MANAGEMENT INVOLVING GRIZZLY BEARS IN YELLOWSTONE NATIONAL PARK 1970-72

Natural Resources Report
Number 7

U.S. Department of the Interior

National Park Service

Management Involving Grizzly Bears in Yellowstone National Park 1970-72

Glen F. Cole
Supervisory Research Biologist
Yellowstone National Park, Wyoming

ACKNOWLEDGMENTS

Much of the information in this paper is from the accumulated daily reports of park personnel that carried out the management program. Many other persons that worked in the park reported their sightings of grizzlies according to standard procedures and thereby made the system for monitoring information on bears work. Research Scientists Mary Meagher and Douglas B. Houston in Yellowstone National Park and Clifford J. Martinka in Glacier National Park are thanked for the use of data obtained in the course of their research and for helpful reviews of the paper.

Ken Greer, Supervisor of Wildlife Laboratory, Montana Fish and Game Department; Frank DeShon, Biologist, Idaho Fish and Game Department; and Kenneth Winters, Biologist, Wyoming Game and Fish Commission, are thanked for the use of their data from state management programs and for comments that aided my interpretations.

ABSTRACT

Management to maintain a population of grizzly bears *(Ursus arctos)* within Yellowstone National Park under natural conditions and reduce bear injuries to humans was evaluated by testing hypotheses that could be rejected by inconsistent data. Practices that eliminated sources of unnatural food and the bear control methods used from 1970-72 had the following results or effects: The numbers of grizzly injuries to humans in the park's developed areas were significantly reduced; declines in the numbers of bears using developed areas or being controlled and changes to spaced distributions on natural foods showed progress was made toward accomplishing the objective of maintaining a grizzly population under natural conditions. Yearly removals of bears due to the park's control program amounted to 8, 2, and 4% of an estimated population of about 250 grizzlies, but additional deaths that were mainly due to hunting or control outside the park increased totals to about 10% in 1970 and 1971, and 5% in 1972. These removals did not appear to be of sufficient magnitude to prevent the park population from either maintaining or subsequently reestablishing its numbers at natural carrying capacity levels. Removals in subsequent years should not exceed 5%, and to fully accomplish the objective of maintaining a population under natural conditions should be as far below 5% as possible. Practices that would reduce the need to control bears in the park by 80% or more and could thereby fully accomplish management objectives are mentioned. Most injuries from bears in backcountry areas seem to be preventable if the locations of female grizzlies with young are known by park personnel, hikers are sufficiently forewarned about bears, and hiking and camping are appropriately controlled.

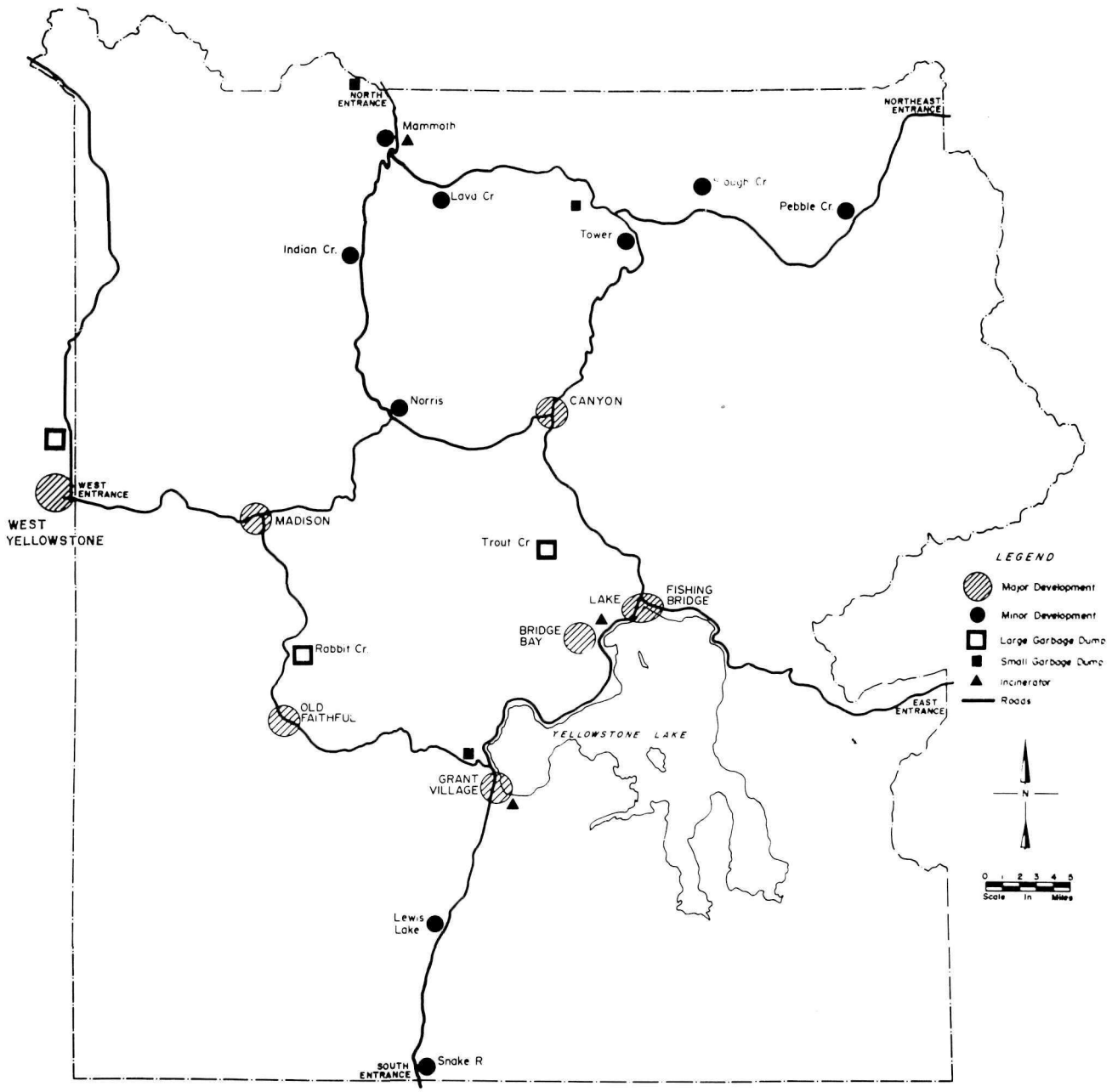

Fig. 1. Location of park developed areas and garbage disposal sites.

INTRODUCTION

This is the third of a series of reports (Cole 1970, 1971a) that evaluates a National Park Service management program that began in 1970. The primary objectives of management were to maintain a grizzly bear population under natural conditions and to reduce bear injuries to humans. These and other subsidiary objectives were set by the Superintendent of Yellowstone National Park after reviews of information on grizzlies with consulting scientists. My evaluations are based on how consistent the results of management are with these objectives, and the effects of management on the grizzly bear population. To evaluate the results of management in the most objective manner possible, statements of objectives were rephrased as hypotheses that could be rejected by inconsistent data or appropriate statistical tests. Figure 1 shows the locations of the different areas and sites that are named in the following sections.

BACKGROUND INFORMATION

Much of the information that was reviewed in 1969 is in papers that have been published (Cole 1971b; Martinka 1971a; Craighead and Craighead 1971). Some of my interpretations of this information as it related to Yellowstone National Park were as follows: Approximately 200-300 grizzlies inhabited the park since it was established. Up to 1970, this population was probably maintained at equilibrium densities ($\bar{N}$ at K)[1] by intraspecific competition for space and food which caused yearly changes in N due to births, immigrations, emigrations, and deaths to average zero. Emigrations of socially subordinate bears (Martinka 1971b) from the park and other movements within home ranges that overlapped park boundaries subjected bears to hunting. Resident grizzlies occurred in outside areas, but in densities that were unlikely to cause significant immigrations into the park. The summer movements of some bears into the park to use a garbage dump were not considered true immigrations. Jonkel's (1967) studies suggest that such movements occurred because young bears learned to use a dump site before they had to emigrate from the park to find a vacant home range.

Open-pit garbage dumps and unfenced incinerator sites concentrated groups of socially-interacting grizzlies within 8 miles or less of major park developments and habituated some bears to humans. A probable additional effect was that bear population numbers were maintained slightly below what they would be with distributions on natural summer foods. The relative use of garbage dumps and/or developed areas by individual bears was probably variously due to their culturally transmitted habits (females to their young), social rank, degree of habituation to humans, prior experiences in obtaining food rewards or punishment (Stokes 1970), and finally, attractions of males to females during the June-July breeding season. Regulatory effects that maintained lower numbers of subadult bears in the population were inferred from the intense intraspecific competition for food or space (Hornocker 1962), and from the relatively high first-year mortality of cubs (Martinka 1969) that occurred in population segments that concentrated at garbage dumps in summer. These effects were avoidable because the natural summer foods of grizzlies were widely distributed and not in limited supply (Murie 1954; Martinka ms.).

Seven dump sites that grizzlies used were closed between 1930 and 1968. The reasons given for closures generally included references to a need to reduce bear intrusions into adjacent campgrounds and/or to prevent injuries to park visitors. By 1968, two garbage dumps that were used by grizzlies still remained in the park. Recommendations resulting from studies of bears that used garbage dumps (Craighead and Craighead 1967), led to an experimental separation of "edibles" from burnable garbage and cans at one dump during the summer periods of 1968 and 1969. After this experiment both dumps were closed according to time schedules that were contingent on the results of the park's management program.

Food sources of garbage or improperly stored camp groceries altered the habits and behavior of bears from what they would otherwise be and were basically responsible for most (95%) of the human injuries that were attributed to grizzlies between 1930 and 1969. The presence of such food sources in or near developed areas also maintained a "need" to control (capture and transplant or destroy) bears to protect humans.

Attempts to use repeated transplants as an alternative to destroying bears that could not be discouraged from using developed areas during the 1960s intensified bear-human conflicts from what they had been during previous decades. Repeated transplants allowed bears that habitually used developed areas to increase their numbers, contributed to increased injuries to humans, and utlimately maintained the need to control bears at high levels.

A comparison of the three injuries from grizzlies in the "wild" (females "defending" young) between 1930 and 1969 with the 60 that occurred from bears that were attracted to developed areas by unnatural food, suggested that injuries could be reduced by eliminating such food and by other actions that restored and thereafter maintained a grizzly population with natural habits. Such actions also seemed to be essential to reduce the need to control bears to the lowest possible levels.

[1] $\bar{N}$: Mean number in population
N: Number in population
K: Carrying capacity

MANAGEMENT PROGRAM

Initial Premises

The program that began in 1970 was based on the following premises: The desired number of grizzlies within Yellowstone National Park was the number that would occur under natural conditions (i.e., without human alterations of bear habits, behavior, or population dynamics). Management that eliminated unnatural food sources and selectively removed incorrigible animals (bears that could not be discouraged from using developed areas) from the population would allow young bears with natural habits or behavior to replace incorrigible animals. Management that maintained "sanitary" conditions (garbage or camp groceries not available to bears) would preclude corruptions of new bears and thereby substitute for the need to control bears to protect humans. The number of years it took to achieve sanitary conditions would determine the numbers of young bears in subsequent generations that either had their habits and behavior altered by such food or were raised under natural conditions.

Management Procedures

The various scheduled and contingency procedures of the management program in outline form were:

I. Scheduled Procedures:

1.
   (a) Construct a substitute fenced sanitary landfill dump for the Rabbit Creek site, or haul garbage outside park boundaries.
   (b) Enclose the Grant Village and Bridge Bay incinerators within bearproof fences.
   (c) Complete the installation of bearproof garbage cans in concession facilities during 1970.

2. Continue to use the Trout Creek dump without the separation of burnables during 1970.

3. Employ sufficient seasonal Rangers to assist in regulating campground use and necessary bear control beginning in 1970.

4. Promptly remove bears from developed areas by the use of live traps, immobilization drugs, or, if necessary, lethal devices. Animals which return to developed areas after being transplanted inside the park during a successive 2-year period (initial plus repeated intrusion) may be donated, as requested, to zoos or to states to reestablish bear populations in remote areas outside the park, or utilized as scientific study specimens for educational institutions (exceptions made for young bears and animals that were passing through and not habitually using a developed area).

5. Construct a substitute fenced sanitary landfill dump for the Trout Creek site by the spring of 1971, or haul garbage outside the park.

6. Have the grizzly population foraging entirely on natural foods by 1972, or at the earliest possible later date.

7. Continue to monitor daily reports of grizzly sightings, property damage, incidents, and control actions to provide records for guiding and evaluating the management program.

8. Obtain records of the numbers, sex, and age of grizzlies killed or sighted in areas outside Yellowstone boundaries to document emigrations from the park grizzly population, contributions to sport hunting, and conflicts with agriculture.

9. Carry out research to develop improved control methods, test aversive agents and other methods to discourage bears from using park developed areas, and assess program results in relation to park objectives of preserving a grizzly population under natural conditions and providing for the safety of visitors.

10. Expand public information programs to eliminate bear-attracting foods that visitors provide by leaving food available to bears in campgrounds.

11. Work with towns, private individuals, and other state and Federal agencies to encourage the proper sanitary disposal of garbage so as to not attract bears to places of human habitation outside park boundaries.

II. Contingency Procedures:

1. Continue to use the Trout Creek dump beyond the scheduled 1971 closure on a "phase out" basis if grizzly intrusions into campgrounds begin to exceed control capabilities, or lead to excessive numbers of animals being destroyed.

2. Manipulate opening or closing dates of campgrounds; restrict camping to enclosed trailer or pickup units; and/or initiate temporary closure of campgrounds, if necessary.

The scheduled procedures were followed as outlined, except that states were unable to accept grizzlies for reestablishing populations elsewhere. Fenced sanitary landfills were employed as an alternative to hauling garbage outside the park. Reductions in personnel and funds prevented scheduled staffing, but this was compensated for by assigning the park management program high-priority status, and by substantial contributions of uncompensated work by park personnel. The contingency procedure of continuing to use the Trout Creek dump beyond the scheduled 1971 closure was not used. The campground in the Canyon development was restricted to enclosed trailer or pickup camper units from 1970-72. The Pelican Creek campground in the Lake Outlet development was permanently closed in 1972 because of its location near natural food sources that sustained high densities of grizzlies.

EVALUATION PROCEDURES

Hypotheses

These were stated as follows: The management actions to eliminate unnatural food sources and the bear control procedures applied in the 1970s will:

1. Reduce the number of grizzly injuries to humans in park developments from 1963-69 levels (4.4 average; 2-8 range).
2. Restore a more natural grizzly population than existed in the 1960s as evidenced by scattered distributions in summer, fewer bears using developed areas, and progressive reductions in the numbers of bears being controlled and destroyed.
3. Not prevent the grizzly population from maintaining or rapidly reestablishing its numbers at natural carrying capacity levels.

Collection of Data

Grizzly sightings, activities, locations, damage to property, injuries to humans, and control actions were reported to a central office on a daily basis. One control action was recorded each time a bear was transplanted, shipped to a zoo, or destroyed. Supplemental data on grizzly distributions, young to female ratios, and use of natural food sources were obtained by park research personnel.

Effects on Bear Numbers

To provide a base for interpretations, the numbers of animals in different segments of the grizzly population in 1970 were tentatively apportioned as below. Segments A-C were apportioned from Hornocker's (1962) censuses of grizzlies that used garbage dumps and park records on the number of bears using developed areas. Hornocker's 1959-61 data indicated that the Trout Creek dump was used by up to 98 different grizzlies; Rabbit Creek, by 40 different bears; two other dumps, by 14; and Montana's West Yellowstone dump, by 27 animals. He considered his yearly counts of 154-169 different grizzlies to be minimum figures. Up to 202 different bears were reported from censuses in subsequent years (Craighead and Craighead 1967).

		Estimated Nos.
A.	Bears that used garbage dumps, but would not use developments or return from transplants	130
B.	Bears that did or would use developed areas and could not be successfully transplanted	40
C.	Annual production of cubs from A-B	30
	Subtotal	200
D.	Other bears that stayed in remote areas	50-100
	Grand total	250-300

Estimates of the numbers of bears that stayed in remote areas (Segment D) were partly based on Barnes and Bray's (1967) censuses of black bears *(Ursus americanus)* and grizzlies in a 580 mile^2 backcountry area in Yellowstone National Park. During 1965 and 1966, black and grizzly bears were seen in ratios of 59:100. The calculated mean density for black bears was 1:20 miles^2; grizzlies, 1:12 miles^2. More than half of the grizzlies that used dumps or developed areas may have had markers during this period (Craighead and Craighead 1971; Cole 1971b) but only 1 marked animal was observed in 113 sightings of grizzlies in backcountry areas (Barnes pers. comm.). Up to 35 different grizzlies, including 7 females with young, were identified by watching 16 placed carrion baits on a 145 mile^2 area. None of these were marked. Barnes and Bray's conclusions that the park had a separate population of backcountry black bears that did not frequent developments, use dumps, or beg for food along roads seemed equally valid for grizzlies.

Grizzlies also appeared to be distributed throughout other backcountry areas in Yellowstone National Park during the summer. The evidence for such distributions was from accumulated sighting records, as well as from unpublished observations of grizzlies or their sign (tracks, digging, scats) that were made during Dr. Mary Meagher's research on bison *(Bison bison)* in the northeast third of Yellowstone since 1963, and during my own research on elk *(Cervus canadensis)* in the remote southern third of the park from 1962-66. My tentative estimate of 50-100 such animals in the park could be overly conservative.

MANAGEMENT RESULTS

Injury Records

The hypothesis that the various management actions applied in the 1970s will reduce injuries to humans in park developments from 1963-69 levels could not be rejected on the basis of injury records (Table 1). The 1970-72 mean of 1.0 injury per year was significantly different (P = 0.05) from the 1963-69 mean of 4.4 per year by the Wilcoxan rank sum test (Wilcoxan and Wilcox 1964).

Injuries in backcountry areas have been low in number and infrequent. Their occurrence since the 1960s coincides with progressive increases in the numbers of persons that travel through backcountry areas on foot. Management actions that were applied to humans in the 1970s probably reduced the number of injuries in backcountry areas from what they would have otherwise been. These involved permanent or temporary closures of areas that were used by female grizzlies with young or had high densities of bears, and other actions that informed or regulated backcountry hikers and campers.

Fatalities

Three human fatalities occurred from grizzlies since 1872. In 1972 a man returned to an unauthorized campsite in the dark and encountered a grizzly that was eating groceries and garbage that had been left on the ground. In 1916, a Government employee was fatally injured when he attempted to chase a grizzly off a freight wagon loaded with groceries. In 1906 a female grizzly fatally injured a man who prodded her cub with an umbrella. Such errors in human judgment are probably not preventable.

Table 1. Numbers of injuries to humans from grizzly bears by periods and years, Yellowstone National Park, 1930-72.

	No. grizzly-caused injuries per year[a]		
Years	Developments	Backcountry	No. of visitors per injury in thousands
1930s	0.6 (0-3)	0	800
1940s	1.2 (0-7)	0	600
1950s	0.6 (0-2)	0	2,700
1960s	3.6 (1-8)	0.3 (0-2)	500
1970	2	1	700
1971	0	0	0
1972	1	1	1,000

[a] Averages of known and probable injuries due to grizzlies by decades from Cole (1971b). The one injury in a development in 1972 was also a probable case.

GRIZZLY DISTRIBUTIONS

The 1970-72 sightings of grizzlies in developments (Table 2) were inflated because night patrols in park campgrounds were increased. High rodent populations in 1968 and an increased availability of elk as predisposed prey or carrion in 1970 also contributed to increased bear sightings in some developments. Other data from control actions and records on individual bears (Table 3) show progressively fewer bears used developed areas through the 1970s.

The numbers of grizzlies seen in the wild in different years varied greatly with natural food conditions that have been described elsewhere (Cole 1972). The yearly totals in Table 2 mainly show that substantial numbers of bears were seen each year. However, the spaced summer distributions seen during the 1970s (in contrast to prior aggregations on dumps) and the data in Table 3 suggest that most of the animals that had previously used dumps were widely distributed on natural foods.

A marked increase in the number of grizzlies using the northern portion of the park in the spring and early summer of 1972 was also documented. Here, grizzlies were either preying on native ungulates or using carrion to a considerably greater extent than previous years (Houston and Meagher, unpublished data). The obvious spaced distributions of grizzlies on natural foods after the closures of dumps and the 1968-72 data on the numbers of different animals using developments or being controlled (in the following section) were consistent with the hypothesis that the elimination of unnatural food sources and control procedures applied in the 1970s would restore a population that lived under more natural conditions.

Table 2. Total number of grizzly bears observed on a daily basis in developments and in the wild within Yellowstone National Park, 1968-72.

Locations	1968	1969	1970	1971	1972
No. in developments	293	99	178	146	105
No. in wild	414	315	614	320	349

BEAR CONTROL

Park Developments

From 1970 to 1972 the numbers of control actions (CAs), different grizzlies handled, and bears intentionally removed from the population (shipped to zoos or intentionally destroyed) declined (Table 3). Grizzlies were captured and handled under less than ideal or safe conditions and unintentional deaths also occurred. Yearly success rates for transplants increased and returns in subsequent years amounted to 4 of the 33 bears handled in 1971; and 4 of the 21 handled in 1972.

The distances bears could be transplanted in the park (up to 50 miles) were not sufficient to overcome the homing capabilities of most animals. Transplant success apparently increased because incorrigible animals were selectively removed from the population and because prompt captures and transplants conditioned most "new" bears to avoid developed areas.

The 22 CAs (18 different grizzlies) in the Old Faithful development during 1970 coincided with Rabbit Creek dump being closed. Transplants of these bears caused eight more CAs in other developments. An additional 40 CAs, involving 32 grizzlies, mainly resulted from intensified efforts to promptly remove grizzlies from other developed areas. Increased sources of carrion or vulnerable ungulates (Cole 1972) contributed to increased bear intrusions into the Old Faithful area and some of the 11 smaller developments in 1970. The 39 1971 CAs, involving 33 bears, coincided with the Trout Creek dump being closed. The 26 1972 CAs, involving 21 bears, were limited to 3 of 16 developed areas.

Other Park Areas

Six other CAs occurred in 1972. A bear that caused a human fatality at an illegal campsite was intentionally destroyed. Another animal that was transplanted from a backcountry campsite failed to recover from an immobilizing drug. A female with two young, that had developed a taste for horse pellets stored in a barn, and a young roadside grizzly that park visitors were feeding were transplanted to remote areas.

Table 3. Records of grizzly bear control actions in developed areas, Yellowstone National Park, 1968-72.

Developed areas:	Control Actions[a]				
	1968	1969	1970	1971	1972
Old Faithful	1[b]	0[b]	22	1	0
Canyon	14	16	9	11	10
Lake Outlet	16	25	11	20	13
Grant Village	20	5	15	5	0
Bridge Bay	8	9	0	1	3
Eleven other units	0	2	13	1	0
Total control actions	59	57	70	39	26
No. different bears[c]	?	?	50	33	21
Pct. successful transplants	33[d]		60	80	74
No. bears destroyed[e]	5(3)	10(5)	12(6)	6(2)	6(4)
No. bears to zoos	0	0	8	0	1

[a] Number of times a bear was captured for transplanting, shipped to a zoo, or destroyed.
[b] Grizzlies present until Rabbit Creek dump opened each year.
[c] Numbers in 1968 and 1969 unknown due to unmarked animals; 4 of 33 were 1970 transplants, 4 of 21 were 1970 or 1971 transplants.
[d] Sample of 20 marked and 1 recognizable bear.
[e] Yearly totals with the number that were unintentional because bears charged personnel, came out of drugs during handling, injured themselves in traps, or failed to recover from drugs shown in parentheses.

Outside the Park

In 1971 the U. S. Forest Service and the Montana Department of Fish and Game initiated a program to close a municipal dump that was used by up to 27 grizzlies (Hornocker 1962). This dump was near the park's west boundary and within 2 miles of the town of West Yellowstone, Montana. Fish and Game Department personnel carried out 23 CAs (19 different bears) in the same year (1971) the dump was closed (Greer 1972). Seven CAs involving seven different animals (two returns from 1971 transplants) occurred in 1972. Transplants were made into the remote Absaroka region north of Yellowstone National Park. As a result of 5 bears returning from transplants, 3 legal hunting kills, 5 illegal kills, and 3 other deaths, 16 of the 24 different bears died—14 in 1971, 2 in 1972 (Greer, pers. comm.).

REMOVALS

Yellowstone National Park apparently served as a refuge for 200-300 grizzlies over periods of time when populations outside park boundaries were either reduced to a remnant of their former numbers or eliminated. These relationships provide a basis for distinguishing between a *core* park population that could exist as a naturally regulated population and other hunted grizzlies that would occur outside park boundaries. The latter could be yearly emigrants from the park and other bears with home ranges that either overlapped or were entirely outside park boundaries.

The home ranges of naturally distributed grizzlies in Yellowstone were probably larger than the 5-12 miles^2 reported for females with young in Glacier National Park (Martinka 1969), but smaller than the averages of 27 and 114 miles^2 for adult females and males in a population of barren ground grizzlies in Canada (Pearson 1970). The distribution of meadow, forest, and subalpine habitat complexes that bears used within 6000-10,000 ft elevations throughout Yellowstone's 3400 miles^2 also suggested that home ranges could be spaced over most of the park.

The intentional and unintentional removals of 35 bears under the park program from 1970-72 (Table 4) amounted to 35% of the 101 different animals that were handled. If the park population contained about 250 grizzlies each year, the removals due to this program amounted to 8% in 1970, 2% in 1971, and 4% in 1972. By assuming the 16 deaths associated with Montana's West Yellowstone program were also from the park population, the combined yearly removals (Table 4)

due to both control programs amounted to about 8% in 1970 and 1971, and 4% in 1972. These 51 animals included 20 adult males, 14 adult females, and 17 sub-adults (cubs to 3-year-olds). An additional two subadults and two females were killed by vehicles inside the park.

Grizzlies were hunted as a game species or killed to protect livestock and property in a 2000 mile^2 area that bordered Yellowstone National Park. This area was predominantly national forest lands and contained large blocks of wilderness. The numbers of bears killed and those with markers (excludes the 16 West Yellowstone bears) are shown in Table 4. These data show that 26 of 91 deaths and 35% of the known 1970-72 removals of 100 bears could be directly attributed to the park control program.

The 13:87 proportions of marked and unmarked bears killed in the adjoining states with sex and age data from Greer (1972) and Winters and DeShon (pers. comm.) indicated that most of the 1970-72 kills were from reproducing population units that had not frequented park developments or garbage dumps. Between 1959-70, 256 grizzlies and up to 60% of the bears that used garbage dumps were reported marked (Craighead and Craighead 1971). In the 1970s, 81 of 101 different bears handled in the park program were marked, suggesting that a 60% or greater proportion of marked animals was maintained in the 200 animal segment that used dumps or developed areas. Therefore, without adjustments for prior or current emigrations or transplant effects, 10 (6 marked and 4 unmarked) of the 45 bears killed in the adjoining states (Table 4) could have been from the dump-developed area population segment. This is probably an over-expansion because five of the six marked bears ranged outside the park after transplants. By allowing for transplant effects and either adding or subtracting three marked bears that could have been emigrants, 4-7 (3-6 marked and one unmarked animal), or about 10-15% of the 45 killed in the adjoining states could be considered members of the population segment that used dumps or developed areas. Adding 7 bears to those in the first three rows in Table 4 increased the known removals from the park population to 25 in 1970, 25 in 1971, and 12 in 1972—or 10-5% of 250 bears.

If all the removals shown in Table 4 were charged against the combined park, Montana, Idaho, and Wyoming population of about 350 bears (discussed later), they would have amounted to 12% in 1970, 11% in 1971, and 6% in 1972. Cowan (1970) concluded that grizzly bear populations could not sustain removals of more than 5-6%, except under circumstances where recruitments of young increased.

Table 4. Numbers of grizzlies removed by park and state control programs and other known deaths of marked and unmarked bears in adjacent state areas, 1970-72.

	Removals due to control programs		Killed by vehicles	Other known kills[a]		
	Park[b]	Mont.		Wyo.	Mont.	Idaho
1970	20	0	2	8(1)	4(1)	7(1)
1971	6	14	1	6	6(3)	5
1972	9	2	1	5	0	4
	35	16	4	19	10	16

[a] Total deaths from hunting or kills to protect livestock or property, with those marked inside Yellowstone Park prior to or since 1970 in parentheses.

[b] Includes 9 animals donated to zoos, 13 unintentional, and 13 intentional deaths.

EFFECTS ON POPULATION

An abundant literature exists on the effects of human exploitation on animal populations. Two common effects when population numbers are at equilibrium densities ($\overline{N}$ at K) are: human exploitation (1) substitutes for deaths and/or emigrations that would otherwise occur from density-influenced intraspecific competition for K—e.g., limited food, space, or mates; and (2) increases rates of population growth from the production and/or survival of young. Populations are maintained at equilibrium densities to the extent that recruitments of young compensate for removals due to human exploitation, natural deaths, and emigrations.

Reproduction

Craighead and Craighead (1971) reported that from 1959-66 an average of one-third of the females (about 15) in a "minimum" population of 175 grizzlies produced an average of 33 cubs. These animals concentrated at garbage dumps during summer periods. The females in this population bred at 4.5 years, but the authors reported many did not produce cubs until they were 8 or 9 years old. Mortality from cub to yearling age averaged 39%. Stokes (1970) postulated that the

behavioral interactions among grizzlies that concentrated at dumps reduced the breeding success of females and the survival of young.

The above 39% mortality rate compares with a 35% rate in a population segment that also used garbage dumps in a Canadian park (Mundy 1963), and 5% and 7% rates in two populations that were distributed on natural foods (Troyer 1962; Martinka 1969). A portion of the cub mortality at dumps occurred because females were unable to adequately protect their young from other bears. Other deaths may have resulted from cubs ingesting toxic or other lethal items (broken glass, metal or plastic objects) or acquiring parasite loads that became critical during their first hibernation period.

Comparisons of the numbers of females and young seen in family groups from 1970-72 with 1959-66 averages (Table 5) suggest that more cubs survived to yearling age than when the animals concentrated at dumps. Females with cubs seemed relatively less observable than other grizzlies under free-ranging conditions, and the 1970-72 data may also reflect conditions where more young females that produced one cub or smaller litters were contributing to population reproduction than previously. Admittedly only a portion of the females with young in the park were sampled and classifications over additional years are needed.

Population Status

The minimum population figure of 175 grizzlies reported by Craighead and Craighead (1971) appeared to be an average from yearly counts of 154-202 marked and otherwise identifiable bears that used five garbage dumps in or adjacent to Yellowstone National Park and, in some years, counts of 2-4 additional bears in the park's Pelican Valley (Craighead and Craighead 1967). These authors believed few other grizzlies occurred in the backcountry areas within a 5000 mile^2 area that included Yellowstone National Park and adjacent national forest lands, and reported an average density of 1 bear: 29 miles^2 (about 175 animals).

The censuses by Barnes and Bray (1967), calculations in the section on Removals, and other observations summarized in the section on Evaluation Procedures show that some additional number of grizzlies were distributed in the backcountry areas of Yellowstone National Park or adjacent national forests during the periods when other bears used garbage dumps. If these additional bears remained in these backcountry areas at mean summer densities of 1:30 miles^2 (about 170 bears in 5000 miles^2), it appears possible that anything short of intensive study could lead to the conclusion that few were present.

The data used to estimate the numbers of bears in different population segments (see Evaluation Procedures) suggests that the park population contained at least 250 grizzlies in 1970. To sustain the mean yearly kills of about 15 grizzlies in the three adjoining states (Montana, 3; Wyoming, 7; Idaho, 5) from 1967-72 (Greer, Winters, DeShon pers. comm.) it seems probable that at least 100 additional grizzlies plus some yearly emigrants from the park would have had to be present within the 2000 mile^2 area bordering Yellowstone National Park.

The above estimate of 350 grizzlies for the 5000 mile^2 area that includes Yellowstone National Park and adjacent state areas would amount to an average density of about 1 bear: 14 miles^2. Allowing for the estimation technique, a more realistic expression of these figures is considered to be 350 $\pm$ 50 grizzlies, or about 1:12-17 miles^2. Density figures from McKinley and Glacier national parks, other Rocky Mountain areas, and northern Canada by Dean (1958), Jonkel (1967), Martinka (1971b), and Pearson (1970) range from 1 bear: 8-15 miles^2. Craighead and Craighead's (1971) reported figures of 175 bears or 1:29 miles^2, for the same 5000 mile^2 area, did not include an estimate of the grizzlies that were not counted at garbage dumps, which I have attempted to do.

Population Trends

Prior to 1970 yearly changes in the numbers of grizzlies in the park population probably averaged zero because births less deaths and emigrations averaged zero. This was inferred from the high mortality of young in population segments that concentrated at garbage dumps, the relatively low removals from park control programs (Cole 1971b), and occurrence of emigrations. Craighead and Craighead (1971) reported mean

Table 5. Numbers and ratios of female grizzlies and young seen in Yellowstone Park during a 1959-66 period[a] and subsequent years[b].

	Numbers			Numbers		
Years	Females	Cubs	Ratios	Females	Yearlings	Ratios
1959-66 average	15	33	2.2	15	20	1.3
1970	16	28	1.7			
1971	16	31	1.9			
1972	31(11)	58(22)	1.9(2.0)	25(9)	48(18)	1.9(2.0)

[a] Average female-cub figures from Craighead and Craighead (1967) with female-yearling figures calculated from a reported 39% mortality rate in a population segment that used garbage dumps.

[b] Figures in parentheses considered to be different individuals; others include some duplicate classifications of the same family group.

annual gains of six bears over deaths from 1959-66, but emigrations from the park were not considered losses.

The 62 bears that were removed from the Park population by various causes from 1970-72 included about 36% adult males, 32% adult females, and 32% subadults (cubs to 3-year-olds). In comparsion with the sex and age structures reported by Craighead and Craighead (1967), these removals would have left higher proportions of subadults and females and a lower proportion of adult males in the population than previously. Such removals would tend to increase rates of population growth, but would probably reduce emigrations until vacant adult home ranges were refilled.

If the 1970 park population approximated 250 animals, about 40 (16%) would have been cubs. Six of these were removed through control actions and vehicle-caused deaths. An additional 5% loss from natural causes would have left 32 as yearlings in 1971. This number of yearlings exceeds the 1970 removal of 25 animals.

The 1971 population could have again approximated 250 animals, but contained a smaller number of cubs because 8 adult females were removed in 1970. Subtracting five cubs (average of 2 cubs each that one out of three of these females might have produced) from 40 gave 35 cubs. No cubs were removed through control actions and an additional 5% loss would have left 33 as yearlings in 1972. This number of yearlings also exceeds the 1971 removal of 25 animals.

The 1972 population could have exceeded 250 animals and may or may not have contained a smaller number of cubs (Table 5) because 8 adult females were removed by control programs and hunting in 1971. By allowing for these removals as above and for one vehicle-death, 34 cubs would have been raised in 1972. An additional 5% mortality from various causes would leave 32 as yearlings in the coming 1973 population. This number of yearlings also exceeds the 1972 removal of 12 animals.

Additional natural deaths and emigrations of unmarked bears would have reduced or cancelled out the population growth that was calculated from the recruitments of yearlings. Thus, population numbers could have been either temporarily depressed or stable from 1970 to 1971. The apparent increase in the numbers of 1971 cubs surviving to yearling age (Table 5) and the reduced removals in 1972 (Table 4) strongly suggest that the trends in population numbers from 1971 toward 1973 were upward. The possible temporary depression or stabilization of numbers from 1970 to1971 with subsequent upward trends is not inconsistent with the hypothesis that grizzly population numbers will either be maintained or rapidly reestablished at natural carrying capacity levels. Subsequent removals that are below 1972 levels (5% of N or 12 bears) and measurements of emigrations are considered necessary to reflect N at K.

CONCLUSIONS AND DISCUSSION

The tests of hypotheses in the preceding sections suggest that from 1970-72 the park management program had the following results or effects. The numbers of grizzly bear injuries to humans in developed areas were significantly reduced. Measurable progress (changes to spaced summer distributions and declines in the numbers of bears using developments or being controlled) was made toward accomplishing the objective of restoring and thereafter maintaining the park grizzly population under natural conditions.Declining 1970-72 removals of 10-5% of bear population numbers by park and state control programs and by hunting outside Yellowstone's boundaries from 1970-72 were probably not of sufficient magnitude to prevent the park population from either maintaining or subsequently replenishing its numbers by yearly recruitments of young. Disproportionate removals of old bears (predominatly males) may have temporarily reduced the need for young adults to emigrate from the park to find a vacant home range.

Further reductions from the numbers of animals controlled in 1972 are necessary to fully accomplish the objective of maintaining the park's grizzly population under natural conditions. The need to control grizzlies in three developments during 1972 (Table 3) was largely sustained by park visitors "baiting" bears into these areas, and by the particular locations of these areas in superior grizzly habitat. Most baiting resulted from campers carelessly ignoring instructions on how to store food so it was unavailable to bears, but some was done intentionally by persons that wanted to see bears. Some possible solutions are to effectively enforce an existing food storage regulation (previously impossible for logistic and legal reasons) or to move or fence the campgrounds in these three developments. The 1971-72 data in Table 3 and earlier records suggest that the above practices would reduce the need to control grizzlies in Yellowstone National Park by 80% or more of what would otherwise be and accordingly reduce yearly removals from the population substantially below the 5% level. End results could conceivably be that the effects of humans on the habits, behavior, and population dynamics of park grizzlies were reduced to the extent that the stated objective of maintaining a population under natural conditions was accomplished.

Grizzly injuries to persons that hiked and camped in backcountry areas were comparatively few, despite a 290% increase in the numbers of such persons from 1970 to 1972. The park's system for monitoring the locations of females with young and other grizzlies in backcountry areas, and for regulating hiking and camping accordingly, probably reduced injuries from what they would have otherwise been. Most backcountry injuries seem to be preventable to the extent that the locations of female grizzlies with young are known by park personnel, hikers are sufficiently forewarned, and hiking or camping is appropriately controlled.

References

BARNES, V. G. and O. E. BRAY. 1967. *Population characteristics and activities of black bears in Yellowstone National Park*. Final Report, Colorado Coop. Wildl. Res. Unit, Colorado State Univ. 199 p.

COLE, G. F. 1970. *Grizzly bear management in Yellowstone Park, 1970*. 2nd Int. Conf. on Bear Research and Mgmt., U. of Calgary, Alberta, *and* Res. Note No. 3, Yellowstone Nat. Park. 14 p. (mimeo.)

. 1971a. *Progress in restoring a natural grizzly bear population in Yellowstone National Park*. Research in National Parks. AAAS Symposium. Unpub.

. 1971b. Preservation and management of grizzly bears in Yellowstone National Park. *BioScience*. **21(16)**:858-864.

. 1972. Grizzly bear-elk relationships in Yellowstone National Park. *J. Wildl. Manage*. **36(2)** :556-561.

COWAN, I. McT. 1970. The status and conservation of bears (Ursidae) of the world—1970. Pages 343-367 *in* S. Herrero, ed. 1972. *Bears—their biology and management*. UICN Publ. New Series No. 23.

CRAIGHEAD, J. J. and F. C. CRAIGHEAD, JR. 1967. *Management of bears in Yellowstone National Park*. Environ. Res. Inst. and Mont. Coop. Wildl. Res. Unit Rep., 113 p. (multi.)

. 1971. Grizzly bear-man relationships in Yellowstone National Park. *BioScience*. **21 (16)** :845-857.

DEAN, F. C. 1958. Investigations on grizzly bear in interior and arctic Alaska. *Quart. Rep*. **9(4)** :61-71. Alas. Coop. Wildl. Res. Unit.

GREER, K. R. 1972. *Grizzly bear mortality and management programs in Montana during 1971*. Job Progress Rept., Proj. W-120-R-3. Mont. Fish and Game Dept. 44 p.

HORNOCKER, M. G. 1962. *Population characteristics and social and reproductive behavior of the grizzly bear in Yellowstone National Park*. M. S. Thesis, Montana State Univ., Missoula. 94 p.

JONKEL, C. J. 1967. *Black bear population studies*. Job Compl. Rep. W-98-R. Mont. Fish and Game Dept. 147 p.

MARTINKA, C. J. 1969. *Grizzly ecology studies, Glacier National Park*. Nat. Park Serv. Prog. Rep. 43 p. (mimeo.)

. 1971a. *Status and management of grizzly bears in Glacier National Park, Montana*. Trans. of the 36th North Amer. Wildl. and Natur. Res. Conf. pp. 312-322.

. 1971b. *Population characteristics of grizzly bears in Glacier National Park, Montana*. Research in National Parks. AAAS Symposium. Unpub.

MUNDY, K. R. D. 1963. *Ecology of the grizzly bear* (Ursus arctos) *in Glacier National Park, British Columbia*. Unpub. M. S. Thesis. Univ. of Alberta, Edmonton. 103 p.

MURIE, O. J. 1954. *Progress report on the Yellowstone bear study*. Yellowstone Park files. 16 p. (typewritten).

PEARSON, A. M. 1970. Population characteristics of the northern interior grizzly in the Yukon Territory, Canada. Pages 32-35 *in* S. Herreo, ed. 1972. *Bears—their biology and management*. IUCN Publ. New Series No. 23.

STOKES, A. W. 1970. An ethologist's views on managing grizzly bears. *BioScience*. **20(21)** : 1154-1157.

TROYER, WILLARD A. 1962. *Size, distribution, structure and harvest of a Kodiak bear population*. Unpubl. M. S. Thesis. Univ. of Montana, Missoula. 49 pp.

WILCOXAN, F. and ROBERTA WILCOX. 1964. *Some rapid approximate statistical procedures*. Lederle Laboratories, Pearl River, New York. 59. p.

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources." The Department works to assure the wisest choice in managing all our resources so that each will make its full contribution to a better United States—now and in the future.

INT. 3038 74