Report of

COMMITTEE ON THE YELLOWSTONE GRIZZLIES

Division of Biological Sciences
Assembly of Life Sciences
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NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, acting in behalf of the National Academy of Sciences. Such approval reflects the Board's judgment that the project is of national importance and appropriate with respect to both the purposes and the resources of the National Research Council.

The members of the committee selected to undertake this project and prepare this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. Responsibility for the detailed aspects of this report rests with that committee.

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PREFACE

The Committee on the Yellowstone Grizzlies was established by the National Academy of Sciences in response to a request from the Secretary of the Interior, Rogers C. B. Morton, in February 1973. In making his request, Secretary Morton called attention to recent research on the grizzly bears of Yellowstone National Park and noted that certain management decisions had drawn public criticism. He cited Department policy "to manage the grizzlies and the attendant natural resources in such a manner as will preserve them in their natural ecological state, and at the same time give visitors to the parks the utmost in protection and opportunity to view an outstanding part of natural America."

The Committee was asked to "study and evaluate data on the population dynamics of the grizzly bears in Yellowstone National Park and to make recommendations concerning the scientific and technical implications of those data." We have tried to take into consideration all available data on the biology of the grizzly bear population in and adjacent to the Yellowstone National Park. We realize that these data are incomplete and that when more data are available, it should be possible to refine some of the biological parameters on which these analyses are based.

Management policies concerning the Yellowstone grizzlies have been subject to controversy during the last three or four years. The dispute arose over the impact on the bear population of a Park management policy that denied access of the bears to campground garbage and to other supplementary food. We do not believe that an examination of these conflicts at this time would serve a useful purpose and trust that they will, in time, be resolved.

The Committee held a series of meetings to examine available information on the population dynamics of the bears and contacted federal and state employees, as well as other scientists knowledgeable in the area under study (see Appendix A). The assistance of all who contributed their time and talent is gratefully acknowledged.

Committee on the Yellowstone Grizzlies

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INTRODUCTION

The grizzly bear elicits strongly held attitudes among various groups in our society. It is rare in the contiguous 48 states, and the population with which we have concerned ourselves in this study may constitute less than half the total number of grizzlies remaining in these states. It is widely recognized as a species confined to wild areas--is indeed considered a symbol of wilderness--and thus attracts the enthusiastic support of those devoted to maintaining intact wilderness ecosystems. There are many, moreover, who are deeply concerned that this species should be maintained within the Yellowstone ecosystem.

To the hunting fraternity, the grizzly is one of the most sought-after of North American trophy animals. Its management and perpetuation as a rare and valuable wildlife resource is, therefore, of great importance to sportsmen. At the other extreme are those who find in the grizzly a threat to the safety of the many people who wish to hike or camp in the National Parks (Moment, 1970). To this latter group the safety of people is of more importance than the survival of the bears within this particular ecosystem.

Since early in the history of the Yellowstone National Park (Skinner, 1925), black and grizzly bears have been accustomed to utilizing garbage as a supplementary food resource, a practice that encouraged concentrations of bears at garbage dumps in and around the Park. The most obvious consequences were: to habituate the bears to the presence of people; to teach them to identify and use the foods associated with man; to provide a readily available "spectacle" for tourist viewing (until the practice was abandoned about 1942); and to accustom people to relatively close contact with bears and thereby increase the likelihood of those foolhardy acts that lead to personal injury and property damage.

In 1968 the National Park authorities decided that garbage-habituation of bears was indeed unnatural, that it reflected a poor image to public viewers, and that it

constituted a substantial and avoidable threat to people using the Park campgrounds. A policy decision was made, therefore, to deny garbage as a food source and to restrict the grizzlies to natural foods.

A controversy soon developed as to the technique that should be adopted. One group supported gradual phase-out of garbage dumps, in the hope that the number of bears gathering at dumps would likewise decline and that after several years all bears would have learned to exist entirely on natural foods. The alternative approach was to close the garbage dumps within, at most, two or three years, beginning with those closest to the campgrounds. This latter policy, it was argued, would shorten the adjustment period and minimize the time during which emergency measures would have to be taken to prevent injuries to people (and damage to camps and vehicles) by hungry bears seeking the food to which they were accustomed. Those espousing gradual phase-out feared that the more rapid closure would require the removal or killing of more bears than would the gradual approach and might well endanger the population.

Proponents of both viewpoints realized that there were very likely to be difficulties. To minimize these, the National Park Service undertook an intensive program that included bear-proofing of all garbage containers; special patrols of campgrounds at night; closing of campgrounds where the danger was regarded as serious; closing of trails where contact with bears was most likely to occur; transporting of incorrigible bears to wilderness areas far removed from the trouble area; and, when dealing with intractable bears, removing them to zoos or, as an extreme measure, killing them.

After seeking the advice of the Natural Sciences Advisory Committee[1], Park authorities chose the management

[1]The Natural Sciences Advisory Committee (NPS) consisted of A. Starker Leopold, University of California, Chairman; Stanley A. Cain, University of Michigan; Charles E. Olmstead, University of Chicago; and Sigurd Olson, Ely, Minnesota.

technique that invoked quick closure. The amount of garbage in open dumps was sharply decreased beginning in 1968, and dumps within the Park were closed during the 1970-71 period. Control actions increased, and a large number of bears were removed from the Park or killed.

Adoption of this policy, with its consequences, led to still further controversy and to the need for an impartial review of data on the grizzly population before, during, and since the removal of edible garbage as a supplementary food source.

In part, at least, in response to public interest in the Yellowstone grizzlies, federal and state agencies with major responsibility either for management of the bears and their habitat or for management research undertook joint studies early in 1973. The National Park Service, the Bureau of Sport Fisheries and Wildlife (now Fish and Wildlife Service), and the U.S. Forest Service agreed to participate, inviting the states of Wyoming, Montana, and Idaho to join in if they so wished. What appeared initially to be an ideal cooperative approach that would provide a truly scientific basis for preservation and management of the grizzly population has not had a promising start, despite the fact that each of the three federal agencies and the state of Wyoming have assigned at least one full-time researcher to the project, and Montana has offered valuable laboratory and analytical services. It appears to us that objectives, procedures, and division of responsibilities of the team members have not been adequately spelled out; that, unwisely, the chairman is from the National Park Service (whose program would be under scrutiny) rather than being a wholly neutral individual; that the restriction on studies of grizzlies within Yellowstone has virtually excluded representatives of other agencies; and that there has been inadequate opportunity for team members to meet to discuss their work in detail.

At a meeting of the Grizzly Bear Committee of the International Association of Game, Fish and Conservation Commissioners (Denver, April 2, 1974), Dr. Theodore Sudia,

Chief Scientist of the National Park Service, described a revision of the interagency team effort intended to make it more effective. These changes included the establishment of a high-level Steering Committee consisting of himself as chairman, Eugene Hester (Fish and Wildlife Service), and Dixie Smith (Forest Service). He stated that this committee would be independent of the federal agencies from which its members were drawn and that the interagency grizzly bear study team would be responsible to it.

A memorandum dated April 26, 1974, to Nathaniel P. Reed, Assistant Secretary, USDI, and Robert W. Long, Assistant Secretary, USDA (see Appendix B), describes in some detail the agreement between the three federal agencies and the plan for conducting further cooperative research on the Yellowstone grizzlies.

NATURE AND ACCURACY OF AVAILABLE DATA

The major sources of information on Yellowstone grizzlies available to the Committee have been communications and reports from the U.S. Department of the Interior. Valuable data have also been contributed by staff members of the U.S. Forest Service and of the game departments of the states of Idaho, Montana, and Wyoming. In addition, the Committee has had access to a large volume of magazine and newspaper articles that clearly demonstrate intense public interest.

Those who are doing research on the Yellowstone grizzlies or who are responsible for management of these bears or their habitat have been generous and helpful in providing information and in responding to our inquiries. Many publications, many unpublished reports, and much correspondence were thus available, as was information derived from personal interviews.

The largest single source of information has been the long-term study carried out by John J. Craighead and Frank C. Craighead, Jr., and their colleagues, which has been reported in a series of publications (see References) and in three substantial progress reports that received limited distribution. These were:

- Craighead, J. J., and F. C. Craighead, Jr. 1967. Management of bears in Yellowstone National Park. 113 p. (A progress report to the National Park Service, which was made available to the Committee at the outset of its work)

- Craighead, J. J., J. R. Varney, and F. C. Craighead, Jr. 1973. A computer analysis of the Yellowstone grizzly bear population. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula. 81 + 61 p. (A prepublication report prepared for review and made available to the Committee on October 27, 1973)

- Craighead, J. J., J. R. Varney, and F. C. Craighead, Jr. 1974. A population analysis of the Yellowstone grizzly bears. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula. (A 51-page manuscript, essentially a revision of the 1973 report noted just above, received in early June 1974)

Other important sources have been the reports and publications of the National Park Service, particularly those of Glen Cole, and the annual progress reports on grizzlies prepared by Kenneth Greer (1972, 1974) for the Montana State Fish and Game Department.

It must be recognized that, extensive as they are, the available data have many shortcomings. While the Craigheads' studies were the most intensive and sustained ever conducted on any grizzly population, the data accumulated by them are not yet fully analyzed, so conculsions drawn can be considered preliminary only. Furthermore, the data were recorded in a form that makes retrieval of information on particular questions both difficult and timeconsuming. As a consequence, the Craigheads have not been able to respond to certain of our questions.

Data assembled later by the Park Service are not in all cases compatible with data from the Craigheads' studies. The Craigheads secured much of their more valuable information from bears marked with conspicuous plastic streamers, which facilitated recognition of individual bears in the field, and from bears that were fitted with radio-transmitter collars for telemetric observations. For example, in 1966, the Craighead census estimate of 202 Yellowstone grizzlies was based upon observations of bears, many of which were carrying visible markers, at garbage dumps. In that year the largest component of the census population--the 128 grizzlies at the Trout Creek garbage dump--included 66 marked animals (see Table 1). Such a high proportion of marked bears gives reasonable assurance that the minimum census figures are rather reliable for the component of the population that frequented the garbage dumps.

Table 1. Numbers of color-marked and unmarked but naturally identifiable grizzly bears observed at Trout Creek; summer, 1966 (Craighead and Craighead, 1967)

Age Class	Marked	Unmarked	Total	% Marked
Cub	1	16	17	6
1 year old	1	24	25	4
2 year old	6	4	10	60
3 year old	14	1	15	93
4 year old	9	2	11	82
5 year old	3	1	4	75
Adult	32	14	46	69
All	66	62	128	52

When the Craigheads' field studies were terminated at the close of the 1970 season, the National Park Service decided that conspicuous markers would no longer be employed in studies of bears and that markers already affixed by the Craigheads would be removed whenever marked animals were captured.

Yellowstone Park authorities have stated to us their conviction that grizzlies are so readily recognized individually by their natural characteristics that conspicuous markers are unnecessary for censusing or other research. We question this and believe that the Yellowstone grizzly population estimates since termination of the Craigheads' studies cannot be substantiated.

It is also difficult to determine what fraction of the total number of bears in the Yellowstone ecosystem were assessed by the Craigheads in their studies, conducted primarily at the garbage dumps. Park authorities maintain that there was a "back-country population" of grizzlies

that did not come to the garbage dumps, a view that is supported by the observations of Barnes and Bray (1967). During their studies of black bears in "the back country" in the northwest quarter of the Park, Bray and Barnes observed 27 different grizzlies closely enough to determine whether or not they carried markers; only one of them was marked (personal communication, 1974). It is also supported by the low ratio of marked to unmarked bears in the hunter kill in Montana and Wyoming. We believe that the garbage dumps introduced an element of bias, not only in relation to censusing the bears but also as regards their behavior, reproductive success, and mortality.

Uncertainty in the data stems also from the fact that it is often difficult to determine age and sex of individual bears in the field. In this connection, the effectiveness of different observers has naturally varied greatly. One of the outstanding values of the Craigheads' studies was that long-time workers certainly became more skilled with years of experience, but many of their data, and those of subsequent studies, have been provided by less-experienced persons. Reports tend to lump data from both skilled and unskilled observers.

The situation is further complicated by instances of the selection of data to be reported. An example is "Table 2. Total number of grizzly bears observed on a daily basis in developments and in the wild within Yellowstone National Park, 1968-72" from Cole (1973). The observations summarized there derive from many different types of observers, some skilled, others inexperienced, and the observations do not represent any constant or reported number of observers or hours in the field or miles traveled. Furthermore, Cole informed us (personal communication) that he rejected data from those observers he thought might be unable to distinguish between grizzly and black bears. In any case, such a table has little if any meaning, since there is no basis for the comparisons of results from year to year, or any verifiable relationship between these figures and the actual populations.

In view of the many problems associated with data-gathering on the Yellowstone grizzly population, it is small wonder that interpretations of different authors vary widely.

To overemphasize the inadequacies in the data, however, would be as ill advised as to ignore them. While the grizzly is a difficult species to study, the information assembled in the 15 years of research by the Craigheads and their colleagues, together with the shorter-term efforts of many other workers, is a uniquely rich data bank. It is certainly the best available for a population of grizzly bears. Additional research is clearly needed to provide an adequate base for management, but it should build upon that available from past studies within the Park. It is essential also that the data already derived be fully analyzed and published as soon as possible, so that the management of the Yellowstone grizzly population can be placed on a firmer scientific footing.

BIOLOGICAL ANALYSIS

Distribution, Population Size, and Density

Distributional History

The grizzly bear of North America, Ursus arctos horribilis Ord (Rausch, 1963) is conspecific with the brown bears, Ursus arctos spp., of the Old World. In North America, grizzly bears formerly occurred from northern Alaska and Canada southward to northern Baja California and Durango, Mexico (Hall and Kelson, 1959), and from the Pacific Coast eastward to at least Ontario, Ohio, and Kentucky (Peterson, 1965; Guilday, 1968). The range of the grizzly bear has been shrinking for at least 10,000 years. Populations east of the Mississippi River disappeared in early post-glacial time, and by the 16th century grizzly bears were found only in western North America. Farther north, grizzlies may have inhabited the "barren-grounds" of the Ungava Peninsula in northern Labrador and Quebec, but the evidence is equivocal, and no specimens exist (Elton, 1954; Harper, 1961). In any case, the range of the "barren-ground" grizzly north and west of Hudson Bay shrank during the 19th century. Grizzlies also disappeared from the Great Plains during the last half of the 19th century and from the Pacific Coast states in the first several decades of the 20th (Allen, 1942). In the Rocky Mountains, grizzly numbers also declined during this period, but more slowly. In the 1930's, grizzlies may have persisted in small numbers in the mountains of Arizona, New Mexico, and possibly Utah, but if so, they disappeared in the next several decades (Baily, 1931), as did populations in northern Colorado and most of Wyoming; the last grizzly was seen in northern Colorado in 1920 (R. J. Tully, unpublished data, 1970; mentioned in Armstrong, 1972, page 271).

By the 1950's grizzly bears survived in Alaska, Canada, and adjacent parts of Washington, Idaho, and Montana. In addition, small, isolated populations survived in three localities: (1) the mountains of Chihuahua,

Mexico (especially the Sierra del Nido); (2) the San Juan Mountains of southwestern Colorado; and (3) the Yellowstone Plateau region of Wyoming and adjacent Idaho and Montana (Cahalane, 1964). In 1957, the number of Sierra del Nido grizzlies was estimated to be between 10 and 30 (Leopold, 1967). By 1968, that population was probably extinct (Koford, 1969). However, another small population is reported to persist in the Sierra Madre (A. S. Leopold, personal communication, 1974). Status of southwestern Colorado grizzlies is less certain, but three were killed in the two decades preceding 1970 (R. J. Tully, unpublished data, 1970, as mentioned in Armstrong, 1972, p. 271), suggesting that a few individuals may survive in more remote parts of the San Juan Mountains (R. M. Hansen, personal communication, 1974).

The only one of these three isolated populations that has maintained significant numbers is on the Yellowstone Plateau. The occupied area includes Yellowstone and Grand Teton National Parks and adjacent portions of the Gallatin, Shoshone, Teton, and Targhee National Forests. The system is variously estimated to comprise 14,000 km^2 (Cole, 1974) or 20,000 km^2 (Craighead et al., 1974). In this report we refer to it as the "Yellowstone ecosystem," about half (8,800 km^2) of which lies within the boundaries of Yellowstone National Park (Cole, 1974).

Present Distribution

The limits of the range of grizzly bears at the present time must be based primarily on records of specimens taken at known localities and, secondarily, on records of sightings that can be judged trustworthy. Records for the last decade that at least marginally meet these criteria are plotted on Figure 1. From this

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Figure 1. Map showing the approximate present distribution of grizzly bears. Solid circles indicate actual specimens or reliable sight records; open circles represent records considered to be beyond the normal range. The crosshatched areas delineate approximate normal ranges of grizzly bears. (Based on unpublished records supplied by D. T. Fluckiger, K. Greer, D. Houston, A. E. Nielson, J. Reese, L. Roop, and T. Russell)

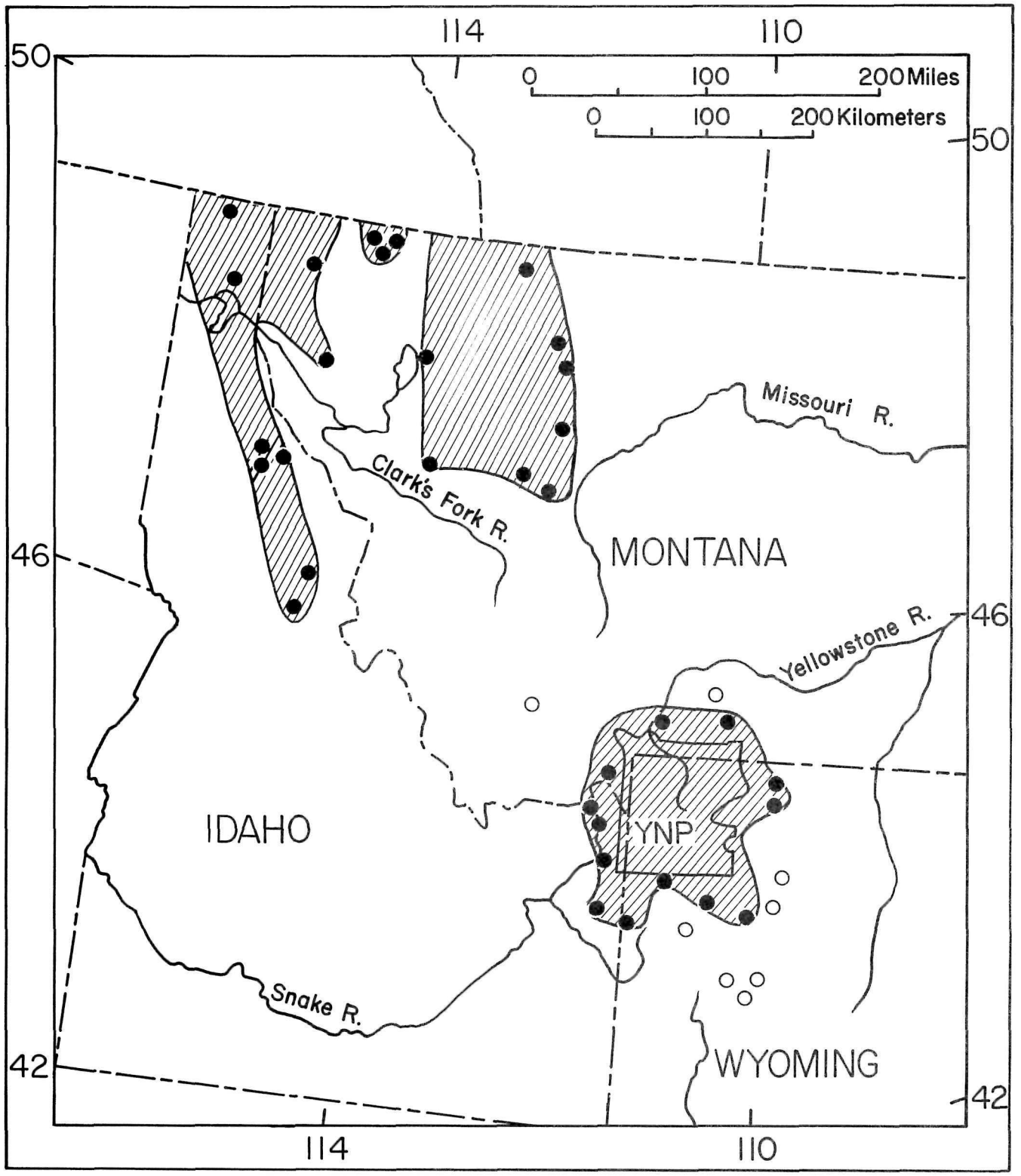
114
110
50
0
100
200 Miles
0
100
200 Kilometers
50
Missouri R.
Clark's Fork R.
MONTANA
46
Yellowstone R.
46
IDAHO
YNP
Snake R.
WYOMING
42
42
114
110

Figure 1.

map it is apparent that the population in the Yellowstone Park region is rather closely confined to the Yellowstone Plateau and that there is a gap of about 200 km between the northeast corner of the Plateau region and the nearest population to the north, on the southeast edge of Montana's Bob Marshall Wilderness Area. The intervening area is interrupted by agricultural lowlands, which grizzlies are highly unlikely to cross. Nor are they likely to re-establish populations in the smaller mountain ranges within the gap, such as the Bridgers, Big Belts, Tobacco Roots, Highlands, or Garnets. To the west, an even greater gap exists in Idaho between grizzlies in the Centennial Mountains on the Montana-Idaho border just west of the Park and the nearest populations in the Clearwater Mountains of north-central Idaho. Along the southern edge of the Plateau, in the Teton and adjacent ranges to the south, and in the Wind River Mountains to the southeast, the present status of grizzly bears is unclear. There are persistent reports of their occurrence, especially in the Wind River Mountains, but specimens are lacking.

Population Size

It is impossible to determine accurately the number of grizzly bears that inhabited the Yellowstone Plateau in the past. From 1925 to 1958, estimates of those within the Park proper were made by Park Service personnel and are summarized in Craighead and Craighead (1967) and Cole (1971). There are some discrepancies between the two sets of estimates, but the figures are generally in accord. In the decade of the 1930's, estimates averaged 240-245; for the decade of the 1940's, 235-258; and for the 1950's, 170-190. The estimates were, however, based on observations of unmarked bears and may best be regarded as guesses; whether there were actually fewer grizzlies in Yellowstone in the 1950's cannot be determined.

The Craigheads' research program, in which bears were captured, immobilized, and individually marked, began in 1959. As the marking program continued year after year, increasing numbers of individually identifiable

grizzlies were present in the population, and the proportion of marked individuals in the total population presumably increased. Regrettably, the number of bears marked each year, the number of marked bears known to be alive, and the proportion of marked to unmarked bears observed each year have not yet been reported. However, certain information may be gleaned from several publications. In 1959, 27 grizzlies were marked and released (Craighead et al., 1960); this represents 17.5 percent of the total count of 154 bears for that year. In 1960, 77 (Craighead et al., 1963), or 78 (Craighead and Craighead, 1972a), were marked or were known to be carrying marks; this represents 46 percent of the total count of 169 bears. In 1965, there were 87 marked bears (45 percent) out of 187 observed (Craighead and Craighead, 1967, page 62, Table 15), but the population of marked bears from which this sample was drawn is unknown or unreported.

The proportion of marked to unmarked bears observed at the Trout Creek dump may be reconstructed from data in Craighead and Craighead (1967, page 41, Table 8). Of 128 bears tallied as different individuals, 66 were marked and 62 were unmarked. If the count be assumed accurate (i.e., that the unmarked bears were counted without duplication or omission), then 52 percent of the total population at Trout Creek was marked. The proportion was higher in older age classes (Table 1). Although observations were made at five other dumps, the largest numbers were observed each year at Trout Creek; an average of 65 percent of the Park totals were seen there. If marking was equally emphasized at each of the census areas and/or if marked individuals moved at random between dumps, then the proportions of marked individuals at each of the census areas would be similar. However, no data on this point are available to us.

After 12 years, a total of 264 bears had been individually marked (Craighead et al., 1974). Population size was estimated from observations of marked bears and of bears that "could be recognized individually from diagnostic natural markings" (Craighead et al., 1973). The validity of using counts of unmarked bears is subject

to question, since the possibility of duplication or omission cannot be excluded. However, as the research team gained experience, these estimates of unmarked individuals probably became more reliable. Thus, population counts made later in the study are probably more accurate than those made in earlier years.

Totals were estimated to fluctuate from 154 in 1959 up to a peak of 202 in 1966 and then down to 179 in 1970 (Craighead et al., 1974). No counts of marked bears were made after 1970. Estimates of bear numbers for 1971 to 1973 (Cole, 1973, 1974) are based on hypothetical calculations and there are no data to verify them.

"Back-country" and "Peripheral" Populations

If the direct count figures for grizzly numbers during the period 1959-1970 given by the Craigheads are accepted, two further questions remain: (1) Do the bears counted at the five or six census localities represent all or nearly all of the bears present in Yellowstone Park, or are there a significant number that are not counted because they remain mostly in the "back-country" and the probability of their being observed at a census locality is low? (2) Are there a significant number of grizzlies inhabiting the Yellowstone Plateau outside of the Park boundaries?

Published statements regarding a distinct "back-country" population are contradictory. Craighead et al. (1974) stated: "Data on the movements of marked grizzlies, back-country censuses, and the relationship of the distribution of marked to unmarked animals, all indicated that the population of grizzlies we were censusing represented a large proportion of the entire population of grizzly bears inhabiting the approximately five million acre Yellowstone Ecosystem. These data conclusively demonstrated that the animals recorded in the annual censuses were from all parts of the Yellowstone Ecosystem and did not represent a local population addicted to garbage."

By contrast, Cole (1971) asserted that the Craighead censuses "since 1959 could be conservative because the portion of the population which remained in the more remote areas of the Park was underestimated." Cole later claimed (1973) that 50 to 100 grizzlies stayed in remote areas, and suggested that this estimate "could be overly conservative."

The controversy hinges upon differing interpretations of various sorts of evidence. Observations of marked grizzlies, radiotracking studies, and kill sites of marked grizzlies all demonstrate that individual grizzlies are capable of moving long distances, often in a short period of time (Craighead et al., 1974). However, this does not prove that all grizzlies actually came to the dump census areas, merely that they were capable of doing so.

The distribution of marked and unmarked bears throughout the Park provides the best opportunity for testing conflicting views. If most or all of the individuals in the population visit the dumps sufficiently often to be counted as part of the population and if these same individuals all also inhabit remote portions of the Park and adjoining National Forests, then the proportion of marked bears seen in all observations of grizzlies in the "back country" should be about the same as the proportion of marked animals in the total population.

Cole (1973) emphasized this fact by citing observations by Barnes and Bray (1967) that "only one marked animal was observed in 113 sightings of grizzlies in back-country areas (Barnes, personal communication)" when "more than half of the grizzlies that used dumps or developed areas may have had markers during this period . . . ." As stated, this is misleading to the extent that data from the 113 sightings do not differentiate among individual bears nor do they indicate in which sightings it was possible to determine whether the bears were marked or unmarked. We have confirmed (Bray and Barnes, personal communication, 1974) that one of 27 different bears, closely observed in 1965, was marked. The proportion of marked bears in this back-country count was thus about 4 percent.

Since the proportion of marked bears at garbage dumps was 45 percent in 1965 (Craighead and Craighead, 1967; see also Table 1), the low proportion of marked bears in the Barnes and Bray study supports the contention that the grizzlies of the Yellowstone ecosystem are not homogeneous in their behavior and that some individuals are much less likely to be observed at dumps than are others.

Craighead and Craighead (1967) also report that they made "numerous back-country censuses" in order to determine whether "a grizzly population other than the six described units [dump census sites] exists. . . ." They concluded: "These censuses showed that few grizzlies confine their activities to remote areas of the park." They did not, however, present any evidence to support this conclusion. In a later report, Craighead and Craighead (1971) state, "During a 3-year period [1966-68], 37 percent (42 of 114) of all the marked grizzlies that visited the Trout Creek dump were also observed in the back country," as evidence to support their contention. Table 8 (page 41) of the 1967 report lists all individual bears visiting Trout Creek dump in 1966, whereas Table 1 (page 848) of the 1971 paper lists marked grizzlies observed at the Trout Creek dump and re-observed in back-country areas from 1966 to 1968. A comparison of these tables reveals, despite a few discrepancies, that most re-observations apparently took place in either 1966 or 1968 and that about 13 of the total of 42 marked bears observed in the back-country were seen there in 1966. Since a total of 66 bears that visited Trout Creek in 1966 were marked, it follows that about 20 percent of the marked bears at Trout Creek were also observed in remote areas.

The critical question--how many unmarked bears were observed in the course of these same back-country censuses--remains unanswered. More detailed reporting of the Craigheads' back-country censuses is desirable, but reliable population estimates may not be possible (Craighead et al., 1974).

Further evidence as to the homogeneity of the grizzly population can be sought by examining the proportion of marked animals killed inside and outside the National Park

boundaries (Craighead et al., 1974). Outside the Park, grizzlies were killed by hunters in the autumn, when the dumps were less used and when the bears were widely dispersed as they moved to hibernation sites (Craighead et al., 1974). Craighead and Craighead (1967, page 59, Table 14) reported a total hunter kill of 46 grizzlies outside the Park during 1959-1965; of these, 20 (43 percent) were marked. They further reported (personal communication) that of the total of 131 grizzlies killed outside the Park in 1959-1970, 31 (24 percent) were marked. These figures were later modified to 55 killed (20 marked) for the 1959-1965 period, and 143 killed (31 marked) for the 1959-1970 period (Craighead et al., 1974). However, these included nonhunter as well as hunter kills. Finally, Cole (1974, Table 4) reported a total hunter, plus depredation, kill of 55 for the 1970-73 period; of these, 7 (13 percent) were marked.

The following data pertaining to these periods are available concerning the proportion of grizzlies within the Park that were marked. In 1960, 77 (Craighead et al. 1963) or 78 (Craighead and Craighead, 1972a) animals out of a total count of 169 (46 percent) were marked. In 1965, of 187 bears counted, 87 (45 percent) were marked (Craighead and Craighead, 1967, page 62, Table 15). Overall, during 1959-70, 39 percent of all bears censused were marked (Craighead et al., 1974).

There might appear to be some agreement between the proportion of marked bears within the population (45-46 percent, 1960, 1965) and those killed outside the Park (43 percent, 1959-1965). However, the proportion of marked bears within the in-Park population varied with the age-class of the bears. Data for 1966 have been published only for the Trout Creek segment of the population (Craighead and Craighead, 1967, page 41, Table 8; see also Table 1 of this report). Of 128 bears counted, 66 (52 percent) were marked. However, for bears 3 years old and older, the proportion of marked animals ranged from 69-93 percent, averaging 76 percent. Since almost all grizzlies shot are in these age classes (Greer, 1972, 1974), this is the proportion that should be compared with

the hunter-kill. The Trout Creek segment averaged 112 animals during 1960-65, or 65 percent of the total Park population (average 173). In the Trout Creek sample for 1966, 76 of the 128 bears counted, or 59 percent, were 3 years old or older. In the population as a whole, the proportion of bears of these age classes was 58 percent during 1960-65, and 58 percent for 1965 alone. Thus, 58 percent seems a reasonable estimate for the proportion of marked grizzlies in the Park population subjected to risk of hunting outside the Park; the average size of this segment of the population was 100 grizzlies, 3 years old or older, during 1960-65. The difference in the two proportions is 15 percent (58 percent minus 43 percent). This difference can be accounted for if an additional 33 grizzlies of these ages were on the average present in the population subject to hunting, but unmarked and uncounted. If 133 grizzlies comprised 58 percent of the total population, including all age classes, the estimate for the total population is 229, or 56 (32 percent) more than the average population size of 173 3stimated for 1960-65.

With reference to the entire period, the average proportion of marked bears in the observed population during the period 1959-70 was 39 percent (Craighead et al., 1974). The average proportion of bears 3 years old and older during this longer period was 60 percent (106 out of 177) of the mean total of bears counted. If three-quarters of the marked grizzlies were 3 years old and older (see preceding paragraph), then on the average 50 percent of the 106 bears estimated to be exposed to risk of hunting each year were marked. But in fact only 24 percent of bears killed during this period were marked. This suggests that as many as 196 unmarked, uncounted bears existed in the population, or more than the average population size of 179 estimated by the Craigheads for the 1959-1970 period.

However, the rate at which newly-marked bears were added to the population apparently declined sharply after 1964. If this were the case, the proportion of marked bears in the population must have been considerably less

after 1966 than in the early years of the study. This probably accounts for the lower proportion (24 percent) of marked bears in the kill when the entire 1959-1970 period is considered, compared to 43 percent in the 1959-1965 period, and particularly the low proportion (13 percent) in the 1970-1973 period. Since changes in the proportion of marked bears were occurring, the most conservative estimate for the size of the unmarked, uncounted portion of the population is probably that based on the 1959-1965 period, or about 32 percent beyond that of the counted population. In view of the observations by Barnes and Bray, this should be regarded as a minimum estimate. Craighead et al. (1974), using the same approach but a somewhat different set of figures (all mortalities rather than hunter kill only), estimated that 141 bears were uncounted. This value is close to the mean of the two different estimates based on hunter kills, which is 126. They point out, however, that certain sources of bias tended to inflate the estimate of uncounted bears. Their adjusted estimate is 57*, which is very close to our independently derived minimum figure of 56 (see above). When the final analyses are published, these estimates may be greatly refined by entering into the calculation the rate of input of newly marked animals and correcting for the age-specific mortality rate of those previously marked.

The minimum estimate of 32 percent (approximately 57 bears) may be considered to comprise the "back-country" and/or "peripheral" population. Both back-country censuses (see above) and data on marked individuals among bears killed outside the Park thus support the view that some grizzlies in the Yellowstone ecosystem had a significantly lower probability of visiting dump census areas and hence of being observed or captured and marked.

The concept of two or three wholly distinct populations--i.e., "back-country" versus "dump" populations (Cole, 1971) or "peripheral" populations--is misleading. All grizzlies inhabiting the Yellowstone Plateau must be regarded as belonging to the same population, as their great mobility demonstrates (Craighead and Craighead, 1971).

*In preparing the 1974 final draft for publication, Craighead et al. revised their calculations to arrive at an estimate of 52 bears in the "peripheral" population.

Within this single population, heterogeneity of behavior exists; some bears apparently visited dumps more frequently than did others, and some spent more time outside of the Park boundaries than did others (Craighead and Craighead, 1971, page 846). Indeed, some probably never visited garbage sites. The uncertainty lies in ascertaining how many bears fall into each of the several behavioral categories.

To summarize, based on counts of marked and unmarked but individually-identifiable bears, the grizzly population at the garbage dumps of Yellowstone rose from 154 in 1959 to 202 in 1966, declined to 175 in 1967, rose again to 195 in 1969, and dropped to 179 in 1970. The average count for this period was 177. If this mean count is accepted, and if an uncounted additional 32 percent is added, the total population is estimated to have averaged 234 grizzlies over the 1959-70 period. Thus, we concur with Craighead et al. (1974) that no more than about three-fourths of the total ecosystem population was included in the garbage dump census.

In the summer and fall of 1970, and for two years thereafter, mortality of grizzly bears increased (see page 32 of this report); hence population size was probably reduced by 1972-73.

Population Density

The various estimates of population density for grizzly bears in the Yellowstone ecosystem depend upon both population size and estimates of the area occupied by bears. Furthermore, the area may be considered either as the largest bounded by the range margins of the species (crude density) or as only the area of suitable habitat (ecological density).

Craighead and Craighead (1971) estimated that grizzly bear density in the Yellowstone ecosystem was 1/75 km^2. It is not entirely clear how this figure was reached. Apparently the average count for 1959-66, 174 bears, was

divided into an area of 12,950 km^2 which included the 8,800 km^2 Park, plus a peripheral area. An adjacent corridor 16.1 km wide surrounding this area is mentioned but not included in the density calculation, perhaps because it was regarded as occupied only on a seasonal basis. Elsewhere in the same paper, they refer to a study area of 19,943 km^2, including the corridor.

On the other hand, Cole (1973, 1974) estimated a minimum of 250 grizzlies within the 8,800 km^2 Park (1/35 km^2) and an additional 100 in the 5,200 km^2 peripheral area outside the Park boundaries (1/52 km^2) for a total of 350 bears and an average density of 1/40 km^2

Both Cole and the Craigheads estimated crude densities; their estimates differ both in bear numbers (174 vs 350) and, less significantly, in area occupied (12,950 vs 14,000 km^2).

If the estimate of a total of 234 grizzlies, as developed in this report (see above), and independently by Craighead et al. (1974), is used together with the two areal values, the estimated grizzly bear density for the Yellowstone ecosystem lies between 1/55 km^2 and 1/60 km^2. These densities have been compared with grizzly population densities in other parts of the species range (Cole, 1971, 1973; Johnson, 1973). In the Whitefish Range, Montana, and in Mt. McKinley National Park, Alaska, grizzly densities were estimated as 1/39 km^2 (Dean, 1958; Jonkel, 1967); in Glacier National Park, Canada, 1/28 km^2 (Mundy and Flook, 1973); in the Yukon Territory, 1/26 km^2 (Pearson, 1972); and in Glacier National Park, Montana, 1/21 km^2 (Martinka, 1971). These estimates thus range from about 1/20 km^2 to 1/40 km^2, and are all higher than those for the Yellowstone ecosystem, except for Cole's (see above). However, these estimates were made without the support of an intensive marking program. Moreover, habitats vary a great deal between the different parts of grizzly bear range where these studies were made, and carrying capacities should also be expected to vary. Hence, to judge the population density estimate of 1/55-60 km^2 in the Yellowstone ecosystem as too low simply because it is below estimates for other areas is unwarranted.

Movements and Behavior

Movement Patterns

That grizzly bears may move long distances has been amply documented by observation of marked bears and by radio-tracking studies (Craighead et al., 1963; Craighead and Craighead, 1970, 1971, 1972b, 1973). Normal movement patterns for Yellowstone Park bears included summer concentration at dumps, and spring and fall movements to and from den sites, often peripheral to the Park. There is some evidence that grizzlies are seen in the National Forests outside the Park more frequently in the spring and fall than in the summer months. Some bears that den outside the Park may thus be summer residents within the Park. However, unequal temporal distribution of observers--there are more hunters and outfitters in the forests in spring and fall--biases the data. Present understanding of normal seasonal movement patterns of grizzlies is fragmentary.

It has been asserted (Craighead and Craighead, 1971) that an unusual pattern of movements of grizzlies to developed areas (campgrounds, etc.) within the Park was caused by closure or partial closure of the dumps where they had traditionally congregated. It is clear that movements, often of considerable length, to developed areas, occurred in the summers of 1968-1970. Because baseline data on normal summer movements during earlier years (1959-1967) have not been presented, it cannot be established that the alleged increase in movements between dumps and campgrounds was caused by dump closure.

Behavior

The only aspect of bear behavior to be considered here is bear-human interactions, particularly in campgrounds. If dump closure did result in increased movements of bears to, and activity in, campgrounds, this ought to be reflected in an increase in bear-human interactions in campgrounds within the Park except where special techniques were implemented to prevent them.

Injuries to humans by grizzlies constitute one sort of interaction. Craighead and Craighead (1971, page 850) and Cole (1971, page 861) seem to accept nearly the same injury total--63 known and provable grizzly-caused injuries to humans within the Park over the 40 years since 1930. However, a closer examination of these two papers reveals a serious discrepancy in injury figures. Table 2 was constructed from data in these two papers and shows that Cole's injury figures are much higher than

Table 2. Number of persons injured by grizzly bears in Yellowstone National Park, 1959-1970.

	Source		
Year	Craighead and Craighead, 1971, Table 5[1]	Cole, 1971 Table 3, Fig.2[2]	Difference
1959	0	1	1
60	0	1 + (1)	2
61	1	2	1
62	2	2	
63	6	8	2
64	1	2	1
65	4	8	4
66	1	2 + (2)	3
67	0	3	3
68	1	2	1
69	6	6	
70	3	2 + (1)	
	25	39 + (4) = 43	18

[1]Include all in-Park injuries.

[2]Injuries in developed areas (from Fig. 2), with back-country injuries in parentheses (from Table 3, plus Cole, 1973 for 1970).

those published by the Craigheads for the 1959-70 period. These discrepant figures form the basis for the conflicting conclusions reached by the respective authors.

Cole (1973, 1974) claimed that the 1970-72 mean of 1.0 injuries per year, or the 1970-73 mean of 0.7 injuries per year in developed areas "was significantly different ($P = 0.05$) from the 1963-69 mean of 4.4 per year . . ." Craighead and Craighead (1971) asserted, by contrast, that the rate of injuries was 1.67 per year during 1959-67, but increased to 3.33 per year during 1968-70; they believe that "the increase is due largely to the present management practices that have forced grizzly bears into campgrounds and developed areas. . . ."

The management practice alluded to is the phase-out of open-pit dumps. Of the four main dumps, the one at Gardiner was closed in 1968, Rabbit Creek in 1970, and Trout Creek and West Yellowstone in 1971. Thus the principal closure period was 1970-71. However, the dump most heavily used by grizzlies, Trout Creek, suffered a drastic reduction in amount of edible garbage disposed of there in 1968 (Craighead and Craighead, 1971, page 852). There was some increase in garbage dumped at Trout Creek in the summers of 1969 and 1970, before the dump was finally closed, but the Craigheads regard the period of dump phase-out as extending from 1968 through 1970.

Cole's basic position is that there was no dramatic increase in injury rates during the period of dump closure but that the injury rate has fallen since then (Table 3). The Craigheads argue that the injury rate did increase during dump closure, as compared to previous years; they do not comment on the 1971-73 period. The figures summarized in Table 3 are cited by each to support their respective conclusions.

These comparisons of injury rates are also suspect because of other uncontrolled factors that may affect them, such as changes in: (1) number of visitors to Yellowstone; (2) garbage disposal practices in campgrounds; (3) frequency and intensity of campground patrols by Park personnel; and

Table 3. Comparison of yearly injury rates by grizzly bears in Yellowstone National Park, 1959-1973.

Year (mean)	Source: Craighead and Craighead, 1971 (Whole Park)	Source: Cole, 1971 (Whole Park)	Source: Cole, 1971 (Developed Areas Only)
1959-67	1.67	3.56	3.22
1968-70	3.33	3.66	3.33
1971-73	--	0.67	0.33

(4) numbers of grizzlies removed from campgrounds. In the final analysis, these uncontrolled sources of bias probably make any comparison of injury rates valueless.

A second sort of bear-human interaction that may be quantified is the number of "control actions" of bears in campgrounds. A "control action" is defined by Park authorities as the capture or killing of a bear. During the 1959-67 period, 117 captures involving 75 individual bears were recorded; mean frequency of capture was 13/year, and mean number of bears captured was 8.3/year (Craighead and Craighead, 1971, Figure 5 and Table 7). During 1968-70, mean capture frequency increased to 63.3/year, and mean bear number to 41.3/year (loc. cit.). In 1971-73, mean capture frequency declined to 25.0/year, and mean bear number to 20.3/year (Cole, 1974, Table 3), values still above the 1959-67 mean. The number of grizzlies killed in control actions shows the same pattern. From a mean of 3 bears killed per year in 1959-67, the rate rises to a peak of 9 per year in 1968-70 and then falls again to 4.67 per year in 1971-73.

These figures strongly suggest that there was increased grizzly activity in campgrounds and other developed areas during the period of dump closure during 1968-70. However, they are also subject to bias similar to those noted above; namely, the frequency and intensity of control activity by

Park personnel in campgrounds. It is reasonable to suppose that in the years immediately following the deaths of two persons in Glacier National Park in 1967, Park authorities were especially sensitive to the threat posed by grizzlies in areas of visitor concentration and were especially vigorous in patrol and control activities.

Finally, data on injury rates or control actions are reliable only to the extent that Park records have been kept accurately. Certain discrepancies among injury records have been noted (Table 2). It has also been alleged (H. V. Reynolds, personal communication, January 19, 1974) that control actions have not always been recorded. If this allegation is true, such failure jeopardizes rational research and management programs for grizzly bears within the National Parks.

Reproductive Rates

Reproductive rate is here defined to be the ratio of the number of cubs surviving to midsummer of their natal year to the number of adult females. From the available data there are two methods of estimating the reproductive rates: (1) the ratio of observed number of cubs to the observed number of adult females; and (2) the reproductive history of identifiable females.

It should first be emphasized that the ratio defined in (1), above, is not to be confused with another statistic often given: the ratio of cubs to females with cubs. The latter ratio is found, for example, in recent reports by Cole dealing with this population. It can be converted to the reproductive rate if the frequency of pregnancy is known. If this frequency is not constant, the ratio of the number of cubs to the number of females with cubs is useful only as an indication of litter size.

The main difficulty in estimating the ratio of cubs to all adult females is in the assumption that each group is equally identifiable. In general, this will not be the

case, since a female with cubs is much more likely to be observed than one without. Also there is a possibility that some adult females are misidentified. Undoubtedly, animals observed at the garbage dumps were equally observable and well identified, but it is not known whether all age and sex groups frequented the garbage dumps to the same degree.

The estimate of reproductive rate from the history of identified females is biased unless information is available on the length of the period from maturity to the occurrence and recording of the first pregnancy. In Craighead et al. (1974) this is taken into account, and their estimate of the reproductive rate from the reproductive histories of 30 marked female bears is 0.658.

On the other hand, another estimate is obtainable by Method (1), above, using the data of Table 1 of Craighead et al. (1974). This table does not separate adults from subadults for the first year of observation (1959); therefore, we use the data from 1960 to 1970. During this period, 890 adults and 351 cubs were observed. If one uses the sex ratio of 46.3 to 53.7 (Craighead et al., 1974), an estimate of the reproductive rate as $351/(0.537)(890)$ or 0.734 is obtained.

As will be pointed out below, both of these values appear to be too low.

Mortality Rates

Mortality rates can be estimated from the data given in several tables in Craighead et al. (1974) showing the age composition of the population, provided some assumptions are made. The critical assumptions are: (1) that the different age classes are equally observable; and (2) that there are no trends in the population. If the population were growing, for example, then any present adult year class would be the survivors of a smaller group of cubs than are currently observed.

As is pointed out by Craighead et al. (1974), there is a significant upward trend in the total population count [for the whole period 1959-70 the rate of growth is apparently 2.8 bears per year where t=2.80 (probability level 0.02)]. However, if the same analysis is applied to the cub segment of the population, the trend is downward (-0.5 bears per year), though this is statistically nonsignificant. The positive trend in the total population is therefore explainable in one of three ways:

- There had been an increasing number of cubs prior to 1959, but this increase ceased during the 1959-70 period.
- The mortality rate decreased during the 1959-70 period.
- The proportion of the total population that was observed and recorded increased during the period of observation.

Since 2.8 bears per year on the basis of the average observed population of 177 (1959-70) is a percentage increase of only slightly more than 1.5 percent, it seems appropriate to begin with the simplest assumption and assume that the population was basically stable during this period. To do so does not imply that there were no fluctuations, in response either to population pressures or to external factors. We assume further that the mortality rate is age-dependent in the subadult ages but essentially constant thereafter.

From Table 1 of Craighead et al. (1974), the 1959-70 population averages by age are as follows:

Age Class	Number of Individuals
1/2:	31.4
1-1/2:	22.6
2-1/2:	17.6
3-1/2 + 4-1/2	26.2
5-1/2:	80.2

From this the following survival rates are estimated:

Age Class	Number of Individuals
1/2 - 1-1/2:	0.72
1-1/2 - 2-1/2:	0.78
2-1/2 - 3-1/2:	0.80
3-1/2 - 4-1/2:	0.84
4-1/2 - 5-1/2:	0.87

The basic data combine 3-1/2 and 4-1/2 year-olds, so that only a combined mortality estimate for the age span 2-1/2 to 4-1/2 is obtained directly from the data. The separate values are determined by interpolation to yield this average and to give a smooth series. The final result is unaffected by this interpolation.

The adult mortality rate is estimated by a formula (Chapman and Robson, 1959) based on the mean adult life span (i.e., measuring from age 5.5). This is calculated from the basic data given in Table 2 of Craighead et al. (1973), which is based on a sample taken in 1966 (52 animals plus 8 animals of known age and known to be members of the adult population in 1966).

$$a = \frac{1}{1 + \mathring{e}}$$

"$\mathring{e}$" is the mean adult life span and "a" is the annual adult mortality rate. From the data cited, a = 0.136.

If it is assumed that the mortality rate of subadult bears between the ages of 3-1/2 to 5-1/2 is the same as the adult rate, then an alternative estimate is available. The subadults, of course, represent the potential recruits to the adult stock. It is well known that the mortality rate can be estimated by the proportion of recruits to the total of subadults and adult stock (Heincke, 1913). This has to be modified here, since the subadults represent recruitment over 2 years. The formula for the survival rate, s(s=1-a), is

$$s^2 = \frac{\text{No. of adults}}{\text{No. of subadults and adults}}$$

For the 1960-to-1967 data given in Table 1 of Craighead et al. (1974), the mortality rate a=0.137; for the 1960-to-1970 date, the estimate by this method is 0.139. These two estimates, based on the proportion of sub-adults and the one above (a=0.136) from the whole age structure, are very similar.

However, the mortality rates are not consistent with the reproductive rates determined in Craighead et al. (1974) or above. If the population were stable or increasing, then the recruitment to the adult stocks must equal or exceed the adult mortality. If the reproductive rate is 0.734 and half the cubs are females, then the recruitment rate to the adult population is derived as follows:

$$(0.734)(0.5)(0.72)(0.78)(0.80)(0.84)(0.87) = 0.120,$$

which is less than 0.136. (The last five figures on the left-hand side of the equation are the successive mortality rates from ages 1/2 to 1-1/2, 1-1/2 to 2-1/2, etc.)

Craighead et al. (1974) show an even greater discrepancy between estimated recruitment and estimated adult mortality, since their reproductive rate is estimated as 0.658. Actually, they go further and develop an "applied reproductive rate," which for the period 1959 to 1970 averages out as 0.641. They overcome this discrepancy by adjusting the mortality rate between ages 1/2 and 1-1/2 from 0.6296 to 0.8 (Craighead et al., 1974, Table 12).

The recruitment rate, calculated with the mortality rates estimated above and the reproductive rate estimate of 0.658, is 0.108. The discrepancy can be shown by another analysis of the basic data for the population model of Craighead et al. (1974, Table 9). This table shows a refined age structure with 42.1 adult females and 33 cubs. But with a reproductive rate of 0.658, 42.1 adult females produce only 27.7 cubs on average. Still further, the adjustment noted above--i.e., to the survivorship estimate from age 1/2 to 1-1/2, attributed to early

weaned yearlings--leaves an unexplained deficiency in the older subadult counts.

All of these discrepancies become reasonable if one assumes that the bears observed by the Craigheads and their colleagues were in fact only a portion of the total population. If this is true, there are sampling errors in the observations. In addition, it is probable that given elements of the population did not all have the same chance of being observed at the garbage dumps (see page 21).

Thus, in assessing future population trends, it is necessary to take into account both sampling errors and biases in the estimates obtained for the period 1959 to 1970 and those changes in the parameters that could be expected after 1970.

In particular, there is the question of compensatory mechanisms in the population in response to changes imposed externally. From 1959-67 the average man-imposed mortality upon the population was 18.9 bears per year. From 1968-73 the man-imposed mortality (or removal of bears from the ecosystem) was 189, or an average of 31.5 per year (Craighead et al., 1974).

A large portion of these losses may undoubtedly be attributed to the changes brought about by garbage-dump closures in 1970-71. In these two years the removals were 53 and 48, respectively. However, the next heaviest mortality (43 in 1967) was primarily due to a large hunter kill (24) in Wyoming. Man-imposed mortality declined to 27 in 1972 and 17 in 1973. In particular, removals due to control actions within the Park fell to 9 in 1972 and 0 in 1973 (Cole, 1974).

If the 1959-67 rate is considered to be characteristic of a stable situation, the "normal" 1968-73 removal could have been 6 x 18.9 or 113 bears. Thus it may be asserted that the "excess" losses in 1968-73 were 76 (189-113). If there were no other changes in population parameters, then the population that we have estimated to be 234 or greater could have been as low as 158 by 1973. This figure

may be compared with the most probable figure of 144 (for 1974) given in Craighead et al. (1974). The difference is explained by the lower reproductive rate they calculated for 1970-73 and extrapolated to 1974. This rate is calculated from the litter size observations made in 1970-73 by different observers and under different conditions. As noted above (page 31), the Craigheads' values for reproductive rates, even for the earlier period, are not fully consistent with other observations. Moreover, these calculations make no allowance for such other changes as a decrease in mortality from age 1/2 to 1-1/2 as suggested by Cole (1973).

This and other possible compensatory responses are discussed more fully in the following section.

Compensatory Processes

The grizzly bear is a species that is characterized by a long life span, delayed maturity, extended parental care of young, nonreproductive intervals, and high adult survivorship--attributes typical of a species that is adapted to living at population densities close to the upper limit of resources (i.e., strongly K-selected, Pianka, E. R., 1972). Furthermore, the grizzly bear is a fearsome carnivore with few natural enemies other than humans. Modern firearms have shifted the balance greatly in favor of humans, but aboriginals on foot, with stone-tipped weapons, represent the condition under which most of the grizzly bear-human interactions occurred over evolutionary time. It seems unlikely that grizzly bear populations in aboriginal North America were controlled by predation to a level substantially below that the resource base would support.

This being the case, one would expect that the grizzly bear would evolve variable life history parameters that would allow flexibility in achieving a balance between the population density and a resource base that varies by season and year.

The number of variable parameters known in bears is very great. In fact, it is doubtful that any parameter is a constant. The age of first breeding is variable (Craighead et al., 1974, Figure 2). The interval between litters is highly variable, and presumably the number of young conceived also varies. Delayed implantation in bears (Jonkel and Cowan, 1971) may allow the response as to number of young born to be conditioned by quality of late summer and fall foods, and the condition of females going into hibernation. Litter size in Yellowstone bears, as reflected by number of cubs at six months of age, varies, whether due to variations in conception or in early mortality. High early mortality of young is typical of mammals and schedules of mortality for all age classes vary depending upon resources and population density (Caughley, 1966).

The rigid characteristics of the model of Craighead et al. (1974) seem, a priori, to be unrealistic, because no compensatory mechanisms are built into the model. The reproductive rate is altered between two fixed levels on rather arbitrary grounds. The model assumes a stable age distribution and is established on the basis of a stationary population. A model based on such equilibrium, in which a given reproductive parameter is lowered, will obviously lead to extinction if compensatory mechanisms are not built into the model; this is true irrespective of the initial population size. Thus, the absence of compensatory mechanisms in the Craighead et al. (1974) model means that a change of reproductive or mortality parameters will, in general, lead to indefinite increase or to extinction. Equilibrium would be achieved only in the special instance where the two rates were adjusted in concert so that changes were in the proper directions and magnitudes as just to offset each other. Since the Craighead et al. (1974) model does not incorporate compensatory mechanisms, the population predictions are subject to question.

Closing the garbage dumps, at which females had formerly been brought into close contact with juveniles and males, may have altered the population status by

altering survivorship rates in the population. There is thus the question whether the Craigheads' data (which are by far the best available) are applicable to a population now dispersed rather widely over the Park.

There is little question that increased adult mortality will be offset by compensatory increases in juvenile recruitment. However, it is equally apparent that grizzly bears are limited in the range of compensatory response that is possible and that, at best, grizzly populations are vulnerable when high rates of mortality are imposed.

In our opinion, the data at hand are not sufficient to make accurate predictions about population responses to various levels of adult mortality.

Our calculations are intended to be on the conservative side. It is agreed that the population observed at the garbage dumps did not represent the total number of bears in the Park, and certainly not those of the entire ecosystem. Most important, if the garbage dump closure altered the biological parameters of the population, then any model based upon data collected prior to 1970 would not yield accurate population projections.

At the same time, our evidence does not suggest that there are compensatory mechanisms adequate to maintain the Yellowstone population under the impact of continued mortality as high as that which occurred in the years 1970-72.

CONCLUSIONS

1. The entire area of the Yellowstone Plateau, including Yellowstone and Grand Teton Parks and the National Forest and state land adjacent, is, for the grizzly bear, a single ecosystem and should be managed as such. The area occupied is 14-20,000 km^2, about half of which is in Yellowstone National Park.

2. The majority of grizzly bears in this ecosystem during the period up to 1968 either inhabited or from time to time entered Yellowstone National Park, and while there are no explicit data on this point for recent years, it is probably still true.

3. While many of the bears in the population frequented the garbage dumps in the past, others had different behavior patterns, and the probability of their being observed at the dumps was small. Thus, the total population was larger than the segment under study at the garbage dumps.

4. Available data on grizzly bear numbers indicate an essentially stable population between 1959 and 1967.

5. A conservative estimate of the size of the grizzly population during this period is 234, of which about 45 percent were of breeding age, i.e., 5-1/2 years plus.

6. The density of grizzly bears in the Yellowstone ecosystem is estimated to have been one bear per 55-60 km^2, and is thus lower than reported densities in Glacier National Park and in the Canadian Rocky Mountains. However, the variables in methods of estimating populations and the differing capacity of environments to support bears make such comparisons largely meaningless.

7. It is not meaningful to compare injury rates or control actions before and after the garbage sources

were removed. In part this arises from absence of data for the pre-1967 period; in part from the greatly altered management effort subsequent to 1968.

8. The average reproductive rate was calculated by two methods. These estimates were 0.658 and 0.734 for 1959-70.

9. Mortality rate for adult bears from 1966 age sample is estimated at 0.136 per year.

10. During the period 1968-73 the man-imposed removal of grizzlies from the Yellowstone ecosystem averaged 31.5 bears per year as opposed to 18.9 per year in the 1959-67 period.

11. Compensatory changes in the survival of young during the 1968-73 period may have occurred as a response to the reduced population size. There is no evidence for or against a change in the natural mortality of adults during this period.

12. During the period 1968-73, the removal of grizzly bears from the Yellowstone ecosystem exceeded that of the 1959-67 period by 76 animals. Despite possible compensatory response in survival of young, it is most probable that the grizzly population was reduced substantially during this period of readjustment to exclusively wild feeding.

13. Mortalities and control actions declined in 1972 and 1973.

14. It is probable that the biological parameters estimated from data obtained from the garbage-fed population are not appropriate for a free-ranging population. There is no evidence as to the role and importance of garbage food sources in the fecundity or mortality rates of the grizzly.

15. It is not possible to determine new biological parameters without re-establishing a recognizably marked element of known size in the population.

16. Such a marked population is essential also to testing the effectiveness of sampling techniques that may be developed for use in long-term management.

17. The research program carried out by the National Park Service administration since 1970 has been inadequate to provide the data essential for devising sound management policies for the grizzly bears of the Yellowstone ecosystem.

18. There is no convincing evidence that the grizzly bears in the Yellowstone ecosystem are in immediate danger of extinction.

19. We believe that the compensatory processes discussed above have resulted in, or will lead to, replacement of bears that were removed from the ecosystem in 1968-73. However, until there is a more precise estimate of the population total and better information on the changes in population parameters that have resulted from the return of grizzlies to total dependence on natural foods, we believe that a conservative policy on removals is essential.

RECOMMENDATIONS

The following recommendations apply to management and research on grizzly bears, but may well be found applicable to other wildlife in the Yellowstone area.

All recommendations are based on the knowledge that the Yellowstone grizzly population occupies an area encompassing more than Yellowstone National Park alone, an area here referred to as the Yellowstone ecosystem. The actions or policies recommended here apply to this ecosystem as a whole unless otherwise specifically stated.

We assume that all agencies responsible for management of Yellowstone grizzlies intend to cooperate effectively to ensure survival of a viable population. In developing the mutual agreements and joint programs essential to conserve Yellowstone grizzlies, no state or federal agencies need cede their basic authority.

For Management

1. We urge the creation of a nongovernmental coordinating body as a permanent mechanism through which concerned state, federal, and private agencies may seek general and specific agreements directed toward the well-being of Yellowstone grizzlies. Membership in this coordinating body should include, but not be restricted to, representatives from the National Park Service, the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the fish and game departments of Idaho, Montana, and Wyoming. It must be chaired by a respected neutral individual acceptable to all cooperating agencies. This body should develop mutually acceptable management guidelines, foster free exchange of information among agencies and concerned scientists, and encourage research essential to management of Yellowstone grizzlies. As noted (page 3), the Interagency Grizzly Bear Study Team and its Steering Committee do not meet all the criteria of this recommendation.

2. Management and research information must be circulated effectively among all those engaged in the study or conservation of Yellowstone grizzly bears. A model for such cooperation exists in the present arrangement under which Yellowstone grizzly carcasses or remains are forwarded to the Wildlife Laboratory of the Montana Fish and Game Department at Bozeman for processing, data being subsequently made available to all concerned parties. This concept should be applied to all information about Yellowstone grizzlies or their habitats.

3. During the 1959-67 period, when the population was essentially stable, the kill of bears by man averaged 18.9 per year. In view of the uncertainties noted in Conclusion No. 19, we recommend that, beginning in 1974, the total of man-caused removals should be held to about 10, if at all possible, until further research demonstrates that larger removals are consistent with maintenance of the population. To the extent that the man-caused kill can be held below 10, the rate of recovery from the 1972 base, which is believed to be lower than the earlier long-term level, will be speeded.

   To hold the kill of grizzly bears within the Yellowstone ecosystem to 10 per year will require efforts by the states of Idaho, Montana, and Wyoming to regulate hunter kill. Specific recommendations to these states are beyond the scope of this report, but we urge them, in cooperation with the proposed coordinating body, to determine in advance the legal kill level each year and to establish regulations that will provide sensitive control over this kill.

4. Yellowstone National Park authorities should continue their efforts to eliminate the need to destroy bears as hazards to humans. Managers of adjoining public and private lands are urged to intensify their efforts in this direction.

5. We urge that all garbage dumps in the Yellowstone ecosystem be closed and that other garbage sources be made bearproof.

6. We recommend against supplemental feeding as being unnecessary to maintain the Yellowstone grizzly population. This does not preclude the use of baits to attract bears away from areas of major human use or for other management and research purposes.

7. We recommend that responsible agencies consider eliminating nuisance-bear control programs outside Yellowstone National Park and substituting legal hunting or compensation for proven damages.

8. We recommend that the U.S. Forest Service be encouraged to phase out whatever sheep grazing permits may still remain in the Yellowstone ecosystem as rapidly as possible, in order to remove the potential of grizzly bear predation on sheep.

For Research

1. We recommend that the National Park Service and the U.S. Forest Service pursue a policy of supporting and encouraging independent research on Yellowstone grizzlies. The freedom of scientists to conduct research throughout the Yellowstone ecosystem is imperative if the data essential to successful management of Yellowstone grizzlies are to be obtained; the presence of independent investigators will enhance and invigorate study programs undertaken by land-management agencies.

   We recognize that the Yellowstone ecosystem clearly cannot host unlimited research and that the best interests of ecosystem conservation or resource management may justify some regulation of research activities. However, we believe that research on certain aspects of grizzly populations should be accorded very high priority.

2. We recommend that the present interagency research approach be re-evaluated; its close ties to management supervision and management authority impose severe constraints on its effectiveness. We further recommend that coordination of the research effort be assumed by the nongovernmental body described earlier under Management Recommendation No. 1.

3. We recommend prompt, adequate funding of a comprehensive research project on the Yellowstone grizzly population by qualified independent scientists, using every appropriate technique, including marking of individual bears for identification. The most urgent needs are to obtain reliable data on present population size, trend, and distribution; present reproductive rates by age class; present mortality rates by age class; and effects of social behavior on population regulation. Of these, the single most critical question is whether bear numbers are now increasing, decreasing, or relatively stable. Investigations since 1970 have not provided satisfactory data on these points. Successive annual censuses would provide such information, but unfortunately no adequately precise census method is yet available. It may, then, be more feasible to approach the matter indirectly by assessing recruitment and mortality through careful analysis of population structure.

4. We urge that the following questions be investigated concurrently with the population assessment and coordinated with it: (1) Has a relatively stable pattern of distribution developed since garbage dumps were eliminated within Yellowstone Park? (2) What seasonal movements are now typical within particular components of the grizzly population? (3) Are there resident grizzlies, or transients only, on National Forest lands of the Yellowstone ecosystem?

5. We recommend thorough study of abundance and quality of grizzly foods under natural conditions, since yearly variations in food supplies may have immediate or delayed (because of delayed implantation) effects on reproductive performance or mortality.

6. We recommend that management agencies and other groups having related research interests intensify work on methods to reduce the frequency of contacts between bears and humans and to reduce the danger to humans in the event of confrontations.

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APPENDIX A

SCHEDULE OF MEETINGS; ACKNOWLEDGMENTS

The Committee on the Yellowstone Grizzlies met as follows:

September 6-7, 1973	at the University of British Columbia, Vancouver
October 27-29, 1973	at the University of Montana, the Yellowstone National Park, and the Montana Wildlife Investigations Laboratory at Bozeman
January 24-25, 1974	at the Sea-Tac Motor Inn, Seattle
March 30-31, 1974	at the Denver-Hilton Hotel, Denver
July 10, 1974	at the Airport Holiday Inn, Denver

The Committee wishes to express its appreciation to the following persons for providing helpful comments and data at committee meetings:

Gene Allen, Montana Fish and Game Department

Jack Anderson, Superintendent, Yellowstone National Park (YNP)

Joseph V. Basile, Intermountain Forestry and Range Experiment Station, U.S. Forest Service

Roger Bumstead, Northern Region Forest Service

Glen F. Cole, Supervisory Research Biologist, YNP

Frank C. Craighead, Jr., State University of New York at Albany, Moose, Wyoming

John J. Craighead, Montana Cooperative Wildlife Research Unit, BSFW

Kenneth R. Greer, Montana Fish and Game Department

Maurice Hornocker, Idaho Cooperative Wildlife Research Unit, BSFW

D. B. Houston, Research Staff, YNP

Richard Knight, Research Staff, YNP

Clifford J. Martinka, Glacier National Park, Research Biologist

B. R. McClelland, University of Montana

Mary Meagher, Research Staff, YNP

M. J. Nakamura, Chairman, Department of Microbiology, University of Montana

Robert T. Pantzer, President, University of Montana

Robert Phillips, Forestry Science Laboratory, BSFW

Neil J. Reid, National Park Service, Omaha

Larry J. Roop, Wyoming Fish and Game Department

Jay Sumner, University of Montana

Joel Varney, University of Montana

Wesley Woodgerd, Chief, Recreation and Parks, Montana Fish and Game Department

Additional comments and data were provided through correspondence by many of the above and by A. Errol Nielson, Big Game Supervisor, Idaho Fish and Game Department; Harry V. Reynolds, Rancho Cordova, California; Victor G. Barnes, Bend, Oregon; Olin Bray, Denver Wildlife Center;

C. T. Coston, U.S. Forest Service; D. T. Fluckiger, U.S. Forest Service; R. M. Hansen, Colorado State University; L. E. Hawkes, U.S. Forest Service; A. S. Leopold, University of California, Berkeley; J. B. Reese, U.S. Forest Service; and T. V. Russell, U.S. Forest Service.

The Committee also acknowledges its indebtedness to various staff members of the National Park Service and of the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, who made available pertinent correspondence and published and unpublished reports.

APPENDIX B

United States Department of the Interior

NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

IN REPLY REFER TO:

N1427-DS

APR 2 6 1974

Memorandum

To: Nathaniel P. Reed, Assistant Secretary for Fish and Wildlife and Parks, USDI
Robert W. Long, Assistant Secretary for Conservation, Research and Education, USDA

From: Director, National Park Service
Director, Bureau of Sport Fisheries and Wildlife
Chief, Forest Service

Subject: Interagency Grizzly Bear Investigations in the Yellowstone Ecosystem

The Interagency Committee for the Grizzly Bear investigations in the Yellowstone ecosystem met on December 14, 1973, and concluded the following agreement concerning the conduct and accomplishment of the study:

> The Steering Committee for the study will consist of the Chief Scientist, NPS, WASO, Chairman; Associate Director, Research, BSF&W; Chief of Range and Wildlife Habitat Research, USDA, Forest Service; and representatives of the States of Montana, Idaho, and Wyoming.
>
> The study team will consist of a representative from the three Federal agencies involved and such other personnel and assistance as can be supplied by the three Federal agencies and the States involved.
>
> The team leader shall be Dr. Richard Knight, Research Biologist, Yellowstone National Park, who shall be under the direct supervision of the Chief Scientist of the National Park Service, WASO. Team members from the BSF&W and the Forest Service shall be supported by their respective agencies, but will be under direct technical supervision of the team leader. The team leader will be supported by the National Park Service.

The objectives of the study are to determine: (1) the status and trend of the Grizzly Bear population, (2) the use of habitats by bears, and (3) the relationship of land management activities to the behavior and welfare of the bear population.

The team leader in consultation with team members will translate the objectives of this study into an annual work plan to cover a detailed plan of action for the coming field season and a general plan of attack covering the next five years together with a unified budget. The work plan is to be in the hands of the steering committee in sufficient time to review, and to submit, to the Assistant Secretaries by February 1 each year.

Funding of the program will be contributed by the three participating agencies. Each agency will fund and payroll the personnel, including all salaries and benefits. A budget for the program will be prepared annually by the team leader. Representatives of the participating agencies will meet annually to agree upon the level of funding of activities for the program for the next fiscal year. The National Park Service will finance all costs of the program other than salaries. Those costs that agencies have previously agreed to will be reimbursed upon billing by the National Park Service on a quarterly basis.

The study team, in the conduct of the study, will abide by all State and Federal regulations and policies with regard to the land upon which they are working and the species with which they are working. It shall be the responsibility of the team leader to ensure conformance and to keep all land managers fully informed of their activities.

It shall be incumbent upon the Chairman of the Steering Committee to keep all participating Federal and State agencies fully apprised of the progress of the work and the problems needing solutions, the budgetary support and logistical requirements, and the accomplishments.

For the purposes of the study, the Chairman of the Steering Committee shall report directly to the Assistant Secretary for Fish and Wildlife and Parks, USDI.

We agree that:

1. Publications may be joint or independent as may be agreed upon, always giving due credit to the cooperation and recognizing proper rights of individuals doing the work. In the case of failure to agree as to manner of publication or interpretation of results, any party may publish data after due notice and submission of the proposed manuscripts to the other. In such instances, the party publishing the data will give due credit to the cooperation but assume full responsibility for any statements on which there is a difference of opinion.

2. Disposal of equipment, materials, and property of any kind purchased wholly from funds provided by the Interagency Committee and not consumed on the project shall be negotiated at the conclusion of the agreement.

3. This agreement may be terminated by any party by giving 90 days' notice in writing.

4. Nothing herein shall be construed as obligating any agency to expend or as involving the United States in any contract or other obligation for the future payment of money in excess of appropriations authorized by law and administratively allocated for this work.

MAY 7 1974

John R. McGuire
Chief, USDA, Forest Service

MAY 1 1974

Lynn A. Greenwalt
Director, Bureau of Sport Fisheries and Wildlife

[illegible]

Ronald M. Walker
Director, National Park Service

Enclosures: (8)
Interagency Grizzly Bear Study Team

Interagency Grizzly Bear Study Team
Yellowstone Ecosystem Workplan for
1974 Field Season

This plan is keyed to the objectives of the study team as attached.

HABITAT CONSIDERATIONS:

1. An inventory will be made of physical characteristics of areas where bears are known to occur. The emphasis during 1974 will be in areas adjacent to Yellowstone National Park where land use impacts are anticipated in the near future.

2. A search of areas in the Custer, Gallatin and Shoshone National Forests around the periphery of the study area to determine the extent of occupied grizzly bear habitat will be made.

3. Spawning streams tributary to Yellowstone Lake, their physical characteristics, dates of spawning runs, and their use by grizzly bears will be inventoried.

4. All team members will collect data on habitat where bears occur. Each observation of grizzly bear or grizzly bear sign will include a habitat description as a part of the observation description.

5. Grizzly bear interactions with recreational users will be documented in the Gallatin Range as part of a cooperative project with Montana State University designed to document Human-wildlife interactions in Yellowstone Park.

6. Initial contacts will be made with livestock operators to initiate investigations into grizzly bear livestock interaction.

POPULATION CONSIDERATIONS:

Aerial Observations

1. Low-level flights: Yellowstone Ecosystem will be divided into sampling units. Each sample unit will be designated with boundaries recognizable from the air.

Prior to each flight, the sample units to be covered will be chosen at random.

Flights will be made as often as weather, budget considerations, and fuel availability will permit during times when the maximum numbers of bears will be visible.

During each flight, each bear observed will be classified according to age, sex, location and activity at time of sighting as far as possible. Exact locations will permit classification of habitat for each observation by comparison with vegetation maps and by on-the-ground sampling. Each bear will also be photographed in an attempt to recognize as many individuals as possible. Preliminary trials during the 1973 field season indicated that a movie camera gives the best results.

2. High-level flights: Preliminary negotiations are underway with the Department of Defense to use high level military reconnaissance planes and high resolution films in attempts to photograph grizzly bears in the Yellowstone Ecosystem area. No details are available at this time. Preliminary habitat maps will be constructed with the aid of EROS data.

Ground Observations

1. Bait Stations: Bait stations are locations where a substance attractive to bears is set out and some method is used to record visitation by bears.

Bait stations will be set out in areas where vegetation and terrain make other means of observation difficult and where chance of discovery by human visitors is at a minimum. In each area, baits will be placed and visitations recorded by: time lapse movie cameras (one per area), trip set cameras (one or two per area), and by track beds (number to be determined by nature of terrain and time allowed for preparation.)

2. Field Observation Routes: Routes on the ground will be traveled throughout the field season as time permits.

All bears and signs of bears will be recorded in the course of reconnaissance routes. Distances traveled in various habitat types will also be recorded. Routes will sample areas characterized by good aerial visibility as well as areas where aerial visibility is at a minimum.

3. Monitoring System: A system will be established to report all grizzly bears sighted and all grizzly bear mortality in the Yellowstone ecosystem. All reports in this system will be evaluated and appraised by the team as a whole with final evaluation being the responsibility of the team leader.

TROPHIC ECOLOGY:

1. A graduate study on grizzly bear food habits was set up with Montana State University in 1973 and will continue through the 1974 field season. Examinations will be made of grizzly bear feeding sites. Scats will be collected and analyzed. Determinations will be made of caloric value of major food items and efficiency of conversion of major food items.

2. Feeding site examinations will be made by all members of the team as opportunity permits. All team members will collect grizzly bear scats as they are encountered.

3. The use of spawning trout by grizzly bears will be evaluated.

GRIZZLY AUTOPSY

1. All grizzly bear carcasses will be autopsied to determine insofar as possible cause of death and other vital statistics pertinent to the objectives of the study.

2. All grizzly bear carcasses obtained will be examined for parasites and disease by the Montana Fish and Game Department Wildlife Laboratory.

GRIZZLY BEAR STUDY TEAM

The Grizzly Bear Study Team consists of research biologists from the National Park Service, Fish and Wildlife Service and U.S. Forest Service cooperating closely with biologists from the States of Wyoming, Montana, and Idaho. Field investigations will be carried out in the Yellowstone ecosystem. Field investigations by Federal team members are supervised by the National Park Service biologist who also coordinates the team's efforts with State biologists. Chief Coordinator for the Federal members of the team is the Chief Scientist, National Park Service. The team's primary objective is to carry out an investigation into the ecology of the Grizzly Bear from which management can be based to insure its preservation and enhancement in the Rocky Mountain Region. Specific objectives for the team have been outlined by representatives of the three Federal agencies involved at a meeting in Washington, D.C., on December 14, 1973, as follows:

I. Habitat Consideration

- A. Evaluation and Analysis
- B. Extent
- C. Land Use Impacts
  1. Recreation
  2. Livestock Management
  3. Timber Management
  4. Non-Recreational Development
  5. Weather Modification
  6. Wildlife and Fishery Management
  7. Agriculture
  8. Fire Management

II. Population Considerations

- A. Population Numbers
- B. Distribution
- C. Population Trends
  1. Mortality
     - a. Natural Causes
     - b. Non-Natural Causes
  2. Natality
  3. Sex and Age Structure
- D. Behavior
  1. Migrations and Movements
  2. Social

III. Trophic Ecology

A. Food Habits
B. Food Chain Relationships and Nutrient Cycling
C. Interspecific Competition
D. Intraspecific Competition

IV. Parasites and Disease

PROJECTED WORK SCHEDULE IN RELATION TO OBJECTIVES

Objective	Initial Effort	Intensity of Effort* 1974	75	76	77	78	79	80	81	82	83	Comp.
IA	1974	1	1	1	1	2	2	2	3	3	3	1983
B	1974	3	3	3	2	1	1					1979
C1	1974	3	3	3	4	4	4	4	4	4	4	1983
2	1975	2	1	1	1	1	1	2	3			1981
3	1974	1	1	1	1	1	1	1	3	3	3	1983
4		4	4	4	4	4	4	4	4	4	4	
5		4	4	4	4	4	4	4	4	4	4	
6		4	4	4	4	4	4	4	4	4	4	
7		4	4	4	4	4	4	4	4	4	4	
8		4	4	4	4	4	4	4	4	4	4	
IIA	1974	1	1	1	1	1	3	3	3	3	3	1983
B	1974	2	2	2	2	2	2					1979
C1	1974	3	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	1983
2	1974	1	1	1	1	1	1	1	1	1	1	1983
3	1974	1	1	1	1	1	1	1	1	1	1	1983
D1	1974	2	2	1	1	1	2					1979
2	1974	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	1983
IIIA	1974	1	1	3	3	3	3	3	3	3	3	1983
B	1974	2	2	1	1	1	1	1	3	3		1982
C	1974	3	3	3	3	3	3	3	3	3	3	1983
D	1974	3	3	3	3	3	3	3	3	3	3	1983
IV	1974	3	3	3	3	3	3	3	3	3	3	1985

(MORE)

* Intensity of Effort

1. Primary emphasis or effort; procedures contributing toward these objectives will be carried out on a first priority basis.
2. Secondary emphasis or effort as permitted by primary emphasis.
3. Minimal effort, monitoring or acceptance of opportunities to collect data.
4. Insufficient knowledge to schedule at this time or dependent upon events that are now unscheduled.