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DRAFT

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POSSIBLE EFFECTS OF ELK HARVEST ON FALL DISTRIBUTION OF GRIZZLY BEARS IN THE GREATER YELLOWSTONE ECOSYSTEM

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Abstract: The tradition of early elk (*Cervus elaphus*) harvest seasons adjacent to Yellowstone National Park (YNP) provides grizzly bears (*Ursus arctos*) with ungulate remains left by hunters. We investigated the fall (August - October) distribution of grizzly bears relative to the boundaries of Yellowstone National Park (YNP) and the opening of September elk hunting seasons. Radio-marked bears that traverse either the park's northern or southern boundaries adjacent to early elk hunting units increased use outside YNP after elk hunting began ($P < .001$). Changes in distribution were primarily attributable to adult males ($P = .003$). Timing of shifts correlate with the opening of hunting seasons, especially in the northern boundary area, and could not be attributed to searches seeds of whitebark pine (*Pinus abiculus*). Increased seasonal bear densities and human presence in early hunt units increases potential for conflicts between bears and hunters. Numbers of reported hunting related grizzly bear mortalities have increased in the Greater Yellowstone Ecosystem (GYE) during the last decade and nearly half this increase is due to bear deaths occurring in early hunt units during September. No difference was observed in proportion of male and female bears dying (*P* = .639) suggesting resident female bears may also be impacted by hunter related bear mortalities. Human-caused grizzly bear mortality thresholds established by USFWS have not been exceeded because other sources of human-caused mortalities have declined, and population parameters, upon which mortality thresholds are based have increased.

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Key words: elk harvest, Greater Yellowstone Ecosystem, grizzly bear, mortality, fall distribution, *Cervus elaphus, Ursus arctos horribilis*

The Interagency Grizzly Bear Study Team (IGBST) was formed in 1973 with the primary goal of monitoring status and trend of the grizzly bear population in the Greater Yellowstone Ecosystem (GYE). Formation of this group was precipitated by the high bear mortality that followed closure of the open pit garbage dumps in Yellowstone National Park (YNP) during 1968-72 (National Academy of Science 1974), and the controversy regarding that populations future. Uncertainty regarding the status and trend of this population also led to its listing as threatened under the Endangered Species Act in 1975. The population remains listed in 2001.

Documenting causes and understanding trends in grizzly bear mortality has been a primary objective throughout the 25-year history of the IGBST (Knight et al. 1988, Blanchard 1990, Mattson et al. 1990). During the decade of the 1990s, hunting-related mortalities have

bear densities and human presence in early hunt units increases potential for conflicts between bears and hunters. Numbers of reported hunting related grizzly bear mortalities have increased in the Greater Yellowstone Ecosystem (GYE) during the last decade and nearly half this increase is due to bear deaths occurring in early hunt units during September. No difference was observed in proportion of male and female bears dying (P = .639) suggesting resident female bears may also be impacted by hunter related bear mortalities. Human-caused grizzly bear mortality thresholds established by USFWS have not been exceeded because other sources of human-caused mortalities have declined, and population parameters, upon which mortality thresholds are based have increased.

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Documenting causes and understanding trends in grizzly bear mortality has been a primary objective throughout the 25-year history of the IGBST (Knight et al. 1988, Blanchard 1990, Mattson et al. 1990). During the decade of the 1990s, hunting-related mortalities have become the single largest source of known human-caused grizzly bears deaths in the GYE (A. Dodd, Montana Department of Fish, Wildlife, and Parks, unpublished data). Factors contributing to increasing hunter-caused bear mortality may be an increasing and expanding bear population, which results in more frequent encounters between hunters and bears. Counts of unduplicated females with cubs (<1 year of age) have increased and expanded in their distribution during the 1990's, as have the distribution of bear conflicts and mortalities (Schwartz et al. In Press).

We suggest another factor possibly contributing to the increased number of lethal encounters between hunters and bears is the tradition of elk harvest occurring adjacent to YNP boundaries. Hunter ungulate harvest and wounding loss may be influencing the fall distribution of grizzly bears by creating dispersed "ecocenters" (Craighead et al. 1995). Grizzly bears are highly motivated to feed during the fall as they prepare for up to 7 months spent in winter dens (Judd et al. 1980). Bears learn to use available food resources quickly, and when food availability becomes predictable, bears will establish traditional use and impart that behavior to their offspring. Availability of food associated with the elk harvest may be considered a predictable food resource to bears using areas where elk harvest is traditional. In 1986, it was estimated that 370 tons of biomass from "gut piles" and other discarded parts was left by elk hunters annually in the GYE (Servheen et al. 1986). In this paper we investigate the distribution of radio-instrumented bears that live in the vicinity of either the northern and southern boundaries of YNP prior to, and during the early elk harvest seasons. Our working hypotheses is that the proportion of locations outside YNP increase during hunting seasons, and that this increased is not due to the availability of other seasonal food, such as whitebark pine.

STUDY AREA

The GYE contains approximately 37,000 km^2 in the states of Wyoming, Montana, and Idaho and encompasses Yellowstone National Park and portions of 6 National Forest that surround the park. Universal Transverse Mercator (Zone 12, NAD27) grids 440000-650000 m East and 4815000-5050000 m North bound the USFWS grizzly bear recovery zone (USFWS 1993) and the area within 10 miles of the recovery zone, and are considered the primary study area. Within the last decade grizzly bears in the GYE have expanded their range primarily to the south and east of their distribution during the 1980's and an increasing number of mortalities are occurring outside of the grizzly bear recovery zone (Schwartz et al. In Press). Detailed descriptions of the GYE can be found in Knight and Eberhardt (1985), Mattson et al. (1991*a*), Blanchard and Knight (1991).

Seasonally important grizzly bear foods include cutthroat trout (Reinhart and Mattson 1990), army cutworm moths (Mattson et al. 1991*b*), seeds from whitebark pine (Kendall 1983), and meat from ungulates, primarily elk and bison (Mattson 1997). Recent studies using N^{15} and C^{13} isotopes from grizzly bear hair suggests that in the GYE, grizzly bears obtain much more of their annual energy requirements from meat than other interior grizzly populations tested (Hilderbrand et al. 1999); as much as 80% for males, and 50% for females (G. Hilderbrand, Alaska Game and Fish, unpublished data). An inverse relationship between annual fall whitebark pine seed crops and man caused grizzly bear mortality has been demonstrated (Mattson et al. 1992). There is also evidence that suggests meat from ungulates becomes more important during years with poor whitebark pine cone crops (Mattson 1997).

Early rifle hunting seasons for elk occur in wilderness settings both north and south of YNP during September. The Montana early hunt begins 15 September in Hunting District 316 (Figure 1) and runs through 26 November. Hunting District 316 is enclosed entirely within the

Absaroka-Beartooth Wilderness of the Gallatin National Forest. This opening is 5 weeks earlier than the opening of the general rifle season for elk in other Montana hunting districts that are adjacent to YNP. The Wyoming early rifle hunt for elk begins 10 September in Game Management Units 60, 70, and 71 (Figure 1) and open 2 weeks earlier than most general rifle seasons. These Wyoming Game Management Units are enclosed within the Bridger-Teton Wilderness of the Bridger-Teton National Forest. In both Montana and Wyoming early hunt areas, hunters must access areas by foot travel or use of saddle stock. Outfitted hunts are common in both areas. In Wyoming, nonresident hunters are required to use a licensed guide in designated Forest Service Wilderness Areas.

Grizzly bears within the GYE have not been legally hunted since 1974. Hunting related grizzly mortalities do occur, and result from a variety of situations.

METHODS

We used locations from radio-instrumented grizzly bears to investigate their distribution relative to the elk-harvest seasons outside YNP during mid- September in both Montana and Wyoming. The IGBST has been instrumenting, and radio-monitoring grizzly bears within the GYE since 1975. All grizzly bears captured are radio-instrumented with the exception of dependent offspring (cubs or yearlings). Adult bears are typically fitted with radio-collars (Telonics, Mesa, AZ) that have breakaway canvas inserts. Independent subadult bears are instrumented with expandable collars (Blanchard 1985), glue-on-hair transmitters, or ear-tag transmitters (Advanced Telemetry Systems, Isanti, MN). Weather permitting, radio-tracking flights to locate instrumented bears are conducted weekly from mid-April through November.

For this analysis we used radio-locations of non-transport influenced bears (i.e. not relocated do to nuisance activity) obtained from August through October during 1984-2000. We used post

1983 data because this is considered the more intensely managed period and is approximately 1 bear generation after cessation of legal grizzly bear hunting in the GYE. We assume that 1 generation after legal hunting ended would allow sufficient time for a tradition of gut piles use to develop. Some 4,200 radio-location were available. From these data a subset was drawn of individual bears that were located both inside, and outside YNP during the specified time period within a calendar year (896 locations). We than selected bears that were also located within ±5 km of either the northern or southern boundary to YNP that had a common boundary with the state hunting units that provided early elk seasons, and were located during both pre-hunt and hunting periods (n= 307).

For northern boundary bears we defined pre-hunt as 1 August – 14 September, and hunt as 15 September – 1 November. Pre-hunt for southern boundary bears was 1 August – 9 September, and hunt was 10 September – 1 November. Actual hunting seasons in both MT and WY extended well past 1 November. We choose to curtail the analysis period at 1 November because by doing so we compare periods of similar duration. We used the chi-square procedure to investigate changes in distribution of bear location relative to YNP boundary and opening of elk hunting seasons.

We used the 1998 GIS vegetation layer developed for the Yellowstone Cumulative Effects Model (Relene Maw, database manager, USDA Forest Service, Region 4, Ogden UT) to assess the availability of whitebark pine cover types. Composite minimum convex polygons (MCP) constructed from north boundary bear locations and south boundary locations were used to delineate extent of fall use by these bears respectively. Each MCP polygon was populated with 2000 random points. Availability of whitebark pine cover types was estimated by intersecting random points with whitebark pine stands delineated within the GIS vegetation layer. Bear association with whitebark pine was estimated via the same procedure except that we used presence of whitebark pine stands within a 250 m radius scan area, which is consistent with estimates of aerial telemetry error. We also investigated presence of whitebark pine producing stands within 1300 m of bear locations. This distance approximates the average daily activity radius for adult female grizzly bears in the GYE. Differences in availability and use (within 250 m and 1300 m) of whtiebark pine stands relative to YNP boundaries and openings of the early elk hunting seasons were assessed using chi-square tests.

Results from 19 whitebark pine cone production transects (Blanchard 1990) read annually from 1980-2000 were used to rate cone production. Years with a majority of tree results below the overall median were considered poor. Years with a majority of trees above the overall median were considered good. Differences in bear distribution relative to hunting seasons openings and whitebark pine cone production was assess using chi-square tests.

We used the 1998 trail coverage developed for the Yellowstone cumulative effects model to contrast distances to trails from random points and bear location. Comparisons of average distances to trails between random points inside verses outside YNP in both the northern and southern boundary areas, and between bear locations and trails were conducted using the students t-test.

Hunting related grizzly bear mortalities documented between 1983 and 2000 were also investigated. We define "hunting related" as incidents that result in bear deaths that were directly related to the pursuit of legal game animals. These primarily include chance encounters between bears and hunters in the field, conflicts over harvested ungulate carcasses, and conflicts at hunter camps, often related to harvested game in camps, that result in bear deaths. Specific information regarding mortalities was obtained from the Montana Department of Fish Wildlife and Parks (A. Dodd, Montana Department of Fish, Wildlife, and Parks, unpublished data), which maintains the grizzly bear mortality database for the GYE. The degree of certainty associated with each record in the mortality database is classified as: (1) known, where carcasses were recovered or other evidence to indicate known status was available; (2) probable, where strong evidence to indicate a mortality had occurred was present but no carcass was recovered; and (3) possible, when there was some presumptive evidence of a mortality but no prospects for validation (Craighead et al. 1988). We used all 3 categories as indicative of the number of incidents occurring in hunting units. ArcView shapefiles for hunting unit boundaries were obtained from each state wildlife management agency. We compared numbers, sex, and timing of bear deaths occurring in early elk harvest units with those occurring during the general rifle seasons for ungulates in Montana and Wyoming.

Spatial analyses were conducted using ArcView with Spatial Analyst (ArcView GIS, version 3.2, Environmental Systems Research Institute, Redlands, California, USA) and the Animal Movement (Hooge and Eichenlaub 1997) which is available as an ArcView program extension via the Internet (http://www.absc.usgs.gov.gistools/animal_mvmt.htm). Statistical tests were conducted using SPSS (version 10.0.7, SPSS Inc., Chicago, Illinois, USA).

RESULTS

Changes in grizzly bear distribution

We observed a significant (n = 307, X^2 = 12.2, 1 df, $P < 0.001$) change in the distribution of grizzly bear locations relative to the boundaries of YNP and the opening of the early elk hunting seasons. Grizzly bears that traversed the Park boundary during August through October, and were associated with either the northern or southern boundary where early elk harvest seasons occurred were located more frequently outside YNP after hunting seasons began (Figure 2). Similar result were obtained when bears associated with the northern boundary (n = 109, X^2 = 4.337, 1 df, P = 0.037), or the southern boundary (n = 198, X^2 = 7.682, 1 df, P = 0.006) were analyzed separately. Among grizzly bears associated with the northern boundary, the proportion of locations occurring outside the Park increased for 6 of 8 individual bears after the early hunting season opened. In 9 of 11 bears associated with the southern boundary the proportion of use outside YNP increased after the elk harvest season opened.

In both areas, the shifts outside YNP during the early elk hunting seasons can be largely attributed to male bears. When locations from both areas are combined and chi-square analyses are conducted on each of 4 sex and age classes only adult males yields a significant result (n = 130, $X^2 = 8.969$, 1 df, $P = 0.003$). The lack of significant results among other subadult and adult females, maybe due to the fact that females generally do not travel as far as males and do not seek out high quality foods such as meat to the same extent. Samples sizes were inadequate for valid tests on changes in distribution of subadult males.

Timing of shifts outside YNP by bears associated with the northern boundary were abrupt, and correlated with the opening of the elk hunting season (Figure 3). Opening dates for the Montana early rifle seasons for elk have been relatively consist, occurring during mid September. Timing of shifts outside YNP for bears associated with the southern boundary were less abrupt (Figure 3). Opening dates for Wyoming hunting units adjacent to the southern boundary of YNP have varied by 1-2 weeks during the period of interest. This, and the fact that there are typically a sequence of opening dates for different ungulate species and classes occurring in early to mid September may explain observed differences.

Whitebark pine distribution and cone production

Our assessment of whitebark pine distribution in the northern boundary combined MCP indicated significantly more whitebark pine stands outside (18%) than inside (11%) YNP (n = 2000, $X^2 = 17.199$, 1 df, $P < 0.001$). However, we observed no significant difference (n = 109,

$X^2 = 0.168$, 1 df, $P = 0.682$) in number of bear locations within 250 m of whitebark stands inside (46.0%) verses outside (50.0%) YNP, or between ($n = 109$, $X^2 = 0.012$, 1 df, $P = 0.913$) the pre-hunt (47.2%) verses during the hunt (48.2%). In the northern boundary area we can not rule out search for whitebark pine cones as a factor contributing the change in the bear distribution. However, the synchrony between timing of the change and the opening of the hunting season does support the position that search for remains left in the field after elk harvest are influencing bear distribution. During typical years, most of the hunter harvest occurs during the first week of the season (K. Frey, Montana Department of Fish, Wildlife, and Parks, personal communication). Bears actively seeking remains left by hunter harvest would have greatest success by timing their efforts to coincide with the opening of the early hunting season. This appears to be the case.

In southern boundary area our analyses more readily supports the hypothesis that elk hunting is influencing fall distribution of bears. Within the combined MCP there was significantly more whitebark pine inside (16.6%) than outside (13.4%) YNP ($n = 1950$, $X^2 = 3.854$, 1 df, $P = 0.05$). Yet bears were located more frequently outside YNP after the hunting seasons open (see above). We observed no difference ($n = 198$, $X^2 = 0.358$, 1 df, $P = 0.549$) in frequency of bear locations within 250 m of whitebark pine stands between the pre-hunt (59.5%) and hunt (55.3%) periods. However, bears locations outside YNP (45.1%) were not closely associated with whitebark pine stands (within 250 m) as often as were locations inside (67.3%) YNP (n = 198, $X^2 = 9.923$, 1 df, P = 0.002).

No significant differences were evident when we compared the presence of whitebark pine stands within 1300 m of bear locations between the pre-hunt and hunt period, and inside versed outside YNP. Of interest was the result that 78.0% of the bear locations associated with the northern boundary occurred within 1300 m of whitebark pine stands; compared to only

61.0% of random points. Similarly 82.8% of the southern boundary bear locations were within 1300 m of whitebark pine stands; compared to only 60.3% of random points. These findings support the known association between grizzly bears and whitebark pine producing stands in the GYE during the fall. The consistent presence of whitebark pine stand within a daily activity radius also suggests that bears could be using areas that would maximizes the potential for finding either elk remains left by hunters, or squirrel middens containing whitebark pine cones.

Median cone production was 3/tree for whitebark pine trees in our sample transects during 1980-2000. Rating annual cone production relative to the median resulted in "good" ratings during 6, and "poor" ratings during 5 years for which we had bear locations (Table 1). During the hunt we observed no difference in proportion of locations inside verses outside YNP relative to our annual assessment of whitebark pine cone production. This was true for both northern ($n = 56$, $X^2 = 0.645$, 1 df, $P = 0.422$) and southern ($n = 114$, $X^2 = 0.002$, 1 df, $P = 0.961$) boundary bears. Comparison of annual cone ratings and northern boundary bears during the pre-hunt period did not contained adequate cell sizes for valid chi-square test. However, during the pre-hunt period southern boundary bears were located significantly more inside YNP during "good" years than during "poor" years ($n = 84$, $X^2 = 6.052$, 1 df, $P = 0.014$). Considered together, these results suggests that regardless of cone production and the greater distribution of whitebark pine inside YNP, southern boundary bears changed their distribution to outside YNP after the ungulate harvest seasons began.

Distance to trails

In both the northern and southern combined MCPs, comparisons of average distance from random points to trails indicated significant changes ($P < 0.05$) in availability of trails relative to the boundary of YNP. In the north, the average distance to a trail inside YNP was 1967 m ($n = 1323$, std = 1673); outside YNP it was 737 m (n = 677, std = 615). In the south, the average distance from random points to trails inside YNP was 2694 m (n = 855, std = 2324); outside YNP it was 1714 m (n = 1095, std = 615). In neither area outside YNP were bear locations more closely associated to trails during the hunt than expected from comparisons of distance from random points ($P > 0.40$). Even so, changes in distribution of bears outside YNP during the hunt would increase the potential for encounters between bears and hunters due to a greater number of people and higher trail density.

In the Montana early hunting unit north of YNP, numbers of backcountry camps increases from less than10 per week prior to the opening of the hunting season, to a high of 90 camps during the week the hunting season opens (unpublished data). Although we do not have similar information on changes in numbers of camps relative to the opening of the hunting seasons for the southern boundary area, we suspect changes similar to those observed in the north are occurring. During recent years, anecdotal descriptions from outfitters, guides, and hunters from both the northern and southern areas indicate encounters between humans and bears are a common occurrence during the hunting season. Two decades ago many of these same outfitters and guides considered observations of grizzly bears a rare event.

Hunting related bear mortalities

During the 1990's, numbers of hunting related grizzly bear mortalities have increased in the GYE (Figure 4). Much of this increase can be attributed to incidents occurring during the early elk harvest units in Montana and Wyoming (Figure 5). Preliminary results compiled by Wyoming Department of Fish and Game indicates that slightly more than half of these incidents (56%, n = 28, known and probable during 1996-2000) occurred because of chance encounters between bears and hunters in pursuit of game (M. Bruscino, Wyoming Department of Fish and Game, personal communication).

We observed no difference in sex of dead bears for which sex could be determined (n = 43, $X^2 = 0.220$, 1 df, P =0.639) between early hunt units and general season hunting units where hunting related bear mortalities occurred. Considered with the earlier result that males may account for most of the influx of bears into early hunt areas, local females populations may be most impacted by hunting related mortalities since its likely resident female that die.

DISCUSSION

Reasons for observed shifts in distribution of our instrumented bears are undoubtedly resource related. August through October coincides with hyperphagia (Nelson et al. 1983) in grizzly bears. During this period in their annual cycle, bears are focused on fattening in preparation for winter denning and hibernation. Important fall foods in the GYE include seeds of whitebark pine, and meat from ungulates (Mattson et al. 1991*a*). When whitebark pine cones are abundant, grizzly bears use them almost exclusively during the fall (Blanchard 1990). Numbers of fall conflicts between humans and bears, and human-caused grizzly bear mortalities are typically reduced during years with abundant whitebark pine (Blanchard 1990, Mattson et al. 1992). During years of poor cone abundance numbers of management actions and human-caused mortalities increase (Blanchard 1990, Mattson et al. 1992). Evidence also suggests that consumption of meat from ungulates also increase during year with poor whitebark pine cone crops (Mattson 1997).

Given the season, timing of shifts in bear distribution, and area of use, we believe our analysis support the hypothesis that search for ungulate meat discarded from hunter kills is the primary factor motivating the change in fall distribution of our instrumented grizzly bears. However, we cannot disregard search for whitebark pine cones as a contributing factor. We also assume that changes in distribution of unmarked bears are similar to those of our radio-marked sample, with the result being seasonally high grizzly bear densities or "ecocenters" associated with the early elk hunting. Regardless of the specific reason for the changes in bear distribution, the areas outside YNP and adjacent to both the northern and southern boundaries where early season elk hunts occur exhibit seasonally high concentrations of grizzly bears and people during a seasons when bears are highly motivated to feed. Years with poor whitebark pine cone crops have the potential for more encounters between bears and hunters.

Approximately 2 bear generations have passed since legal hunting stopped and grizzly bears in the GYE were given protected status. During this time the long-standing tradition of early elk harvest seasons adjacent to YNP has provided considerable food resources to bears (Serhveen et al. 1986), with little negative feedback from increasing familiarization to humans. Given that bears can learn quickly (Bacon and Burghardt 1974) and females pass on learned behaviors to their offspring (Jonkel 1978, Gilbert 1989, Meagher and Fowler 1989), this seem amply time and motivation for a pattern of traditional use to be expressed. Similar circumstances surrounding deer and elk hunting, with a correlating increase in hunting related bears mortalities has been documented on Kodiak and Admiralty Island (Smith et al. 1989, Barnes 1994).

While recent increases in numbers of hunter related grizzly bear mortalities in the GYE are cause for concern, total human-caused mortality limits established in the Grizzly Bear Recovery Plan (USFWS 1993) have not been exceeded in recent years (Haroldson and Frey In Press). This is due to a combination of two factors, 1) population parameters from which minimum populations estimates are derived have increased, and 2) other sources of human-caused bear mortalities, such as management removals due to livestock depredation or nuisance activity in human developments, have declined. However, there is concern because uncertainty about these estimates is lacking both for population size and unreported human-caused bear mortalities. Recent efforts by Boyce et al. (2001), and Keating et al. (In Press) address uncertainty in estimates of adult females in the GYE; Cherry et al. (In Press) address uncertainty in estimates of unreported human-caused mortalities. Additional work focused on other sources of uncertainty and incorporating these efforts into revised populations and mortality estimates are proposed by the IGBST.

Maintaining human-caused grizzly bear mortality below sustainable limits of population size is a critical component of grizzly bear recovery. During the early 1980s, an array of measures was taken to reduce bear-human conflicts and mortalities. These included: (1) back-country food storage orders, (2) garbage management in the major communities surrounding YNP, (3) bear-proof garbage containers within YNP, (4) removal of domestic sheep within the recovery zone, (5) increased law enforcement, and (6) translocation rather than euthanizing problem individuals. These strategies (Mattson 1990, Gunther 1994) in concert with a series of good food years (Mattson 1998) appear successful. Indices of bear abundance have increased (Haroldson In Press), and the population has expanded into once vacant habitat (Schwartz et al. In Press). These actions were successful at changing the nature of human-caused mortality by reducing both livestock-related deaths and management removals (Mattson 1998). However this success could easily change if hunter-related mortality continues to increase, and/or if hunter related mortality goes undetected (unreported). Such concern prompted managers (Yellowstone Ecosystem Subcommittee) to establish a working group of interested agency, outfitter, environmental, and other concerned individuals to identify and prioritize recommendations to address this issue. Recommendations focus on increased education, improved management, and research. The information we provide here clearly links grizzly bear movements and feeding behavior with early elk hunting and were useful in formalizing these recommendations.

Continued vigilance and adaptive change on the part of agencies and the public appears critical to the long-term survival of the grizzly bear in the GYE.

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Figure 1. The Greater Yellowstone Ecosystem, combined northern and southern boundary minimum convex polygons (MCP). Also shown are the Grizzly Bear Recovery Zone (U.S. Fish and Wildlife Service Grizzly Bear Recovery Plan 1993) early elk hunting unit boundaries, and location of hunting related mortalities during 1983-00.

Figure 2. Percent of grizzly bear locations occurring inside or outside Yellowstone National Park relative to the early elk harvest seasons. Northern and southern boundary bears are combined.

Figure 3. Proportion of northern and southern boundary radio-marked grizzly bears outside YNP during August through October. Early elk rifle seasons began the 2nd half of September along the northern boundary to YNP, and the 1st half of September along the southern boundary.

Figure 4. Documented total known and probable man-caused grizzly bear mortalites, and numbers hunting related grizzly bear mortalities during 1975-00 in the Greater Yellowstone Ecosystem.

Figure 5. Numbers of reported known and probable hunting related grizzly bear mortalities occurring in early elk hunting units and other areas by month during 1990-00 in the Greater Yellowstone Ecosystem. Grizzly bear mortalities occurring during May and August where the result of mistaken identity kills during legal black bear hunting seasons.

Figure 1.

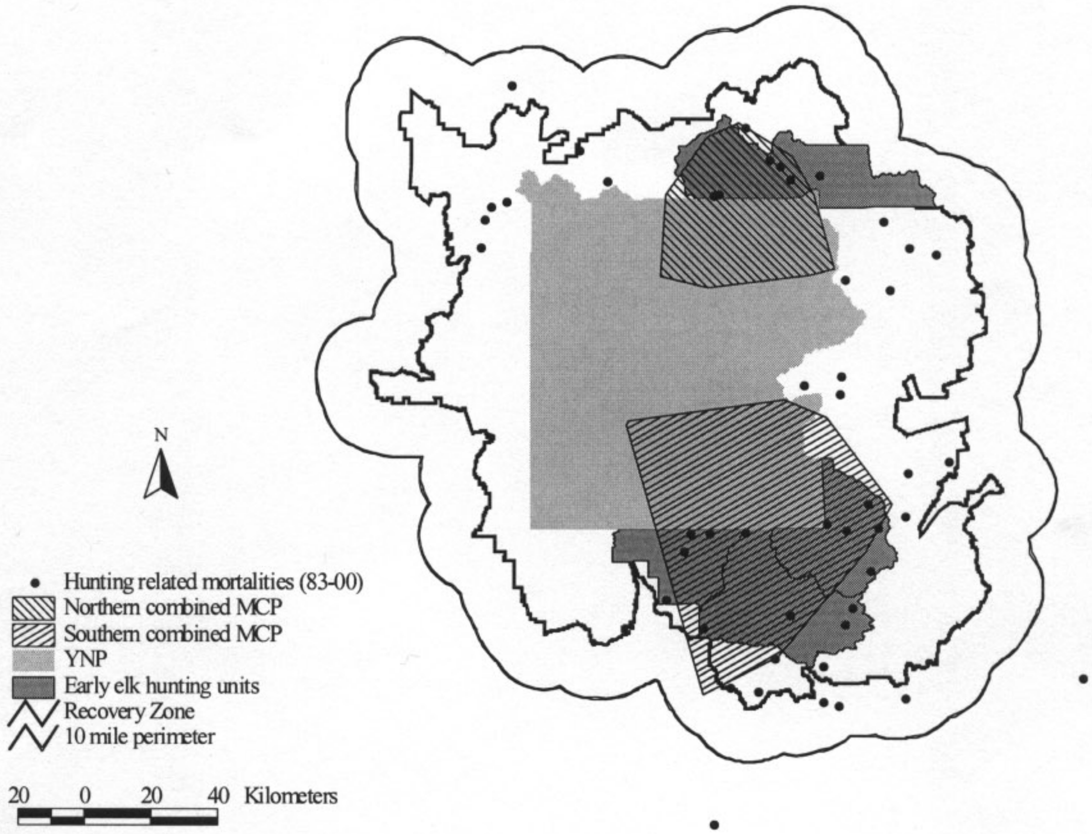

N
Hunting related mortalities (83-00)
Northern combined MCP
Southern combined MCP
YNP
Early elk hunting units
Recovery Zone
10 mile perimeter
20 0 20 40 Kilometers

Figure 2.

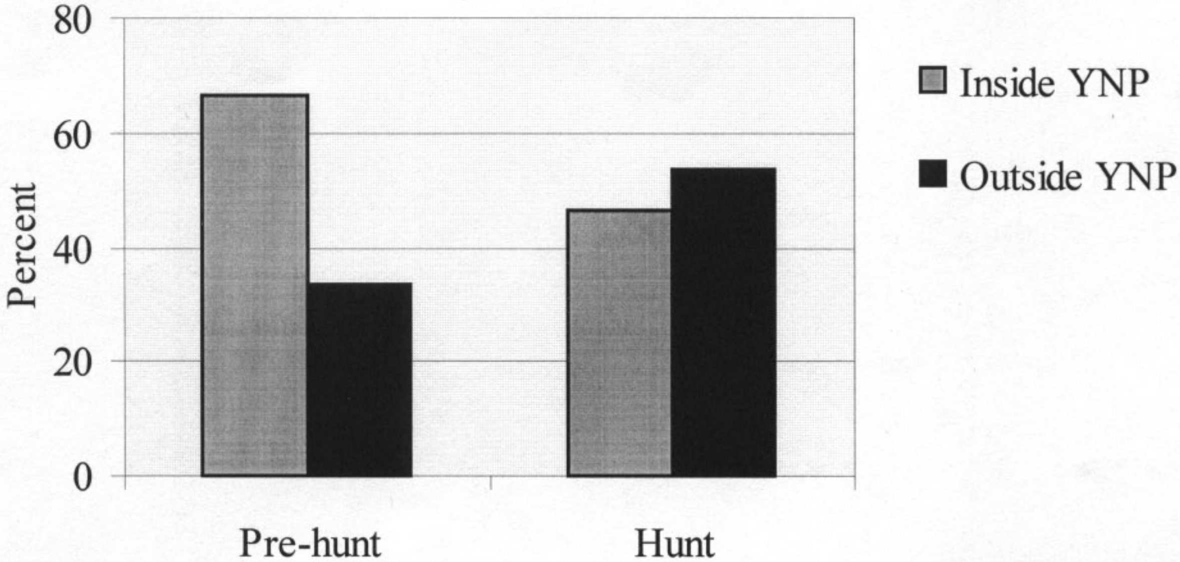


Figure 3.

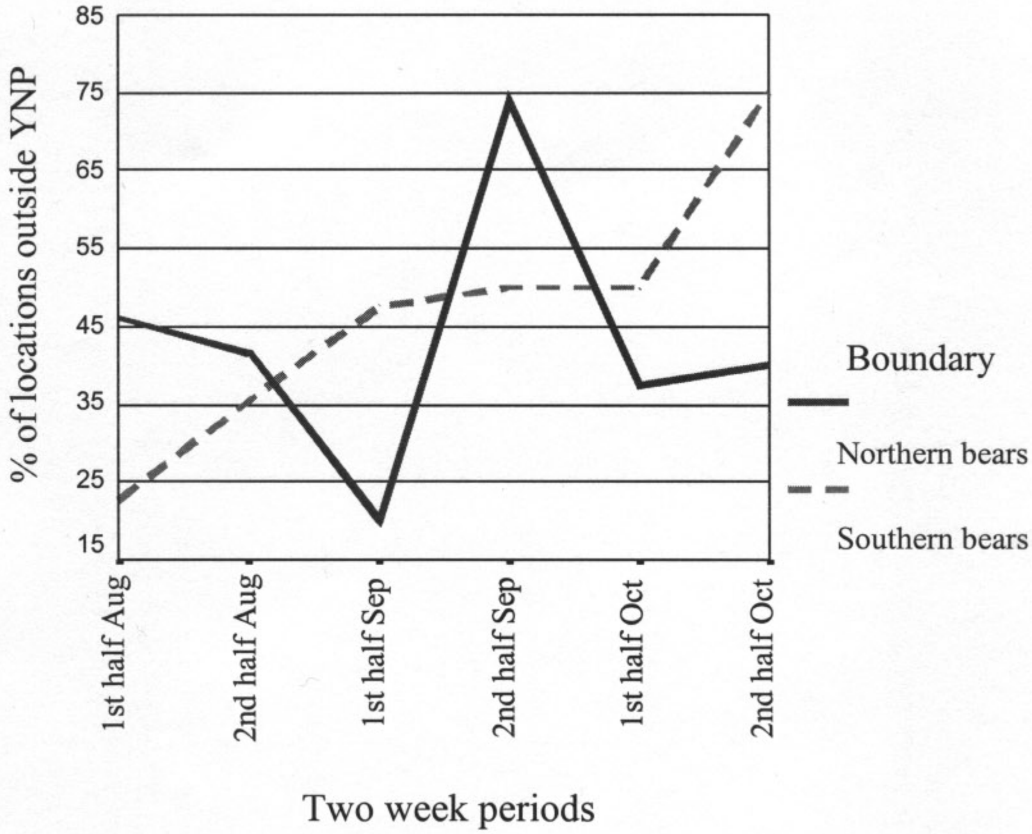

85
75
65
55
45
35
25
15
% of locations outside YNP
1st half Aug
2nd half Aug
1st half Sep
2nd half Sep
1st half Oct
2nd half Oct
Two week periods
Boundary
Northern bears
Southern bears

Figure 4.

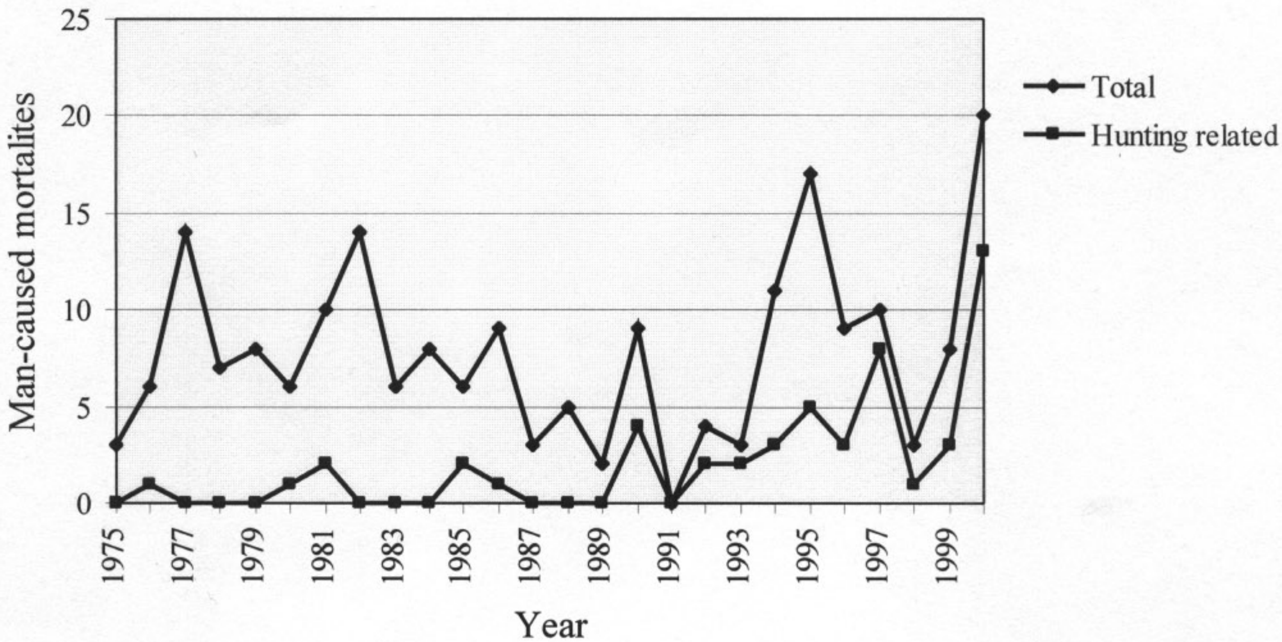
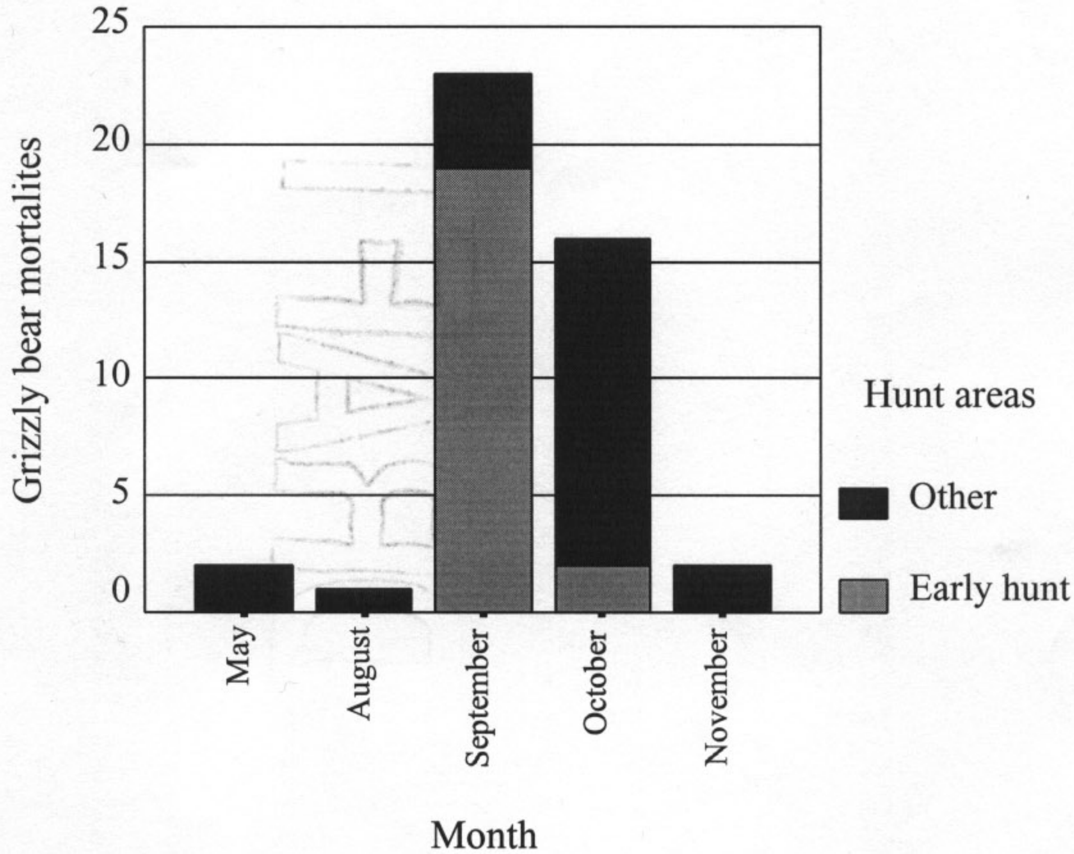

25
20
15
10
5
0
Man-caused mortalites
Total
Hunting related
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
Year

Figure 5.


25
20
15
10
5
0
Grizzly bear mortalites
May
August
September
October
November
Month
Hunt areas
Other
Early hunt