explained by the environmental variate. Total redundancy is the variation in all visitor-use variables that was explained by all environmental variables (McIntire 1978).

Midday distribution of people on trails in the study area was evaluated through trail censuses. Each of 10 trails in the study area was hiked once every 15 days during 1980 and, with the help of an assistant, twice every 15 days during 1981. Trails were scheduled systematically during 1980; they were hiked in the same order during each 15-day period. They were scheduled using a randomized block design during 1981; trails were hiked once every 15 days by the investigator and by the assistant, but according to a prescheduled random order, subject to the constraint that the same trail was not hiked by both people on the same day. At specific points along each

trail (a total of 30 points), the number of people who passed during 30 minutes was counted (Appendix 2). One point was located in each distinct trail section, defined by trail intersections and destinations. Where possible, census points were located in open vegetation and at sites where observations of grizzly bears were expected to be most likely, based on past reports of grizzly bear sightings and on personal experience of the investigator. Fifteen-day sets of hikes on which counts were made on the way up the trail were alternated with sets on which counts were made on the way down. Hikes were timed so that the counts would be centered around midday as much as possible. Information recorded during 30-minute censuses included the number of people in each group that passed; whether the people were day-hikers, backpackers, or on horseback; and whether they had bear-bells. Bear-bells are bells, of a variety of shapes and sizes, worn by some hikers who hope that they might somehow ward off a dangerous encounter with a bear. Type and relative amount of sound emanating from bells were not evaluated. Other types of noise-makers, such as cans of rocks, were not recorded. Daily temporal distribution of people was not evaluated.

Reports of grizzly bear observations by hikers in the study area were examined to identify factors influencing the behavior of grizzly bears toward people with a variety of behaviors and group sizes and under a variety of circumstances. The investigator either talked to the people who observed bears or knew the National Park Service employees who received reports and was familiar with their ability to evaluate the reliability of reports and to accurately record infor-

mation. Only reports considered reliable were used. Information recorded in each report included date; time; location; elevation; number of people in the group; whether the people were on horseback; whether the people had bear-bells; whether the bear was an adult, a subadult, or a female with young; the bear's closest distance to the people; the behavior of the bear when first seen; the response of the people; and the subsequent behavior of the bear. Time from midsummer was represented by a sine function of the date, calculated by sine ((date - minimum date)/ range of dates). A value of 1 indicates midsummer, and a value of 0 indicates the beginning or end of the season. The parameter will be referred to as "sineday." Time from sunrise or sunset, whichever was less, was used to evaluate crepuscularity. Values approaching 1 indicate proximity to midday. This parameter will be referred to as "midday." Unless otherwise stated, reports of bears seen in Bear Valley from Granite Park Chalet were not included in analyses since the chalet did not constitute a hiking situation.

Relationships between seasonal distribution of reported grizzly bear observations and of hiker use were evaluated by comparing the number of bear observations reported during each time period with the estimated number of people on the Swiftcurrent Pass, Iceberg/Ptarmigan, and Swiftcurrent Nature trails during each time period using X^2 tests. Because trail use was not measured simultaneously on all trails, seasonal trail use was estimated by regressing the use of each trail on day and sineday and interpolating trail use for periods when it was not measured.

Reported behavior of grizzly bears was categorized as (1) no movement in relation to people; (2) movement away from the people; (3) movement past the people, in which approximately the same distance was maintained; (4) movement toward the people; and (5) charge (Appendix 3). Charges included full charges, described by Egbert (1978:41), as well as "hop-charges." In a hop-charge, the bear moved toward the people with a rapid, stiff-legged, hopping gait, moving both front legs together. Its head was held high, and the fur around its neck stood on end, making the bear appear larger than it was. The bear's ears were forward. A hop-charge was very brief and lasted for only a few paces. Human responses were classified as (1) move away, (2) not move, or (3) move past or toward the bear. Factors affecting the bear's initial and subsequent behavior were evaluated using X^2 tests. Environmental circumstances of observations in which charges did or did not occur were compared using discriminant function analysis. Discriminant function analysis finds 1 or more linear combinations of the environmental variables that best distinguish between categories of a dependent variable (here, whether or not a charge occurred). F-tests were used to determine whether additional environmental variables contributed significantly ($P \leq 0.05$) to the separation.

Intensive observations of grizzly bears were made in order to examine in greater detail correlations between the behavior of grizzly bears and environmental circumstances. Areas in sight of trails on which hikers were censused were scanned, using binoculars, for grizzly bears. When a grizzly bear was observed, the following

data were recorded: date; time of day; cloud cover or precipitation; direction of the wind in relation to the bear and people; the bear's initial distance from the trail and its closest distance to people during the observation; geographic location; habitat type; number of people present when the observer first saw the bear; and the type of bear group, such as lone adult, lone subadult, or family group. Wind direction was later categorized as -1 indicating wind blowing to the side or from the bear toward the people, 0 indicating no wind, or 1 indicating wind blowing from the people toward the bear. Distances were evaluated by pacing, estimation, or measurement on 1:24,000 topographic maps. Elevation was measured on 1:24,000 topographic maps.

At 1-minute intervals during the observation, the bear's activity and the number of people present were recorded. Rate of people passing was calculated by dividing the number of people who arrived during the observation by the duration of the observation. Bears' activities were classed as traveling, feeding, investigating, or obscured from view. Investigation involved interruption of feeding or traveling to sniff or look toward the surroundings. When a bear became obscured from view, the observer waited for at least 20 minutes to see whether it would reappear. If the bear did not reappear, the last minute when it was seen was designated as the termination of the observation. Occurrence of bear-initiated interactions, defined as an action by the bear that resulted in a change in activity by the person to accommodate it, was also recorded.

The bear's initial distance to the trail, closest distance to

people, and amounts of time spent feeding, traveling, investigating, and obscured from view are collectively referred to as behavior variables. Year, day, sineday, time, midday, maximum temperature, minimum temperature, changes in temperature, lightning, wind direction, initial number of people present, rate of people passing, and elevation are collectively referred to as environmental variables. The initial number of people present during an observation and the amounts of time spent by the bear in feeding, traveling, investigating, and obscured from view were normalized using a logarithmic transformation before being used in analyses that assumed normal distribution of the variables. Rate of people passing during an observation, which incorporated measures of time and number of people, was transformed using the square root of the logarithm. Initial distance of bears to the trail and their closest distance to people were transformed using square-root transformation.

A non-hierarchical, divisive clustering method (C. D. McIntire, Oregon State Univ., pers. comm.) was used to group observations of grizzly bears based on behavior variables. Discriminant function analysis was then used to determine whether the groups of observations could be separated by the environmental circumstances under which they took place. Canonical correlation analysis was also used to evaluate correlations of environmental variables with the behavior of observed bears. In order to eliminate the effects of observations of bears in Bear Valley and to more accurately describe the behavior of bears seen while hiking during both years, observations of bears in Bear Valley were excluded from a canonical correlation analysis

of the 1980 and 1981 observations combined. Because discriminant analysis indicated that there were differences in the behavior of grizzly bears and in the circumstances under which they were observed during 1980 and 1981, separate canonical correlations also were done for each year.

Factors associated with the occurrence of grizzly bear observations were examined by comparing the proportional occurrence of observations in relation to date, weather type, maximum daily temperature, and habitat type with the availability of the different categories of those factors. Availabilities of dates, weather types, and maximum daily temperatures for observations of grizzly bears were calculated by the number of days on which trails were hiked under different categories of each factor. Aerial photographs were used to delineate segments of differing vegetation structure along trails. Habitat types were determined using the key and descriptions of habitat types identified by Pfister et al. (1977), verified by comparing species lists with those of Pfister et al., and then mapped on 1:24,000 topographic maps. Availability of habitat types for observations of grizzly bears was determined by multiplying the length of trail through each habitat type by the number of times that it was hiked. In comparing occurrence of bear observations with availability of habitat types along trails, only observations in which the bear was in a habitat type contiguous with the habitat type of the trail were considered. Habitat type was not determined for locations off of trails.

Huckleberries are an important food of grizzly bears in Glacier

National Park (Martinka 1972). To quantify the amount and distribution of production by huckleberry plants in the study area, the numbers of berries found on 15 huckleberry plants at each census point and 12 additional locations in the study area were counted during 19-29 August 1980 and 19-27 August 1981, periods that seemed to be the height of huckleberry production. Berries were counted on plants at least 1 m from the trail. No more than 4 plants were sampled per group of plants, and groups sampled were separated by at least 5 m, but were all within a 100-m distance along the trail. Differences in the amount of huckleberry production between 1980 and 1981 were evaluated using Wilcoxon's signed-rank test (Steel and Torrie 1980:539-540).

Throughout the analyses, means were compared using standard t-tests (Snedecor and Cochran 1980). Nonparametric distributions were compared using X^2 tests or, for small sample sizes, Fisher's exact test (Steel and Torrie 1980:504). Proportional distributions were compared using simultaneous confidence intervals (Neu et al. 1974). Tests were considered significant at $P \leq 0.05$. Values of $0.05 < P \leq 0.1$ were interpreted as indicating trends of marginal significance.

RESULTS

Visitor Use

A total of 2,429 people in 832 groups were counted along trails in the study area (Appendix 1). Excluding 7 boat-tour groups comprising 229 people, 94.1% of the groups were hikers, with a mean of 2.6 people/group; 4.5% of the groups were backpackers, with 2.6 people/group; and 1.5% were groups on horseback, with 8.1 people/group. Of the 776 hiker groups, 25.3% had bear-bells, and 35.1% of the 37 backpacker groups had bear-bells, whereas none of the 12 horseback groups had bear-bells. The proportion of groups with bear-bells was consistent throughout the study area except in the Grinnell valley, where only 17.2% of the 331 groups counted had bells ($z = 4.49$, $P < 0.0001$).

Of the variation in hiker use, 29.4% was associated with variation in seasonal and weather variables, when differences between years were not considered (Table 1). Two canonical variates accounted for 97% of this correlated variation, or redundancy, in environmental and visitor-use variables. Hiker use generally increased in midsummer and on warmer days ($R_c^2 = 0.751$, $P < 0.005$). Use of Granite Park backcountry campsite tended to be relatively greater in late summer than did use of trails, boats, or Cracker Lake campsite ($R_c^2 = 0.206$, $P < 0.005$).

In 1980 alone, 40.8% of the variation in visitor-use variables was associated with variation in the seasonal and weather variables.

Table 1. Factor structure and canonical correlation coefficients (R_c^2) of the first 2 canonical variates (CV1, CV2) of environmental and visitor-use variables, Many Glacier and Granite Park, 1980-81. Factor correlations of ≥0.3 are underlined.

Variables	1980-81 (Redundancy = 0.294)[a]		1980 (Redundancy = 0.408)		1981 (Redundancy = 0.362)	
	CV1	CV2	CV1	CV2	CV1	CV2
Environmental variables						
Sineday	0.915	-0.356	0.945	-0.296	0.831	-0.487
Max. temperature	0.497	-0.059	0.364	-0.628	0.626	0.454
Day	0.233	0.921	0.397	0.732	0.074	0.936
Min. temperature	0.227	-0.326	0.071	-0.296	0.283	0.125
Change in temperature	0.215	0.034	0.166	0.066	0.227	-0.134
Lightning	0.108	0.052	0.073	0.073	0.132	-0.037
Visitor-use variables						
Boats	0.953	-0.154	0.936	-0.088	0.926	-0.254
Granite Park campsite	0.601	0.770	0.683	0.474	0.571	0.759
Swiftcurrent Pass	0.408	-0.175	0.447	-0.015	0.416	0.009
Iceberg/Ptarmigan	0.378	-0.082	0.262	-0.241	0.414	-0.196
Cracker Lake campsite	0.357	-0.276	0.409	-0.359	0.288	0.213
SNT - east	-	-	0.768	-0.262	-	-
SNT - west	-	-	0.726	-0.591	-	-
R_c^2	0.751	0.206	0.796	0.312	0.782	0.403

[a]Redundancy is the amount of variation in visitor-use variables expressed by variation in the environmental variables.

Hiker use was greatest on warm days in midsummer, and it tended to be greater in late summer than in early summer ($R_c^2 = 0.796$, $P < 0.005$). Use of Granite Park backcountry campsite contrasted with use of Cracker Lake campsite and SNT - west in 1980 in that use of Granite Park campsite tended to increase as the season progressed and to be lower on warmer days, whereas use of Cracker Lake and SNT - west tended to be higher on warmer days ($R_c^2 = 0.312$, $P < 0.005$).

In 1981, 36.2% of the variation in visitor-use variables was associated with variation in season and weather variables. As in 1980, hiker use was greatest in midsummer and on warmer days, but there was little difference between early and late summer ($R_c^2 = 0.782$, $P < 0.005$). Use of Granite Park campsite, however, was greater in late summer and, unlike 1980, tended to be greater on warmer days ($R_c^2 = 0.403$, $P < 0.005$).

Reported Observations of Grizzly Bears

Geographic distribution.—The geographic distribution of reported grizzly bear observations was correlated with the distribution of habitat types. The rate of reported bear observations per hiker group per km of trail was correlated with the product of the proportions of trail distance that passed through the Abla/Gatr and Abla/Luhi-Vasc habitat types ($R^2 = 0.682$, $P < 0.05$). This correlation indicated that the rate of reported bear observations was related to some sort of interaction of the 2 habitat types. There was no correlation of the rate of bear observations with the mean level of hiker

use on each trail ($R^2 = 0.364$, $P > 0.1$) or with an interaction between hiker use and habitat type ($R^2 = 0.012$, $P > 0.1$).

The geographic distribution of reported bear observations differed between the years ($X^2 = 43.2$, 7 df, $P < 0.005$)(Table 2) although there was no difference in the geographic distribution of hikers ($X^2 = 11.0$, 15 df, $P > 0.1$). The difference in distribution of bear observations may have reflected geographic variation in productivity of the habitat. The distribution in production of one bear food item, huckleberries, was found to differ geographically between the years ($X^2 = 779.7$, 32 df, $P < 0.005$), and the level of huckleberry production was greater in 1981 than in 1980 ($T = 38.5$, $n = 35$, $P < 0.005$)(Table 3).

Seasonal distribution.—Seasonal distribution of the numbers of reported bear observations was not related to the estimated seasonal distribution of hikers ($X^2 = 16.1$, 7 df, $P < 0.025$)(Table 4). Hiker use peaked between 13 July and 9 August, whereas the number of reported bear observations peaked during 10-23 August.

Age and reproductive status.—The age/sex composition of bears reported in the study area did not differ from their proportional occurrence in the Glacier National Park population (Martinka 1974:24) (Table 5). However, the composition of bears reported in Bear Valley differed from those in the rest of the study area ($X^2 = 68.9$, 2 df, $P < 0.005$). The majority of observations in Bear Valley were of females with young, exceeding their proportion in the population ($z = 6.64$, $P < 0.001$), whereas few observations of females with young

Table 2. Geographic distribution of reported grizzly bear observations, Many Glacier and Granite Park, 1980-81.

Trail	1980	1981
Swiftcurrent Ridge	0	1
Iceberg Lake	0	3
Josephine Lk., Grinnell Lk.	0	3
Piegan	1	3
Ptarmigan Lake	3	0
Grinnell Glacier	6	7
Iceberg/Ptarmigan	7	12
Swiftcurrent Pass	7	29
Granite Park chalet area	9	0
Cracker Lake	13	3
Granite Park trails	22	10

Table 3. Mean number of huckleberries counted at each site that had huckleberry plants along trails in the study area, Many Glacier and Granite Park, 1980-81.

Trail	No. of sites examined	No. of sites with huckleberry plants	Mean no. of huckleberries/site	
			1980	1981
Chlorinator Road	1	0	-	-
Iceberg/Ptarmigan	4	2	6.5	32.5
Swiftcurrent Pass	5	5	7.4	43.4
Swiftcurrent Ridge	6	6	7.5	39.2
Cracker Lake	3	2	12.0	67.5
Granite Park trails	5	4	14.3	86.8
Josephine Lk., Grinnell Lk.	8	7	15.7	126.3
Ptarmigan Lake	4	3	21.7	51.3
Grinnell Glacier	1	1	32.0	166.0
Iceberg Lake	1	1	50.0	57.0
Piegan	3	3	55.7	82.7
Granite Park chalet area	1	1	190.0	156.0

Table 4. Seasonal distribution of hikers and reported observations of grizzly bears, Many Glacier and Granite Park, 1980-81.

Period	Estimated number of people[a]	Number of reported grizzly bear observations	Rate of reported grizzly bear observations (people/report)
15 Jun - 28 Jun	3,286	6	548
29 Jun - 12 Jul	5,187	20	259
13 Jul - 26 Jul	5,687	17	335
27 Jul - 9 Aug	6,124	31	198
10 Aug - 23 Aug	5,430	34	160
24 Aug - 6 Sep	3,617	18	201
7 Sep - 20 Sep	1,881	7	269

[a]Numbers of people were estimated through regressions on day and sineday of the numbers of hikers on the Iceberg/Ptarmigan, Swiftcurrent Pass, Grinnell, and Swiftcurrent Nature trails.

Table 5. Age/sex composition of reported grizzly bear observations in Many Glacier and Granite Park.

Area	N	Adults	Subadults	Females with young
Study area, excluding Bear Valley				
1980	70	0.714	0.286	0
1981	73	0.671	0.205	0.123
Total	143	0.692	0.243	0.063
Bear Valley				
1980	22	0.273	0.455	0.273
1981	46	0.283	0	0.717
Total	68	0.279	0.147	0.574
Total study area, 1980-81	211	0.559	0.213	0.227
Glacier National Park[a]		——— 0.723 ———		0.277

[a]Martinka (1974:24)

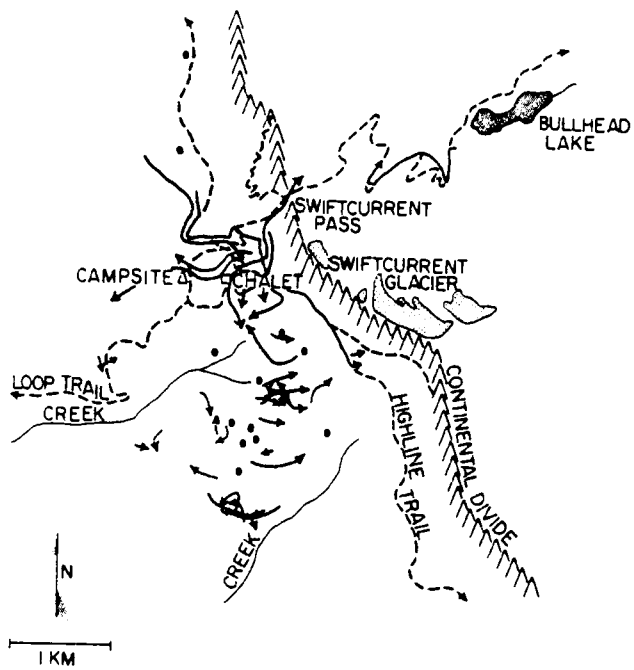
were reported in the rest of the study area. Throughout the study area, a greater proportion of observations were of females with young in 1981 than in 1980 ($z = 5.66$, $P < 0.0001$). The proportion of subadults observed in Bear Valley varied inversely with the total number of other bears and with the proportion of females with young observed there.

Bears observed at Granite Park.—Most bears observed in Bear Valley were feeding, and as many as 2 lone adults and 2 females with 2 cubs each were observed there at one time. A heavily used human trail traversed the slopes above Bear Valley, but the valley itself received virtually no human use. Bears that used the food resources there could thus do so without disturbance by people.

In spite of the preferential use of Bear Valley by females with young during 1981, they were never observed traveling through the nearby chalet area. Lone adults and subadults, on the other hand, traveled through the chalet area on numerous occasions during 1980 and, less frequently, in 1981 (Fig. 2). In several instances, they moved from the wooded drainage north of Granite Park or from the area of Swiftcurrent Pass and Swiftcurrent Glacier through the chalet area, foraging as they went, and sometimes traveling on human trails and moving into close proximity with people. Bedding bears were observed near Swiftcurrent Glacier in 1981, and the wooded slopes north of Granite Park may also provide sites for bedding. In moving to Bear Valley to feed, however, bears traveling from these areas or from Many Glacier must cross either the Highline trail, the Loop trail,

Fig. 2. Observations, made by the investigator, bear management rangers, and Swiftcurrent lookout, of grizzly bears and their movements in the Granite Park area during 1980. Observations reported by park visitors are not included.

Fig. 2


BULLHEAD LAKE
SWIFTCURRENT PASS
SWIFTCURRENT GLACIER
CAMPSITE
CHALET
LOOP TRAIL
CREEK
HIGHLINE TRAIL
CONTINENTAL DIVIDE
CREEK
N
1 KM

or the Swiftcurrent Pass trail, all of which are heavily used, and may pass through the vicinity of Granite Park chalet or the back-country campsite.

Factors Influencing Reported Behavior of Grizzly Bears

Age and reproductive status.—No difference existed in the initial behavior of adults and subadults ($X^2 = 1.7$, 2 df, $P > 0.1$) nor in their subsequent behavior ($X^2 = 3.5$, 4 df, $P > 0.1$). The initial behavior of females with young did not differ from that of other bears (Fisher exact test, $P = 0.296$), but their subsequent behavior differed in that females with young charged the observers more often than did other bears (Fisher exact test, $P = 0.021$).

Excluding observations of bears in Bear Valley, there was no difference in the distance from people of females with young and of adults (Fisher exact test, $P = 0.216$). A greater proportion of subadults than other bears were seen within 150 m of people ($X^2 = 8.2$, 2 df, $P < 0.025$)(Table 6). Because there is intrinsically more disturbance by people in areas that are near people, these areas may constitute somewhat less favorable habitat and may therefore receive less use by adult bears than areas that are farther from people. Subadults that use areas near people may be subject to greater disturbance by people but to less harassment by adult bears, an apparently acceptable tradeoff.

Distance from people.—The initial behavior of bears differed depending on whether their closest distance was less than or greater

Table 6. Proportion of each age/sex-class of grizzly bears that was reported within 150 m of people, Many Glacier and Granite Park, 1980-81.

Age/sex-class	N	Proportion that was within 150 m	90% confidence interval
Adults	99	0.636	$0.522 < p_1 < 0.750$
Subadults	35	0.857	$0.727 < p_2 < 0.987$*
Females with young	9	0.444	$0.132 < p_3 < 0.757$
All bears	143	0.678	

*Differs from expected for all bears, $P < 0.1$.

than 150 m from people ($X^2 = 12.3$, 2 df, $P < 0.005$)(Table 7). The subsequent behavior of bears that were >150 m from people did not differ from their initial behavior ($X^2 = 1.2$, 1 df, $P > 0.1$); in 39 of the 46 observations, the bear's subsequent behavior was the same as its initial behavior. On the other hand, the subsequent behavior of bears that were within 150 m of people differed substantially from their initial behavior ($X^2 = 58.0$, 4 df, $P < 0.005$). Of the observations within 150 m, 10% resulted in charges. Because interactive behavior occurred primarily in observations in which the bear's closest distance was ≤150 m, the remainder of the results presented on reported bear observations will refer only to observations of bears that were within 150 m of people unless otherwise stated.

Bear-bells.—Presence or absence of bear-bells was recorded in 97 of the 143 reports of grizzly bear observations at all distances. Of these, 23.7% of the observer groups had bells. This does not differ from the proportion of the 832 groups censused who had bells (25.1%, $z = 0.31$, $P > 0.1$). There was also no difference in the proportion of groups reporting bears within 150 m who had bells (30.6%) and the proportion of groups censused who had bells ($z = 0.91$, $P > 0.1$). Thus, if reporting effort by hikers with and without bells was the same, there was no difference in the frequency of grizzly bear observations made by people with or without bells.

Considering bears observed at all distances, people with bells observed bears at closer distances than did people without bells. The mean closest distance of all bears seen outside of Bear Valley

Table 7. Reported initial and subsequent behavior of grizzly bears in relation to the bears' minimum distance from people, Many Glacier and Granite Park, 1980-81.

Behavior category	Closest distance ≤150 m (N = 97)		Closest distance >150 m (N = 46)	
	Initial behavior	Subsequent behavior	Initial behavior	Subsequent behavior
No movement	0.59	0.30	0.87	0.76
Move away	0.05	0.40	0.04	0.17
Move past	0.13	0.15	0.07	0.04
Move toward	0.23	0.04	0.02	0.02
Charge	0	0.10	0	0

was 303 m from people without bells and 80 m from people with bells ($t = 2.89$, 87 df, $P < 0.01$). This difference may not have been due to a difference in behavior of the bears, however, but to the confidence of hikers with bells and their consequent lack of attention to their surroundings. For bears that were seen within 150 m of the observers, there was no difference related to presence or absence of bells in the bears' frequency at various distances ($X^2 = 5.8$, 3 df, $P > 0.1$), nor was their distribution different from an even distribution ($X^2 = 1.8$, 3 df, $P > 0.1$).

When bears within 150 m of people were initially not moving, there was no change in their behavior when they were closer to people with bells than to people without bells ($t = 4.05$, 20 df, $P < 0.01$). This suggests a reduction in flight distance of bears from people with bells. Information was not available concerning the initial distances from which bears either moved toward or charged people with and without bells.

There was no difference in the initial behavior of bears seen by people with and without bear-bells. Also, in observations by people both with and without bells, the bear's subsequent behavior differed from its initial behavior. The way in which the behavior changed, however, was related to whether or not the observers had bells ($X^2 = 6.0$, 2 df, $P < 0.05$)(Table 8). For example, of the bears that were initially not moving, 67% moved away from people with bells and 26% moved away from people without bells ($z = 2.47$, $P = 0.007$); 25% continued not moving in relation to people with bells and 48% continued not moving in relation to people without bells ($z = 1.40$,

Table 8. Reported initial and subsequent behavior of grizzly bears observed by hikers with or without bear-bells. Only observations in which the bear's closest distance was within 150 m of people are included.

Behavior category	Hikers with bells (N = 19)		Hikers without bells (N = 43)	
	Initial behavior	Subsequent behavior	Initial behavior	Subsequent behavior
No movement	0.63	0.16	0.53	0.33
Move away	0.11	0.68	0.05	0.35
Move past	0.05	0.16	0.09	0.12
Move toward	0.21	0	0.33	0.07
Charge	0	0	0	0.14

$P = 0.081$). Bears may have been more frequently unaware of people without bells than of people with bells. Of the bears that were initially moving toward people, they either moved away or moved past people with bells, whereas the most frequent subsequent behavior toward people without bells was to either move away (50%) or to charge (21%). No bear observed by people with bells subsequently charged, whereas 14% of the bears observed by people without bells subsequently charged ($z = 2.64$, $P = 0.008$).

Bells are thus useful as unambiguous informational implements. Bears in Glacier do not encounter the sound of bells except in association with people, and most bears in the park have probably had sufficient exposure to bells to have learned to associate them with people. There is no evidence to suggest that bears fear bells, but for bears that are wary of people, bells may give adequate warning for them to accommodate to approaching people, precluding the stressful consequences of a surprise encounter.

Human response.—Different initial behaviors by bears resulted in different responses by people ($X^2 = 14.8$, 4 df, $P < 0.01$)(Table 9). Overall, people responded by standing and watching in 59% of the observations, by moving away in 28% of the observations, and by moving past or toward the bear in 13% of the observations. People responded by watching most frequently when the bear was moving past them, and by moving away when the bear was moving toward them. When people moved past or toward the bear, it most frequently had not been moving. In spite of the differences in initial behavior that elicited

Table 9. Response of observers in relation to initial behavior of grizzly bears, Many Glacier and Granite Park, 1980-81. Only observations in which the bear's closest distance was within 150 m of people are included.

Human response	Initial behavior of bear			
	Not moving (N = 57)	Moving away (N = 5)	Moving past (N = 13)	Moving toward (N = 22)
Move away	0.19	0.40	0.15	0.55
Not move	0.60	0.60	0.77	0.45
Move past or toward	0.21	0	0.08	0

different human responses, there was no difference in the bears' subsequent behavior ($X^2 = 10.3$, 6 df, $P > 0.1$).

Hiker group size.—Assuming equal reporting effort, a greater proportion of large groups and a smaller proportion of small groups observed bears ($X^2 = 57.3$, 2 df, $P < 0.005$). Groups of 8 or more people made up 3.1% of the groups censused but made 18.2% of the reported bear observations, while groups of 1-2 people constituted 67.1% of the groups censused but made 50.3% of the reported bear observations. Larger groups may be more likely to see bears because of the greater number of people in the group and thus the greater likelihood that someone in the group will sight a bear that is nearby.

There was no difference in the initial behavior of bears encountered by hiker groups of different sizes ($X^2 = 0.8$, 4 df, $P > 0.1$), but there was an apparent slight relationship between group size and the bear's subsequent behavior ($X^2 = 11.7$, 6 df, $P < 0.1$). Most of the difference, however, could be attributed to the significant relationship between hiker group size and the presence of bear-bells ($X^2 = 16.6$, 2 df, $P < 0.005$). Of the groups of 5 or more people, 44% had bells, while only 14% of the lone hikers had bells. The only effect of hiker group size over and above the effect of bells was that for hikers without bells, a greater proportion of bears tended to move away from groups of 1-2 hikers than from larger groups (Fisher exact test, $P = 0.101$). This may be related to relatively unpredictable behavior of smaller groups (Schultz and Bailey 1978) or to the degree of uncertainty in the bear's identification of small groups without bear-bells as people.

Horses.—Assuming equal effort in reporting observations, a greater proportion of groups on horseback saw bears than did hiker groups. Horse parties made up 1.5% of the groups censused on the trails, but they reported 8.2% of the grizzly bear observations ($z = 2.41$, $P = 0.008$) although the mean group sizes of horse parties (4.1) tended to be smaller than the mean of 7.0 hikers in groups that saw bears within 150 m ($t = 1.64$, 23 df, $P < 0.1$).

No difference was detected in the initial behavior of bears observed by groups on horseback and by hikers ($X^2 = 0.09$, 1 df, $P > 0.1$). There was an apparent slight difference in the bears' subsequent behavior, although the sample size was small ($X^2 = 2.9$, 1 df, $P < 0.1$) (Table 10). Six of the 8 bears observed by people on horseback were initially not moving. Of these, 1 (17%) remained not moving, while 2 (33%) charged after the people yelled at the bear or attempted to move past it. Of the 51 bears that were initially not moving when observed by hikers, 49% remained not moving and 4% charged. People on horseback had a slightly greater tendency to move past or toward the bear than did hikers (Fisher exact test, $P = 0.072$). Because of their large size, horses may constitute more intense stimuli than hikers, and bears' responses to them may therefore sensitize rather than habituate with repetition (Peeke et al. 1979a). The form of a horse probably more closely resembles a large bear, which would constitute a threat, than does the form of a hiker.

Observations involving charges.—Charging of hikers by grizzly bears is of concern because surprise and/or a charge was involved in

Table 10. Initial behavior of grizzly bears, and their subsequent behavior in relation to whether the observers were on horseback, Many Glacier and Granite Park, 1980-81.

Behavior category	Initial behavior of the bear (N = 97)	Subsequent behavior of the bear	
		Observers on horses (N = 8)	Observers hiking (N = 89)
No movement	0.59	0.13	0.30
Move away	0.05	0.25	0.43
Move past	0.13	0.25	0.15
Move toward	0.23	0.13	0.03
Charge	0	0.25	0.09

at least 78% of the 23 injuries to hikers by grizzlies in Glacier (Appendix 4). The proportion of observations that involved charges on trails in the study area that were more heavily used by people did not differ from the proportion on trails that received little human use ($z = 1.14$, $P > 0.1$). On trails where ≤1.5 groups of people were counted per hour during midday, 15% of the 26 reported observations involved charges, whereas 7% of the 75 observations reported on trails with >3.0 groups per hour involved charges.

A hop-charge generally seems to be a bear's initial response to something that startles it, and a full charge is commonly considered a response to a perceived threat or, at an aggregation, a dominance display. All 4 charges reported on trails with ≤1.5 groups/hour were full charges, whereas 1 of the 5 charges on trails with >3.0 groups/hour was a full charge. The difference in the proportions of reported observations that involved full charges is significant (4/26 vs. 1/75, $z = 1.95$, $P = 0.026$). The only full charge on a trail with >3.0 groups/hour involved a female with cubs. This family of bears was not seen along a trail for the remainder of the study. On the other hand, the only hop-charge on a trail with ≤1.5 groups/hour was one that preceded a full charge. Occurrence of hop-charges on trails with more people indicates that bears near those trails can still be startled by people, but the lower rate of full charges suggests that they have a lower propensity to perceive people as a threat.

The differences in occurrence of charges was not related to the proportions of people with bells on those trails. In fact, the proportion of groups with bells on relatively heavily used trails (24.7%)

tended to be lower than on low-use trails (32.5%, $z = 1.40$, $P = 0.081$).

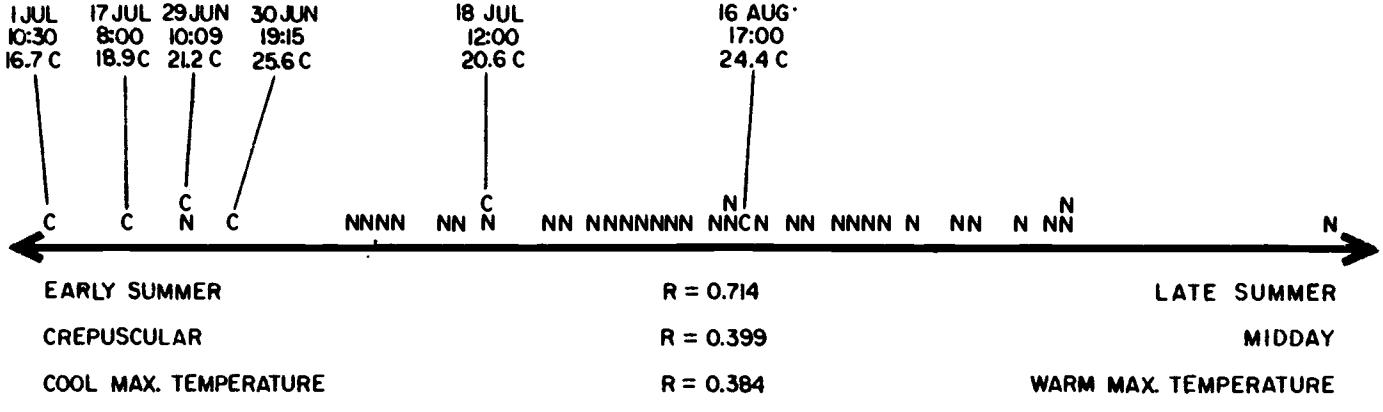
Discriminant function analysis showed that when only the observations by hikers without bells were considered, environmental variables separated observations with charges from those without charges with 90% accuracy (Fig. 3). Charges tended to occur at crepuscular times on cool days early in the summer. McArthur (1980) also found that charges in Many Glacier and Granite Park occurred before midsummer during 1977-79.

One observation without a charge was incorrectly classified by the discriminant function as having involved a charge. It occurred at 18:00 on 10 July 1981, on which the maximum temperature was 20.0C. An adult grizzly bear was observed feeding along the Swiftcurrent Ridge trail, above Windy Creek. The person backed away, and the bear continued to feed. The person believed that the bear was not aware of his presence.

The tendency for charges in the study area to occur only before midsummer may be related to the habituation process. Stonorov and Stokes (1972:241) and Egbert (1978:22) observed that the occurrence of charges at feeding aggregations declined over time as the bears habituated to one another's proximity. In Many Glacier and Granite Park, charges in early summer may involve bears that either have not yet habituated to contact with people or have not yet adopted means of avoiding human contact.

Fig. 3. Locations along discriminant axis of reported grizzly bear observations in which charges did (C) or did not (N) occur, Many Glacier and Granite Park, 1980-81. Only observations by hikers without bells are included.

Fig. 3


1 JUL 10:30 16.7 C
17 JUL 8:00 18.9 C
29 JUN 10:09 21.2 C
30 JUN 19:15 25.6 C
18 JUL 12:00 20.6 C
16 AUG 17:00 24.4 C
C C C N C
NNNN NN C N NN NNNNNNN NNCN NN NNNN N NN N N N N
EARLY SUMMER
CREPUSCULAR
COOL MAX. TEMPERATURE
R = 0.714
R = 0.399
R = 0.384
LATE SUMMER
MIDDAY
WARM MAX. TEMPERATURE

Intensive Observations of Grizzly Bears

We made 24 observations of grizzly bears during 1980 and 28 observations during 1981. One observation during 1981, on the final day of the field season, lacked weather data and was excluded from analyses involving weather data.

Factors influencing numbers of bears observed.—Seasonal patterns of habitat use by grizzly bears influenced the numbers of bears observed by the investigators. Numbers of bears seen were significantly related to date. More bears than expected were seen between 13 July and 9 August (21 observed vs. 11.5 expected, $z = 2.05$, $P = 0.020$). There was also a significant relationship between habitat type and the numbers of bears observed. Although 30.4% of the distance hiked by the investigators was in the Abla/Gatr habitat type, 61.3% (19/31) of grizzly bears observed were in that habitat type ($z = 3.51$, $P < 0.001$). In contrast, 27.5% of the distance hiked was in the Abla/Clun-Clun habitat type, but no grizzly bears were observed there ($z = 3.43$, $P < 0.001$). Locations of habitat types along trails are shown in Appendix 5.

There was no relationship between numbers of bears seen and either the weather type ($X^2 = 1.3$, 3 df, $P > 0.1$) or the maximum temperature ($X^2 = 0.2$, 2 df, $P > 0.1$). State of the weather when bears were observed was representative of the general weather type over the entire day ($X^2 = 19.7$, 2 df, $P < 0.005$).

Behavioral classification of observations.—Six groups of observations were identified using cluster analysis of behavior variables (Table 11). Although discriminant function analysis indicated that year, sineday, and maximum temperature could be used to predict correct assignment of the observations to behavior clusters with 47% accuracy, groups 3-6 could not be distinguished. In general, bears were observed feeding at a great distance (group 1) primarily during 1981. This was probably related to productivity of the habitat in areas that were in sight of trails, such as Bear Valley. Bears were observed feeding and traveling at a moderate distance from trails (group 2) on cool days near midsummer in 1980 and 1981. Bears were briefly observed traveling near trails (group 3) early or late in the season only during 1980. Observations of bears feeding near trails (group 4) occurred early or late in the season during both 1980 and 1981. In these observations, bears spent little time investigating.

Bears were observed feeding and traveling near trails (group 5) and interacted with people while traveling on or near trails (group 6) on midsummer days in 1980 and 1981. In both of these behavior groups, bears spent a greater proportion of time investigating than occurred in the other behavior groups. Interactions with people occurred in 55% of the observations in these 2 groups. No difference was detected in environmental variables associated with group-5 and group-6 observations. However, discriminant function analysis showed that environmental variables could be used to distinguish the observations in these 2 groups, which occurred at close quarters and were

Table 11. Grouping of observations resulting from cluster analysis based on behavior variables, Many Glacier and Granite Park, 1980-81.

Group	Description of observation
1 Feeding, a great distance away	Adult feeding on mountainside above picnic area
	Adult digging at head of Cracker Lake
	Adult feeding on slope above lower Cracker L. trail
	Adult feedong on slope across from Loop trail
	Female with cubs traveling in Bear Valley
	Adult digging in Bear Valley
	Female with cubs feeding in Bear Valley
	Female with cubs feeding in Bear Valley
	Adult walking in Bear Valley
	Female with cubs feeding in Bear Valley
	Adult digging in Bear Valley
	Adult digging in Bear Valley
	Subadult feeding near trail, west of Redrock Falls
	Female with cubs feeding and digging in Bear Valley
	Female with cubs traveling in Bear Valley
	Adult feeding on south side of Grinnell Point
	Female with cubs digging in Bear Valley
	Female with cubs traveling in Bear Valley
	Adult feeding on north side of Grinnell Point
2 Feeding and traveling at a moderate distance	Adult feeding on hillside above Iceberg/Ptarm. trail
	Adult feeding on hillside above motor inn
	Adult traveling on Highline trail, north of chalet
	Adult feeding along trail west of Swiftcurrent Pass
	Adult traveling on Highline trail, south of chalet
	Adult walking near Granite Park campsite
	Female with cubs walking on slope across from Loop trail
	Adult traveling and feeding, north of Bullhead L.
	Adult traveling at head of Swiftcurrent valley
	Adult traveling south of Fishercap L.
	Adult traveling up slope, west of Redrock Falls
	Adult feeding, east slope of Mt. Wilbur
3 Brief observation traveling near trail	Adult feeding on hillside above Iceberg/Ptarm. trail
	Adult traveling on Iceberg/Ptarm. trail
	Adult traveling on Iceberg/Ptarm. trail
	Adult traveling on slope across from Loop trail
	Adult walking through brush near Loop trail
	Adult walking through brush near Loop trail

Table 11. Continued.

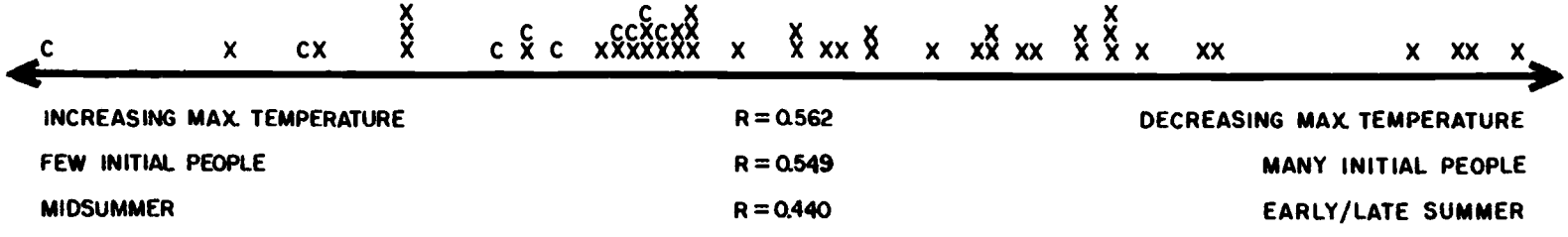
Group	Description of observation
4 Feeding near trail	Adult digging on trail west of Swiftcurrent Pass
	Adult feeding above Iceberg/Ptarm. trail
	Adult feeding near Loop trail
	Adult feeding near Cracker Lake trailhead
	Adult feeding below Iceberg/Ptarm. trail
	Adult digging below Iceberg/Ptarm. trail
5 Feeding and traveling near trail	Adult feeding above Iceberg/Ptarm. trail
	Adult walking near Granite Park trail cabin
	Adult feeding and traveling near Cracker L. trail
	Adult moving away from other bear, west of Redrock Falls
6 Traveling on or near trail, interacted with people	Adult feeding above Iceberg/Ptarm. trail, hop-charged
	Adult traveling on trail at head of Bullhead L.
	Adult traveling on trail below Swiftcurrent Pass
	Adult running off trail, head of Bullhead L.
	Adult walking on Iceberg/Ptarm. trail

collectively interpreted as potential interactions, from the other observations with 80% accuracy (Fig. 4). The close observations occurred near midsummer, when maximum temperatures were rising, and when few people were present.

Of the 9 close observations, 5 involved interactions. Four of the interactions involved mutual surprise when the observer and the bear were separated by distances of less than 25 m. In one interaction, a grizzly bear moved onto the trail on which the investigator was traveling, apparently unaware of the person. When it saw her, it moved back into the brush adjacent to the trail. A moment later, it returned to the trail and walked toward the investigator and 2 other hikers. The 3 people moved off of the trail, and the bear walked past at a distance of 3 m. In another interaction, a bear walking on the trail encountered the investigator walking in the other direction. When it saw the investigator, the bear paused and then resumed walking toward the investigator, who backed away. When the bear encountered an apparently attractive patch of huckleberries adjacent to the trail, it began to feed. A moment later, the bear heard the sound of bells and ran off into the brush. The 2 hikers wearing bells never saw the bear. The difference in response of the bear may be attributable to a factor of choice. The bear was unaware of the investigator until it had already been seen, but when the approaching sound of bear-bells gave it a choice, it chose not to be seen. In a third interaction, a bear stood up from the winding trail ahead, looked at the investigator, and ran off of the trail. It was soon heard in the brush beside the investigator, at a distance

Fig. 4. Locations along discriminant axis of grizzly bear observations that were at close quarters and were interpreted as potential interactions (C) and other observations (X) by the investigator and assistant, Many Glacier and Granite Park, 1980-81.

Fig. 4


INCREASING MAX. TEMPERATURE
FEW INITIAL PEOPLE
MIDSUMMER
R = 0.562
R = 0.549
R = 0.440
DECREASING MAX. TEMPERATURE
MANY INITIAL PEOPLE
EARLY/LATE SUMMER

of about 10 m, sniffing. It then apparently left. In the fourth interaction, a bear that had been drifting in the direction of the trail hop-charged when it suddenly became aware of the investigator and 7 other people. It then resumed traveling, crossed the trail, and disappeared into dense vegetation. The fifth interaction involved a bear that the investigator first saw as it approached a trail, in full view of a group of 4 hikers. The bear was probably aware of the hikers, but the hikers continued to walk toward the bear, apparently unaware of it. When the hikers saw the bear, they turned and walked away. The bear moved onto the trail and followed the hikers, at their pace. After the hikers had preceded the bear for a distance of about 200 m, they climbed into the rocks above the trail, and the bear continued on the trail past them.

Correlations between environment and behavior.—Canonical correlation analysis of 1980 and 1981 observations together, excluding observations of bears in Bear Valley, showed that 38.3% of the variation in behavior variables was associated with variation in environmental variables, when year was not considered (Table 12). Although this correlation is low, it does signify the existence of an interaction between the behavior of grizzly bears and the circumstances under which they were observed. Bears traveled less, were obscured from view less, and were closer to people on early- or late-summer days with increasing maximum temperatures when there was a low rate of human activity ($R_c^2 = 0.679$, $P < 0.005$). Bears tended to investigate more, travel more, feed less, and be obscured from view less at

Table 12. Factor structure and canonical correlation coefficients (R_c^2) of the first 3 canonical variates (CV1, CV2, CV3) of environmental and behavior variables for 51 observations of grizzly bears, Many Glacier and Granite Park, 1980-81. Factor correlations of ≥0.3 are underlined.

Variables	1980-81 (Redundancy = 0.383)[a]			1980 (Redundancy = 0.474)			1981 (Redundancy = 0.604)		
	CV1	CV2	CV3	CV1	CV2	CV3	CV1	CV2	CV3
Environmental vars.									
Change in temp.	0.513	0.322	-0.016	0.190	0.706	-0.112	-0.159	0.037	0.132
Max. temperature	0.118	0.367	0.019	-0.323	0.083	0.263	0.212	-0.240	0.308
Day	0.009	-0.073	0.037	-0.566	0.100	0.170	0.252	-0.057	0.087
Wind direction	-0.007	-0.248	-0.185	0.031	0.049	-0.451	0.091	0.172	-0.341
Elevation	-0.045	-0.399	-0.286	-0.105	-0.306	-0.312	0.937	0.014	-0.262
Min. temperature	-0.084	0.276	0.436	-0.230	-0.085	0.444	-0.166	0.154	0.416
Midday	-0.091	0.702	-0.176	0.545	0.140	0.572	-0.154	-0.423	0.524
Time	-0.102	-0.207	0.327	-0.250	-0.268	-0.058	-0.064	0.119	-0.540
Initial people	-0.157	-0.620	-0.181	-0.236	-0.493	-0.395	0.611	0.015	-0.183
Lightning	-0.204	-0.418	-0.379	-0.013	-0.516	-0.427	0.235	-0.509	-0.384
Rate of people	-0.400	-0.055	0.266	0.576	-0.099	-0.300	-0.274	0.399	-0.130
Sineday	-0.644	0.207	-0.511	0.450	-0.501	-0.040	0.179	-0.442	-0.163
Behavior vars.									
Feed	0.155	-0.504	0.008	0.099	-0.036	-0.473	0.018	0.488	0.248
Initial distance	0.011	0.240	0.090	0.625	0.417	0.193	0.823	-0.072	-0.407
Investigate	-0.176	0.497	0.258	0.168	0.121	0.266	-0.373	0.126	0.542
Closest distance	-0.376	-0.221	-0.032	0.517	-0.365	-0.001	0.897	0.110	-0.394
Travel	-0.490	0.301	-0.687	0.786	-0.116	-0.195	-0.038	-0.658	0.357
Obscured	-0.586	-0.419	0.382	0.291	-0.514	-0.178	-0.526	0.363	-0.229
R_c^2	0.679	0.570	0.448	0.889	0.796	0.714	0.919	0.663	0.575

[a]Redundancy is the amount of variation in behavior variables expressed by variation in the environmental variables.

low elevations at midday on warm days, when temperatures were rising, with no lightning, and with few people present ($R_c^2 = 0.570$, $P > 0.1$). Bears tended to be observed traveling more on midsummer days with lightning and low nighttime temperatures ($R_c^2 = 0.448$, $P > 0.1$).

In 1980, 47.4% of the variation in behavior variables was associated with variation in the environmental variables. Bears traveled less and were seen for shorter periods near people and trails in morning or evening of warm days in late summer when there was little human activity ($R_c^2 = 0.889$, $P < 0.05$). Bears also tended to be seen closer to trails but were obscured more when more people were present on midsummer days with lightning and a falling maximum temperature ($R_c^2 = 0.796$, $P > 0.1$). Longer observations of feeding grizzly bears tended to be made by larger numbers of people when the wind was blowing from them toward the bear in the morning or evening of cool days on which lightning occurred ($R_c^2 = 0.714$, $P > 0.1$).

Discriminant function analysis indicated that bears tended to be observed earlier in the summer, earlier in the day, and when more people were present in 1981 than in 1980. Bears observed in 1981 were also farther from trails and from people than in 1980. In 1981, 60.4% of the total variation in behavior variables was associated with variation in environmental variables. Bears were seen farther from people and were obscured from view less when they were seen at higher elevations by larger groups of people ($R_c^2 = 0.919$, $P < 0.005$). This correlation is attributable to observations of grizzly bears in Bear Valley, in which the bear was generally more than 1 km from the chalet, at a relatively high elevation, and was observed by a large

number of chalet guests as well as the investigator. Bears tended to travel more, feed less, and be obscured from view less when they were seen near midday on midsummer days with lightning and when the rate of human activity was low ($R_c^2 = 0.663$, $P > 0.1$). Bears tended to investigate more, travel more, and be closer to people when the wind was not blowing from the people to the bear, in the morning or middle of days with warm maximum and minimum temperatures and with no lightning ($R_c^2 = 0.575$, $P > 0.1$).

These results consistently indicate that grizzly bears investigated more at midday on days with no lightning and with warm and/or increasing temperatures, and when the wind was not blowing from the people toward the bear. Warm days with no lightning are likely to be less humid than warm days with lightning (Reifsnyder 1980:86). At midday on warm days with relatively little humidity and unfavorable wind, perception of scent is probably difficult (Darling 1956, Bossert and Wilson 1963, Regnier and Goodwin 1977). Under such circumstances, bears probably had to rely on their less sensitive hearing and sight to detect and identify animals and people nearby. Bears also spent more time investigating when fewer people were present. A high level of human activity was probably readily identified by the bear. When there were few people and little movement of scent, however, it was probably more difficult for a bear to detect the approach of a person and, once detected, to determine its identity as a person rather than as another bear which might constitute a threat. Persistence of vigilance after habituation of other components of avoidance behavior is consistent with the

findings of Melzack (1961), Russell (1967), Peeke and Peeke (1970, 1973), and Peeke et al. (1971). The vigilance of a given bear to people may habituate in areas that are heavily used by people but dishabituate where human contact is infrequent. Location-specificity of habituation was suggested by Peeke and Peeke (1973) in discussing the importance of context in habituation.

Incidents Involving Hiker Injury

Twenty-three hikers have been injured and 10 campers have been injured (4) or killed (6) by grizzly bears in Glacier National Park (Appendix 4). Ten of the victims were women (26% of hikers, 40% of campers; no difference, $z = 0.77$, $P > 0.1$). Only 1 woman was menstruating when injured, giving no support to the common belief that menstrual odors invite attack by grizzly bears (Cushing 1980).

One hiker was wearing bear-bells when injured. The bear was at a distance of 20 m and already charging when it was first seen by the lone hiker. Although the wind was blowing ahead of the hiker, the bells were attached to the back of his daypack and there was a creek nearby that may have made the sound of the bells less noticeable to the bear. If the proportion of hiker groups with bells is the same outside the study area as within the study area, then hikers with bells are injured less frequently than are hikers without bells (4.3% vs. 25.1%, $z = 4.61$, $P < 0.001$).

One other hiker was injured while actively making noise, playing music on a tape deck. Since the behavior of the female and yearlings that he encountered indicated that they were surprised,

the bears may not have heard the sound or may not have recognized it as representing people.

Although charges in the study area tended to occur before mid-summer, 13% of the hiker-injury incidents parkwide occurred in August and 33% occurred in September. Contact with people by grizzly bears outside of the study area may not be sufficiently frequent for habituation to occur. Charges, some of which result in injury, therefore continue to occur during late summer. No reason is apparent for the large proportion of incidents that occurred during September.

In response to the grizzly bear-caused deaths of 2 campers in 1967, efforts were initiated to make people's food unavailable to bears. In spite of these efforts, the increasing trend in the number of injuries by grizzly bears per million park visitors through the past 3 decades has continued (Martinka 1982). Data presented in previous sections showed that bears observed near heavily used trails were involved in a lower rate of full charges. Because hiker injuries have been associated with charges, this evidence indicates that habituation to people was not responsible for the increased rate of injuries.

Concurrent with the increase in the injury rate has been a change in the type of bears involved in incidents (Fisher exact test, $P = 0.004$). Females with young were involved in 8 of the 9 injuries to hikers during 1958-69, but in only 3 of the 13 hiker injuries during 1970-81 (Glacier National Park records). A possible mechanism for this change and for the increase in the injury rate is related to increased use of the park by people. In 1965, 665 backcountry

campfire permits were issued in Glacier. In 1970, there were 6,582 backcountry camper-nights recorded. Backcountry use rose to 24,000 camper-nights in 1975. This increased level of human use probably resulted in at least a proportionate increase in the number of contacts with people by each female grizzly bear with young. Stuart (1978, 1980) suggested that an increase in human use would result in a disproportionately greater increase in the number of contacts with people by each bear. Because females with cubs-of-the-year have not been shown to habituate, either to other bears (Hornocker 1962, Egbert and Stokes 1976) or to people (McArthur 1980), the proportion of encounters that resulted in charges may be assumed not to have declined. Therefore, more human use would have resulted in a greater frequency of charges by each female with cubs. Cubs are usually present when their mother charges people, and it is generally believed that cubs learn from observing their mothers. Increased frequency of charges by females with young would therefore result in a greater likelihood that cubs would learn that charging is an appropriate response to encounters with people. The possibility that such learning takes place was supported by an incident that occurred on a backcountry trail on 19 August 1977. At 8:20, a group of people enccuntered a female grizzly bear with 1 cub and were charged by the female. The people turned and left. At 9:00, another group of people encountered the bears. This time, the cub charged them.

DISCUSSION

Human use of the study area was primarily related to season and weather. Numbers of grizzly bears observed in the study area were also related to season as it reflected patterns of habitat use. The behavior of grizzly bears was primarily associated with the local level of human activity, the presence of bear-bells, and the climatic conditions under which the bears were seen. Although grizzly bears' fear response toward people apparently habituated, bears maintained a degree of vigilance that was related to the current acuity of their senses in perceiving their environment.

Habituation to people has been observed in a number of wildlife species. Hicks and Elder (1979) found that the distribution of California bighorn sheep (Ovis canadensis californiana) was positively correlated with the distribution of food resources and not negatively correlated with the distribution of people. The terrain allowed bighorns to watch people approaching from below. When people approached from above, hindering the bighorns' escape, the bighorns were more likely to respond with alarm. Schultz and Bailey (1978) observed that in winter and spring, elk (Cervus canadensis) in Rocky Mountain National Park were not disturbed by vehicles that continued driving, but fled when vehicles slowed. In autumn, people who left roads and approached elk caused them to leave open areas, but had no lasting effect on elk distribution or their use of open areas. Titus and Van Druff (1981) found that nesting loons (Gavia immer) on remote lakes in the Boundary Waters Canoe Area responded with more

excitement and aggression when approached by people than did loons on heavily used lakes. Some loons on remote lakes flushed at great distances and remained away, allowing their eggs to cool and increasing the eggs' vulnerability to predation. On lakes that were heavily used by people, loons' fear response habituated and the birds adopted an energy-conserving strategy of "gentle flushing," in which the loon slipped quietly into the water while people were still far away, swam a moderate distance underwater, and resurfaced away from the nest without commotion.

A disturbance may be most detrimental if it is frequent and unpredictable, so that the animal cannot escape it (Geist 1971:417). Although human use of the study area was heavy, it was generally predictable, geographically as well as temporally. Most people remained on or near trails, and most human activity occurred during daylight hours. Thus, habituation is probably to the stimulus of people traveling on trails during the day. Habituation of grizzly bears' fear response allowed them to use the resources in an area that was heavily used by people while minimizing the frequency of energy-demanding responses. Other ways in which grizzly bears may respond to high levels of human activity are through modification of temporal activity patterns, by restricting activity to periods of the day when contact with people is least likely, or geographic withdrawal from habitat that is heavily used by people. These alternatives would result in a reduction of the temporal-geographic amount of habitat available to grizzly bears and a reduction in carrying capacity.

Data indicated that by reducing the occurrence of full charges, habituation of grizzly bears' fear response may reduce the rate of hiker injuries that result from surprise encounters with adult and subadult grizzly bears. No injury to a hiker in Glacier National Park involved a bear that had been observed to exhibit habituated behavior. Instead, hiker injuries occurred where habituation had not generally been observed. Fear-induced aggression is 1 of 7 types of aggression, each involving distinct behavior patterns, stimulus situations, and physiological substrates, that were identified and discussed by Moyer (1968). Fear-induced aggression requires an agent perceived as threatening and a perceived inability to escape. Fear-induced aggression and territorial aggression are the only types of aggression that have been shown to be subject to habituation (Peeke et al. 1971, Corning et al. 1977).

Three other types of aggression are directly relevant to danger of human injury from grizzly bears. Maternal aggression requires a threatening agent and the presence of offspring, and may be influenced by hormones (Moyer 1968). Habituation of grizzly bear females with young to other bears and to people has not been observed (Hornocker 1962, Egbert and Stokes 1976, McArthur 1980). Perception of other bears as threats is reinforced by incidents of cannibalism and attempted cannibalism. It is possible that habituation of grizzly bears' maternal aggression toward people may occur if a female develops a perception of people as non-threatening. It would probably result in a reduction in the likelihood of human injury resulting from charges by that female bear, but implications of

observational learning by the cubs have not been examined.

Predatory aggression is evoked by the presence of prey and does not require hunger (Moyer 1968). This conclusion was supported by the work of Mysterud (1980) on overkilling of domestic sheep by brown bears. In Glacier National Park, a climber was severely injured by a grizzly bear and partially consumed by it in 1958. The bear that killed and entirely consumed a camper in 1980 was not positively identified; a possibility exists that it was a bear that had been involved in killing domestic sheep. Thorpe (1966:460) stated that recognition of prey by Carnivora is learned rather than innate. No research has examined the factors influencing bears' recognition of prey, and no information is available concerning the ontogeny of predatory attacks on people.

Instrumental aggression is a learned response involving increased tendency to engage in destructive behavior in a particular situation in which the behavior has been reinforced in the past (Moyer 1968). The individual learns that aggression can be used to achieve a certain objective. Instrumental aggression is involved in and depends upon the acquisition of a reinforcement such as food. Two grizzly bears in the study area obtained people's food during the study period, and both responded aggressively to hikers that were subsequently encountered. The fatalities of 2 campers in 1967 involved bears that were accustomed to eating people's food. The fatality of a camper in 1976 involved 2 subadult bears that had apparently obtained food from 2 parties of illegal campers and from a party of 2 fishermen. The bear that killed 2 campers in 1980 had

habitually fed at a refuse pile, where human scent may have been present, though it was active at night and avoided contact with people. Understanding the development of instrumental aggression by grizzly bears will require information on bears' perception of and generalization among situations and on the factors involved in bears' development of learned associations.

IMPLICATIONS FOR MANAGEMENT

The stated objective of bear management in Glacier National Park is to minimize the risk of human injury while preserving a naturally regulated population of grizzly bears (Glacier National Park 1981). Application of the findings of this research will aid the park in achieving these objectives.

1. Occurrence of surprise enccunters with people by bears which fear people and are therefore most likely to respond with fear-induced aggression can be minimized if hikers in Glacier use bear-bells. Bells are superior to other noise-makers in that their sound indicates unambiguously, to bears that are experienced with them, that a person is approaching.

2. Evidence indicates that habituation of grizzly bears' fear response to people over a relatively small area may reduce danger to hikers. However, the effect of habituation on population dynamics of the bears and implications of habituation for safety of backcountry campers are concerns that have not been examined.

3. Making human activity in areas that receive high levels of human use as predictable as possible, by discouraging or prohibiting off-trail or nighttime hiking and by encouraging the use of adequate bear-bells, will minimize the stress imposed on bears in areas that receive high levels of human use, as well as minimizing occurrence of surprise encounters.

4. Most injuries have been attributable, to some extent, to improper behavior by people, though not always by the victim. Effective dissemination of accurate and current information about bears, in addition to warnings, by National Park Service and concession employees to people using the park will increase the likelihood that people will have adequate information to avoid dangerous encounters with bears and will behave wisely if an encounter does occur.

5. The possibility of observational learning by cubs to charge in response to people will be minimized by prohibiting human use of areas frequented by females with cubs-of-the-year. A low level of use by people with adequate bear-bells may achieve the same result.

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APPENDICES

Appendix 1. Summary of censuses for each trail section, Many Glacier and Granite Park, 1980-81.

Trail section	No. of times censused	No. of groups counted	Mean groups per hour	Mean group size	% of groups with bells	% of groups			Trail length (km)
						Hikers	Back-packers	Horse-back	
Chlorinator road	19	0	0	-	-	-	-	-	1.40
Upper Piegan	14	0	0	-	-	-	-	-	8.00
Lower Piegan	16	1	0.13	3.00	0	100	0	0	3.83
Sherburne cutoff	17	2	0.24	2.50	50	0	100	0	1.71
Hotel to Iceberg/Ptarmigan	19	4	0.42	1.50	0	100	0	0	1.88
Upper Swiftcurrent Ridge	18	4	0.44	2.75	50	50	50	0	1.89
Middle Cracker Lake	18	5	0.56	3.80	0	40	40	20	2.70
Swiftcurrent Ridge Lake	18	5	0.56	3.60	40	40	60	0	0.53
Lower Swiftcurrent Ridge	18	6	0.67	2.33	17	33	50	17	2.51
Upper Swiftcurrent Pass	18	7	0.78	3.86	43	57	29	14	5.05
East shore Josephine Lake	19	10	1.05	1.80	40	100	0	0	2.45
Lower Cracker Lake	18	10	1.11	2.70	50	60	30	10	2.56
Upper Cracker Lake	19	11	1.16	4.00	27	46	27	27	3.75
Swiftcurrent Pass - west	18	12	1.33	2.00	33	83	17	0	1.55
Middle Swiftcurrent Pass	19	18	1.89	2.33	33	94	6	0	2.73
Head of Josephine Lake	19	18	1.89	2.39	17	100	0	0	0.20
Appekunny Falls	19	22	2.32	2.73	23	100	0	0	1.05
Ptarmigan Lake	20	30	3.00	2.40	37	90	10	0	2.70
Loop	19	29	3.05	2.76	31	97	3	0	6.53
Grinnell Glacier	18	39	4.33	3.00	15	100	0	0	4.38
West shore Josephine Lake	18	40	4.44	2.28	18	100	0	0	1.73
Grinnell Lake	18	43	4.78	3.70	16	91	0	9	1.60
Highline	18	44	4.89	2.23	32	98	2	0	1.03
Iceberg Lake	19	52	5.47	2.60	37	100	0	0	3.40

Appendix 1. Continued.

Trail section	No. of times censused	No. of groups counted	Mean groups per hour	Mean group size	% of groups with bells	% of groups			Trail length (km)
						Hikers	Back-packers	Horse-back	
Motor inn to Iceberg/Ptarm.	18	50	5.56	2.86	36	94	6	0	0.24
SNT - west	18	51	5.67	2.22	18	100	0	0	0.98
Iceberg/Ptarmigan	35	112	6.40	2.93	30	95	5	0	3.76
SNT - east	19	61	6.42	2.39	10	100	0	0	1.43
Lower Swiftcurrent Pass	19	66	6.95	2.62	23	98	0	2	2.78
Asphalt[a]	19	80	8.42	5.16	21	100	0	0	0.23

[a]Includes 7 boat-tour groups, with 32.71 people/group.

Appendix 2. Key to locations of census points, Many Glacier and Granite Park, 1980-81. Locations of census points are mapped on next page.

Swiftcurrent Ridge trail
1 Swiftcurrent Ridge Lake
2 Sherburne cutoff
3 Upper Swiftcurrent Ridge
4 Lower Swiftcurrent Ridge

Appekunny Falls trail
5 Appekunny Falls

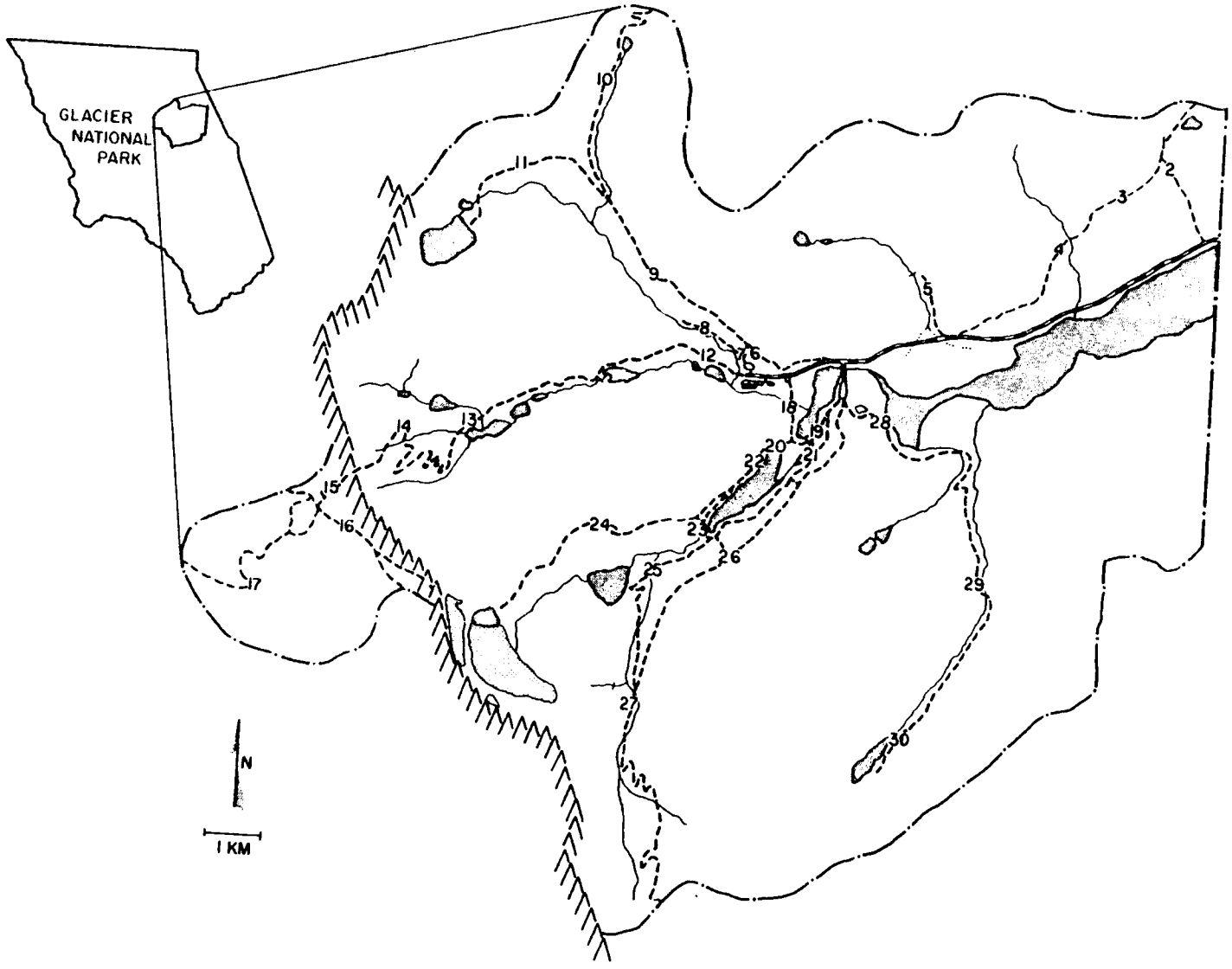
Iceberg/Ptarmigan trail
6 Trail from hotel
7 Trail from motor inn
8 Chlorinator road
9 Redrock outcrop
10 Ptarmigan Lake
11 Iceberg Lake

Swiftcurrent Pass trail
12 Fishercap Lake
13 Bullhead Lake
14 Devil's Elbow

Granite Park trails
15 Swiftcurrent Pass - west
16 Highline trail
17 Loop trail

Grinnell valley trails
18 Swiftcurrent Nature Trail - west
19 Swiftcurrent Nature Trail - east
20 Asphalt trail
21 Josephine Lake - east shore
22 Josephine Lake - west shore
23 Josephine Lake - head
24 Grinnell Glacier
25 Grinnell Lake
26 Lower Piegan
27 Upper Piegan

Cracker Lake trail
28 Governor's Pond
29 Canyon Creek
30 Cracker Lake


GLACIER
NATIONAL
PARK
N
1 KM

Appendix 3. Categorization and number of occurrences of reported behaviors of grizzly bears, Many Glacier and Granite Park, 1980-81.

Behavior category	Reported behavior	No. of occurrences	
		Initial behavior	Subsequent behavior
No movement in relation to people	Feed or forage	72	43
	Travel, unspecified direction or great distance away	9	9
	Look or sniff	5	2
	Feed, on trail	5	1
	Chase prey	2	0
	Look, feed	1	5
	Eat people's food	1	1
	Travel, great distance away, and feed	1	1
	Travel, great distance away, and chase prey	1	1
	Look and growl	1	0
	Look, eat people's food	0	1
Move away	Walk away	4	5
	Run away	2	7
	Move away a short distance, feeding	1	4
	Run off trail and away	0	4
	Look, run away	0	4
	Look, walk away	0	4
	Run away, on trail	0	3
	Walk away, on trail	0	3
	Look, walk off trail a short distance	0	3
	Look, move away a short distance, feeding	0	3
	Look, run off trail a short distance	0	2
	Look, run off trail and away	0	1
	Look; growl; run away, on trail	0	1
	Look, move away a short distance, chasing prey	0	1
	Walk off trail a short distance	0	1
	Walk toward, look, walk away	0	1

Appendix 3. Continued.

Behavior category	Reported behavior	No. of occurrences	
		Initial behavior	Subsequent behavior
Move past or maintain distance	Walk past	5	3
	Walk on trail, unspecified direction	5	1
	On trail, chasing prey	1	1
	Walk past, feeding	1	1
	Follow person, walking on trail	1	1
	Run across trail	1	0
	Precede person, walking on trail	1	0
	Run past, on trail	0	1
	Run past, on trail, feed	0	1
	Look, walk past	0	1
	Walk across trail, feeding	0	1
	Look, walk across trail	0	1
	Walk past, on trail	0	1
	Look, walk past, on trail	0	1
	Follow person, walking off trail	0	1
Move toward	Walk toward, on trail	10	0
	Walk toward	3	0
	Drift toward, feeding	2	3
	Run toward, on trail	2	0
	Walk onto trail	2	0
	Walk toward, onto trail	2	0
	Run toward, feeding	1	0
	Walk toward, onto trail, look, make unspecified noise	1	0
	Walk toward, on trail, feeding	0	1
	Walk toward, off trail	0	1
Charge	Hop-charge	0	2
	Hop-charge, then feed, on trail	0	2
	Charge	0	1
	Look, charge	0	1
	Hop-charge, charge	0	1
	Run toward, then run away	0	1
	Run toward, look, run away	0	1
	Run toward, look and growl, run away	0	1

Appendix 4. Recorded injuries to hikers and campers by grizzly bears in Glacier National Park. Information was obtained from Glacier National Park records. Locations of hiker injuries (○) and camper injuries (□) are mapped on the following page.

Hiker Injuries

1. In 1939, a female bear, that was probably a grizzly bear, with 2 young injured 1 of 2 men hiking near Piegan Pass.

2. On 18 June 1959, a 4- to 5-year-old female grizzly bear severely injured 1 of 2 men hiking off-trail, climbing Mount Altyn. The incident resembled predation in that the bear walked toward the man, who was sitting still. The bear then sniffed him and began to lick and then bite him.

3. On 8 July 1960, a female grizzly bear with 2 cubs inflicted minor lacerations on a man hiking on the Otokomi Lake trail.

4. On 19 July 1960, a female with 2 cubs injured 1 female and 2 male hikers in a group of 5 hiking on the Otokomi Lake trail.

5. On 23 July 1963, a female bear with 1 yearling severely injured a man and woman hiking at the head of Bowman Lake.

6. On 17 September 1967, a female grizzly bear with 2 cubs injured 1 man in a group of 2 hiking on the Mineral Creek trail.

7. On 28 May 1968, a female with 1 yearling injured a man who was attempting to photograph them at close range near the east-side tunnel on the Going-to-the-Sun Road.

8. On 25 July 1974, a female with cubs injured a man who was hiking alone off-trail near Feather Plume Falls. The man had not been making noise and surprised the bear at close range.

9. On 7 August 1975, a family of 4 people surprised a lone adult bear along the Grinnell Glacier trail, and it injured the father, sone, and daughter. It was early morning, and these people were apparently the first hikers on the trail that day.

10. On 7 September 1975, 1 of 2 or 3 unknown-age bears feeding in a huckleberry patch along the Rockwell Falls trail injured a man and a woman, pulling them down as they tried to climb trees.

11. On 9 September 1976, 2 subadult grizzly bears "sprang from the brush" 2 km west of Stoney Indian Lake and injured 2 in a party of 4 hikers, the man in the lead and a woman as she was climbing a tree.

12. On 17 August 1978, a man and a woman hiking on the Cracker Lake trail surprised a female grizzly bear with 1 yearling feeding

next to the trail. The yearling knocked the woman down and bit her but did not break the skin.

13. On 12 September 1979, a female with 2 yearlings near Firebrand Pass injured 1 of 2 men who ran to climb trees. The hikers had been playing music on a portable tape deck.

14. On 21 July 1981, a lone adult grizzly bear injured a fisherman who surprised it in downed timber off-trail, in the North Fork Flathead River drainage. The bear knocked him down, bit his ear, and then sniffed his fishing gear, catching a fishhook in its nose.

15. On 31 July 1981, a hiker nearing the Camas Creek trailhead was injured by a lone bear. The hiker was wearing bear-bells attached to the back of his daypack, but the sound of a nearby creek may have made them less noticeable for the bear.

16. On 6 September 1981, 2 men hiking off-trail on Heavens Peak ran when they encountered a lone adult grizzly bear. One person succeeded in climbing a tree, but the bear caught and injured the other person.

Camper Injuries

1. In early August 1956, a man was bitten by a lone bear, believed to be a grizzly bear, while in his sleeping bag at Stoney Indian Pass.

2. On 7 July 1962, a man in his sleeping bag at Granite Park campsite received minor lacerations from a grizzly bear, believed to be a female with young. The bear had been sniffing his sleeping bag and "took a swipe at him" when he attempted to chase it off.

3. On 13 August 1967, a woman was killed and a man was severely injured by an old female with 2 cubs at Granite Park campsite. The bear had frequently fed on refuse at the chalet and was described by chalet employees as being bold and difficult to chase away.

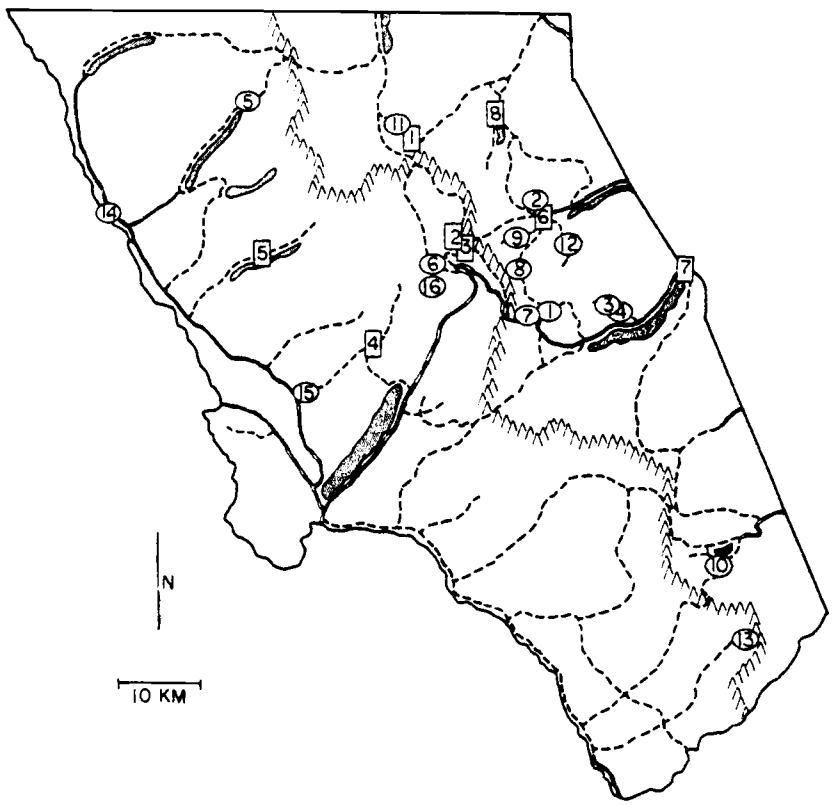
4. Also on 13 August 1967, a woman in a party of 3 men and 2 women was killed by an old female grizzly bear at Trout Lake campsite. The campers had a dog with them. The bear had, on several occasions, obtained food from people and at inholders' cabins.

5. On 16 July 1976, a lone adult grizzly bear injured 1 of 2 male campers in a tent at Middle Logging Lake campsite. The bear remained at the campsite for 1 hour following the injury.

6. On 23 September 1976, a subadult grizzly bear killed 1 of 5 female campers at Many Glacier Campground. The bear had previously obtained food from fishermen and illegal campers.

7. On 24 July 1980, a subadult grizzly bear killed a man and a woman camped off-trail on the park boundary at St. Mary. The bear had been observed on several occasions, feeding at a refuse pile outside of the park.

8. On approximately 25 September 1980, a lone adult grizzly bear killed a man camped alone at Elizabeth Lake campsite. The bear was not identified with certainty. The Board of Inquiry concluded that the bear responsible for the fatality was a 6-year-old male that had been observed in the Many Glacier area on several occasions and exhibited habituated behavior toward people. A possibility exists, however, that the bear that killed the man was one that had been involved in killing sheep on the Blackfeet Reservation adjacent to the east side of the park. This bear was transplanted in September 1970 and released outside of the park, but near the head of the trail to Elizabeth Lake.

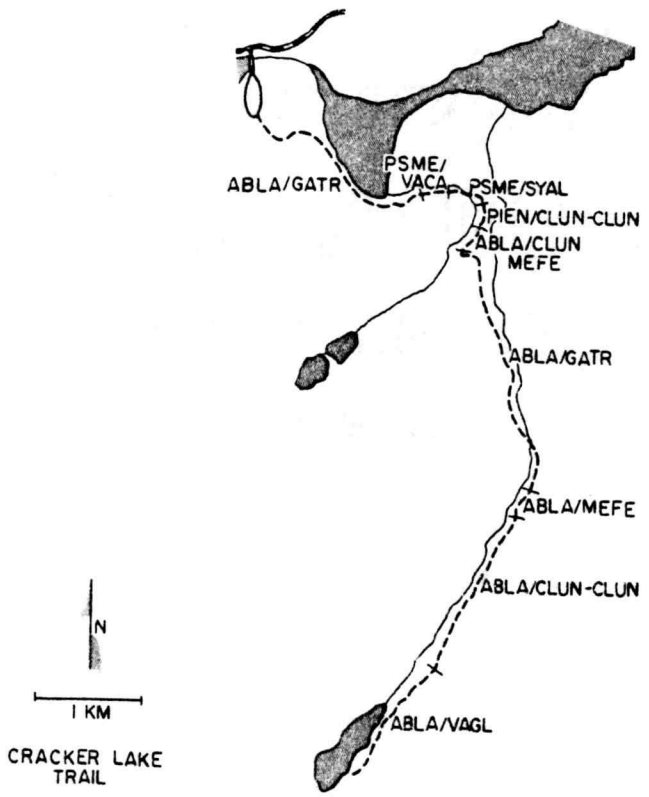

N
10 KM

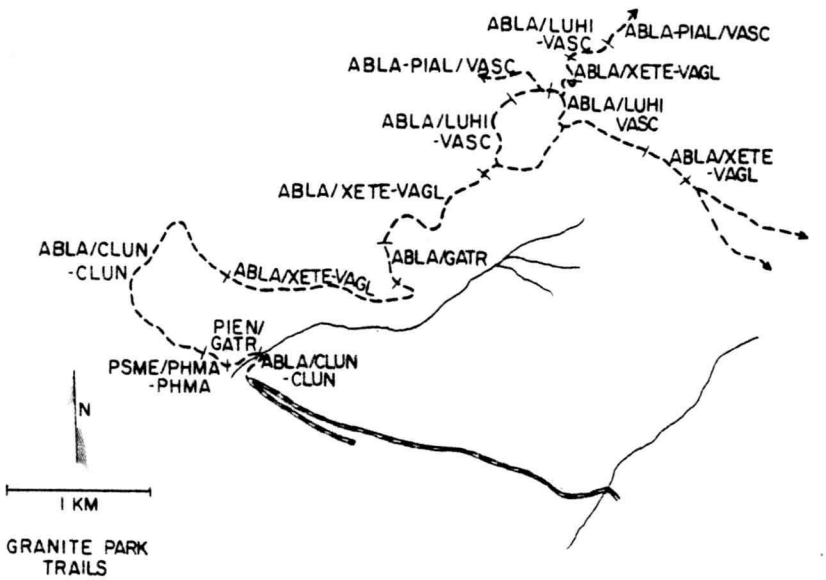
Appendix 5. Key to abbreviations of names of habitat types (Pfister et al. 1977) found along trails in Many Glacier and Granite Park. Locations of habitat types along the trails are mapped on the following pages. Species names are according to Hitchcock and Cronquist (1973).

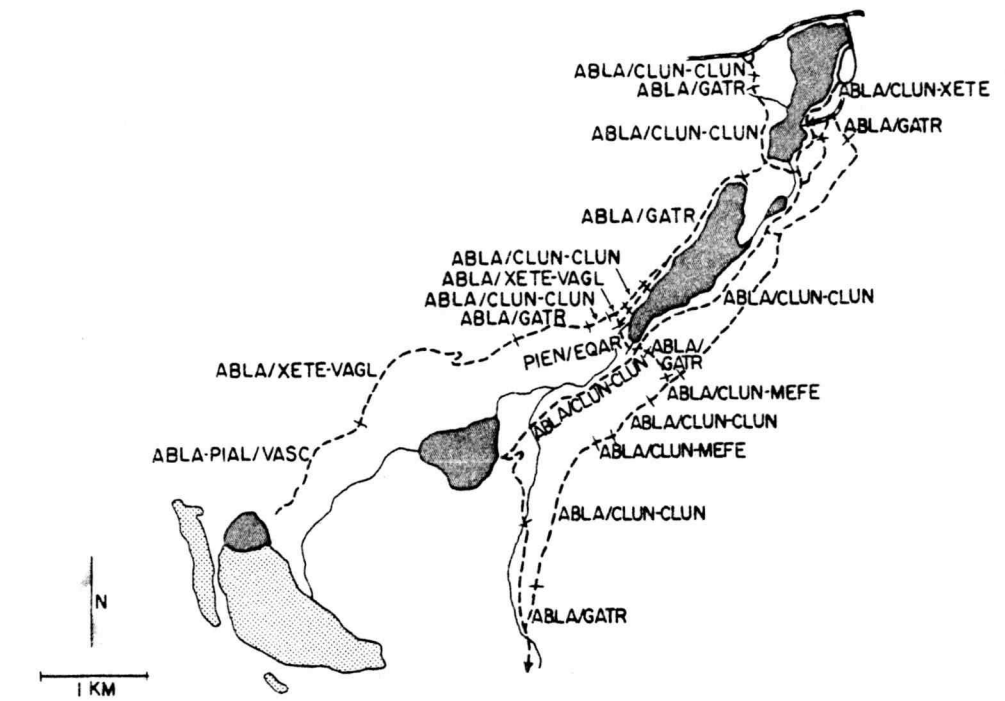
Abbreviation	Scientific name	Common name
Abla/Caca	Abies lasiocarpa/Calamagrostis canadensis h.t.	Subalpine fir/reedgrass h.t.
-Caca	-Calamagrostis canadensis phase	-reedgrass phase
Abla/Clun	Abies lasiocarpa/Clintonia uniflora h.t.	Subalpine fir/beadlily h.t.
-Clun	-Clintonia uniflora phase	-beadlily phase
-Mefe	-Menziesia ferruginea phase	-fool's huckleberry phase
-Vaca	-Vaccinium caespitosum phase	-dwarf huckleberry phase
-Xete	-Xerophyllum tenax phase	-beargrass phase
Abla/Gatr	Abies lasiocarpa/Galium triflorum h.t.	Subalpine fir/bedstraw h.t.
Abla/Luhi	Abies lasiocarpa/Luzula hitchcockii h.t.	Subalpine fir/woodrush h.t.
-Vasc	-Vaccinium scoparium phase	-whortleberry phase
Abla/Mefe	Abies lasiocarpa/Menzesia ferruginea h.t.	Subalpine fir/fool's huckleberry h.t.
Abla/Vaca	Abies lasiocarpa/Vaccinium caespitosum h.t.	Subalpine fir/dwarf huckleberry h.t.
Abla/Vagl	Abies lasiocarpa/Vaccinium globulare h.t.	Subalpine fir/globe huckleberry h.t.
Abla/Xete	Abies lasiocarpa/Xerophyllum tenax h.t.	Subalpine fir/beargrass h.t.
-Vagl	-Vaccinium globulare phase	-globe huckleberry phase
-Vasc	-Vaccinium scoparium phase	-whortleberry phase

Appendix 5. Continued.

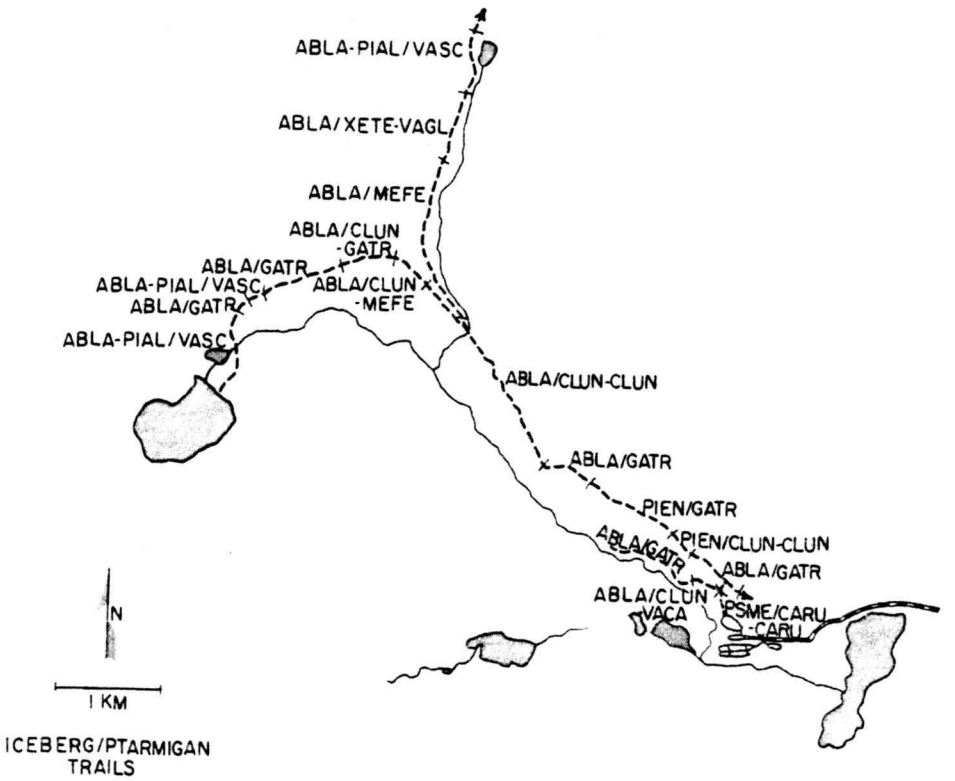
Abbreviation	Scientific name	Common name
Abla-Pial/ Vasc	Abies lasiocarpa-Pinus albicaulis/ Vaccinium scoparium h.t.	Subalpine fir-whitebark pine/ whortleberry h.t.
Pial-Abla	Pinus albicaulis-Abies lasiocarpa h.t.	Whitebark pine-subalpine fir h.t.
Pien/Clun	Picea engelmannii/Clintonia uniflora h.t.	Engelmann spruce/beadlily h.t.
-Clun	-Clintonia uniflora	-beadlily phase
Pien/Eqar	Picea engelmannii/Equisetum arvense h.t.	Engelmann spruce/horsetail h.t.
Pien/Gatr	Picea engelmannii/Galium triflorum h.t.	Engelmann spruce/bedstraw h.t.
Psme/Caru	Pseudotsuga menziesii/Calamagrostis rubescens h.t.	Douglas fir/pinegrass h.t.
-Caru	-Calamagrostis rubescens phase	-pinegrass phase
Psme/Phma	Pseudotsuga menziesii/Physocarpus malvaceus h.t.	Douglas fir/ninebark h.t.
-Phma	-Physocarpus malvaceus phase	-ninebark phase
Psme/Syal	Pseudotsuga menziesii/Symphoricarpos albus h.t.	Douglas fir/snowberry h.t.
Psme/Vaca	Pseudotsuga menziesii/Vaccinium caespitosum h.t.	Douglas fir/dwarf huckleberry h.t.

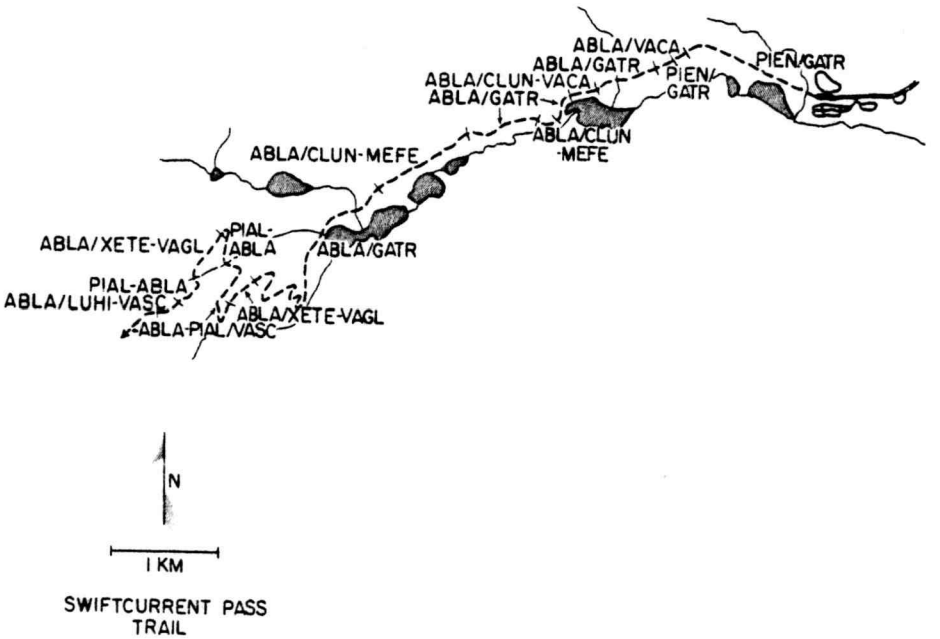

ABLA/GATR
PSME/
VACA
PSME/SYAL
PIEN/CLUN-CLUN
ABLA/CLUN
MEFE
ABLA/GATR
ABLA/MEFE
ABLA/CLUN-CLUN
ABLA/VAGL
N
1 KM
CRACKER LAKE
TRAIL

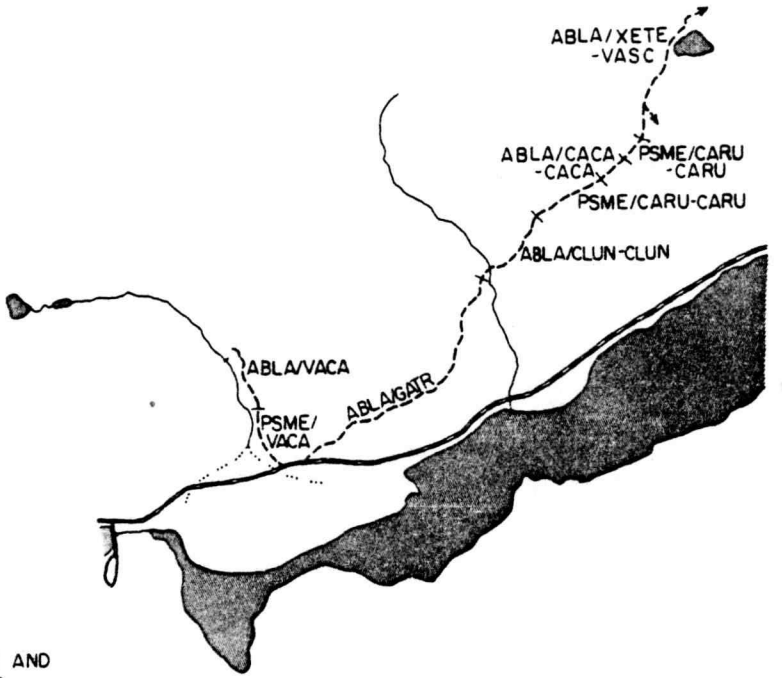

ABLA/LUHI
-VASC
ABLA-PIAL/VASC
ABLA-PIAL/VASC
ABLA/XETE-VAGL
ABLA/LUHI
VASC
ABLA/LUHI
-VASC
ABLA/XETE
-VAGL
ABLA/XETE-VAGL
ABLA/CLUN
-CLUN
ABLA/XETE-VAGL
ABLA/GATR
PIEN/
GATR
PSME/PHMA
-PHMA
ABLA/CLUN
-CLUN
N
1 KM
GRANITE PARK
TRAILS



GRINNELL VALLEY
TRAILS


ABLA-PIAL/VASC
ABLA/XETE-VAGL
ABLA/MEFE
ABLA/CLUN
-GAIR
ABLA/GATR
ABLA-PIAL/VASC
ABLA/CLUN
-MEFE
ABLA/GATR
ABLA-PIAL/VASC
ABLA/CLUN-CLUN
ABLA/GATR
PIEN/GATR
PIEN/CLUN-CLUN
ABLA/GATR
ABLA/GATR
ABLA/CLUN
VACA
PSME/CARU
-CARU
N
1 KM
ICEBERG/PTARMIGAN
TRAILS


ABLA/VACA
ABLA/GATR
PIEN/GATR
ABLA/CLUN-VACA
ABLA/GATR
PIEN/GATR
ABLA/CLUN-MEFE
ABLA/CLUN-MEFE
ABLA/XETE-VAGL
PIAL-ABLA
ABLA/GATR
PIAL-ABLA
ABLA/LUHI-VASC
ABLA/XETE-VAGL
ABLA-PIAL/VASC
N
1 KM
SWIFTCURRENT PASS TRAIL



SWIFTCURRENT RIDGE AND
APPEKUNNY FALLS
TRAILS