Bear Biology Association Monograph Series No. 1

A Proposed Delineation of Critical Grizzly Bear Habitat in the Yellowstone Region

by
John J. Craighead

Monograph presented at the Fourth
International Conference on Bear Research
and Management

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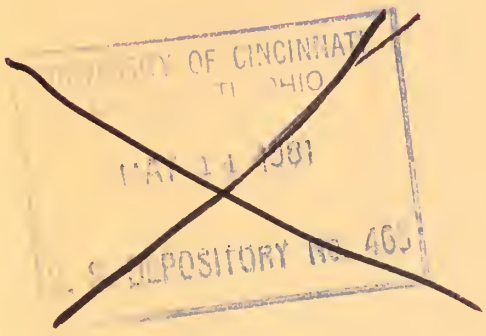

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FRONTISPIECE. Survival of the grizzly bear in the Yellowstone ecosystem is dependent on preservation of habitat, enlightened management, agency cooperation, public understanding, and freedom to conduct objective research. The price for survival will be constant citizen concern and scientific vigilance.

A PROPOSED DELINEATION OF CRITICAL GRIZZLY BEAR HABITAT IN THE YELLOWSTONE REGION[1]

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CONTENTS

[1]Sponsored jointly by the University of Montana, U.S. Fish and Wildlife Service, and the Wildlife Management Institute, Cooperating.

INTRODUCTION

The Purpose of the Endangered Species Act of 1973 is to perpetuate threatened and endangered species and, where possible, to extend their populations. On 1 September 1975, the grizzly bear (*Ursus arctos horribilis*) was listed as "Threatened" south of the Canadian Border. Thereby, all Federal Agencies conducting land management programs were required to prevent destruction or adverse modification of critical grizzly bear habitat. Critical habitat determination involved delineating an area essential for the survival and recovery of the species. Federal Rules published 22 April 1975 defined critical habitat as the entire habitat or any portion of it necessary to meet the nutritional and spatial needs of the species. It must provide for specific physical, seasonal, and behavioral requirements, as well as assure specialized sites for breeding, reproduction, and shelter.

Most of the currently occupied range of the grizzly bear has been recommended for designation as critical habitat, following professional and agency recommendations. A proposed rule-making, delineating critical grizzly bear habitat in the contiguous 48 states, was published in the Federal Register on 6 November 1976; public hearings that followed indicated widespread public and agency opposition. The opposition was due, in part, to alleged economic, social, and jurisdictional conflicts and to a lack of sound scientific data corroborating the delineation.

The extensive land areas proposed by the U.S. Fish and Wildlife Service as habitat for the grizzly bear's survival constitute four regions totalling about 13 million acres, as follows:

(1) The conterminal region of Wyoming, Montana, and Idaho in Yellowstone National Park and adjacent areas, including parts of Custer, Shoshone, Teton, Targhee, Beaverhead, and Gallatin National Forests and part of Grand Teton National Park;

(2) Northwestern Montana in Glacier National Park; the Bob Marshall Wilderness Area; most of the Flathead National Forest and adjacent areas, including parts of the Lewis and Clark, Helena, and Lolo National Forests; and small parts of the Blackfeet and Flathead Indian Reservations;

(3) Extreme northwestern Montana and northern Idaho in the Cabinet Mountains and largely, in the Kootenai, Kaniksu, and Lolo National Forests;

(4) Extreme northern Idaho and northeastern Washington, largely in the Kaniksu National Forest.

This initial step, taken by the Endangered Species Section of the U.S. Fish and Wildlife Service to broadly define critical habitat, essentially delineated habitat known to be occupied by grizzly bears. Occupied habitat means that grizzly bears or their sign have been observed in an area. It may or may not be habitat required by the species to satisfy biological needs. Thus, it may or may not be critical habitat.

The next step must be to refine the boundaries of these land areas with more definitive data on bear distribution, habitat use, and spatial requirements and to specifically identify areas of prime habitat where competititve land uses exist. Scientific information for habitat delineation is available for the Yellowstone area.

Thus, the first objective of this paper is to specifically designate critical habitat within the Yellowstone region through (1) observations of marked grizzly bears, (2) movements and distribution data derived from the place of death of marked and unmarked animals, and (3) analysis of spatial and habitat needs of the species. The second objective is to document competition between grizzly bears and man for the same habitat.

Various aspects of grizzly bear habitat south of Canada have been described by Shaffer (1971), Craighead and Craighead (1972), Sumner and Craighead (1973), Varney, Craighead, and Sumner (1974), Mealey (1975, 1976), Roop (1975), U.S. Forest Service (1975), and Craighead, Sumner, and Varney (1976). This literature deals with habitat surveys, establishing criteria for evaluating habitat, developing habitat rating systems, habitat typing and mapping techniques, distribution and occurrence of plant foods, and relating food habits of grizzly bears to habitat types and generalized vegetation complexes. The results of these and future studies will eventually provide the data needed for description and evaluation of bear habitat in terms of the nutritional requirements of the species.

In the Yellowstone area, a considerable biological basis has already been established for describing and evaluating spatial requirements of grizzlies (Craighead 1976), breeding behavior and reproductive biology (Craighead, Hornocker, and Craighead 1969), reproductive rates (Craighead, Craighead, and Sumner 1976), shelter and denning (Craighead and Craighead 1972), population size and structure (Craighead, Var-

ney, and Craighead 1974), food habits (Mealey 1975; Craighead in prep.) and occupied habitat (Knight et al. 1975, 1976).

METHODS

In Yellowstone National Park and adjacent areas, 277 grizzly bears were captured using traps or tranquilizer darts, individually color-marked, and released during the 12-year period from 1959 through 1971. In addition, 23 individual bears were radio-tagged. The color marking, instrumenting, and radiotracking techniques have been described by Craighead et al. (1960, 1961, 1963), Craighead and Craighead (1965), and F. C. and J. J. Craighead (1971). Sight records, movements, radio-fixes, and death records of these individually recognizable bears were recorded and mapped. Sightings and death records of unmarked bears were also mapped. The accumulated observations served as the data base for delineating critical habitat. Only confirmed death records of marked and unmarked grizzlies were considered (Craighead, Varney, and Craighead 1974). Home and seasonal ranges of grizzly bears were determined using the techniques described by Craighead et al. (1973) and Craighead (1976).

Major vegetation types used by grizzly bears were established by analyzing vegetation ground truth data by means of LANDSAT multispectral imagery and computer-assisted technology (Craighead, Sumner and Varney 1976). Data on land use and practices modifying or altering grizzly bear habitat in the Yellowstone region were obtained through interviews with stockmen and from U.S. Forest Service records of livestock allotments and logging operations.

Delineating critical habitat consisted, first, of defining a geographic area used by grizzlies; second, of describing spatial requirements, habitat, and habitat use within the area; and third, of identifying and comparing conflicting uses that modified or degraded the habitat for the species.

MOVEMENT, DISTRIBUTION, AND MORTALITY OF GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM

It was thought that data on movement, distribution, and mortality of grizzly bears would provide the information required to delineate critical habitat. Accordingly, data for these biological parameters were analyzed and the results reported.

Movement of Color-Marked Grizzlies

Casual sight records are acceptable as a means of roughly determining occupied habitat, but because they reveal little as to movement or habitat use by grizzly bears and are subject to identification error, they are weak criteria for delineating habitat crucial for the species. In this paper, critical habitat is interpreted to mean heavily used, essential habitat — i.e., habitat where the grizzly satisfies major biological requirements. For this purpose, sightings of marked bears by field biologists provide more rigid scientific evidence than do casual observations of unmarked bears.

Records of movement (radio-instrumented bears excluded) are based on 203 observations of color-marked bears made throughout Yellowstone National Park and adjacent areas from 1959 through 1974. A sighting of an identified marked bear 5 miles or more from a site of original marking or of previous observation constituted an observed movement. Movement from point A to B implies use of the intervening space; therefore, the distribution of a large number of observations identifies occupied habitat. A total of 171 natural movements were recorded for bears marked at Trout Creek, 20 for Rabbit Creek bears, 6 for Gardiner bears, and 6 for bears marked at West Yellowstone (Fig. 1). Of the observations of Trout Creek bears, 70

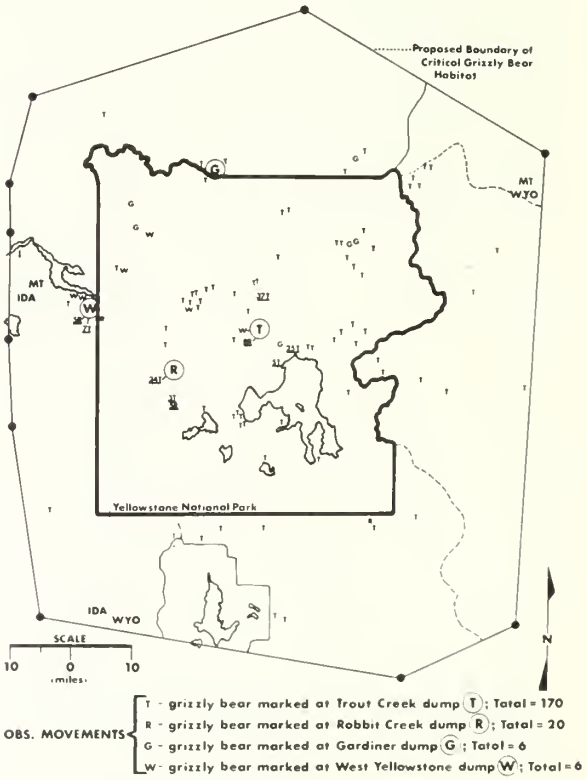

Fig. 1. Individual natural movements of grizzly bears in the Yellowstone ecosystem (proposed boundary of critical grizzly bear habitat), 1959-74.

were made in the backcountry, while 101 were in campgrounds or developed areas (25 at Lake, five at Bridge Bay, 37 at Canyon, three at Old Faithful, 24 at Rabbit Creek, and seven at West Yellowstone). Similarly, of the bears marked at Rabbit Creek, eight were observed at Trout Creek, five at West Yellowstone, five at Old Faithful, and two in the backcountry. These and other observations indicate that considerable movement occurred between the open pit garbage dumps and between the dumps and developed areas of the Park. However, most of the movement into the developed areas occurred in 1968-70 following closure of the dumps (J. J. Craighead and F. C. Craighead 1971). The movement was greatest between Trout Creek and Canyon and nearly equal between Trout Creek and Lake and Trout Creek and Rabbit Creek. Before closure of the dumps, an average of six grizzly bears became campground foragers each year and as such, constituted a problem, but not a serious threat. After the dump closures, however, nearly four times as many grizzly bears (23) became campground foragers annually (J. J. Craighead and F. C. Craighead 1971). Such a large number of bears represented a serious problem for the National Park Service and a threat to Park visitors. The bears developed campground foraging habits during spring and fall when they crossed campgrounds and developed areas in search of food. However, many of these same marked bears, as well as radio-tagged bears, traveled into the Park backcountry and to the adjoining national forests in the fall (Craighead 1976).

The aggregation of bears at the open pit garbage dumps evolved gradually over many decades until movement to those areas became traditional. Originating from both outside and inside the park, travel patterns became so strongly established that movements of individual bears were predictable from year to year (J. J. Craighead and F. C. Craighead 1971). All movement data (J. J. Craighead and F. C. Craighead 1971; Craighead and Craighead 1972; and Craighead 1976) strongly supported the concept that the Yellowstone region was inhabited by a single population of grizzlies that moved freely throughout the ecosystem. Most members of the population visited one or more of the open pit dumps over a period of years. Some were chronic visitors, others occasional. There was no substantial evidence for a hypothesis of two separate populations, one garbage-oriented and one "backcountry" (G. F. Cole, personal communication). On the contrary, long-term census data at the dumps and in the backcountry, and an analysis of the dynamics of the Yellowstone population (Craighead, Varney, and Craighead 1974), showed a census efficiency of 77% for an ecosystem population of between 222 and 245 grizzlies.

Similarly, movement of marked bears from sites of capture to distant parts of the Park supported the concept of a single population of naturally free-roaming members (Fig. 1). The bears marked at Gardiner tended to occupy the Lamar Valley and Mirror Plateau to the east and, along with West Yellowstone bears, the Electric Peak-Swan Pass country to the west. Bears marked at Rabbit Creek were not sighted in the Park backcountry, but moved frequently between the West Yellowstone and Trout Creek areas. Those bears marked at Trout Creek, the geographic center of the Park, were sighted throughout the Park. The data indicate that grizzlies utilizing the open pit dumps were free-ranging animals, and that, as a population, they utilized the entire Park and were not garbage-addicted aberrants. Traditional movements to the dumps were comparable to movements of Alaskan brown bear (*Ursus arctos middendorfii*) to salmon streams (Craighead et al. 1960) and were not behavioral constraints on freedom of movement. Knight et al. (1975) and Mealey (1975) assumed that grizzlies utilizing the open pit dumps did not move freely into the backcountry, but were confined to the dump areas, and further, that once the dumps were closed, all grizzlies became "free-ranging" (to quote their terminology). Such misunderstanding of home range concepts and bear movements has retarded bear management and has confused attempts to delineate critical habitat for the species in the Yellowstone area.

The movement data (Fig. 1) show that grizzly bears marked within Yellowstone National Park, or immediately adjacent to it at Gardiner and West Yellowstone, moved into the adjoining national forests. Marked animals were observed and recognized in four national forests (Table 1). Twelve grizzly bears marked

Table 1: Movements of Grizzly Bears in National Forests Adjacent to Yellowstone National Park, Based on Observations of Marked Animals, 1959-74.

Original Marking Site	National Forests Where Sighted				
	Shoshone	Gallatin	Targhee	Teton	Total
Trout Creek	12	13	2	6	33
Rabbit Creek	0	0	5	1	6
West Yellowstone	0	2	0	0	2
Gardiner	0	1	0	0	1
Total	12	16	7	7	42

at Trout Creek were observed in the Shoshone National Forest. The maximum movement was 46 airline miles (74 km). Similarly, 13, 2, and 6 bears marked at Trout Creek were observed in the Gallatin, Targhee, and Teton National Forests, respectively. Maximum movements of 44, 45, 49, and 54 airline miles (70, 72, 78, and 86 km) were recorded. Among bears marked at Rabbit Creek (Fig. 1), five were observed in Targhee National Forest and one in Teton National Forest. Two bears marked at West Yellowstone and one marked at Gardiner were observed in the Gallatin National Forest. Of marked bears sighted outside Yellowstone Park, 67% were in the Shoshone and Gallatin National Forests, an indication that portions of these two forests are important habitat for grizzlies.

Movements of Marked Grizzly Bears Determined from Kill Records

Two categories of information were obtained from kill records of marked and unmarked animals: movement of marked animals from place of capture to place of death and presence of an unmarked animal at a specific geographic location at the time of death. Of 277 color-marked grizzly bears, there were 137 known

Table 2: Numbers and Relative Percentages of 277 Grizzly Bears Marked at Four Locations, 1959-71.

Marking Site	Number Marked	Percent of 277 Marked
Trout Creek	224	80.9
Rabbit Creek	16	5.8
West Yellowstone	26	9.4
Gardiner	11	4.0
Total	277	—

mortalities; 79 were killed within Yellowstone Park, while 58 were killed outside the Park. The deaths of 35 (15.6%) of 224 bears marked in the Trout Creek area were recorded in the five adjoining national forests. Among 57 of 58 marked animals that died outside the boundaries of Yellowstone National Park, 29 (51%) of varied age and sex died in the Gallatin National Forest alone (Table 3; Fig. 2). Though all four marking locations were represented, most of these bears were from the Trout Creek area and from West Yellowstone. Six of the 29 deaths occurred immediately following transport and release, but even if these are omitted, the data show major movements from the Park into the Gallatin and Shoshone National Forests. Heavy use by bears of these two National Forests can be inferred from the large number of deaths that occurred there. The remaining 28 bears that died in the other four national forests had all been marked at Trout Creek.

Clearly, the movement of grizzly bears from the original marking sites was massive and extensive (Fig. 2). Airline distances from locality of marking to site of death were as great as 54 miles (86 km); the seven greatest distances recorded ranged from 45 to 54 miles (72 to 86 km) and averaged 50 miles (80 km).

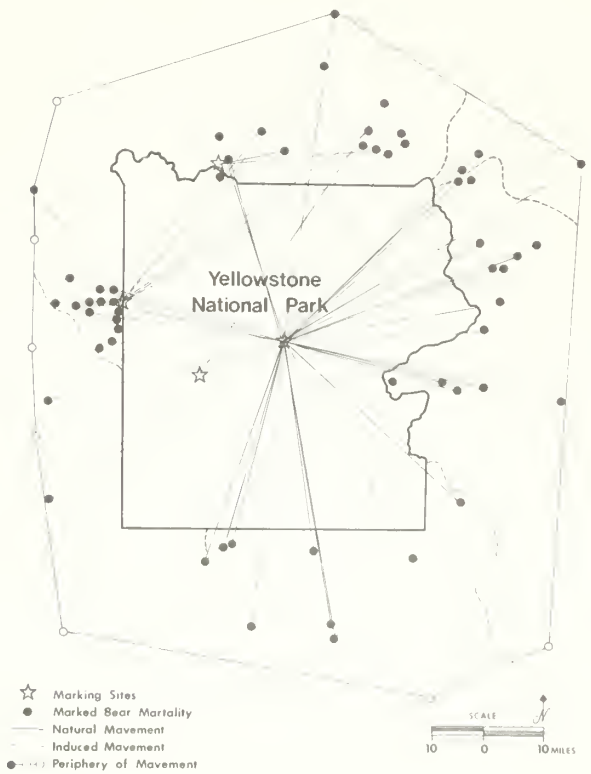

Fig. 2. Movements of marked grizzly bears from marking sites to localities of death.

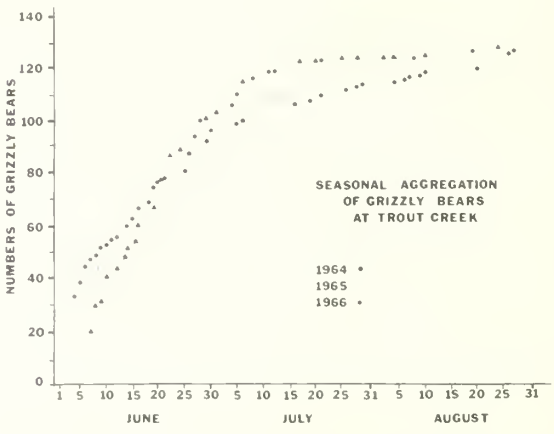

Fig. 3. Seasonal aggregation of grizzly bears at Trout Creek (numbers observed daily from 1 June - 31 August, 1964-66).

Table 3: Number of Bears that Died in National Forests Adjacent to Yellowstone National Park, 1959-74.

Marking Site	National Forest Where Death Occurred					Total Deaths	
	Shoshone	Custer	Gallatin	Targhee	Teton	Number	Percent
Trout Creek	13	3	9 (1)*	2	9	36	63.2
West Yellowstone			16 (5)*			16	28.1
Rabbit Creek			1			1	1.8
Gardiner			2			2	3.5
Unknown	1		1			2	3.5
Total	14	3	29	2	9	57	—
Relative Percent of Deaths	24.6	5.3	50.9	3.5	15.8	—	—

( )* Numbers in parentheses refer to bears dying following "induced" movements from sites to which they had been artifically conveyed

Census data (Craighead, Varney, and Craighead 1974) showed that much of the movement between the Park and the national forests was seasonal. The summer aggregation of grizzly bears at Trout Creek (Fig. 3) also strongly supports a seasonal movement of grizzlies from within and outside the Park.

I conclude from the movement data that both the Park and the adjoining national forests contain habitat components essential to the Yellowstone grizzly bear population and that many animals seasonally and annually use land areas both within and outside the Park.

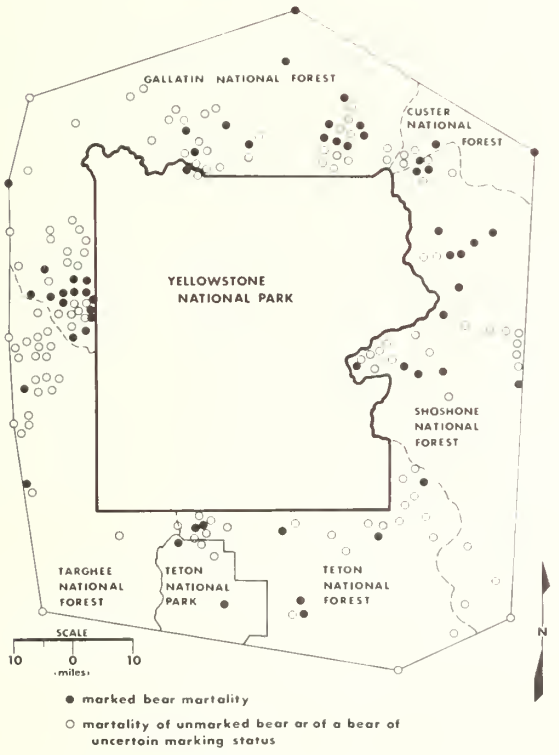

Fig. 4. Proposed Yellowstone ecosystem (critical grizzly bear habitat) as delineated by distribution of marked and unmarked grizzly bears that died outside of Yellow-stone National Park, 1959-74.

Distribution of Marked and Unmarked Grizzly Bears Outside Yellowstone National Park Determined from Kill Records

Among 228 deaths of grizzly bears recorded in national forests outside Yellowstone Park in 1959-74, the place of death was known for 180 or 78.9% (Table 4; Fig. 4). The geographic distribution of these deaths was relatively unbiased by time and effort, and was hypothesized to be random.

The known sites of death for 123 unmarked bears coincided reasonably well in terms of distribution with the sites of death recorded for 57 marked bears, as

Table 4: Number of Grizzly Bear Mortalities, by Year, in the National Forests Adjacent to Yellowstone National Park, 1959-74.

Year	Total Deaths	Category of Bears Found Dead		
		Marked	Unmarked	Unknown*
1959	4	1	3	0
1960	16	2	14	0
1961	12	5	7	0
1962	5	2	3	0
1963	6	2	4	0
1964	4	4	0	0
1965	8	4	4	0
1966	9	2	6	1
1967	32	1	4	27
1968	9	1	4	4
1969	11	2	9	0
1970	27	5	14	8
1971	40	19	3	18
1972	17	2	9	6
1973	15	1	0	14
1974	13	5	6	2
Total	228	58**	90	80

* Designation as marked or unmarked not established.

** Place of marking for one of the 58 bears was unknown and does not appear on Figure 2.

Table 5: Location of Marked and Unmarked Bear Mortalities in National Forests Adjacent to Yellowstone National Park, 1959-74.

National Forest	Total Bear Mortalities		Percent of Total That Were Unmarked	Mortalities by Category			
				Unmarked		Marked	
	Number	Percent		Number	Percent	Number	Percent
Shoshone	39	21.7	64.1	25	20.3	14	24.6
Custer	6	3.3	50.0	3	2.4	3	5.3
Gallatin	78	43.3	62.8	49	39.8	29	50.9
Targhee	26	14.4	92.3	24	19.5	2	3.5
Teton	31	7.2	71.0	22	17.9	9	15.7
Total	180	—	—	123	—	57	—
(Percent of Total)	(100.0)	—	—	(68.0)	—	(32.0)	—

described earlier (Table 5; Fig. 4). The greatest number of deaths of marked and unmarked animals combined (43.3%) occurred in the Gallatin National Forest to the west and north of Yellowstone Park. The high total would be expected for three reasons: proximity of the Forest to the West Yellowstone marking site; extensive movement of grizzlies out of the Park into the Forest (Fig. 2); and because the Forest shares the longest border with the Park. Percentages of total deaths in the other national forests were as follows: Shoshone, 21.7%; Teton, 17.2%; Targhee, 14.4%; and Custer, 3.3%. The percentage of total unmarked bear deaths (19.5%) compared to percentage of total marked bear deaths (3.5%) in the Targhee National Forest indicated a relatively small movement of marked animals into this area. The possibility also existed that some marked bears were killed by ranchers on livestock range in this Forest, but were not reported as marked.

Trout Creek, lying near the geographic center of the Park, was visited by bears from all parts of the ecosystem. If Yellowstone national Park and adjacent areas are quartered by bisecting Trout Creek from east to west and from north to south, the distribution of deaths of marked bears is dissimilar for each quadrant. This distribution of deaths reflects the established bear movement pattern from the Trout Creek marking site to the Gallatin and Shoshone National Forests. However, if the total number of deaths (both marked and unmarked bears) are compared for each quadrant, they prove to be extremely similar, with the exception of the northwest quadrant (Table 6; Fig. 4).

The proportion of all deaths by north-south halves and east-west halves (Table 7) is also similar, suggesting uniform use of these large geographic areas and thus, equal importance value for the ecosystem population of grizzlies. It can be safely concluded that those portions of the national forests surrounding the Park and lying within the outer perimeter shown in Figure 4 are not simply occupied habitat, but are geographic land areas critical to the spatial and biological needs of the grizzly bear in the Yellowstone area and therefore, can be designated as critical habitat.

The boundaries of the outer perimeter (Fig. 4) are as follows: from the SW corner west of the Targhee National Forest at Felt, Idaho, NW to a point SW of Island Park; north to the most westerly extension of Hebgen Lake near Rock Creek; NE to a point on Beaver Creek west of Hwy. 191 in Montana; NE across Hwy. 191 to a point at the intersection of the Park and Sweet Grass county lines just NE of Fourmile Guard Station; SE across the Custer National Forest to a point near the Beartooth Plateua north of Lonesome Moun-

Table 6: Distribution, by Quadrant, of Bear Mortalities Occurring Outside Yellowstone National Park, 1959-74.

Quadrant*	Marked Bears		Unmarked Bears		Total Bears	
	Number	Percent	Number	Percent	Number	Percent
Northwest	18	31.6	38	30.9	56	31.0
Northeast	20	35.1	21	17.1	41	22.8
Southwest	8	14.0	31	25.2	39	21.7
Southeast	11	19.3	33	26.8	44	24.4
Total	57	—	123	—	180	—

*Based on a north-south line intersecting an east-west line at Trout Creek, near the geographical center of Yellowstone National Park.

Table 7: Distribution, by Two-Quadrant Sectors, of Bear Mortalities Occurring Outside Yellowstone National Park, 1959-74.

	Marked Bears		Unmarked Bears		Total Bears	
Sector*	Number	Percent	Number	Percent	Number	Percent
North	38	66.7	59	48.0	97	53.9
South	19	33.3	64	52.0	83	46.1
Total	57	100.0	123	100.0	180	100.0
East	31	54.4	54	44.0	85	47.2
West	26	45.6	69	56.0	95	52.8
Total	57	100.0	123	100.0	180	100.0

*Based on combined values for quadrants (see Table 6) in north-south and east-west halves of the Yellowstone ecosystem.

tain; SE to the most easterly point south of Dead Indian Creek and north of Trout Peak, Wyoming; south to a point at East Fork Creek east of Shoshone Plateau in the Teton National Forest; SW to Togwotee Pass on Hwy. 287; and NW to the point of origin at Felt.

Grizzly Bear Mortalities Within Yellowstone National Park

A total of 146 man-caused mortalities were recorded in Yellowstone National Park from 1959 through 1974, of which 79 were marked (Table 8). Most of these mortalities were the result of control measures at campgrounds and at open pit dumps and developed areas. These deaths clearly show that Yellowstone Park is not an inviolate sanctuary for the grizzly. Severe conflicts occur between bear and man for the same habitat in areas where both grizzlies and visitors have traditionally concentrated.

Table 8: Number of Grizzly Bear Mortalities, by Year, in Yellowstone National Park, 1959-74.

		Category of Bears Found Dead	
Year	Total Deaths	Marked	Unmarked
1959	8	5	3
1960	8	5	3
1961	9	7	2
1962	10	5	5
1963	9	5	4
1964	8	4	4
1965	7	4	3
1966	4	3	1
1967	11	7	4
1968	12	6	6
1969	12	7	5
1970	26	8	18
1971	8	6	2
1972	10	5	5
1973	2	1	1
1974	2	1	0
Total	146*	79	66

* Total includes the 1974 mortality of one bear of unknown marking status.

Distribution of Grizzly Bears in Yellowstone National Park

Although the distribution and movements of grizzlies within and beyond the Park borders have been discussed, a comparison of past and present distribution of grizzly bears in Yellowstone National Park is necessary to evaluate critical habitat and competition between bear and man for the same space. After the abrupt closure of open pit dumps (with the exception of one at Cooke City, Montana), great stresses were placed on the bear population. The stresses and their effects were discussed by J. J. and F. C. Craighead (1971), Craighead, Varney, and Craighead (1974), and Craighead, Craighead and Sumner (1976).

The density-distribution pattern of grizzly bears plotted by the author prior to the closure of the open pit dumps in 1968 was also representative of the major summer concentrations of grizzlies from 1959 through 1967 (Fig. 5). A comparison of the data of Knight et al.

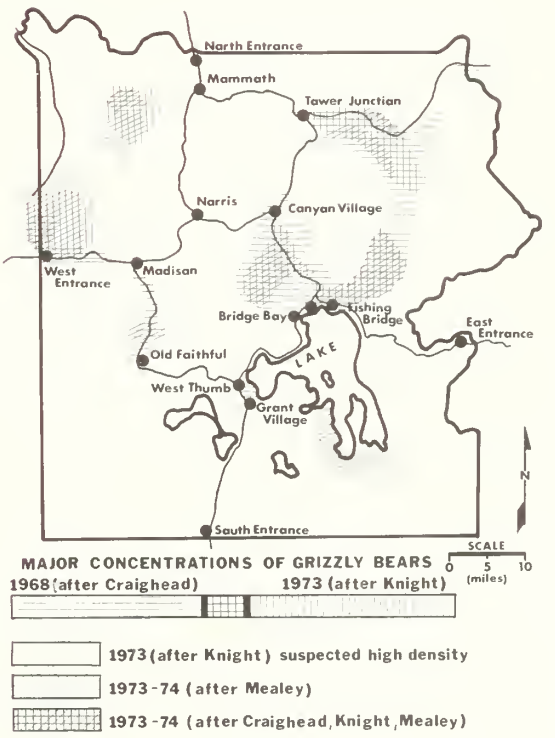

Fig. 5. Comparative distribution of grizzly bears in the Yellowstone National Park (1968 and 1973).

(1975) and Mealey (1975) with my data for 1968 showed no important change in the concentration distribution of grizzly bears within the Park. The major summer concentrations were still in the Hayden Valley between Bridge Bay and Canyon Village; in the Pelican Valley northeast of Fishing Bridge; in the Lamar Valley and Mirror Plateau area east of Tower Junction; in the Swan Pass and Mt. Holms area to the west of Mammoth; and in the area of the west entrance to Yellowstone Park. An apparent decline along the Firehole river between Madison Junction and Old Faithful may have been due to lack of investigative effort in 1973-74 (R. R. Knight, personal communication, 1976) rather than to an actual change in the distribution patterns. A suspected increase in bear numbers at the south end of Yellowstone Lake (Knight et al. 1975) may have been a real response to natural foods in the area, especially fish. Bear sign was observed in this area in earlier years, but few bears were seen and the area was not considered to be a major concentration site. The Cooke City, Montana dump was considered a minor concentration site from 1959 to 1970, but this dump was never closed. It was not considered a concentration site by Knight, although Greer trapped and instrumented five grizzlies there (Knight et al. 1976). Leaving this dump open for trapping purposes will attract an ever increasing number of animals. The area could rapidly develop into a major concentration center for grizzlies, defeating the original purpose of closing the open pit dumps.

Little major change has been demonstrated in the grizzly bear concentrations from 1968 through 1974. Therefore, Park management actions to disperse bears from the established concentration sites and nearby developed areas of the Park were apparently unsuccessful. Thus, habitat occupancy was not altered importantly, although more intensive use of the habitat for foraging no doubt occurred. Distribution data presented by (Knight et al. 1976) indicated that the situation had changed little by 1975. Local changes probably occur from year to year in response to food availability and there may be population shifts between the long-established high density sites; however, the geographic areas where grizzlies concentrated in summer prior to dump closures are still attracting and holding bears. Because those areas originally provided suitable breeding sites and natural food augmented from the open pit dumps and campgrounds, such stability of distribution was predictable. Although the dumps have been closed, the other attractions — including established home ranges — still exist. If, indeed, little change has occurred in the major concentration patterns of bears during a 6-7 year period after the dump closures, then competition between bear and man for the same space is still acute in some of the developed areas of the Park. An examination of the Park's log books recording grizzly bear visits to the Yellowstone Lake campgrounds and developed areas in 1971-73 showed a substantial increase in grizzly visitations (F. C. Craighead, personal communication, 1976). Unfortunately, logs for the Old Faithful district and other areas have been withheld because of litigation against the National Park service in the case of Harry E. Walker vs. The United States of America. Until all Park logs are available for analysis, it will be difficult to evaluate competition between bear and man for the same space. Current, but incomplete, evidence suggests that competition is still acute in many of the developed areas of the Park.

ECOLOGICAL REQUIREMENTS OF GRIZZLY BEARS

The ecological requirements of the grizzly bear are

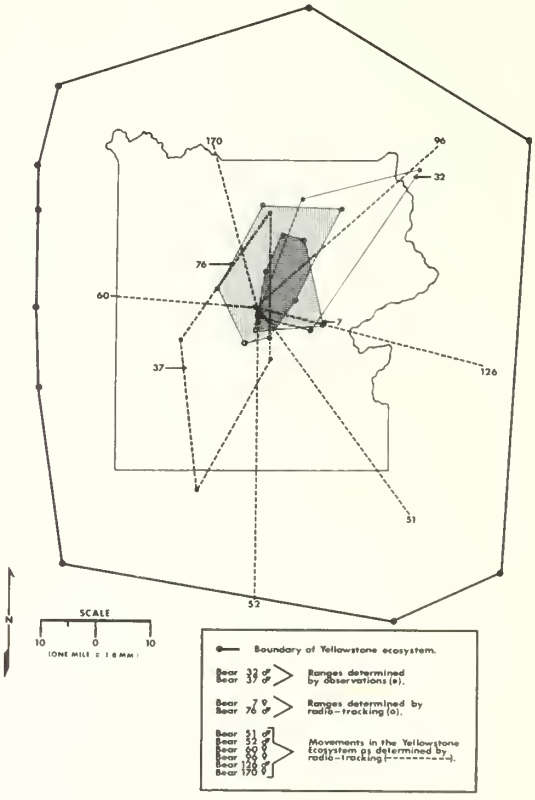

Fig. 6. Examples of home and seasonal ranges and movements of grizzly bears in the Yellowstone ecosystem, illustrating the extensive spatial requirements of the species (refer also to Table 9).

varied and complex. They must meet the biological demands of the species' omnivorous feeding habits, its complex population and social interactions, winter denning, and its aggressive intra- and inter-specific behavior. Spacious habitat, with landforms and vegetation types providing varied seasonal foods in stable to periodic abundance, is essential to its welfare and survival.

Spatial Needs

The grizzly bear in the Yellowstone area is a mobile, wide-ranging animal that establishes seasonal and home ranges, but exhibits little or no territoriality. Ranges vary greatly in area, depending on the sex and age of the animal, seasonal and annual food availability, reproductive condition of females, and other factors (Craighead 1976). The spatial needs of individual animals are great and must be considered in delineating essential or critical habitat. Radiotracking confirmed that some animals had seasonal ranges connected by migratory corridors (Table 9; Fig. 6). Male bears 51, 52, and 60, and female 96, which were instrumented at Trout Creek, had summer ranges in Hayden Valley and fall ranges and denning sites outside the Park. Male 60 and female 96 traveled 28 and 40 airline miles (45 and 64 km), respectively, from summer ranges to fall ranges or foraging areas (Table 9). Male 52 traveled an airline distance of 55 miles (88 km) in 20 days and was shot 13 miles (21 km) south of Yellowstone National Park. Males 51 and 126 met similar fates 48 and 44 airline miles (77 and 70 km), respectively, from localities where they were last observed. Female 170 traveled 34 miles (54 km) within a period of a few days. Data obtained from color marked bears showed that male 32 had a home range of at least 272 mi^2 (705 km^2) which extended beyond the Park to the northeast. Male 37, which occupied a home range of about 470 mi^2 (1217 km^2) that extended beyond the Park border to the southwest (Table 9; Fig. 6), was shot 50 airline miles (80 km) from the site of last observation the previous fall.

A home range is an area within which an individual meets all of its biological requirements. In any given land area, individual home ranges critical to the survival of a number of individuals must also be critical to the survival of the species, as a whole. Home ranges. therefore, must be consisered as definitive of critical or essential habitat.

Female 7 had a home range of 106 mi^2 (275 km^2) which was well defined by radiotracking (Craighead 1976). Her core area, or center of activity, lay to the east of Trout Creek and the Yellowstone River. She was observed swimming across the river on six occasions. Core areas, for all animals tracked by radio, were small, seldom exceeding a square mile. Core areas represent the most intensively used sites within a home range, but critical habitat is not restricted to the core areas alone. The intervening habitat is also important, for without it, core areas could not be used by bears or protected for their use by man. Male 76 (Table 9) frequently moved seven to ten airline miles daily within a home range of 168 mi^2 (435 km^2). On one occasion this male traversed 10,243-foot Mt. Washburn at about the 9,000-foot level and crossed the Grand Canyon of the Yellowstone river five times, traveling 58 airline miles (93 km) over extremely rough terrain during an 8-day period. The ground distance was estimated to be three times the airline distance.

Spatial needs of an individual may vary from year to

Table 9: Selected Movements and Home Ranges Illustrating Spatial Requirements of Grizzly Bears (see also Figure 6).

Bear Number	Sex	Mode of Detection*	Number of Fixes or Observations	Maximum Airline Distance Moved		Area of Home Range	
				Mi	Km	Mi^2	Km^2
51	M	R	—	48	77	—	—
52	M	R	—	55	88	—	—
60	M	R	—	28	45	—	—
96	F	R	—	40	64	—	—
126	M	R	—	44	70	—	—
170	F	R	—	34	54	—	—
7	F	R	32	—	—	106**	275
76	M	R	21	—	—	168**	435
32	M	C	11	50	80	272	705
37	M	C	8	20	12	470	1217

* R = radio-tracking; C = colored ear tags.

** Area of home range based on 256 individual radio bearings for bear No. 7 and 129 for bear No. 76.

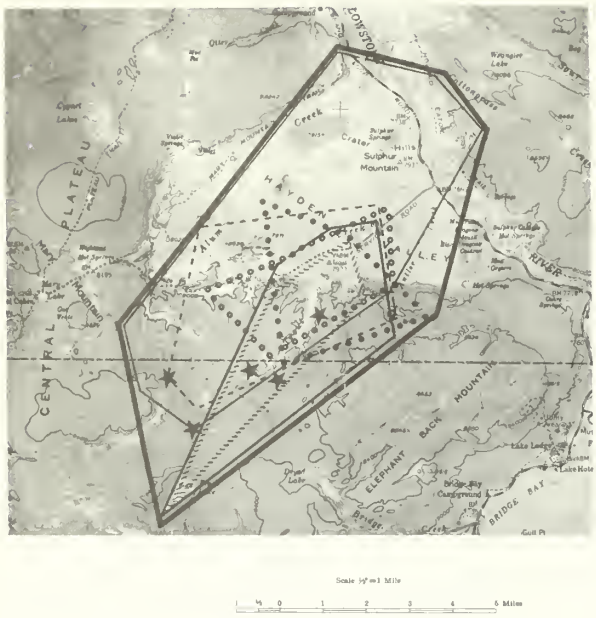

Fig. 7. Established life range of female grizzly bear No. 40 illustrating annual variations in range size from 1961 (age 2.5) through 1968 and the development of a strong attachment to a distinctive home area in the vicinity of Trout Creek.

year, as illustrated by female 40 (Fig. 7). This female was radiotracked for eight consecutive years from 1961 through 1968 (Craighead 1976). She was instrumented at the age of 2.5 years and shot when 10.5 years old. Her life range, smaller than home ranges of most females, encompassed an area of about 30 mi² (78 km²). Her core areas remained basically the same year after year (none exceeded a square mile), but her seasonal and home ranges varied considerably. As a subadult during 1961 and 1962, her summer-fall range did not exceed 8 mi² (21 km²). In 1963 at the age of 4.5, she used an area of 8 mi² (21 km²) during the summer, was observed breeding, and became pregnant. In 1964, she produced two cubs (one of which died) and had a fall range of 15 mi² (40 km²). She entered her den on November 10 with her cub. In 1965 she weaned her yearling and mated; she was radiotracked for 106 days beginning June 28, and is known to have entered a den on November 11. Her home range was 20 mi² (52 km²). Accompanied by two new cubs in 1966, her summer and fall range was 7 mi² (19 km²). She dug a new den and wintered with her cubs. In the spring of 1967 she weaned the cubs and bred. During the fall of 1967 she ranged within an area of 11 mi² (29 km²). Her den was not located, but she emerged in 1968 with three cubs and occupied a home range of 22 mi² (57 km²). She was shot in 1969.

The home ranges and the life range of female 40 are probably atypical because she was a frequent visitor to the Trout Creek dump. This food source supplemented her "natural" food intake and that of her offspring. The result was probably a reduction in foraging area and thus, in range size. Nevertheless, she made frequent and extensive seasonal movements to feed on winter-killed elk (*Cervus canadensis*) and bison (*Bison bison*) in the riparian communities and the sagebrush-bunchgrass habitat types. She also ate *Vaccinium* berries in the subalpine fir, huckleberry, and dwarf whortleberry habitat types, both of which were well represented within her life range. In fall she traveled to the ridges for whitebark pine nuts (*Pinus albicaulis*) in the subalpine fir-whitebark pine forests types and hunted *Microtus* spp. in the sagebrush-bunchgrass parklands.

The initial home range of a sub-adult may be relatively small, for example, male 202 with a home range of 27 mi² (70 km²) as a yearling and 125 mi² (324 km²) as a two year old. Female 187 had a home range of 34 mi² (88 km²) at the age of five. Male 14, a 750 lb. animal, had a range of only 12 mi² (31 km²) during the fall of 1964; however, data from trapping and sightings over a period of years suggested that the life range of this large adult male may have exceeded a thousand square miles.

A home range must contain habitat types that provide all of the biological requirements of the animal. Thus, these areas are not readily abandoned by the individuals. On the contrary, they exert a strong stabilizing effect on distribution and movement patterns. In some bears (e.g., female 40) biological requirements were met within relatively small areas and within a limited altitudinal range. In other cases (e.g., males 14 and 76), the home ranges were large and included an elevational range in landforms of more than 3,000 feet, supporting a diversity of habitat types. The areas constituting these home ranges were critical for each individual; therefore, individuals tended to maintain the home range area despite forces compelling them to move. This was true whether the home range was a single geographic unit or two units separated by a migratory corridor.

The welfare of the grizzly bear depends on seasonal foraging areas, travel corridors and patterns, denning and escape areas, and activity centers within home and seasonal ranges. However, these cannot be singled out and protected separately under the label of critical habitat. Designated "enclaves" of critical habitat would be contrary to the holistic relationships of the vegetation types and the holistic use of them by the species.

The movements and ranges of instrumented grizzlies discussed in detail by Craighead (1976) confirm the extensive space requirements of individual grizzly bears and the strong attachment to home ranges. Even in a population where range overlap is common, core areas small, and territoriality rare, thousands of square miles of undisturbed habitat, with few competing land uses, are necessary to support a population of several hundred animals.

Major Vegetation Types Used by Grizzlies

A definition of critical grizzly bear habitat requires knowledge of the spatial requirements of the bear and a description, in scientific terms, of vegetation types characteristic of the habitat. Such information must be related, in turn, to the biological and behavioral needs of the species. A LANDSAT image of more than 1.8 million acres (0.7 million hectares) of densely occupied grizzly bear habitat in central Yellowstone Park (Fig. 8) is helpful in analyzing these relationships. The home ranges of five instrumental grizzly bears (7, 40, 76, 101, and 187) are superimposed over the vegetation and landforms. Centers of activity for bears 7, 40, and 187 are also shown. These ranges, and the ranges of other grizzlies not included in the figure, encompassed nearly the entire area displayed. The vegetation for this area was classified following Pfister et al. (1974), Mueggler and Handl (1974), and Craighead et al. (1976). General Electric's Image 100, a user-interactive computer, was employed to develop four vegetation and landform classifications based on ground truth data. The acreage and percentage of total area comprising each of the four were calculated (Table 10). The two vegetation classes (Grassland/Shrubland and Coniferous Forest) were then described in terms of the major habitat types and plant communities occurring in each class.

Fig. 8. LANDSAT-1 multispectral imagery map showing distribution of vegetation within home ranges (polygons) of five adult grizzly bears, and core areas (shaded) for three (Nos. 7, 40, and 187); dark areas represent primarily coniferous forest and lighter areas primarily grass-shrubland.

Table 10: Areas and Percentages Occupied by Different Landforms and Classes of Habitat in Central Yellowstone National Park as Determined by LANDSAT-1 Imagery (Figure 8).

Class	Number of Acres	Percent of Total
Grassland and Shrubland	418,653	22.6
Coniferous Forest	838,868	45.3
Bare Ground and Rock	245,519	13.2
Water	30,270	1.6
Unclassified	320,070	17.3
Total	1,853,380	100.0

Most of the area characterized lies within the Subalpine Zone. Mountain grassland and shrubland habitat types and associated riparian communities represented about 23% of the total area. The grass and shrublands are represented primarily by two habitat types, *Artemisia tridentata/Festuca idahoensis* and *Festuca idahoensis/Agropyron spicatum*. The riparian communities have not been typed and will require considerable work. Sedges (*Carex* spp.) predominated in most of the riparian communities and, in some situations, formed nearly pure stands over extensive areas.

Perennial herbs such as *Geranium viscosissimum, Campanula rotundifolia, Geum triflorum, Trifolium repens, Circium scariosum,* and *Perideridia gairdneri* characterized the grass-shrubland habitat types. Instrumented grizzly bears were observed to eat a wide species range of succulent greens, corms, and tubers in these habitats. They also fed on small mammals — *Microtus, Peromyscus,* and *Thomomys* — that were periodically very abundant. Many of the elk and bison frequenting the grass-shrubland subalpine parks failed to survive the occasionally severe winters; some of

those that died in the sedge marshes or in the grass-shrublands were eaten by grizzly bears from March through June. Feeding by bears was documented at 135 carcasses and predation on elk recorded.

Coniferous forests comprised about 45% of the area (Table 10), a percent coverage twice that of the grass-shrubland types. The distribution of coniferous forests relative to grass-forb shrublands creates a tremendous edge effect (Fig. 8). This interspersed distribution of vegetation types in subalpine parklands was an important habitat requirement of grizzly bears. Without exception, all core areas within defined home ranges contained both forest and grass-shrubland components and encompassed riparian plant communities. The dispersed pattern of grassland and forest enabled bears to graze sedges, grasses, and succulent forbs in season, and to feed on berries of *Vaccinium* spp. and nuts of whitebark pine, all within relatively small home ranges.

Coniferous forests were largely represented by seral stages of the subalpine fir series. Three habitat types were common: *Abies lasiocarpa/Calamagrostis rubescens; Abies lasiocarpa/Vaccinium globulare;* and *Abies lasiocarpa/Vaccinium scoparium.* The second and third types named, commonly supported heavy ground cover of *V. globulare* and *V. scoparium.* Though berry crops fluctuate spatially and temporally, they are major foods. Grizzly bears frequented these two habitat types from mid-July to mid-September. They sought ripening berries at lower elevations early and fed on fruit maturing at higher altitudes later in the season. The *Abies lasiocarpa* (*Pinus albicaulis*)/*Vaccinium scoparium* habitat type was common on dry ridges and easterly exposures at the higher altitudes. Bears fed on whitebark pine nuts in the fall and spring. Although the nut crops fluctuated locally and annually, when and where available, they formed a major dietary item. This habitat type also supplied berries of *V. scoparium* and thereby, offered a double dietary incentive; thus, grizzly bears used the habitat type extensively.

The spruce series generally was represented in moist situations along the streams and rivers by the *Picea engelmannii/Linnaea borealis* habitat type. This habitat type was often dominated by *V. globulare* with *V. scoparium* common. The Douglas fir series was represented by several habitat types, but the one most frequented by grizzlies was *Pseudotsuga menziesii/Calamagrostis rubescens.* This was not a preferred habitat type for feeding, although *Fragaria virginiana* and *Erythronium grandiflorum* were common.

Alpine meadows and spruce-fir-whitebark pine krummholz were poorly represented within the habitat study area shown in Figure 8, though small areas occurred on Mt. Washburn, the highest peak. Alpine areas are more extensive in other parts of the Park, but were only moderately used by grizzlies. In other portions of the grizzly bear's range within the contiguous 48 states — especially in the Scapegoat-Bob Marshall Wilderness areas of Montana — the alpine zone is heavily used in late June and July. The bears seek the emerging alpine plants, feeding primarily on species of *Lomatium, Claytonia,* and *Carex,* and on various grasses.

Some grass-shrubland and forest habitat types are more important than others, seasonally and annually, as sources of food. Although it is beyond the scope of this paper to document grizzly bear food habits in the area, I wish to emphasize that both grass-shrub and coniferous forest habitat types of the subalpine zone are essential habitat components for the grizzly bear in the Yellowstone region. The entire study area, including many habitat types, was used by grizzly bears. Although some types were used more than others and must be rated as more important, the entire complex of habitat types within the Yellowstone ecosystem is essential and critical for the grizzly bear. Therefore, the totality of the system must be considered and evaluated, not just portions of the habitat that appear to be more important than others.

As indicated earlier, core areas or activity centers are the sites within home or seasonal ranges that are the most intensively used by individual animals. Habitat types in the five core areas for bears 7, 40, and 187 (Fig. 8) are identified in Table 11. *Abies lasiocarpa/Vaccinium scoparium* habitat type and riparian communities were identified in all five core areas and constituted the highest percentage of the total vegetation cover. *Abies lasiocarpa/Linnaea borealis* and *Artemisia tridentata/Festuca idahoensis* types were iden-

Table 11: Habitat Types Occurring in Five Core Areas of Grizzly Bears 7, 40, and 187 (see Figure 8).

Habitat Type	Number of Core Areas	Percent Occurrence
Abies lasiocarpa/Vaccinium scoparium	5	100
Abies lasiocarpa/Linnaea borealis	3	60
Artemisia tridentata/Festuca idahoensis	3	60
Festuca idahoensis/Agropyron spicatum	2	40
Riparian communities	5	100

tified in three core areas, and *Festuca idahoensis/Agropyron spicatum* in two. The presence of grass-shrubland types and riparian vegetation in all core areas indicates that these types are of great importance to the grizzly bear, but not that they should be singled out and isolated as critical habitat. The grizzly bear satisfies only some — not all — of its biological requirements in these core areas.

Denning requirements for grizzly bears are highly specific (Craighead and Craighead 1972); however, the availability of suitable denning sites was not critical in the study area. Of 11 active and six inactive dens located in four forest habitat types, 11 (nearly 65% of the total) were in the *Abies lasiocarpa/Vaccinium scoparium* type. This habitat type was in an advanced seral stage following burning. Mature lodgepole pine dominated the type, with a reproductive understory of subalpine fir and whitebark pine. Two dens were located in *Abies lasiocarpa (Pinus albicaulis)/Vaccinium scoparium,* three in *Picea engelmannii/Linnaea borealis,* and one in *Pseudotsuga menziesii/Calamagrostis rubescens.* All dens were in secluded areas, generally on north facing exposures, and at altitudes of 7,600 to 9,200 feet. The dens at the highest elevations were in the *Abies lasiocarpa (Pinus albicaulis)/Vaccinium scoparium* habitat type, at 9,000 to 9,200 feet. Most of the dens were at elevations of 7,800 to 8,200 feet; the lowest den occurred in the upper edge of the Douglas fir forest at 7,600 feet. The disturbance of bears by human intrusion at the time of denning could be critical (Craighead and Craighead 1972). Fortunately, denning occurs at a time (mid-October to mid-November) when deep snow force hunters out of the high country where the bears den. Thus competition between bear and man for this habitat is not great.

INTERACTION AND COMPETITION BETWEEN GRIZZLY BEARS AND MAN

Both the grizzly bear and man require space and habitat. When man modifies, destroys, or usurps the bears' habitat, competition develops and interactions follow. An understanding of bear-man interactions is necessary to an understanding of what constitutes critical habitat.

Competition for Space and Habitat

There is competition between man and grizzly bears for space and habitat in the Yellowstone ecosytem. It is most obvious at highly developed recreation sites, areas of livestock use, logging sites, and whenever the bear is hunted throughout National Forests adjoining the Park. The grizzly was a co-dominant with the American Indian and frequently competed with him for the same food and similar habitat. Grizzlies continue to compete with modern man wherever habitat use overlaps. Grizzlies are omnivorous; they have high energy requirements, but are physically, biologically and socially adapted to exploit a wide range of foods. They traverse large home ranges seeking food; therefore, spatial requirements for a population are extensive. The core areas are small and can be highly specific. The aggressive nature of the grizzly bear has put it in direct conflict with man's use of the land.

Competition between grizzly bear and man can be classified as primary or secondary. Primary competition occurs where bears compete directly with livestock for similar vegetation; though usually complex, the effects can be defined and quantified. Secondary competition occurs where man's use of the land conflicts with that of the bears; the impact can be measured directly as mortality of livestock or bears, and on rare occasions, of man. Data on primary competition are few, but considerable data are available for evaluating secondary competition. These data exist in the numbers on man-caused bear deaths and in human land-use statistics.

Recreation Competition

Competition between bear and man was negligible in Yellowstone National Park before 1971 because recreational patterns had developed in such a way that there was relatively little use of the backcountry by visitors (J. J. Craighead and F. C. Criaghead 1971) and because long-established open pit dumps tended to concentrate the grizzly bear population within zoned areas during most of the visitor season. Thus, the probability of bear-man confrontations was reduced. However, grizzly bear-man confrontations and personal injuries from grizzly bears have always been a source of concern in the highly developed areas of the Park (Fig. 5). Personal injuries per year averaged 1.7 in 1959-67 and 3.3 in 1968-70 (J. J. Craighead and F. C. Craighead 1971). Severe personal injuries and human deaths in developed portions of the Park have increased since 1970; a record number of bear visitations to campgrounds and developed areas occurred during 1971. Logs recording visits of grizzly bears to campgrounds since 1971 are not currently available. However, areas of high bear densities that prevailed from 1959 through 1970 (Fig. 9) still prevail. Since there has been no basic change in these high-density

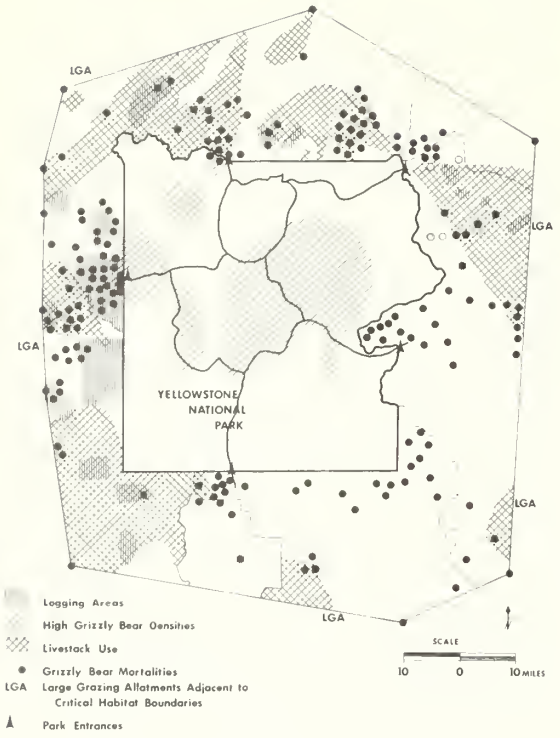

Fig. 9. Competition for space and habitat within the Yellowstone grizzly bear ecosystem.

areas, it would appear that as visitor use increased, grizzly-man encounters would also increase.

The number of visitors to Yellowstone Park rose from 1.4 million in 1959 to 2.5 million in 1976 — an increase of over one million during a period of 18 years (Table 12). The effect of this increase in numbers has been reflected in improved roads and expanded visitor accomodations in the Park. Areas of increasingly high human density coincide with areas of high bear density (Fig. 5). At certain developed sites, as mentioned earlier, there is severe competiton for the same space or "habitat". This problem must be solved by the National Park Service, as it constitutes a threat to both grizzlies and man.

During the 10-year period 1967-76, use of the backcountry by visitors increased more than fourfold (Table 13). This situation may necessitate seasonal zoning of some areas and a more standardized program of releasing captured bears in the backcountry. Improved methods for informing backcountry campers, hikers, and outfitters of bear releases would reduce the risk of bear-man encounters. That competition has also existed just outside the five park entrances is evident from the geographic distribution of bear deaths (Fig. 9). Most of these deaths were either illegal or control kills in developed areas (Table 14). The control kill in 1971, after the closure of the Trout Creek and West Yellowstone dumps in 1970, was exceptionally high. The sudden closure of both dumps forced grizzlies from these areas into developed sites in search of food. Also, a statistically significant increase ($0.05>p\geq0.03$) in the total number of grizzlies moving throughout the ecosystem increased the chances of bear-man encounters and destruction of personal property, which in turn initiated bear control actions. Control deaths declined in 1973 and 1974. Whether this reduction was due to better management or to a lower

Table 12: Number of Visitors to Yellowstone National Park, 1959-76.

Year	Number of Park Visitors*
1959	1,408,667
1960	1,443,288
1961	1,524,088
1962	1,925,227
1963	1,872,417
1964	1,929,316
1965	2,062,475
1966	2,130,313
1967	2,210,023
1968	2,229,657
1969	2,193,894
1970	2,297,290
1971	2,120,487
1972	2,246,827
1973	2,061,537
1974	1,937,768
1975	2,246,132
1976	2,525,174

* Averages: 1959-67 — 1,833,979;
1968-76 — 2,206,529
(Courtesy National Park Service)

Table 13: Backcountry Use by Visitors in Yellowstone National Park, 1967-76.

Year*	Number of Visits to Backcountry
1967	10,750
1968	14,592
1969	28,547
1970	10,653
1971	21,790
1972	24,946
1973	36,806
1974	41,624
1975	44,387
1976	42,212

* Values for 1967-70 include visits to two campgrounds not in the backcountry; reliability of numbers shown is unknown, but they probably exceed the true values.
(Courtesy National Park Service)

Table 14: Major Causes of Death of Marked and Unmarked Grizzly Bears Outside Yellowstone National Park, 1959-74.

Year	Control in Developed Areas		Control on Rangeland or Illegal Kills		Legal Kills by Hunters		Other*		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
1959	0	—	0	—	4	3.2	0	—	4	1.8
1960	0	—	0	—	14	11.3	2	9.1	16	7.0
1961	1	3.1	2	4.0	5	4.0	4	18.2	12	5.3
1962	0	—	1	2.0	4	3.2	0	—	5	2.2
1963	1	3.1	0	—	5	4.0	0	—	6	2.6
1964	0	—	1	2.0	3	2.4	0	—	4	1.8
1965	0	—	0	—	7	5.6	1	4.5	8	3.5
1966	3	9.4	3	6.0	2	1.6	1	4.5	9	3.9
1967	0	—	6	12.0	24	19.4	2	9.1	32	14.0
1968	1	3.1	4	8.0	3	2.4	1	4.5	9	3.9
1969	0	—	3	6.0	7	5.6	1	4.5	11	4.8
1970	3	9.4	10	20.0	14	11.3	0	—	27	11.8
1971	12	37.5	8	16.0	17	13.7	3	13.6	40	17.5
1972	7	21.9	1	2.0	4	3.2	5	22.7	17	7.5
1973	2	6.3	7	14.0	4	3.2	2	9.1	15	6.6
1974	2	6.3	4	8.0	7	5.6	0	—	13	5.7
Total	32	100.0	50	100.0	124	100.0	22	100.0	228	100.0
Percent of 16-year Total	14.0		21.9		54.4		9.6			

* Traffic and undetermined causes.

population level is debatable. Nevertheless, over a 16-year period, 14% of all recorded grizzly bear kills outside the Park were made for purposes of controlling animals in developed areas (Table 14).

Livestock Competition

Illegal kills and kills by ranchers to protect livestock constituted about 22% of all deaths of marked and unmarked bears outside Yellowstone National Park in 1959-74 (Table 14). However, only for marked bears could kills by ranchers be distinguished from illegal kills; ranchers accounted for 9.6% and illegal kills, 11.5% (combined total for marked bears of 21.1%). Other categories of marked bear mortalities compared as follows: control in developed areas, 11.5%; hunters, 59.6%; others (unspecified), 7.7%.

The distribution of grizzly bear deaths overlaps considerably with areas of livestock grazing (Fig. 9). Annual grazing allotments for each national forest (Table 15) indicate that the grizzly bear habitat outside the Park is supporting a total of over 66,000 animal-months per year. This number varies slightly from year to year, but not importantly. In contrast, the entire ecosystem (including the Park) is supporting less than 1,000 grizzly bear-months per year, based on the population estimate of 136 for 1974 (Craighead, Varney, and Criaghead 1974). Even assuming a larger population — e.g., 200 — the animal-months per year for grizzly bears (6 × 200) are still insignificant in comparison with those for cattle and horses and for sheep.

Table 15: Grazing Allotments (Expressed as Number of Animal Months Per Year) in National Forests Adjacent to Yellowstone National Park, 1976.

National Forest	Cattle and Horses	Sheep	Total
Targhee	2,955	17,593	20,548
Gallatin	5,713	13,412	19,125
Shoshone	9,593	6,732	16,325
Bridger-Teton	10,297	—	10,297
Total	28,558	37,737	66,295

At lower elevations, livestock are put on the forest grazing sites between June 15 and July 16, and direct competition for forage between bear and livestock is minimized. At the higher elevations, however, competition is more direct because of the delayed phenology. In early summer, bears and livestock both feed on the succulent, high-protein, emerging vegetation at elevations of 6,000 to 8,000 feet.

Where grizzlies and livestock inhabit the same area, depredations occur. This indirect competition results in bear deaths and can be more serious to the welfare of the species than the direct competition for food. As a carnivore, the grizzly bear perfers meat to vegetation and, following hibernation, requires high-protein food.

A prime source, when present, is highly vulnerable livestock. Usually only one animal is killed at a time, but there are records of more than 20 sheep being killed in a single night. Also, a bear may, at times, kill livestock periodically over several weeks or months. Such severe depredation requires some control of the offending individual, as frequently accomplished by illegal as by legal action. About 10% of the bear deaths in livestock use areas were caused by livestock owners. The number of such deaths can be reduced by strict enforcement of the Endangered Species Act. The federal agency issuing the lease, license, or permit may modify, suspend, or revoke the lease agreeement if the lessee is convicted of a criminal violation of the Act. In some instances, modification of federal grazing allotments to reduce total animal-month units might ease feeding competition with bears in early summer at the higher elevations. Compensation for losses and a combination of livestock protective measures would be helpful. The problem is complex and sensitive, and directly affects the welfare of ranchers. Solutions will require more intensive investigation in areas of habitat competition in the Yellowstone ecosystem.

Mortalities Due to Hunting

Hunters accounted for 54.4% of all grizzly bear deaths occurring outside the Park in 1959-74 (Table 14; Fig. 9). The harvest by hunters can be well-regulated by state Fish and Game Departments. Annual quotas should be set each year after the previous years' total death statistics from all causes have been evaluated and compared with annual reproductive rates. In as much as precise reproductive rates have not been obtained by members of the Interagency Grizzly Bear Study Team (Knight et al. 1975, 1976). precise comparisons cannot yet be made with data obtained in previous years by Craighead, Craighead, and Sumner (1976). Nevertheless, Montana, Wyoming, and Idaho have placed a moratorium on grizzly bear hunting in the Yellowstone Region until there is conclusive evidence of an increase in the bear population.

As pointed out earlier, Yellowstone National Park is not an inviolate sanctuary; 146 grizzly bear deaths were recorded in 16 years, i.e., an average of 9.1 per year, compared with 14.3 per year outside the Park where 54.4% of the deaths are the result of hunting. If hunter kills are disregarded, the annual man-caused death rate outside the Park is 6.5 bears and is lower than the annual man-caused death rate of 8.6 within the Park. Of all deaths within the Park, 54% resulted from control actions, generally in developed areas. This percentage is equal to that of the hunter harvest outside the Park. Thus, in terms of percent, the effect of control actions within the Park are equivalent to hunter kills outside the Park. Inside the Park, the remaining 46% of the deaths include such causes as road kills, shootings by tourists, drug casualties, and "natural causes" (Table 16).

Table 16: Causes of Death of Marked and Unmarked Grizzly Bears in Yellowstone National Park, 1959-74.

Year	Control in Developed Areas		Other*		Total	
	No.	%	No.	%	No.	%
1959	5	6.3	3	4.5	8	5.5
1960	3	3.8	5	7.5	8	5.5
1961	6	7.6	3	4.5	9	6.2
1962	5	6.3	5	7.5	10	6.8
1963	6	7.6	3	4.5	9	6.2
1964	2	2.5	6	9.0	8	5.5
1965	2	2.5	5	7.5	7	4.8
1966	2	2.5	2	3.0	4	2.7
1967	6	7.6	5	7.5	11	7.5
1968	5	6.3	7	10.4	12	8.2
1969	11	13.9	1	1.5	12	8.2
1970	16	20.3	10	14.9	26	17.8
1971	4	5.1	4	6.0	8	5.5
1972	4	5.1	6	9.0	10	6.8
1973	0	—	2	3.0	2	1.4
1974	2	2.5	0	—	2	1.4
Total	79	100.0	67	100.0	146	100.0
Percent of 16-year Total	54.1		45.9			

* Traffic, drug overdoses, illegal kills, and undetermined causes.

Logging Competition

Logging operations (Fig. 9) modify grizzly bear habitat ecologically; the habitat is also made more accessible to man. Precise effects of ecological alterations in the Yellowstone ecosystem are unknown, but it is suspected that certain types of logging may increase *Vaccinium, Ribes, Fragaria* and other berry producing plants. The establishment of logging and construction camps, with their accompanying refuse sites, attracts grizzly bears and increases the chances of bear-man encounters and the temptation to poach or to conduct illegal control actions. The influx of hunters and recreationists on logging roads is a further threat to the security of the bears. It is difficult to relate grizzly bear mortalities directly to logging operations because logging areas tend to overlap areas of livestock and recreational use. However, it is evident that mortalities increase with the intensity of land use. About 75% of 180

grizzly bear mortalities recorded outside Yellowstone National Park occurred in areas of highly competitive land use. More detailed studies are needed to document the effects of logging, road-building, and burning on grizzly bear habitat and on the bear population.

Summary — Grizzly Bear vs. Man

Although the grizzly bear is essentially a wilderness species, it can and does adapt to the presence of man; however, it has not and cannot adapt to man's intensive use and modification of its habitat. Man must adapt to the grizzly bear . . . an adaptation that will require much more tolerance and understanding than in the past. Until both citizens and resource agencies have learned to coexist with the animal in areas of competitive use, such interactions must be considered as potentially detrimental to the species.

Man is competing directly with grizzly bears for critical habitat in the Yellowstone region, both inside and outside the Park. To perpetuate the species and to expand the population where possible, as directed by the Endangered Species Act of 1973, federal and state agencies must develop guidelines and management programs that will alleviate direct competition between bear and man for the same geographic space and habitat.

DELINEATING CRITICAL HABITAT OF THE GRIZZLY BEAR IN YELLOWSTONE NATIONAL PARK AND ADJACENT AREAS

I have delineated a specific land area in the Yellowstone region as critical habitat on the basis of bear mortality records and biological, physical, and behavioral requirements of the species. The land area consists of Yellowstone National Park and portions of five adjoining national forests and encompasses an area of about 5 million acres (2 million hectares), with minor exclusions for towns, campgrounds, and developed areas. The area, considered a discreet ecosystem for the grizzly bear, supports a wide range of forest and grass-shrub habitat types of which some have been described and quantified. Vegetation zones range from temperate forests and grasslands at 5,000 feet to alpine tundra at 10,000 feet and higher.

A boundary for the critical habitat area has been defined (Fig. 9) with the understanding that refinements will be necessary so that easily observable landmarks and landforms are provided in the boundary description. Refinements will also be necessary to make adjustments for private holdings, developed areas, and intensive land use economies, as well as to include new information in the future.

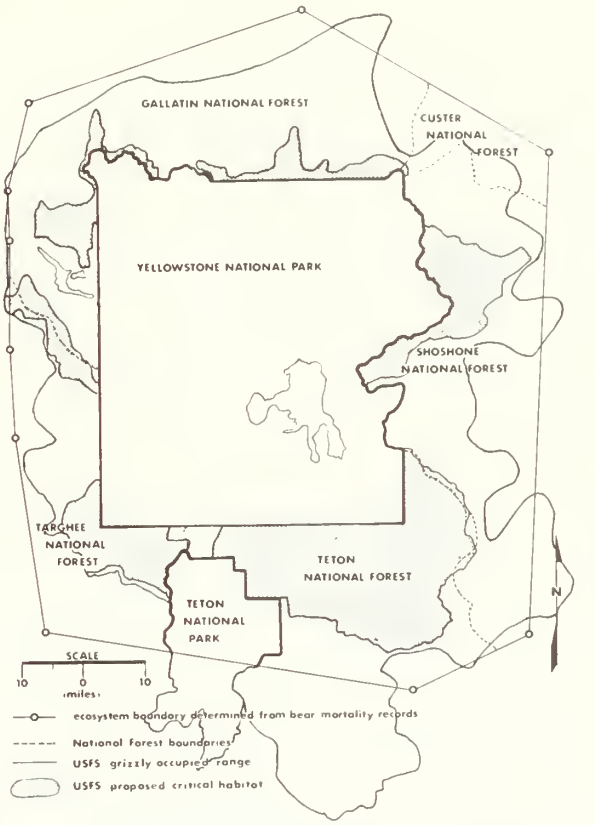

Fig. 10. U.S. Forest Service delineation of occupied and critical habitat in the Yellowstone region and critical habitat as delineated in the present paper.

The area delineated by the U.S. Forest Service as occupied habitat (Fig. 10) is closely comparable to the area I have identified as critical habitat on the basis of criteria set forth in the Endangered Species Act. Thus, the habitat designated by the Forest Service as occupied is, by my evaluation, actually critical habitat. On the other hand, the area defined as critical by the U.S. Forest Service (stippled area, Fig. 10) is considerably smaller and partitioned, probably because it is not based on long-term biological studies or a holistic concept of the biological needs of the grizzly bear.

The area of critical habitat delineated by the U.S. Fish and Wildlife Service (Fig. 11) has received considerably public criticism from state fish and game agencies, special interest groups, and some bear biologists; however, the federal delineation, except for an area east of the Jackson Hole Valley, Wyoming, rather closely matches the area I have identified using long-term data. The critical habitat designation that I have proposed is intended to be a refinement, based on

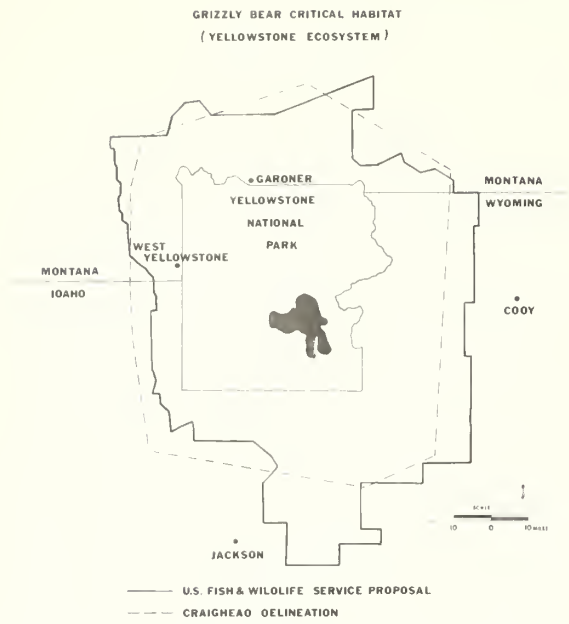

Fig. 11. Critical habitat of the grizzly bear in the Yellowstone ecosystem as proposed by the U.S. Fish and Wildlife Service and as delineated in the present paper.

long-term biological data, of areas delineated as critical by the various federal agencies. As additional data become available, habitat essential to the grizzly bear must be further defined and delineated if the species is to survive and coexist with man.

DELINEATION OF HABITAT AND THE FUTURE OF THE GRIZZLY BEAR

Where grizzly bears and man compete for the same habitat, man-caused bear deaths rise. The bear has a low reproductive rate (about one cub per adult female every two years). This birthrate cannot offset heavy and persistent man-caused mortality. Where habitat is shared by bear and man, precautions must be taken to keep man-caused mortalities to a minimum. Such mortalities appear to be a greater threat to the grizzly bear in the Yellowstone ecosystem than is the direct modification of the habitat.

Delineation of a discrete ecosystem for grizzly bears in the Yellowstone region indicates that it will be feasible in the future to delineate precisely other ecosystems critical to the survival of the grizzly bear within its historical range in the United States. Delineations can be accomplished by identifying the basic biological and ecological requirements of the bear and the competing socio-economic needs of society in each ecosystem. Where grizzly bears and man compete for the same space and habitat, conflicts can be resolved by improved land-use and people-bear management that conserves the grizzly bear and its environment, and yet duly considers and protects other users and uses of the land. Grizzly bears and man can coexist. However, management agencies must guard against unreasonable demands and undocumented assertions by concerned groups, as well as their own sometimes untenable positions based on alleged jurisdictional authority. Such disputes can defeat objective habitat delineation of ecosystems essential to the preservation of the bears, and prevent peaceful coexistence.

A suggested alternative is to remove the grizzly bear from "endangered" status. This have been advocated by a few bear biologists, game administrators, and some special interest groups. Such action at this time would be highly questionable, if not irresponsible, in view of the recognized habitat conflicts and the demonstrated high man-caused mortality rates. The recovery potential of a grizzly bear population is low because of the low reproductive rate of the species, the vulnerability of the bear to man, and the lack of known or as yet demonstrated biological compensating mechanisms to offset these factors. As the history of the species shows, grizzly bear populations do not readily make a comeback. They require large wilderness-type environments, well delineated and managed as ecosystems of critical habitat. This can be done, to perpetuate the species as directed by the Endangered Species Act, without seriously infringing on the socio-economic uses of the ecosystem.

One may well ask the obvious question, "Will preservation of habitat preserve the grizzly?" There is little doubt that it will reduce the bears' vulnerability to man. However, the full implications of a high death rate must be recognized and understood if the future of the species is to be secure. The grizzly is readily attracted to bait such as gut piles from elk, a strategically placed elk or deer quarter, or a pack animal deliberately shot and positoned. When putrefaction occurs, a grizzly can detect the scent from great distances. An animal attracted to such a lure is easily poached. Illegal kills are difficult to confirm and may mean a death rate that is much higher than actually recorded. The death rate can also rise from too readily justified control killings to protect bureaucratic errors in judgement following bear-man encounters. The grizzly can be overharvested as a result of erroneous or overoptimistic population estimates and politically-, rather than biologically-, based game regulations. Thus, precise

control of the annual death rate is mandatory if critical habitat delineations are to be effective.

I have taken for granted that the grizzly bear merits protection in our national parks and forests. There are those who question this and therefore, also question the need to protect and to manage its habitat. The maintenance of ecological diversity and stability should be sufficient justification. But to those who place economic progress before ecological considerations and material values before aesthetic ones, I suggest that man has a moral obligation and perhaps also, a deep-seated psychological need to preserve and protect a once co-dominant species. The grizzly is one of the few inhabitants of our primevil environment that can, on occasion, remind us with lethal action that we are not and should not be immune masters of the wild places.

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