

BEAR-INFLICTED HUMAN INJURIES IN YELLOWSTONE NATIONAL PARK, 1970–1994

KERRY A. GUNTHER, Bear Management Office, Box 168, Yellowstone National Park, WY 82190, USA, email: Kerry_Gunther@nps.gov
HOPI E. HOEKSTRA,¹ Bear Management Office, Box 168, Yellowstone National Park, WY 82190, USA

Abstract: The implementation of a new bear management program in Yellowstone National Park in 1970 began a new era in bear–human interactions within the park. The rate of bear-inflicted human injuries decreased from 2.7/million visitors from 1970 through 1979 to 0.5/million visitors from 1980 through 1994. This was primarily due to decreased roadside injuries from black bears (*Ursus americanus*) as public education increased and food conditioned bears were removed from roadsides and developed areas. After 1980, the majority of injuries occurred in the backcountry. Backcountry injuries tended to be more severe and were more often caused by grizzly bears (*Ursus arctos*) than those that occurred along roadsides. Of the 34 injuries that occurred in the backcountry from 1970 through 1994, 13 (38%) were considered severe and 3 (9%) resulted in human fatalities. Ninety-one percent of all injuries in the backcountry involved people as they were hiking, and 9% occurred in backcountry campsites. Ninety-seven percent of the hikers injured by bears reported surprise encounters as the cause of the attack, and 68% of these incidents involved female bears with young. Most hikers that were injured (61%) reacted to encounters with bears by running or attempting to climb trees. Most (80%) hikers that resisted during bear attacks were severely injured. Backcountry injuries occurred both in forested habitat (68%) and nonforested areas (32%). Visitor and employee education on precautions to take when hiking in bear habitat may be the most useful tool in further decreasing bear-inflicted human injuries within Yellowstone National Park.

Ursus 10:377–384

Key words: black bear, grizzly bear, human injury, management, *Ursus americanus*, *Ursus arctos*, Yellowstone National Park.

Due to concerns for human safety and grizzly bear population viability, bear management policy within Yellowstone National Park (YNP) has been progressively intensified (Schullery 1992, Gunther 1994). Improvements in bear management, in addition to increased public education, are thought to be responsible for the decline in bear-inflicted human injuries from 1970 through 1994, despite an increase in park visitation (Table 1).

From 1931 to 1969, an average of 45 people/year were injured by black bears within YNP (Cole 1976, Meagher and Phillips 1983). During the same period, grizzly bears injured an average of 2 people/year (Cole 1976). Most of these injuries occurred along roadsides or in developed areas and involved bears attracted to human foods or garbage (Cole 1971, 1976; Meagher and Phillips 1983).

Murie (1944) and Cole (1971) suggested that the high incidence of bear-caused human injuries resulted from changes in bear behavior caused by the availability of human food and garbage. Bears that become conditioned to human food and habituated to the presence of people often become more dangerous to humans (Herrero 1970a, 1985; Craighead and Craighead 1971). Prior to 1970, bears in YNP commonly fed on human food from a variety of sources. Black bears obtained human food as roadside handouts, from unsecured food and garbage in campgrounds and developed areas, and by scavenging in open-pit garbage dumps (Barnes and Bray 1967, Craighead et al. 1995). Grizzly bears obtained human

Table 1. Number of park visitors, number of bear-inflicted human injuries, and number of injuries/million visitors/year in Yellowstone National Park, 1931–1994.

Time	Number of visitors	Number of injuries	Injuries/million visitors/year
1931–39	3,004,516	527	19.5
1940–49	5,522,272	307	5.6
1950–59	13,555,585	570	4.2
1960–69	19,589,244	448	2.3
1970	2,297,290	12	5.2
1971	2,120,487	9	4.2
1972	2,246,827	8	3.6
1973	2,061,537	6	2.9
1974	1,937,768	7	3.6
1975	2,246,132	3	1.3
1976	2,525,174	8	3.2
1977	2,487,084	3	1.2
1978	2,623,141	2	0.8
1979	1,891,927	3	1.6
1980	2,009,581	1	0.5
1981	2,544,242	3	1.2
1982	2,404,862	0	0
1983	2,405,653	1	0.4
1984	2,262,969	5	2.2
1985	2,262,455	0	0
1986	2,405,063	3	1.3
1987	2,618,249	0	0
1988	2,219,128	0	0
1989	2,680,376	1	0.4
1990	2,857,096	0	0
1991	2,957,856	0	0
1992	3,186,190	1	0.3
1993	2,912,193	0	0
1994	3,046,645	4	1.3

¹Present address: University of Washington, Dep. of Zoology and Burke Museum, Box 351800, Seattle, WA 98198–1800, USA.

foods primarily from garbage dumps and occasionally from unsecured human food and garbage in campgrounds and developments (Craighead and Craighead 1971, Craighead et al. 1995). Roadside feeding of grizzly bears by tourists was rare (Craighead et al. 1995).

In an effort to reduce bear-human conflicts in YNP, park managers implemented a bear management program in 1960 (Natl. Park Serv. 1960). This plan concentrated on translocating or removing (bears sent to zoos, other ecosystems, or killed) potentially dangerous bears, although some effort was made to reduce the human food and garbage which initially attracted bears to developed areas and roadsides.

In 1970, YNP initiated a program to restore black bear and grizzly bear diets to natural forage and reduce bear-caused human injuries and property damages (Leopold et al. 1969). Regulations prohibiting feeding or approaching bears became strictly enforced, as were regulations requiring that human food and garbage be kept secured from bears (Meagher and Phillips 1983). In addition, all remaining old style non-bear proof garbage cans in the park were made bear-proof and garbage dumps within and adjacent to the park were closed: Rabbit Creek in 1970, Trout Creek in 1971, West Yellowstone (outside YNP) in 1971, Gardiner in 1978, and Cooke City (outside YNP) in 1979. The park also intensified efforts to inform visitors about bear behavior, the causes of bear-human conflicts, and proper food and garbage storage procedures. Management actions, including translocations and removals of bears that persisted in seeking human food and frequenting developed areas, were continued. Cole (1974) hypothesized that these management actions would reduce the number of bear-inflicted human injuries in developed areas from the 1963-69 levels ($\bar{x} = 4.4/\text{yr}$; range = 2-8/yr).

From 1970 through 1978, there were 125 translocations of black bears and 147 of grizzly bears from roadsides and developed areas to backcountry areas (Meagher and Phillips 1983). Additionally, 28 incorrigible black bears and 39 grizzly bears within YNP were removed from the population. By 1979, most bears that had depended on human foods were no longer in the population (Meagher and Phillips 1983).

The objective of our study was to review reports of bear-inflicted human injuries since 1970, the year YNP implemented management programs designed to reduce the influence of human food on bear behavior. We also analyzed factors which may have influenced bear-human confrontations.

We acknowledge the dedication and contributions to bear management made by all YNP employees. Addi-

tionally, S. Fowler, D. Fraser-Herring, K. West, R. Danforth, K. Churchill, M. Biel, and S. Rice compiled much of the data. R. Renkin conducted statistical analysis of the data. J. Mack provided computer graphics for the conference presentation. B. McLellan and 2 anonymous reviewers provided valuable comments on the draft manuscript. This project was funded by the National Park Service, Yellowstone Center for Resources, YNP.

STUDY AREA

Yellowstone National Park was established in 1872 and encompasses 8,995 km² in the states of Wyoming, Montana, and Idaho. During the study period of 1970-94, visitation to the park gradually increased from an average of >2 million visitors/year from 1970 through 1979, to almost 3 million visitors/year from 1990 through 1994. Most (>80%) visitation occurs from June through September. Approximately 1% of YNP is developed, including 531 km of paved roads that run through the park. Most of the park is considered pristine backcountry area, which contains a wide variety of vegetation, cover types and habitat types (Despain 1990). The park is 80% forested, of which 60% has subalpine fir (*Abies lasiocarpa*) as the climax species.

Elevations within YNP range from 1605 m in the north to several peaks between 3050 m and 3350 m along the eastern and northern boundaries (Despain 1990). Upper timberline is near 3000 m, while most of the park lies between 2100 m and 2750 m in the subalpine zone.

Grizzly bear distribution, habitat use, food habits, and population trend in YNP have been extensively studied (Blanchard and Knight 1991, Mattson et al. 1991, Blanchard et al. 1992, Eberhardt et al. 1994). Relatively little is known about the black bear population in the park.

METHODS

We reviewed 25 years (1970-94) of YNP files, incident reports, personal statements, and newspaper articles of bear-caused human injuries, excluding those that occurred during bear research or management handling. Information obtained from the files included date, approximate time, and location (developed area, roadside, or backcountry) of bear-caused human injuries. Developed areas are defined as areas within 100 yds (91 m) of human developments. Roadside injuries included all incidents that occurred in the road corridor. Backcountry was defined as all areas excluding roadsides and developed areas. Further information collected included the number of people in the party, gender of

the injured person, activity of the party prior to injury, reaction of the person to the attacking bear, species of bear involved, and sex and age class of bear, if known. The extent of the injury, minor (requiring <day of hospitalization or <35 sutures) or severe (requiring >day of hospitalization or >35 sutures), was also recorded.

Backcountry activities included camping and hiking. Location of hikers (on-trail or off-trail), was also analyzed. Backcountry use-nights was defined as the total number of people in an overnight party multiplied by the number of nights spent in the backcountry. Records of day use of the backcountry in YNP were not available.

Vegetation in YNP has been classified and digitized to a 2-ha resolution by Despain (1990). We calculated universal transverse mercator (UTM) grid coordinates for the locations of bear-caused human injuries and plotted them to habitat maps to identify the habitat type in which backcountry injuries occurred. Because of the high number of habitat types ($n = 51$) compared to the low number of injuries that occurred in the backcountry ($n = 34$), habitat types were pooled as forested cover class and non-forested cover class. The frequency of injuries in different cover classes was compared to the availability of different cover classes using the method described by Neu et al. (1974).

RESULTS

The total number of YNP visitors increased through the 1970s and 1980s ($R = 0.692$) and reached an all time high of >3 million visitors in 1992 (Table 1). Backcountry use-nights increased through the 1970s, dropped during the early 1980s, and increased again in the early to mid-1990s. During the same period, however, total bear-inflicted human injuries steadily decreased ($R = -0.778$), while the bear-inflicted injury numbers in the backcountry remained relatively constant.

In the 25 years of 1970–94, 80 people were injured in 75 incidents in YNP (Table 2). Of these injuries, 60 (75%) were considered minor, 19 (24%) were severe, and 3 (4%) resulted in fatalities. Black bears and grizzly bears were involved in 31 (39%) and 41 (51%) of the injuries, respectively, and species was not determined for 8 (10%) injuries. Only 1 person was injured in most (93%) bear attacks; 2 people were injured in the remainder of the cases (7%). There were no incidents reported in which >2 people were injured. Female bears with cubs (offspring in their first year of life) were involved in 4 of the 5 (80%) incidents where 2 people were in-

jured. Fifty-eight (73%) of the people injured were male and 21 (26%) were female; 1 (1%) report did not list the gender of the injured person. Injuries occurred within developed areas (14%), along roadsides (44%), and in backcountry areas (43%).

The trend in the location of bear-inflicted injuries changed dramatically from 1970 to 1994. Whereas roadside injuries predominated (57%) during 1970–79, there were no roadside injuries reported from 1980 to 1994. From 1980 through 1994, most (90%) bear-inflicted injuries occurred in the backcountry.

There was also a change over time in the proportion of black and grizzly bears involved in human injuries. From 1970 to 1979, when most injuries occurred along roadsides, 40 (66%) bear-inflicted human injuries were reportedly caused by black bears, 15 (25%) by grizzly bears, and 6 (10%) by unidentified species. From 1980 to 1994, when most injuries occurred in the backcountry, 16 (84%) bear-inflicted human injuries were caused by grizzly bears, 1 (5%) by a black bear, and 2 (11%) by bears of unidentified species. Whereas black bear-caused injuries decreased dramatically with the decrease in roadside begging by black bears, injuries inflicted by grizzly bears in backcountry areas remained relatively constant over time.

Injuries in Developed Areas

From 1970 to 1994, 11 bear-caused injuries occurred within developed areas in YNP; 9 (82%) of these injuries occurred prior to 1979. Only 2 (18%) of the injuries within developed areas occurred during the last 16 (1979–94) years. All injuries in developed areas occurred within (91%) or near (9%) campgrounds: 4 at Grant Village, 3 at Fishing Bridge, 2 at Canyon, and 1 each at Bridge Bay and Madison. Grizzly bears and black bears were involved in 5 (46%) and 3 (27%) of the injuries, respectively. The species of bear involved could not be determined for 3 (27%) of the injuries.

All injuries caused by grizzly bears in developed areas occurred between 0100 and 0400 hours. All injuries caused by black bears in developed areas occurred between 0530 and 1430 hours.

Female grizzly bears with cubs were involved in 4 (36%) of the injuries. Six (55%) of the injuries (4 by grizzly bear, 2 by black bear) were considered severe and 5 (45%; 1 by a grizzly bear, 1 by a black bear, and 3 by unknown species) were minor. Only 1 person was injured in most (90%) attacks that occurred in developed areas. The only incident in which 2 people were injured involved an adult female grizzly bear accompanied by a cub.

Table 2. Number of visitors, backcountry use-nights (BUN), and bear-inflicted human injuries by grizzly bears (Gr), black bears (Bl), and unknown species (Unk) of bear in Yellowstone National Park, 1970–94. BUN were not available before 1973.

Year	Visitation	BUN	Developed area			Roadside			Backcountry			Total		
			Gr	Bl	Unk	Gr	Bl	Unk	Gr	Bl	Unk	Gr	Bl	Unk
1970	2,297,290		2	1	1	0	5	1	2	0	0	4	6	2
1971	2,120,487		0	0	0	0	9	0	0	0	0	0	9	0
1972	2,246,827		0	0	1	0	5	0	2	0	0	2	5	1
1973	2,061,537	36,219	0	0	1	0	3	0	0	2	0	0	5	1
1974	1,937,768	41,282	0	0	0	0	7	0	0	0	0	0	7	0
1975	2,246,132	44,374	0	0	0	0	1	0	2	0	0	2	1	0
1976	2,525,174	50,580	2	0	0	0	4	0	2	0	0	4	4	0
1977	2,487,084	55,331	0	1	0	0	0	0	1	1	0	1	2	0
1978	2,623,141	52,795	0	0	0	0	0	0	0	1	1	0	1	1
1979	1,891,927	51,182	0	0	0	0	0	0	2	0	1	2	0	1
1980	2,009,581	54,874	0	0	0	0	0	0	1	0	0	1	0	0
1981	2,544,242	55,060	0	1	0	0	0	0	1	0	1	1	1	1
1982	2,404,862	49,400	0	0	0	0	0	0	0	0	0	0	0	0
1983	2,405,653	43,738	0	0	0	0	0	0	1	0	0	1	0	0
1984	2,262,969	34,936	1	0	0	0	0	0	4	0	0	5	0	0
1985	2,262,455	32,532	0	0	0	0	0	0	0	0	0	0	0	0
1986	2,405,063	31,414	0	0	0	0	0	0	2	0	1	2	0	1
1987	2,618,249	32,906	0	0	0	0	0	0	0	0	0	0	0	0
1988	2,219,128	25,188	0	0	0	0	0	0	0	0	0	0	0	0
1989	2,680,376	32,747	0	0	0	0	0	0	1	0	0	1	0	0
1990	2,857,096	37,318	0	0	0	0	0	0	0	0	0	0	0	0
1991	2,957,856	41,476	0	0	0	0	0	0	0	0	0	0	0	0
1992	3,186,190	42,124	0	0	0	0	0	0	1	0	0	1	0	0
1993	2,912,193	45,135	0	0	0	0	0	0	0	0	0	0	0	0
1994	3,046,645	45,460	0	0	0	0	0	0	4	0	0	4	0	0

Of the 11 people injured by bears in developed areas, 5 people (45%) were involved in improper behavior: 4 incidents (3 by grizzly bears, 1 by unknown species) involved improper food storage and 1 injury (by a black bear) occurred in an unsanctioned camp. Of these 5 injuries, 2 involved people that were in sleeping bags outside next to improperly stored food, 1 involved a person that had food stored next to his tent at night, 1 injury resulted from a man leaving his trailer to attempt to chase a female grizzly bear with cubs away from an improperly stored cooler at night, and 1 incident involved a person sleeping outside in a sleeping bag in an illegal camp.

Six attacks in developed areas were considered unprovoked: 2 (1 by a grizzly bear, and 1 by a black bear) involved people sleeping in tents, 2 (1 by a grizzly bear, 1 by an unknown species) involved people sleeping outside in sleeping bags, 1 incident (by an unknown species) involved a person walking through a developed area, and 1 incident involved a black bear attempting to carry off an infant that had been sleeping outside in a playpen.

Ten (91%) of the people injured in developed areas were male (4 by grizzly bears, 3 by black bears, 3 by

unknown species). Only 1 (9%) of the injured people was female (by a grizzly bear).

Injuries along Roadsides

From 1970 to 1994, there were 35 people injured in 34 incidents along roadsides; all occurred prior to 1977. Black bears were involved in 34 (97%) of the roadside injuries, while the species of bear was not determined for 1 (3%) injury. No grizzly bear-caused human injuries along roadsides were reported. All roadside injuries occurred between 0800 and 2000 hours; most (59%) occurred between 1100 and 1500 hours. Female bears with cubs were involved in 2 (6%) injuries, and a female with a yearling was involved in 1 (3%). Thirty-four of the injuries that occurred along roadsides were minor; only 1 roadside injury was considered severe. In the severe injury, a person was bitten on the arm by a black bear that was attempting to get food from an occupied vehicle along the roadside. The person sustained a broken arm and lacerations that required >100 sutures. In 33 of the 34 incidents that occurred along roadsides, only 1 person was injured. In 1 incident, a subadult black bear of unknown

sex bit 2 children that approached to get their picture taken with it.

Fifteen (43%) of the people injured reported improper behavior as a cause for injury: 9 (26%) fed bears, 3 (9%) attempted to touch or pet bears, 2 (6%) attempted to have their pictures taken with bears, and 1 (3%) approached a bear for a better view. Twenty of the injured people (57%) reported that they were either viewing (43%) or photographing (14%) bears when the injury occurred. However, the proportion of people injured due to improper behavior may be under-reported because of repercussions of improper behavior (i.e., fear of citations, fines, or embarrassment). Of the people injured along roadsides, 22 (63%) were male and 12 (34%) were female; 1 (3%) report did not list the gender of the injured person.

Backcountry Injuries

Backcountry injuries ranged from 0 to 4 ($\bar{x} = 1 \pm 1$ SD yr) per year from 1970 to 1994. The annual number of injuries in the backcountry has remained relatively constant despite an increase in the number of visitors to YNP. A total of 34 people were injured by bears in 31 incidents in the backcountry. In 3 incidents, 2 people were injured; all 3 involved female bears with cubs (2 by grizzly bears, 1 by a black bear).

Grizzly bears and black bears were involved in 26 (76%) and 4 (12%) of the injuries, respectively. The species of bear involved could not be determined for 4 (12%) injuries. Backcountry injuries occurred throughout the day and night. All injuries to people that were hiking occurred between 0745 and 1900 hours. All injuries in backcountry campsites occurred at night.

Most (68%) backcountry injuries involved female bears with cubs (50%) or yearlings (18%). These percentages may be underestimated because young sometimes run off as the mother charges and thus may not be seen. Eighteen (53%) of the bear-caused injuries that occurred in the backcountry were minor, 13 (38%) were considered severe, and 3 (9%) resulted in fatalities. Of the three fatalities 2 occurred in backcountry campsites. Of the 34 people injured by bears in the backcountry, 25 (74%) were men and 9 (26%) were women.

Thirty-one people were injured while hiking (24 by grizzly bear, 3 by black bear, and 4 by unknown species): 16 (52%) were hiking off-trail and 15 (48%) were hiking on-trail. Of these 31 incidents 30 involved surprise encounters with bears, while 1 was probably caused by a photographer approaching a grizzly bear.

The photographer was killed and partially consumed by the bear (Natl. Park Serv. 1986). Two of the people injured while hiking off-trail surprised bears on carcasses.

Only 3 backcountry injuries (2 by grizzly bear, 1 by a black bear) involved people camping. Two of these 3 incidents resulted in fatalities. Both fatalities in backcountry campsites involved grizzly bears and occurred at night.

Another factor involved in backcountry injuries is the number of people in the group. The average number of people hiking into the backcountry of YNP with an overnight permit was 3.2 people/group from 1987 to 1992; stock groups averaged 4.6 persons/group (S.T. Olliff, Natl. Park Serv., YNP, pers. commun., 1995). People injured by bears were in groups averaging 1.8 people/group. Fourteen (45%) of the injuries involved a group of 2 people and 13 (42%) of the injured people hiked alone. Only 3 (9%) of the people injured by bears in backcountry areas were hiking in groups of >2 people.

Of the 31 people injured while hiking, only 4 (13%) reported making an effort to make noise as they hiked. Of these, 1 was hiking near a waterfall, which may have muffled the noise she was making, and 1 was wearing a small bell.

Initial Reaction of Hikers to Encounters with Bears.—The reaction that hikers had to bears when first encountered probably influenced the outcome of bear-human interactions. Running to or attempting to climb a tree during an encounter with a bear preceded 15 (48%) of the injuries incurred while hiking. Attempting to run from a bear during an encounter preceded 4 (13%), and yelling at a bear during an encounter preceded 4 (13%). Three (10%) of the injured people stood their ground or had no time to react when charged. In 1 (3%) incident a hiker sprayed a charging bear with oleoresin capsicum spray before the bear made contact. The hiker received only a minor injury after spraying the bear. Only 1 (3%) of the injured people reported playing dead initially. In 1 (3%) incident, a hiker dropped to the ground when charged, but then kicked at the charging bear and was bitten on the foot. The initial reaction of the people injured was not recorded for 2 (6%) attacks.

Reaction of Hikers after Initial Attack by Bears.—Of the 31 people injured in the backcountry, 11 (36%) reported that they played dead after being attacked by a bear. Of these, 9 (82%) stated that the bear left them as soon as they stopped resisting, and 7 of these 9 (78%)

received only minor injuries. Bears continued to attack (for an unknown length of time) 2 of the 11 (18%) people that played dead after the initial attack. Both were severely injured.

Five (16%) people reported that they continued to resist (usually kicking, punching, or fending off an attacking bear) after initially being attacked; 4 of the 5 (80%) received severe injuries. In 3 (10%) incidents, bears that had injured people were chased off by a second person. In 1 of the 3 (33%) incidents, the bear attacked the second person. In 3 (10%) incidents, people reported that the attacking bear terminated the attack on its own and left. In 2 (6%) incidents, people climbed trees to escape the attacking bear after being injured, and in 1 (3%) incident a person ran from a bear after being injured and the bear did not follow. In 1 (3%) incident, a person injured by a grizzly bear sprayed the bear with oleoresin capsicum spray. The spray also got into the hiker's eyes, and the reaction of the bear was not observed. The bear terminated the attack sometime after being sprayed, and the person was not severely injured. The reaction of people after the initial attack was not known or reported for 5 incidents.

Habitats Types Associated with Injuries.—Of the backcountry injuries, 21 of 31 (68%) incidents occurred in forested areas and 10 (32%) occurred in non-forested areas. Cover classes in which injuries occurred were not proportional to habitat availability ($\chi^2 = 10.33$, 1 df, $P < 0.01$). Injuries occurred more frequently in non-forested areas and less frequently in forested areas than would be expected based on the availability of those cover classes.

DISCUSSION

Reduction in Bear-Inflicted Human Injuries over Time

From the 1930s through 1960s, an average of 48 people/year were injured by bears in YNP (Cole 1976, Meagher and Phillips 1983). Most injuries during this period occurred along roadsides and within developed areas and involved bears attracted by human food or garbage (Cole 1971, Meagher and Phillips 1983).

Between 1970 and 1978, bear management programs in YNP changed considerably (Meagher and Phillips 1983). Prior to 1970, bears were extensively influenced by the availability of human food and garbage in developed areas and along roadsides. From 1970 through 1978, bears were increasingly less influenced by human food and garbage. From 1970 through 1978, bear-in-

flicted human injuries decreased from previous levels to an average of 6.4/year. Of these injuries, an average of 3.8/year occurred along roadsides, 1.6/year in backcountry areas, and 1.0/year within developments.

By 1979, there were fewer bears with prior knowledge of sources of human foods in the population, and bears were mostly uninfluenced by human food and garbage (Meagher and Phillips 1983). At this time management emphasis changed from correction of a problem (sanitation) to awareness that a high level of preventive management must become a routine part of park operations (Meagher and Phillips 1983). From 1979 through 1994, bear-inflicted human injuries declined further to an average of 1/year. During this period, bear-inflicted human injuries along roadsides ($\bar{x} = 0/\text{yr}$) and within developed areas ($\bar{x} = 0.1/\text{yr}$) became rare, while injuries in backcountry areas remained approximately the same ($\bar{x} = 1.3/\text{yr}$) as 1970–78.

The bear management program implemented in 1970 successfully reduced bear-inflicted human injuries within YNP (Table 1), especially injuries in developed areas and along roadsides. Cole's (1974) prediction that the 1970 bear management program would reduce the number of bear-inflicted human injuries in developed areas was correct. The number of bear-inflicted human injuries in developed areas decreased from 4/year from 1963 to 1969 to an average of <1/year from 1970 to 1994.

Injuries inflicted by black bears were reduced from 46/year prior to 1970 to 2 per year from 1970 to 1994 and <1/year ($\bar{x} = 0.1$) from 1979 to 1994. During the same period, human injuries inflicted by grizzly bears were reduced slightly from an average of 2/year from 1931 to 1969 to an average of 1/year from 1970 to 1994.

The large reduction in injuries along roadsides and in developed areas after human foods and garbage were mostly eliminated supports the theory that the combination of food conditioned bears and the availability of human food and garbage in developed areas and along roadsides caused the high incidence of bear-inflicted human injuries occurring in the park prior to 1970 (Murie 1944, Natl. Park Serv. 1960, Leopold et al. 1969, Cole 1971, Meagher and Phillips 1983). The correlation between food-conditioned bears, the availability of human food and garbage, and bear-inflicted human injuries has been reported for other areas (Herrero 1970a, 1970b, 1985).

Bear-Inflicted Human Injuries in Backcountry Areas

During 1979–94, most bear-inflicted human injuries in YNP occurred in backcountry areas. Most

backcountry injuries involved surprise encounters between female grizzly bears with young and hikers in small groups (<3 people). Most people injured reacted to surprise encounters with bears by running, attempting to climb trees, or resisting an attack. The circumstances surrounding bear-caused human injuries reported in this study are similar to those reported by Herrero (1970a, 1976, 1985) for bear-caused human injuries throughout North America. Herrero (1985) suggested that the chance of being injured by a bear while hiking can be reduced by taking steps to avoid surprise encounters and hiking in large groups. In most cases during our study, running, attempting to climb a tree, or resisting an attack did not appear to be good strategies during an encounter with a bear.

Herrero and Fleck (1990) reported an increasing trend of bear-caused human injuries to occur off-trail. During our study, over half of the people injured by bears while hiking were off-trail. It is difficult to accurately compare the proportion of injuries that occur on-trail and off-trail because YNP does not keep records of visitor use of trails and off-trail areas. Bears may associate trails with people and react less aggressively to encounters with people on trails where they expect to find them. Bears may be more likely to be surprised by encounters with people in off-trail areas and thus may react more aggressively to off-trail encounters.

Although more people were injured while hiking than while in backcountry campsites, injuries to people in backcountry campsites tended to be more severe. All 3 injuries that occurred in backcountry campsites occurred at night, and 2 resulted in fatalities. In both fatalities, the people were partially consumed. Herrero (1985) recommended aggression and resistance as the most appropriate response to attacks that occur at night in backcountry campsites.

When backcountry camping, keeping food secured from bears also appeared to be important. Herrero (1985) strongly recommended keeping backcountry camp food secured from bears. In our study, bears had gotten into food left unsecured by the injured person in 2 of the 3 injuries in backcountry campsites. In the third incident, the bear obtained food even though it was apparently hung properly (Natl. Park Serv. 1984). However, it is not known whether the bear got into the food cache before or after attacking the backcountry camper.

Bears and Menstruating Women

On the evening of 13 August 1967, 2 women were attacked and killed by grizzly bears in separate incidents in Glacier National Park (Herrero 1985). Following these

incidents, there was speculation that due to odors associated with menstruation, women may be more prone to attack by bears than men (Rogers et al. 1991). Some safety brochures warn women against hiking or camping in bear country during menstruation.

Most injuries occurring in YNP prior to 1980 involved food-conditioned bears and human food or garbage as attractants and were therefore probably unrelated to menstruation. After 1979, human food attractants had been largely eliminated and were probably not a factor in most bear-inflicted injuries. Over 38 million people visited YNP during the 15 years from 1980 through 1994 (Gunther 1995). These visitors spent over 8 million use-nights camping in developed area campgrounds and over 600,000 use-nights camping in backcountry areas in the park (Gunther 1995). Although statistics are unavailable, many menstruating women undoubtedly hike and camp within YNP each year. From 1980 to 1994, 19 people were injured by bears within the park. Of these 19 injuries, 14 (74%) were men and 5 (26%) were women. Most (84%) of these injuries involved surprise encounters between bears and hikers and were therefore probably unrelated to menstruation. Of the 3 (16%) incidents where bears entered campsites and injured people, 2 of the injured people were male and 1 was female. The woman was not menstruating at the time of the attack (Natl. Park Serv. 1984). There was no evidence linking menstruation to any of these 19 bear attacks.

It is difficult to accurately compare the ratio of males to females that are injured by bears in YNP because the park does not keep records of visitor use by gender. However, the injury data for YNP does not suggest that females are more likely to be attacked by bears than males.

MANAGEMENT IMPLICATIONS

Our data demonstrate that feeding black bears along roadsides was responsible for the high number of black bear-inflicted human injuries that occurred along park roads prior to 1977. Public education efforts and effective enforcement of regulations prohibiting the feeding of bears by tourists has virtually eliminated bear-inflicted injuries to humans along roadsides; these efforts must remain a permanent component of future bear management programs within the park.

Our data also strongly suggest that the presence of human food-conditioned bears combined with the availability of human food and garbage in campgrounds led to most bear-inflicted human injuries in developed areas. Public education programs and strict enforcement

of sanitation regulations substantially reduced the number of bear-inflicted human injuries in campgrounds and developed areas. Public education programs and programs designed to prevent bears from obtaining human food and garbage must remain a permanent bear management priority in YNP.

Despite the success of the 1970 bear management program in reducing the number of bear-inflicted human injuries in the park, an average of 1 bear-inflicted human injury/year still occurs. These injuries most often involve surprise encounters between backcountry hikers and female grizzly bears with young. It will be difficult to reduce the frequency of this type of injury, especially if both backcountry recreational activity and the grizzly bear population (Eberhardt et al. 1994) in YNP continue to increase. Public education programs informing hikers how to avoid surprise encounters and how to react to encounters and attacks once they occur may be the most useful tool in further decreasing the number and severity of bear-inflicted human injuries in the park.

LITERATURE CITED

- BARNES, V.G., AND O.E. BRAY. 1967. Population characteristics and activities of black bears in Yellowstone National Park. Final Rep., Colorado Wildl. Res. Unit, Colorado State Univ., Fort Collins. 199pp.
- BLANCHARD, B.M., AND R.R. KNIGHT. 1991. Movements of Yellowstone grizzly bears. *Biol. Conserv.* 58:41–67.
- , AND D.J. MATTSON. 1992. Distribution of Yellowstone grizzly bears during the 1980's. *Am. Midl. Nat.* 128:332–338.
- COLE, G.F. 1971. Preservation and management of grizzly bears in Yellowstone National Park. *BioScience* 21:858–864.
- . 1974. Management involving grizzly bears and humans in Yellowstone National Park, 1970–73. *BioScience* 24:335–338.
- . 1976. Management involving grizzly bears and black bears in Yellowstone National Park, 1970–1975. U.S. Dep. Inter. Natl. Park Serv., Nat. Res. Rep. 9. 26pp.
- CRAIGHEAD, J.J., AND F.C. CRAIGHEAD. 1971. Grizzly bear–man relationships in Yellowstone National Park. *BioScience* 21:845–857.
- , J.S. SUMNER, AND J.A. MITCHELL. 1995. The grizzly bears of Yellowstone, their ecology in the Yellowstone ecosystem, 1959–1992. Island Press, Covelo, Calif. 535pp.
- DESPAIN, D. 1990. Yellowstone's vegetation: the consequences of history and environment. Roberts Rinehart, Inc. Publ. Boulder, Colo. 239pp.
- EBERHARDT, L.L., B.M. BLANCHARD, AND R.R. KNIGHT. 1994. Population trend of the Yellowstone grizzly bear as estimated from reproductive and survival rates. *Can. J. Zool.* 72:360–363.
- GUNTHER, K.A. 1994. Bear management in Yellowstone National Park, 1960–93. *Int. Conf. Bear Res. and Manage.* 9(1):549–560.
- . 1995. Bears and menstruating women. Inf. Pap. No. BMO-7. U.S. Dep. Inter. Natl. Park Serv., Yellowstone Natl. Park, Wyo. 2pp.
- HERRERO, S.M. 1970a. Human injury inflicted by grizzly bears. *Science* 170:593–598.
- . 1970b. Man and the grizzly bear (present, past, but future?). *BioScience* 20:1148–1153.
- . 1976. Conflicts between man and grizzly bears in the national parks of North America. *Int. Conf. Bear Res. and Manage.* 3:121–145.
- . 1985. Bear attacks—their causes and avoidance. Winchester Press, New Century Publ., Inc., Piscataway, N.J. 287pp.
- , AND S. FLECK. 1990. Injury to people inflicted by black, grizzly or polar bears: recent trends and new insights. *Int. Conf. Bear Res. and Manage.* 8:25–32.
- LEOPOLD, A.S., S. CAIN, C. OLMSTED, AND S. OLSON. 1969. A bear management program and policy for Yellowstone National Park. Rep. to the Director by the Nat. Sci. Advisory Comm. Natl. Park Serv. U.S. Dep. Inter. Natl. Park Serv., Yellowstone Natl. Park, Wyo. 8pp.
- MATTSON, D.J., B.M. BLANCHARD, AND R.R. KNIGHT. 1991. Food habits of Yellowstone grizzly bears, 1977–87. *Can. J. Zool.* 69:1619–1629.
- MEAGHER, M., AND J.R. PHILLIPS. 1983. Restoration of natural populations of grizzly and black bears in Yellowstone National Park. *Int. Conf. Bear Res. and Manage.* 5:152–158.
- MURIE, O.J. 1944. Progress report on the Yellowstone bear study. U.S. Dep. Inter. Natl. Park Serv., Spec. Res. Rep. 13pp.
- NATIONAL PARK SERVICE. 1960. National Park Service bear management program and guidelines. U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo. 5pp.
- . 1984. Board of inquiry into the death of: Brigitta Fredenhagen. U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo. 40pp.
- . 1986. Board of Inquiry—Otter Creek incident. U.S. Dep. Inter. Natl. Park Serv., Yellowstone Natl. Park, Wyo. 16pp.
- NEU, C.W., C.R. BYERS, AND J.M. PEEK. 1974. A technique for analysis of utilization-availability data. *J. Wildl. Manage.* 38:541–545.
- ROGERS, L.L., G.A. WILKER, AND S.S. SCOTT. 1991. Reaction of black bears to human menstrual odors. *J. Wildl. Manage.* 55:632–634.
- SCHULLERY, P. 1992. The bears of Yellowstone. High Plains Publ. Co., Inc., Worland, Wyo. 318pp.