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Wildlife Society Bulletin, Vol. 19, No. 3. (Autumn, 1991), pp. 339-349.

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FACTORS RELATED TO GRIZZLY BEAR-HUMAN INTERACTIONS IN DENALI NATIONAL PARK

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Denali National Park and Preserve (NPP) in southcentral Alaska receives >500,000 visitor-days of use per year in an area with grizzly bear (*Ursus arctos*) densities as high as 1 bear per 31 km² (Dean 1987). Use of national parks is likely to increase as Alaska's tourist industry grows with the potential for even nonconsumptive uses to adversely affect wildlife and their habitats (Snepenger and Bowyer 1990). Indeed, as outdoor recreation in Denali NPP increases, so will the potential for conflict between grizzly bears and people. Grizzly bear-human conflicts are of major concern to park managers because such interactions threaten human safety and could result in the loss of wild and free-ranging bears (Denali General Management Plan 1986, unpubl. Natl. Park Serv. Rep., Denali Park, Alas., 1986; Gilbert 1989). Consequently, factors affecting grizzly bear-human interactions and their outcomes have received considerable attention (Herrero 1976, 1985; Chester 1977; Jope and Shelby 1984; and others).

The National Park Service (NPS) uses specialized terminology to describe interactions between grizzly bears and people as defined by Singer (Problem Analysis—Grizzly Bear Management Denali National Park, unpubl. rep., Natl. Park Serv., Denali Park, Alas., 1982). (1) Bear Incident—Any situation where a bear made physical contact with a person, where damage or loss was caused to any type of personal or governmental property or food, where any charge by a bear to within close proximity of people occurred, or where people took extreme evasive action (i.e., climbing a tree, playing dead) in response to a bear,

whether such evasive action seemed warranted. (2) Bear Encounter—Any situation of close proximity between bears and humans where the bear clearly knew of the human presence. This category includes all recorded cases of a bear advancing upon humans where no serious charge, property damage, or physical contact resulted (i.e., curious approaches, distant bluff charges), where a bear moved away, or where a bear showed no reaction in cases where it clearly "should have" responded to people, either due to close proximity or because the humans were yelling at it. If an interaction met criteria of both incidents and encounters, it was assigned to the more serious category. (3) Bear-Human Interaction—This category includes encounters and incidents, but not mere sightings.

Another type of interaction, a confrontation, was used to compare with research conducted in Denali NPP from 1979 to 1981 by Jope (Research on Interactions Between Backpackers and Grizzly Bears in Denali National Park and Preserve, unpubl. Natl. Park Serv. Prog. Rep., Denali Park, Alas., 1983). A confrontation is an interaction between a grizzly bear and a backpacker in which a bear charges a person, approaches or follows a person, enters a camp with people present, or obtains food from people or a campsite in the backcountry. This category includes criteria of both incidents and encounters.

Visits to Denali NPP increased substantially with the completion of the Parks Highway in 1972, allowing convenient access to the park from population centers in Anchorage and Fairbanks. An increase in grizzly bear-human

incidents and encounters accompanied this increased visitation (Dalle-Molle and Van Horn 1989).

In 1982 the NPS conducted an analysis in Denali NPP to identify problems associated with the management of grizzly bears and humans (Singer, unpubl. Natl. Park Serv. Rep., 1982). Singer concluded that bear-human incidents in the "frontcountry" (≤ 0.5 km from roads or developments) could be minimized despite increased visitation, by improved methods of garbage disposal and increased visitor awareness. However, bear problems in the "backcountry" (> 0.5 km from roads or developments) had increased, and the rate of 9 backcountry incidents per 10,000 visitor nights in Denali NPP was extremely high compared to other parks with grizzly bear populations. One key problem was the inability of many backpackers to make food secure from bears. Jope (unpubl. Natl. Park Serv. Rep., 1983) suggested that bears were learning to seek food from people, and that high rates of incidents resulted from repeated food-seeking by a few bears.

A Bear-Human Conflict Management Action Plan for the park was revised to address these problems (Dalle-Molle and Van Horn 1989). Beginning in 1982, research was conducted to modify and test a lightweight, portable bear-resistant container (Dalle-Molle et al. 1986) to make human foods unavailable to grizzly bears in backcountry areas. Simultaneously, an experimental program of aversive conditioning was initiated to deal with bears that had become habituated to human food or garbage—NPS personnel shot problem bears that entered backcountry camps with rubber, 12-gauge shotgun slugs (Stenhouse and Cattet 1984, Derocher and Miller 1986). This program provided an alternative to relocation or destruction of these bears. Moreover, emphasis was placed on collection of accurate data related to bear-human interactions, and making visitors aware of potential problems.

From 1982 through 1987, bear incidents in

backcountry areas were reduced by 92%, occurrences of bears obtaining human food were reduced by 95%, and property damage caused by bears was reduced by 93% (Dalle-Molle and Van Horn 1989). Although improved management reduced the number of the more serious bear incidents, the total number of interactions reported between grizzly bears and humans increased from 40 (80 per million visitors) in 1987 to 118 (197 per million visitors) in 1989 (Denali Natl. Park and Preserve files).

Habituation, or a decline in the fear response of bears to people, occurs when bears and people come into frequent innocuous contact (McCullough 1982). Predictable patterns of human use also contribute to habituation of bears (Jope 1985). Even in the absence of food conditioning, habituated grizzly bears pose high risks to human safety (Herrero 1989). In areas of human use, habituated bears may gain access to natural foods, leading to conflicts with people. This is particularly evident in Denali NPP, where grizzly bears have preyed on moose calves (*Alces alces*) and arctic ground squirrels (*Spermophilus parryii*) in campgrounds, parking lots, and other areas of human use. In addition, bears that tolerate people in close proximity are more likely to obtain human food or garbage, thereby reinforcing this behavior (McCullough 1982). Conversely, Jope (1985) believed that habituation to hikers might reduce the risk of human injury through a reduction in fear-induced aggression.

We identified factors associated with the occurrence and types of interactions between grizzly bears and people in Denali NPP, and tested for differences in these variables between frontcountry and backcountry areas. Strategies to reduce the number of bear-human interactions also are discussed.

STUDY AREA

Denali NPP is located in south-central Alaska ($62^{\circ}45' - 64^{\circ}00'N$, $148^{\circ}45' - 153^{\circ}00'W$). Elevations in the park range from 250 m to $>6,000$ m at the summit of Mt. McKinley. The study area is characterized by wide

glacial valleys and braided river channels in the Alaska Range and foothills to the north. Important plant foods of grizzly bears include crowberry (*Empetrum nigrum*), blueberry (*Vaccinium* spp.), peavine (*Hedysarum alpinum*), horsetail (*Equisetum arvense*), polar grass (*Arctagrostis latifolia*) and soapberry (*Shepherdia canadensis*) (Stelmock 1981). Plant nomenclature follows Hultén (1968). More extensive descriptions of park vegetation and climate are available elsewhere (Murie 1981, Stelmock 1981, Heebner 1982, Darling 1987, Dean 1987). Populations of grizzly bears in the park have not increased markedly in recent years (Dean 1976, 1987). No evidence exists of substantial changes in bear numbers during our study (F. C. Dean, Dep. Bio. and Wildl., Univ. Alaska Fairbanks, pers. commun.).

The most concentrated development and human use in Denali NPP is in the East District, which includes the easternmost 23 km of the Denali Park Road. This encompasses Park Headquarters, Riley Creek (102 sites) and Morino (30 sites) campgrounds, the Visitor Access Center, the Denali Park Hotel and train depot, NPS and concession employee housing, and Savage River Campground (22 km, 34 sites). The Denali Park Road extends from the entrance of the park to the Kantishna mining district, 150 km to the west. Shuttle and tour buses provide access to the interior of the park for most visitors. Special permits for road use are available to professional photographers, researchers, Kantishna guests and residents, and visitors with campground reservations. Areas of concentrated human use in the West District include Sanctuary River (38 km, 7 sites), Teklanika River (48 km, 50 sites), and Igloo Creek (57 km, 7 sites) campgrounds, Toklat Road Camp (88 km), Eielson Visitor Center (108 km), and Wonder Lake Campground (143 km, 29 sites). The Kantishna mining district (150 km) consists of private lodges and mining claims within Denali NPP. With the exception of Eielson Visitor Center and Wonder Lake Campground, all developed areas are characterized by relatively low elevations (<900 m), forested habitats, and proximity to rivers. All park facilities are in areas frequently used by bears. Further, bears are observed by large numbers of people along the park road and occasionally in developed areas.

Overnight users of the backcountry must obtain a backcountry-use permit and carry food in bear-resistant containers provided by the NPS. Overnight camps in the backcountry are required to be concealed from view and >1 km from the park road. Further, a backcountry quota system limits numbers and distribution of overnight backcountry campers to minimize effects on vegetation, wildlife, and wilderness experiences of others.

METHODS

Reports of interactions between people and grizzly bears were gathered from May to September 1988–1989 using standardized Bear Information Manage-

ment System (BIMS) forms (Smith 1983). Overnight backpackers were interviewed by park personnel when these campers returned their bear-resistant food containers. Shuttle bus users and day hikers without permits for overnight camping in the backcountry, however, were not sampled systematically for interactions with bears. Hence, our data underestimate the number of bear-human interactions involving these user groups. Bear-human interactions in campgrounds and developed areas were investigated by NPS research technicians, including examination of interaction sites and interviews with people involved.

Information recorded for each interaction included Julian date, location, habitat type, type of bear group, whether food was obtained by the bear, number of people in the group, activity of people, and the function of people in the park (i.e., visitor, NPS employee, concession employee). Habitat types in which bear interactions occurred were categorized as forest, river or gravel bar, tall brush, or tundra. No interactions were reported on glaciers or rocky alpine areas that dominate the southwestern one-third of the park; these habitats were not included in our analyses. Types of bear groups recorded included single bears, family groups, siblings, and mated pairs. Interactions occurred when people were hiking (off the park road), were along the park road, in camp (either in the frontcountry or backcountry), or in other developed areas.

Human use was indexed by the number of people visiting the park (visitor days), the number of people using the shuttle bus system (which transports visitors, including backpackers, along the park road), and from overnight camping permits in the backcountry. Although most users of the shuttle bus system do not directly interact with bears, level of shuttle bus use does provide an index of human activity along the road corridor and in frontcountry developments. Indeed, day hikers and backcountry campers depart from shuttle buses at many locations along the park road. Conversely, backcountry use-nights (calculated from overnight camping permits) reflect levels of human activity outside the road corridor and developed areas.

Bear-human interactions were calculated for 2-week periods from 15 May to 15 September in both years. This sampling period was chosen to allow adequate numbers of interactions within each period ($n \geq 5$). Regression analysis was used to examine relationships between levels of human use and bear-human interactions (Zar 1984:263), and slopes of regression lines were compared between years (Zar 1984:304).

The Wilcoxon signed-ranks test was used to examine differences in numbers of interactions reported between years (Conover 1980:280). The G-test was used to investigate differences in bear groups encountered between years, and differences in bear behavior toward people between frontcountry and backcountry areas (Sokal and Rohlf 1981:735). Differences in the number of interactions that occurred among locations, and group sizes associated with different behavioral responses were analyzed with the Friedman test (Conover 1980:299).

Availability of habitat types was obtained from Dean

(1987) and Dean and Heebner (1982), and by use of a computerized digitizing system and Landsat satellite images archived at the Geophysical Institute, University of Alaska Fairbanks. The method of Neu et al. (1974) was used to compare numbers of interactions in each habitat with the relative availability (proportions) of habitats; Bonferroni 95% confidence intervals were used to compare observed to expected frequencies. For these analyses we used a 2,500 km² area that was identical to that described by Dean (1987, Fig. 1).

Stepwise logistic regression was used to identify factors that differentiated avoidance and approach (or aggressive) behavior of bears towards people (Agresti 1990:85, Dixon 1985). Behavioral categories (response variable) were coded (1) if the bear approached, investigated, or behaved aggressively, and (0) if the bear avoided people. A goodness-of-fit Chi-square was used to assure aptness of the logistic model (Agresti 1990:109). Other variables on BIMS forms were considered as potential independent variables. A correlation matrix was examined to control for multicollinearity in regressions (Neter et al. 1985:390, Bowyer et al. 1988). Stepwise logistic regression (alpha-to-enter = 0.05, alpha-to-remove = 0.06) was used to determine the model that would best predict bear behavior with the fewest independent variables (Dixon 1985).

RESULTS

A total of 203 grizzly bear-human interactions was reported, 85 in 1988 and 118 in 1989. Interactions were distributed throughout frontcountry areas of the park (Table 1). Bears were reported to have obtained human food or garbage twice in 1988 and once in 1989. The only reported human injury was a person "swatted" by a bear while he slept on the ground in upper Savage River in 1988. He sustained moderate head lacerations requiring stitches. Of 203 interactions, 18 (6 in 1988, 12 in 1989) were considered incidents in which a person was charged, injured, had property damaged, or took extreme evasive action. Pooled estimate of property damage for both years was \$640.

Levels of Human Use and Bear-Human Interactions

Use of shuttle buses by visitors increased from 76,700 passengers in 1988 to 82,400 in 1989. In both years, peak levels of shuttle bus use occurred in late July. Mean rate of bear

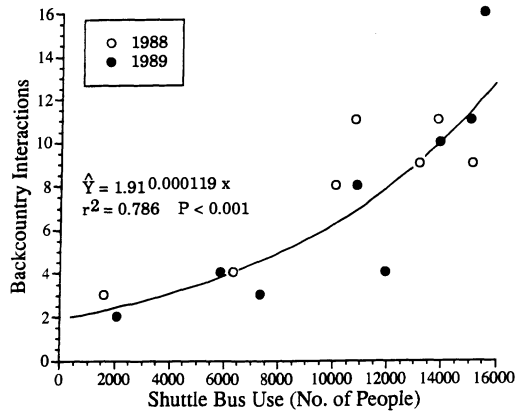


Fig. 1. Relationship between the number of people riding shuttle buses and grizzly bear-human interactions in backcountry areas of Denali National Park, Alaska, 1988-1989. The number of people riding shuttle buses was selected as an overall index of human activity along the road and in developed frontcountry areas. Bus use and backcountry interactions represent totals within 2-week periods.

incidents for 2-week sample periods (1988 and 1989 pooled) was 0.16 per 1,000 shuttle bus users (SD = 0.16, range = 0.0-0.48, $n = 16$). This represents a mean annual rate of 16.1 bear incidents per million visitor days (range = 10.1-22.1) for the 2 study years. Mean rate of total interactions for both years was 1.4 interactions per 1,000 shuttle bus users (SD = 0.87, range = 0.60-3.86, $n = 16$). A strong positive relationship existed between number of grizzly bear-human interactions in backcountry areas and number of people using shuttle buses in both years (Fig. 1); regression lines did not differ between 1988 and 1989 ($F = 0.58$; 2, 12 df; $P = 0.67$). Interactions occurring in frontcountry areas, however, were not directly related to levels of shuttle bus use ($r^2 = 0.10$, 6 df, $P = 0.40$).

Backcountry use-nights were 10,200 and 10,900 in 1988 and 1989, respectively. Highest levels of overnight backcountry use occurred in August. Rate of interactions in backcountry areas was 7.1 per 1,000 backcountry use-nights (SD = 3.92, range = 3.34-16.94). A significant positive relationship also occurred between

Table 1. Number of grizzly bear-human interactions in frontcountry and backcountry areas of Denali National Park, Alaska, 1988-1989.

Bear-human interactions	1988	1989	Total
Frontcountry			
East District	4	15	19
West District	6	19	25
Kantishna	5	0	5
Park Road	5	24	29
Backcountry	65	60	125
Total	85	118	203

backcountry interactions and number of backcountry use-nights ($r^2 = 0.41$, 14 df, $P = 0.008$). Partial correlations, however, strongly indicate that level of shuttle bus use ($r_{12.3} = 0.85$) rather than backcountry use-nights ($r_{12.3} = 0.02$) was more strongly associated with bear-human interactions in the backcountry.

Locations of Interactions and Types of Bear Groups

More interactions occurred in backcountry areas than frontcountry areas or along the park road ($X^2_r = 24.3$, 6 df, $P = 0.001$). Grizzly bear-human interactions in backcountry areas increased steadily from May to late July, and then decreased through September (Fig. 2). Interactions in frontcountry areas, however, peaked in early June, decreased sharply in late June and early July, and gradually increased to a second, smaller peak in late August. With years pooled, a significant inverse correlation existed between frontcountry and backcountry interactions for periods of heaviest human use (June-August; $r_5 = -0.89$, $n = 6$, $P < 0.05$, 1-tailed test).

Although total number of interactions was not different between years for 2-week intervals from May through September (1988, $\bar{x} = 8.5$, $SD = 4.6$, range = 0-15, $n = 10$; 1989, $\bar{x} = 11.8$, $SD = 6.6$, range = 2-24, $n = 10$; Wilcoxon test = 1.17, $P = 0.221$), a difference did occur in types of bear groups encountered ($G = 18.24$, 1 df, $P < 0.001$). In 1988, 64% of 85

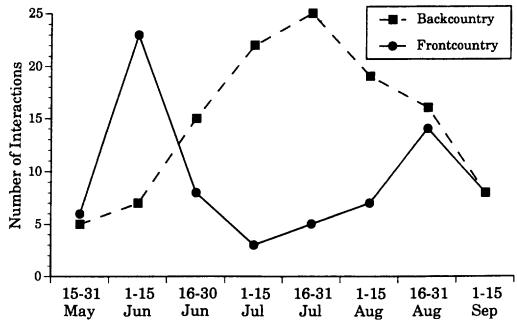


Fig. 2. Timing of grizzly bear-human interactions in frontcountry and backcountry areas of Denali National Park, Alaska, by 2-week periods in 1988-1989.

interactions involved single bears, and 31% involved family groups. In 1989, however, single bears accounted for 32% of 118 interactions, whereas family groups composed 63% of the total. In both years, 5% of interactions involved mated pairs or subadult siblings.

Habitats Associated with Interactions

Habitats in which bear-human interactions occurred were not proportional to habitat availability ($\chi^2 = 176.96$, 3 df, $P < 0.001$). Bonferroni 95% confidence intervals indicate that interactions on river and gravel bars occurred more frequently and on tundra less frequently than expected (Table 2). Interactions in forest and tall brush were not different from expected frequencies. Bears acted aggressively (charged, injured, or otherwise threatened people) in all habitats (range = 20-33%, $n = 16$); sample size was too small for meaningful statistical comparisons.

Analysis of Bear Behavior

Grizzly bears approached people, followed people, or entered a camp with people present in 42% of 203 reported interactions. Bears avoided people in 38%, ignored people in 12%, and acted aggressively toward people in 8% of these interactions. Further, bears behaved dif-

Table 2. Occurrence of grizzly bear-human interactions in forest, river bar, tall brush, and tundra habitats in Denali National Park and Preserve, Alaska, 1988-1989.

Habitat	Proportion of total study area* (P _e)	Observed number of interactions	Expected number of interactions ^b	Proportion observed in each habitat (P _o)
Forest	0.159	35	29	0.189
River bar	0.050	53	9	0.286*
Tall brush	0.073	11	14	0.059
Tundra	0.718	86	133	0.466*
Total	1.000	185	185	1.000

* Proportions of total area represent expected interaction values if bear-human interactions occurred in each habitat in proportion to availability.
^b Calculated by multiplying proportion P_e × n.
 * Indicates a difference (α = 0.05) between observed (P_o) and expected (P_e) values.

ferently toward people in frontcountry than backcountry areas ($G = 9.14, 3 \text{ df}, P = 0.03$). In frontcountry areas, bears approached people in 50%, avoided people in 25%, did not respond to people in 15%, and behaved aggressively toward people in 10% of 78 interactions. Conversely, bears avoided people in 45%, approached people in 38%, did not respond to people in 11%, and behaved aggressively toward people in 6% of 125 backcountry interactions.

Analysis of confrontations (Jope, unpubl. Natl. Park Serv. Rep. 1983) between grizzly bears and hikers indicated that bears followed or approached people in 83%, displayed aggression in 15%, and subsequently obtained human food in 2% of 55 confrontational interactions. Human group sizes involved in ag-

Table 3. Sizes of human groups involved in grizzly bear-human interactions, Denali National Park, Alaska, 1988-1989.

Human group size	Behavioral response category of bears ^a			
	1	2	3	4
\bar{x}	1.67A ^b	3.56B	2.11AB	2.39B
SD	0.90	5.67	2.11	2.68
Range	1-4	1-40	1-10	1-20
n	15	62	18	58

^a 1 = aggressive, 2 = inquisitive, 3 = neutral, 4 = avoidance.
^b Different capital letters indicate significant ($P = 0.05$) differences in group size between behavioral response categories with a posteriori multiple comparisons of the Friedman test.

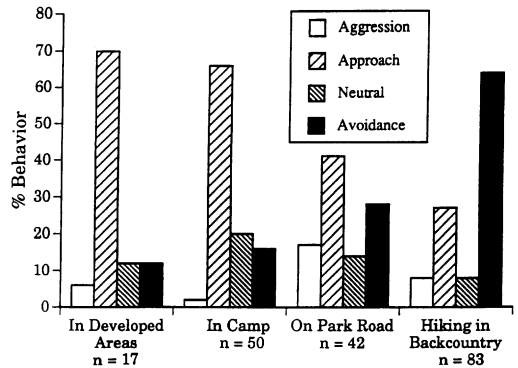


Fig. 3. Percent of behaviors displayed by grizzly bears in interactions with people in developed areas, in camp, along the park road, and hiking in backcountry areas, Denali National Park, Alaska, 1988-1989.

gressive interactions were smaller than group sizes involved in both inquisitive interactions and those where bears avoided people ($X^2 = 14, 6 \text{ df}, P = 0.006$) (Table 3).

Logistic regression analysis of grizzly bear-human interactions indicates that significant variation in bear behavior was explained by the location in which interactions occurred and the function of people in the park ($\chi^2 = 194.18, 163 \text{ df}, P = 0.048$). The Hosmer-Lemeshow goodness-of-fit Chi-square suggests that the logistic model was apt ($\chi^2 = 6.38, 8 \text{ df}, P = 0.61$). Consideration of interaction location and type of people involved correctly discriminated between approach and avoidance behavior in 72% of all interactions. Other independent variables including type of bear group, habitat type, and human group size failed to enter the model. Of 169 interactions characterized by approach or avoidance behavior, bears showed a greater inclination to approach people in developed areas (9 approaches of 11 interactions), in camps (34 approaches of 42 interactions), or on the park road (24 approaches of 36 interactions) than when people were hiking in the backcountry (29 approaches of 80 interactions) (Fig. 3). In addition, concession employees tended to report more serious grizzly bear interactions (19 approaches of 27 inter-

actions) than did NPS employees (21 approaches of 50 interactions). Interactions reported by visitors to the park (56 approaches of 92 interactions) were intermediate between NPS and concession employees.

DISCUSSION

Although rates of serious bear incidents in Denali NPP have declined since 1980, rate of human injury inflicted by grizzly bears remains high compared to other national parks in North America with grizzly bear populations (Dalle-Molle and Van Horn 1989, Herero and Fleck 1989). Further, total interactions between bears and people have increased since 1987. Factors that may contribute to this are habituation of bears to people and increasing human activity in bear habitat.

Distribution of Interactions

Temporal variation in distribution of bear-human interactions (Fig. 2) might be explained by seasonal variation in habitat selection by grizzly bears. For example, most campgrounds and developed areas occur in forest habitats close to rivers. High levels of frontcountry interactions in late May and early June could result from bears entering these areas in search of newborn moose calves or important plant foods in riparian areas. Similarly, production of soapberries on river bars in late August also could bring bears into contact with people near frontcountry areas. Increased bear-human interactions in backcountry areas in midsummer could represent movement of bears to utilize productive habitats in those areas, concurrent with increasing human use. Interactions in backcountry areas were strongly correlated with levels of human use along the park road (Fig. 1), whereas those in the frontcountry were not. Indeed, partial correlations suggest that backcountry interactions were most strongly related to human use of shuttle buses in the frontcountry. Moreover, frontcountry and

backcountry interactions were inversely related during periods of heavy shuttle bus use by park visitors. These patterns may reflect non-habituated bears avoiding the frontcountry during periods of high human activity. Indeed, Tracy (1977) reported that significantly more bears occurred in backcountry than frontcountry plots and concluded that some bears were avoiding the vicinity of the park road. Similarly, studies from other areas have demonstrated that use of habitats near roads and developments by grizzly bears was less than expected based on habitat availability (Mattson et al. 1987, McLellan and Shackleton 1988, 1989).

We hypothesize that nonhabituated bears are displaced into backcountry areas by high levels of human activity in the frontcountry. This increases the likelihood of bear-human interactions in the backcountry and also may increase use of less productive habitats. Conversely, in areas close to human activity, habituated bears may experience less intraspecific competition and gain access to higher quality sources of food. Habituation to people, therefore, may be a particular advantage for subadult bears or adult females that must provide both nourishment and security for dependent offspring (Mattson 1989). Indeed, Tracy (1977) reported a predominance of females and family groups in observations of grizzly bears near the Denali Park Road. If adult females with cubs are selecting habitat close to human activity, offspring may habituate to people at an early age. Habituation at a young age has been associated with several bear incidents, and was related to the destruction of 1 bear during this study (Denali Natl. Park and Preserve files).

Efforts to minimize displacement of bears will help maintain natural patterns of habitat selection and behavior of bears relative to human use. More nonhabituated bears in the frontcountry are unlikely to increase risk of human injury substantially because these animals tend to avoid people. Nonetheless, fur-

ther research is necessary to identify what types and magnitudes of human activity affect grizzly bear distribution and habitat selection.

Habitats Associated with Interactions

Grizzly bear-human interactions are likely when patterns of human use overlap habitats selected by bears. Although seasonal selection of habitat by bears in Denali NPP is not fully understood, disproportionate occurrence of interactions on river and gravel bars probably reflects the tendency of many hikers and grizzly bears to use rivers and dry washes as corridors of travel. In addition, these habitats contain plant foods that are seasonally important for grizzly bears (Murie 1981, Stelmock 1981). Poor visibility in riparian habitats also may contribute to disproportionate levels of bear-human interactions. This is not the sole explanation, however, because interactions in tall brush and forest habitats did not differ from expected values (Table 2). Conversely, good visibility in tundra habitats may allow people to avoid bears more effectively, thereby reducing occurrence of bear-human interactions.

Analysis of Bear Behavior

Interactions that occurred most frequently were bears approaching people, following people, or entering camps with people present; these were reported 86 times (43% of all interactions) in 2 years. This percent is higher than that reported from the Many Glacier and Granite Park areas of Glacier National Park, where bears have habituated to high levels of human use (McArthur Jope 1983). Further, bears in our study behaved more aggressively toward smaller groups of people (Table 3), an outcome previously noted by Herrero (1985). The number of interactions in which bears avoided people in our study (78 in 2 years) was probably underestimated, especially those involving day hikers in backcountry areas where reporting was nonsystematic. Additionally,

bears may have avoided hikers without being observed.

An analysis of 69 confrontations between grizzly bears and backpackers in Denali NPP from 1978 to 1981 indicated that bears charged people in 17%, followed or approached people in 41%, and obtained food from people in 42% of confrontational interactions (Jope, unpubl. Natl. Park Serv. Prog. Rep., 1983). Our study demonstrates that the percent of bears obtaining food during confrontations with backpackers has decreased (42% to 2%), but the percent of bears approaching or following people has increased (41% to 83%). Percent of confrontations in which bears behaved aggressively toward people was similar between the 2 studies (17% to 15%). Although an increase in percent of approach or inquisitive behavior by bears may be an artifact of a decrease in number of bear-human confrontations between studies, confrontations were not substantially higher in the earlier study (66 in 1978-1981, 55 in 1988-1989). Additionally, annual backcountry use was similar between these studies. We conclude that although the reward of food has been reduced, bears still show a strong tendency to investigate people. Thus, food probably is not the primary factor affecting current levels of bear-human interactions in Denali NPP.

Grizzly bears in Denali NPP appear habituated to people in some situations (Tracy 1977, Singer and Beattie 1986, Darling 1987). Bears showed less fear and greater interest in people in developed areas, in camps, and along the park road than when people were hiking in the backcountry (Fig. 3). Interactions in these areas have greater potential for bears approaching or otherwise behaving aggressively, and the probability of obtaining food or garbage from people is increased (McCullough 1982). These may be high-risk situations in terms of grizzly bear-human conflicts (Gilbert 1989). Indeed, Herrero (1970) and Merrill (1978) noted that campgrounds and other developed areas were the focus of bear incidents

and human injuries. This potentially dangerous condition is exacerbated by people often trying to get close enough for a photograph or close look at a bear (McCool and Braithwaite 1989).

Grizzly bear-human interactions reported by concession employees tended to be more serious than those reported by visitors to the park or by NPS employees. This outcome may reflect careless behavior or lack of knowledge about bears by those employed by park concessions, or that concession employees often work in developed areas where more serious interactions occurred.

MANAGEMENT IMPLICATIONS

Habituated bears in Denali NPP present a considerable problem to park managers because habituation and food conditioning of bears have been associated with serious and sometimes fatal attacks on people (Herrero 1970, 1985, 1989; Herrero and Fleck 1989). Although the rate at which bears obtain food from such interactions has declined in Denali NPP, increasing rates of bear-human incidents and encounters must be reversed to ensure reasonable visitor safety.

Facilities that concentrate human use (e.g., trails, campgrounds, bus rest stops) in areas frequently used by grizzly bears may result in high levels of bear-human interactions. Grizzly bear-human interactions could be reduced by restricting access to campgrounds in riparian habitats during seasons of heavy use by bears. In addition, we caution against further development of facilities in such habitats.

We hypothesize that displacement of grizzly bears from frontcountry areas during periods of heavy human use increases interactions between bears and people in the backcountry (Fig. 1). Further, habituated bears remaining near human developments may benefit from decreased intraspecific competition, thereby reinforcing this behavior. If this hypothesis is correct, regulating human activity along the

park road and other frontcountry areas may provide the best alternative to reduce bear-human interactions, and maintain natural patterns of bear behavior and habitat selection. Further research to identify patterns of habitat selection by grizzly bears in frontcountry and backcountry areas, however, is needed. Moreover, types and levels of human activity that may contribute to displacement of bears must be identified.

Finally, education of park visitors as well as NPS and concession employees about bear behavior and safety is critical to the successful management of bear-human conflicts in Denali NPP. Specialized training of all NPS and concession employees must be provided, and efforts to educate park visitors increased. In addition, proper storage and disposal of all human food and garbage must continue to be strictly enforced.

SUMMARY

Although improved management has reduced the number of more serious incidents between grizzly bears and people in Denali NPP, the rate of interactions has increased from 80 per million visitors in 1987 to 197 per million visitors in 1989. Most interactions in frontcountry areas occurred in early June and late August, and probably involved bears habituated to humans. Backcountry interactions were strongly correlated with the number of people riding shuttle buses and may have been caused by less-habituated bears moving from frontcountry to backcountry areas, or from seasonal changes in habitat selection by bears. Interactions occurred on river and gravel bars more frequently and on tundra less frequently than expected by occurrence of these habitats within the park. Although bears in Denali NPP are seldom conditioned to people by the reward of food, there is a high rate of bears approaching people or entering camps with people present. Further, bears showed a greater tendency to approach people in developed areas, along

the park road, and in camps than when people were hiking in the backcountry. Efforts to minimize interactions between bears and people will increase visitor safety and reduce opportunities for bears to obtain food from humans. We believe better education of NPS personnel, concession employees, and park visitors about bears, and reducing human activity in habitats used by both people and bears offer the greatest likelihood of achieving this goal.

Acknowledgments.—We thank J. Dalle-Molle and J. Van Horn, who were instrumental in the initiation of this study. D. Albert was employed by the NPS as a seasonal wildlife technician involved in grizzly bear-human conflict management throughout this project. We are indebted to those who reported and collected data on bear-human interactions. P. DelVecchio, J. Van Horn, and D. Waring investigated interactions and deserve special mention. We thank P. Brease and R. Densmore for logistic and administrative support, and for permission to use these data in our analysis. Helpful discussion and critical review of the manuscript were provided by L. G. Adams, F. C. Dean, W. G. Eastland, E. G. Follmann, L. D. Mech, J. R. Rachlow, and V. Van Ballenberghe. We also thank D. L. Thomas and P. X. Quang for helpful discussion of statistical applications.

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Received 2 October 1990.

Accepted 30 March 1991.



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