6.4 GRIZZLY BEAR MORTALITY AND HUMAN ACCESS IN THE CENTRAL ROCKIES ECOSYSTEM OF ALBERTA AND BRITISH COLUMBIA, 1972/1976–2002

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ABSTRACT

We acquired grizzly bear mortality data from 1972–2002 and 1976–2002 for the Alberta and British Columbia (BC) study areas of the Central Rockies Ecosystem (CRE). We conducted spatial and temporal analyses to examine the relationship between access and changing grizzly bear and land use management practices on grizzly bear mortality. We summarized mortalities by cause of death, sex, age, and cohort. Human-related causes were the primary sources of grizzly bear mortality in both study areas. In Alberta, legally harvested grizzly bears accounted for 48% of 229 known human-caused mortalities, followed by management control (18%), illegal kills (16%), self defense kills (11%), and other causes of death (7%). In BC, 81% of all known mortalities were legally hunted bears followed by management control (16%) and illegal kills (3%). Total human-caused and harvest mortality, and percent females in the kill were within management guidelines for population sustainability in both jurisdictions. The total number of grizzly bears and the proportion of females killed both dropped following the implementation of limited entry hunting. Grizzly bears spend much of the year at lower elevations in both study areas, and roads and trails usually follow valley bottoms, potentially fragmenting riparian habitats. Eighty-six percent of 549 mortality locations in Alberta and BC fell below 2000m. Ninety percent of 185 known human-caused mortalities with accurate locations in Alberta and 56% of 369 in BC fell within 500m of roads and 200m of trails. Buffered roads and trails occupied 54% and 41% of the area of suitable habitat (<2400m) in each study area. Area-concentrated kills occurred along many drainages accessible by road or trail and around townsites and First Nations Reserves. Management of access, in particular of open roads, and human food and garbage, and educating hunters are critical issues with respect to managing grizzly bear mortality in the CRE. We present recommendations for reducing grizzly bear mortality.

INTRODUCTION

Grizzly bears in southern Alberta and adjacent British Columbia (BC) are part of a regional ecosystem in Canada called the Central Rockies Ecosystem (CRE, Figure 1). The CRE is experiencing intensive exploration and development of coal, oil, gas, and timber reserves. Cattle production, rural residential development, and outdoor recreation are also increasing, and hunting for large game, including grizzly bears occurs throughout much of grizzly bear range in Alberta and BC (Chapter 13, this report). Concomitant with this development, an infrastructure of roads has expanded into regions previously only accessible by non-motorized means (Chapter 13, this report). Motorized access roads are frequently implicated in contributing to grizzly bear mortality as they facilitate access for a host of human activities, increase the frequency of energetically costly flight responses, and increase vehicle related mortalities (Mattson et al. 1987, Nagy et al. 1989, Gibeau et al. 1996). As well, roadside vegetation may attract bears to roads compounding the risk. At some undetermined level of use, grizzlies, in particular established adult females, will cease crossing major transportation corridors (Gibeau and Herrero 1998, Proctor *et al*. 2002, Proctor and Paetkau 2004). As a result, the regional grizzly bear population is continuing to suffer from habitat loss and degradation, fragmentation of its range and potentially unsustainable mortality rates (Horejsi *et al*. 1998, Herrero *et al*. 2000, Stenhouse *et al*. 2003, Chapter 5.1, 5.2, this report).

Natural survival rates for adult grizzly bears not killed or removed by humans are consistently high (Knight and Eberhardt 1985, McLellan 1989, McLoughlin and Messier 2001), whereas young bears die more frequently of natural causes such as intraspecific aggression (Stringham 1983), accidents (Nagy et al. 1983), and nutrition related causes (Nagy et al. 1983, Knight et al. 1988). Tracking natural mortality is difficult because habitat is often remote and heavily forested, and carcasses are soon scavenged. Natural causes are probably a minor proportion of adult grizzly bear mortality (McLellan 1994, McLellan et al. 1999). Data from around North America show that the number of recorded human-caused deaths far exceeds the known natural mortalities (Craighead et al. 1988, McLellan 1989, Dood and Pac 1993, Gunson 1995). Historical (Storer and Tevis 1955, Noble 1972, McCrory and Herrero 1982) and recent works (McLellan and Shackleton 1988a, Mattson et al. 1996) consistently link the type and degree of human land use with grizzly bear mortality.

Present attitudes towards the grizzly bear, a potentially dangerous animal (Herrero 1985) and competitor for food and space (Mattson 1990), challenge human-grizzly bear coexistence. Interagency planning for effective land use at the regional scale (Herrero 1995), whereby bears can meet their energetic requirements, and encounters between humans and bears can be reduced, may be the best option for reducing grizzly bear mortality (Mattson and Knight 1991).

Sustainable total and harvest mortality rates for bears have been estimated in computer-simulated populations (Bunnell and Tait 1980, Harris 1984, Harris 1986). Garshelis et al. (2005) were able to calculate the sustainable mortality rate, ≥91%, for grizzly bears in the Bow River Watershed, 1994–2002, based on 9 years of demographic data. Such data do not exist for the rest of the CRE. The threshold mortality rate where grizzly bear populations begin to decline can rarely be determined precisely. The determination of vital rates for grizzly bears requires long-term study deploying radiotelemetry, such as was done in the Bow River Watershed. Lacking this, the number of undetected mortalities is typically estimated by inference. McLellan et al. (1999) used the mortality data from radiocollared grizzly bears from thirteen studies in Canada and the United States to estimate the percentage of unreported human-caused mortality. They found that management agencies would have only detected between 45 and 51 percent of the human-caused mortalities of these radio-collared bears.

In this section, we analysed grizzly bear mortality from the CRE portion of Alberta (Alberta study area) for the 31-year period 1972–2002 and the East Kootenay region of BC from 1976–2002. Results are presented as summaries, and we discuss them temporally with respect to changing grizzly bear management strategies, and spatially to examine the effects of access on mortality in the bear population.

STUDY AREA

The Alberta and BC study areas encompass 21,150 km² and 10,960 km² of the CRE respectively (Figure 1). The area boundaries are defined by the limits of access maps and a digital elevation model. From the northwest corner, the Alberta study area leaves the Banff National Park boundary and runs east along 52^0 15´ N latitude to its intersection with Alberta Highway 11. It follows Highway 11 to Rocky Mountain House, then south along Highway 22 to 50^0 0´ N latitude. The south boundary follows 50^0 0´ N to the Alberta-BC border. The west boundary follows the Alberta/BC border and the east Banff Park boundary to 52^0 15´ N latitude. The digital elevation model extends further east and includes 3 mortalities that occurred east of the access maps. The area of Banff National Park is not included.

Commencing in the northeast, the BC study area leaves the Banff National Park boundary and runs west along 52^0 0´ N latitude to the Rocky Mountain Trench. The west boundary follows the trench and Highway 93 south to 50^0 0´ N latitude. It runs east along 50^0 0´ N to the Alberta-BC border and turns north following the Alberta-BC border and the boundaries of Kootenay and Banff National Parks. The areas of Kootenay and Yoho National Parks are not included.

Elevation generally increases from east to west and north to south throughout the Alberta study area. The BC study area elevation increases from the valley bottom of the Rocky Mountain Trench east to the summits of the Continental Divide.

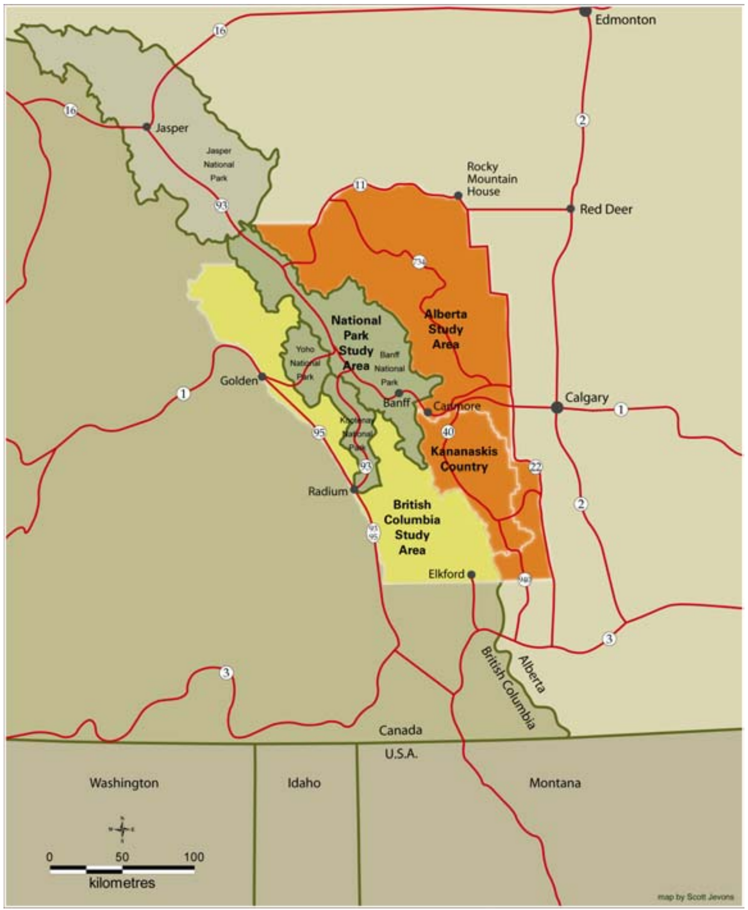

Figure 1. Study area map. The Central Rockies Ecosystem of Alberta and British Columbia.

METHODS

Grizzly bear mortality and translocation databases were supplied by Alberta Fish and Wildlife for the period 1972–2002. The British Columbia Ministry of Environment, Lands and Parks (BCMOELP) provided mortality records (Compulsory Inspection and Problem Wildlife files) for the period 1976–2002 but did not include information on translocated bears. Mortalities included dead bears, and in Alberta, bears translocated to more remote areas (generally north) that were not known to have returned, translocated bears that died in other jurisdictions and bears placed in zoos. We used all mortality data to summarize mortality by cause, sex, age and cohort, and a subset of mortalities with suitably accurate locations to conduct spatial analyses with respect to human access.

The conclusions reached and recommendations offered are based on the following three assumptions:

- the databases represent the minimum number of grizzly bear deaths and translocations;
- the stated goal of management agencies is to maintain or enhance the present population size and distribution of grizzly bears in the respective jurisdictions; and
- recreational hunting of grizzly bears is an acceptable practice, provided it is scientifically demonstrated to not cause population decline.

The following abbreviations for mortality types apply throughout this paper: LH legal harvest, PW management kill or translocation, IL illegal kill, SD self-defence, TI-H Treaty Indian hunt, TI-F Indian Reserve food attractant, Re research, H highway, AC accident.

Spatial Analyses

Locations of bear mortalities were referenced to the Universal Transverse Mercator (UTM) grid to the nearest 100 m in Alberta and 1000 m in BC, and included a descriptor such as a river, creek, or cultural feature. We interviewed past and present conservation officers (wildlife officers and park rangers) and regional biologists to collect additional information about specific mortalities and their locations. We also interviewed as many successful Alberta hunters as we could locate and who were willing to participate.

For Alberta mortalities, “accurate” locations had a UTM designation to ±100 metres and matching geographic descriptor. “Reasonable” locations were described as being within some stated distance from a known road, trail, drainage or development. For practical purposes and due to the lower resolution (±1000 m), all BC mortalities with UTMs were classified as “reasonable”. Mortalities with “estimated” and “unknown” locations were excluded from spatial analyses.

A human access map was created from the most recent and accurate spatial data for motorized and non-motorized access for the study area. The BC Ministry of Forests provided 1:20,000 scale motorized access data (updated 2001). For Alberta, 1:50,000 scale motorized access data were derived from Alberta Base Feature data. Data were updated using orthocorrected digital air photos, Indian Satellite imagery or GPS surveys.

Non-motorized access data were derived from a variety of sources including interpretation from orthocorrected air photos and Indian Satellite imagery, topographic maps, surveys using GPS, and existing digital materials provided by different agencies. Accuracy of these data varies from 5 to 25 metres (Scott Jevons, Alberta Community Development, Canmore, Alberta, personal communication).

Motorized access included railway lines and all roads open to the public and negotiable by 2-wheel drive vehicle. The trail layer included closed roads, utility corridors, and any other linear features accessible by ATV, hiking, mountain biking, or horseback.

We entered the access and mortality data into a geographic information system, ArcView GIS 3.2 (Environmental Systems Research Institute Inc.). For Alberta mortalities, zones of influence (ZOI) of 500m and 200m were set around roads and trails respectively. Buffer widths of 500m for motorized roads and 300m for non-motorized trails were implemented in the Yellowstone National Park grizzly bear cumulative effects model (Mattson 1999). As the Central Rockies Ecosystem generally has steeper and narrower valleys than Yellowstone, we are comfortable with 200m wide buffers for non-motorized trails in this forested mountain landscape.

We calculated the proportion of each study area that was considered suitable grizzly bear foraging and denning habitat (<2400 m, Gibeau et al. 2001) and the area of suitable habitat that occupied by road and trail buffers. Mortality locations were overlain on the access maps and the proportion of locations falling along buffered roads and trails calculated. Road and trail buffers were combined into a single coverage and the area of overlap was only calculated once. Mortality locations in the area of road and trail overlap were analysed within road buffers as roads were assumed to have a greater effect on mortality risk than trails.

We calculated the proportion of a sample of randomly generated points equaling 1 point per 5 km^2 (Nielsen et al. 2004) that fell within road and trail buffers. We tested the distribution of mortality locations against the randomly distributed points (expected values) with the single classification Goodness of Fit test (G-test with William’s Correction Factor).

Due to the lower resolution of location accuracy for BC mortalities (± 1000m), we set the ZOIs along roads and trails at 1000 m as we felt that narrower zones would fail to capture some mortalities that actually occurred within the buffers.

Non-sport mortalities were tallied with respect to proximity to townsites, landfills, commercial tourist operations and First Nations reserves. We assumed that bears were attracted to these areas by the presence of food and garbage (Weaver et al. 1986, Mattson et al. 1987). This assumption was supported by data from mortality records and discussions with bear managers.

Elevational Analyses

The Digital Elevation Model (DEM) for the study area is a hybrid of two scales: 1:50,000 for Banff, Yoho and Kootenay NPs, and 1:20,000 for the provincial lands. The 1:20,000 DEM for the Alberta side and a portion of the BC side was provided by the Miistakis Institute. The remaining DEM (BC side) was constructed based on approximately 250 Themtatic Resource Inventory Mapping (TRIM) map sheets (digital contour lines). All of the component DEMs were pieced together and re-sampled to 30 meter pixel to match the resolution of Landsat TM imagery (Wierzchowski 2000).

We used the elevation of Alberta grizzly bear mortality locations to assess the effects of tourist destinations, town sites and other developments. This analysis was not performed for BC mortalities, as the potential range of elevations for each point was large. The placement of a location within 1000 m horizontal in a narrow valley could mean a vertical difference of greater than 1000 m.

Temporal Analyses

We stratified the mortality data into 2 periods (Alberta 1972–87 and 1988–2002; BC 1976–1989 and 1990–2002) to relate changes in mortality characteristics with changing patterns of human use and evolving management concerns and actions. Major change did not occur in any single year. Rather, a series of events in the 1980s led to a progressive modification in management practices. These actions included 1) increased efforts at communication and public education with respect to bears and improved garbage management, 2) closure of backcountry roads in Kananaskis Country in 1980–81, and 3) implementation of limited entry hunting (LEH) which was complete within the Alberta study area by 1987, and by 1982 in the BC study area. We recognized that it would take a few years for the bear population to adapt behaviorally to events such as the landfill and road closures.

Seasonal Analyses

Finally, we analysed cause of death by seasons. We used 3 seasons of biological importance to bears (April-July = pre-berry, July–Oct = berry, Oct–Dec = post-berry). Other times of year that affected grizzly bear mortality were the spring (April–May) and fall (September–November) hunting seasons and the peak of tourist activities (mid-June to mid-September).

RESULTS

Alberta Summaries

We collected 229 records of known human-caused grizzly bear mortalities from 1972–2002 on Alberta provincial lands within the CRE. These included 16 long distance translocations where we deemed the bears to have been effectively removed from the population. There were also three deaths of unknown cause and one natural mortality recorded in the database (Table 1).

The average annual human-caused mortality for the 31 year period 1972–2002 was 7.4 bears/year with the highest number of deaths occurring from 1980–87 (91 mortalities; 11.4/year; Figure 2). There were only 12 grizzly bear deaths recorded during the first 4 years, 1972–75, possibly due to less rigorous reporting of grizzly bear mortalities in these early years of record keeping.

Legally killed grizzly bears (LH) accounted for 48% (n=110) of all known human-caused mortalities followed by management kills or removals (PW 18%), illegally killed bears (IL 16%), self-defence kills (SD 10%) and all other causes of death (H, AC, RE 7%).

Table 2 shows the types of human activities and developments, and factors (e.g. firearms, food and garbage attractants) that contributed to 69 non-legal harvest kills in the Alberta study area. A minimum of 51 mortalities were associated with food attractants (31 food/garbage, 11 livestock, 9 hunter-killed carcasses)

Table 1. Causes and number of grizzly bear mortalities, and percentage of known human-caused mortality type in the Alberta study area of the Central Rockies Ecosystem, 1972–2002.

	No. of mortalities			Percentages of known		
Kill Type*	1972-1987	1988-2002	1972-2002	1972-1987	1988-2002	1972-2002
LH	82	29	111	62	30	48
PW	13	28	41	10	29	18
IL	21	16	37	16	16	16
SD	13	11	24	10	11	10
AC/RE	1	2	3	1	2	1
H	1	1	2	1	1	1
TI-H	0	5	5	0	5	2
TI-F	1	5	6	1	5	3
N	0	1	1			
UNK	0	3	3			
total	132	101	233			

* LH legal harvest, PW management kill or translocation, IL illegal kill, SD self-defence, TI-H Treaty Indian hunt, TI-F Indian Reserve food attractant, Re research, H highway, AC accident

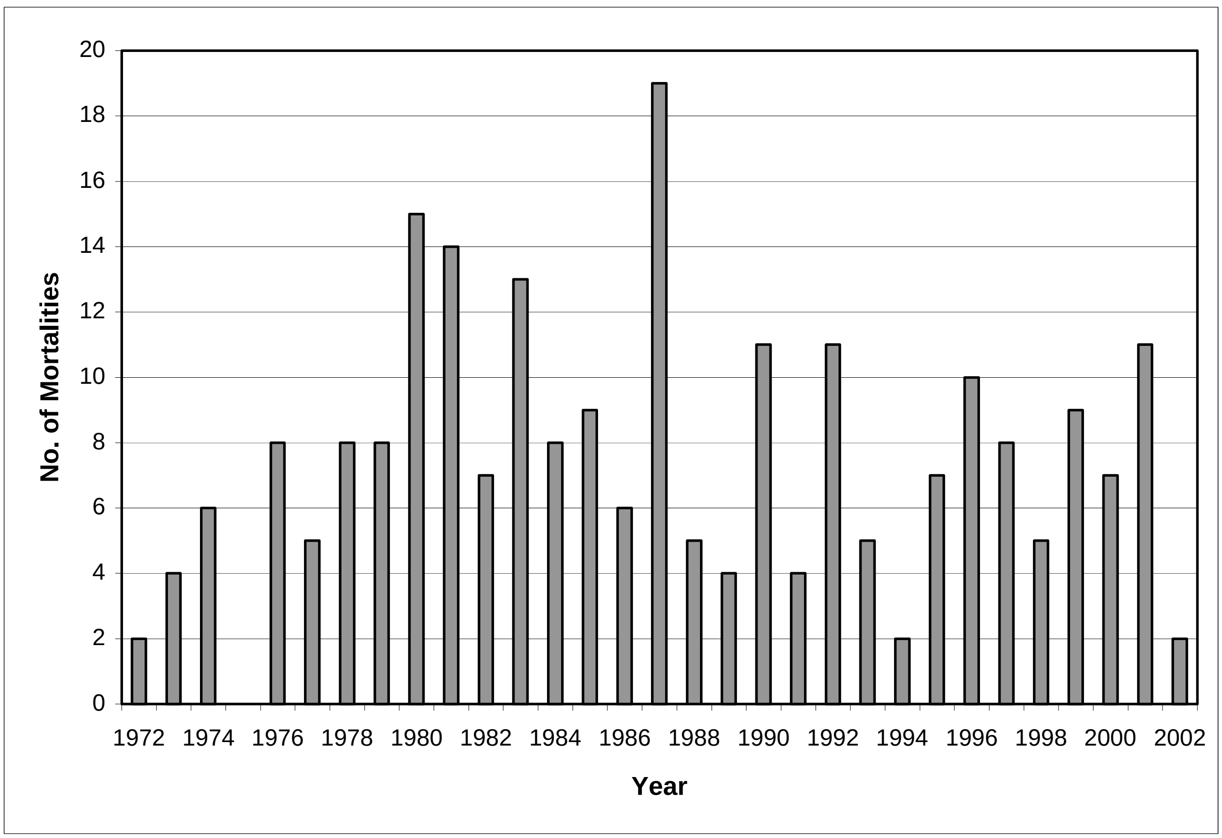

Figure 2. Known human-caused grizzly bear mortalities by year in the Alberta study area of the Central Rockies Ecosystem, 1972–2002 (n=229).

Table 2. Types of developments and land uses, and the number of incidents involving known attractants where grizzly bear mortalities occurred in the Alberta study area of the Central Rockies Ecosystem, 1972–2002 (n=69).

Location of kill	**No**	**Attractant**	**Firearms present**
Alberta campgrounds	11	food and garbage (11)	
Hiking trails	1	good habitat	
Kananaskis Country Golf Course	1	probably introduced grasses	
Fortress Ski Resort	1	good habitat	
Highway	2		
Townsites	6	open garbage (4), unknown (2)	
Commercial Lodges	3	open garbage (2), unknown (1)	
Ranching operations (private and	15	livestock (7), carcasses (4), granaries (4)	yes
First Nations Reserves	9	garbage, smokehouse, meat hanging	yes
Hunting (SD kills)	20	bear approached or charged (4), sloppy camp (4), bear shot off carcass (4), unknown (8)	yes

Sex and Age Analysis

We knew the sex, age and cohort of 212, 212 and 204 grizzly bears that died (all causes, Table 3). The overall sex composition of dead bears was 66% male and 34% female.

Table 3. Numbers and percentages of human-caused grizzly bear mortalities by sex, age and cohort in the Alberta study area of the Central Rockies Ecosystem, 1972–2002.

No. of mortalities					Percentages of known		
SEX	1972-1987	1988-2002	1972-2002		1972-1987	1988-2002	1972-2002
male	72	67	139		62	71	66
female	45	28	73		38	29	34
unknown	15	2	17				
total	132	97	229				
AGE	1972-1987	1988-2002	1972-2002		1972-1987	1988-2002	1972-2002
dependent	19	9	28		15	10	13
subadult	66	45	111		52	52	52
adult	41	32	73		33	37	34
unknown	6	11	17				
total	132	97	229				
COHORT	1972-1987	1988-2002	1972-2002		1972-1987	1988-2002	1972-2002
dependent	19	9	28		16	10	14
subad male	43	32	75		36	37	37
subad fem	18	13	31		15	15	15
ad male	18	22	40		15	26	20
ad fem	20	10	30		17	12	15
unknown	14	11	25				
total	132	97	229				

This included nine dependent bears (cubs of the year or yearlings) with sex recorded. Subadult males accounted for 37% of bears killed followed by adult males (20%), adult females (15%) and subadult females (15%). At least 9 family groups including 6 cubs of the year, 5 yearlings and 4 2-year olds were destroyed or translocated out of the study area as a result of management removals, illegal kills and self-defense kills, all prior to 1991. Thirty-three records had either no sex or age data.

Twenty-eight percent (27 of 97) of the LH mortalities were independent female bears. When all hunting related mortalities (IL, SD, TI-H) were included, the female proportion of the kill increased to 34% (51 of 97). The female portion of the kill associated with food attractants (PW, TI-F) was 32%.

Alberta Spatial and Temporal Analyses

Ninety-three percent (17,755 km^2) of the Alberta study area was in suitable grizzly bear foraging and denning habitat (<2400 m). Zones of influence occupied 52% of the Alberta study area and 54% of the area of suitable grizzly bear habitat. Mortalities were not randomly distributed on the landscape. Ninety percent (166 of 185 with accurate locations) of human-caused grizzly bear deaths occurred within buffers along roads (34% north of the Bow R; 52% south of the Bow River) and trails (55% north of the Bow R; 41% south of the Bow River) compared to 51% of the sample of random points. This clumping of mortalities within the zones of influence was significant (G =125.773, df=1, P=0).

Of 37 bears killed outside of ZOIs, 33 were hunting related (24 LH, 6 SD, 3 IL). In addition, seven hunters interviewed stated that they initially observed the bear that they shot (outside of the ZOI) from a road or trail. Three management kills/removals occurred outside of road and trail buffers. Area-concentrated kills occurred along the upper Highwood valley, Bow Valley at Canmore, Evan-Thomas Valley, Ghost River, Waiparous Creek, Fallen Timber Creek, Panther River, Red Deer River near the Ya Ha Tinda Ranch, North Ram River, Clearwater River, and Job Creek (Figure 3).

Since 1987, the average annual mortality dropped to 6.5 deaths/year (n=97) from 8.3 deaths/year (n=132) during the early analysis period. This was predominantly the result of a 74% decline in LH mortalities during 1988–2002. During this same period, management removals more than doubled from the 1972–87 period. Deaths of independent female bears (all human causes) declined from 38% during the early period, 1972–87, to 29% from 1988–2002.

North of the Bow River

Legal hunting accounted for 110 of 185 mortalities north of the Bow River valley. The total number of mortalities dropped by 42% (7.3-4.5 deaths/year) into the 1988–2002 period and legal grizzly bear kills declined by 74% (5.4-1.5 deaths/year). Causes of mortality related to non-grizzly bear hunting (SD, IL, Ti-H) also declined slightly (1.5-1.3 deaths/year) following the implementation of LEH. Mortality types associated with food attractants (PW, TI-F) increased substantially (0.7-1.2 deaths/year) into the later period.

The percentage of female bears in the overall legal harvest averaged 28%, declining from 31% to 19% from the 1972–87 to the 1988–2002 period. Thirty-eight percent of the non-LH mortality was female bears, with 47% and 31% occurring during the early and late periods respectively.

South of Bow River

Causes of mortality related to hunting species other than grizzly bears (SD=10, IL=10, TI-H=3) accounted for 51% of all human-caused mortalities south of the Bow River. This was followed by management kills/removals and other food attractant (TI-F) related mortalities at 40%, and other causes (AC, RE, H) at 9%. Grizzly bear hunting was only legal within Kananaskis Country in 1987, and resulted in the one legally hunted grizzly in the study area south of the Bow River.

Human-caused grizzly bear deaths more than doubled (0.9-2.1 deaths/year) in the 1988–2002 analysis period versus the 1972–1987 period. Hunting related mortality types (IL, SD, TI-H) exhibited a minor increase (0.7-0.9 deaths/year) in the later period, while PW and TI-F kills increased five-fold (0.2-1 death/year). Other causes of mortality (AC, RE, H) showed an increase of 1 grizzly bear death into the later period.

Females accounted for 65 and 38% of the non-LH mortalities south of the Bow River during the 1972–87 and 1988–2002 periods respectively. However, 60% of these mortalities between 1997–2002 were female.

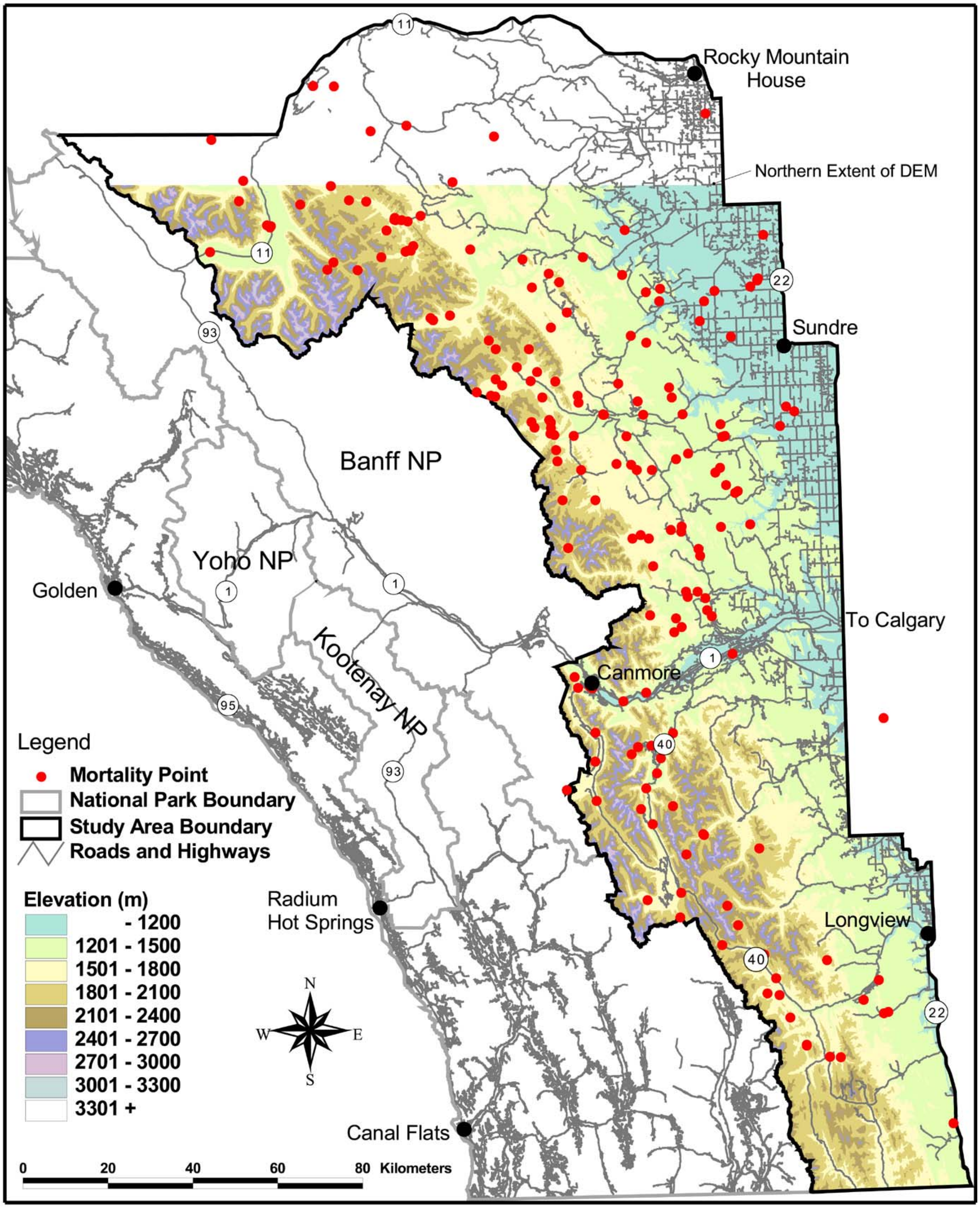

Figure 3. Grizzly bear mortality locations in the Alberta portion of the Central Rockies Ecosystem from 1972–2002.

Elevational Analysis

Elevations were determined for 180 grizzly bear mortality locations in the Alberta study area (Figure 4). Treeline averages approximately 2210–2270 m (7200–7400 ft) along the eastern slopes of the Rocky Mountains.

Forty-four mortality locations south of the Bow River ranged from 1200–2300 m (4240–7500 ft) and 91% occurred below 2000 m (6520 ft). Major valley bottom elevations south of the Bow R. range from approximately 1350 m (4400 ft) on the eastern edge of the study area and in the Bow Valley to 1820 m (6000 ft) at the high point along the Smith-Dorrien Road and 2220 m (7240 ft) at the Highwood Pass.

Base elevations of major river valleys (e.g. Red Deer R., Clearwater R., James R.) north of the Bow R. range from approximately 1350 m (4400 ft) in the east to 1700 m (5540 ft) at the Banff National Park boundary. Eighty-five percent of 136 grizzly bear deaths ranging from 1000–2300m (3260–7500 ft) north of the Bow River occurred below 1800m (5870 ft). Only 2 human-caused mortalities in the Alberta study area occurred above 2100m (6850 ft).

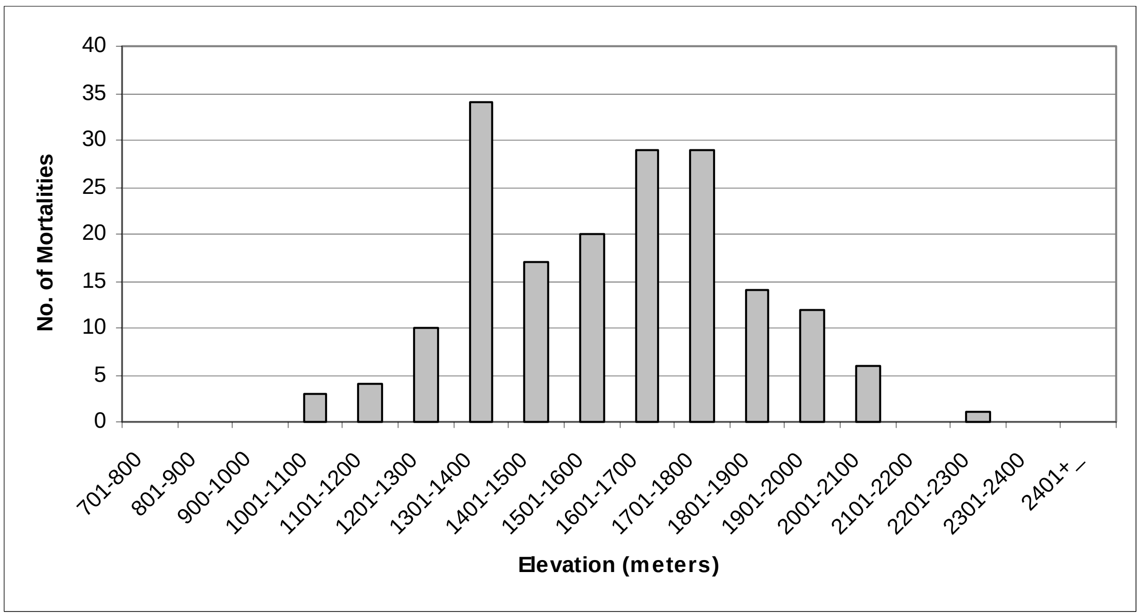

Figure 4. Elevations of grizzly bear kill locations in the Alberta study area of the Central Rockies Ecosystem, 1972–2002 (n=180).

Seasonal Analysis

Of 116 dated non-sport grizzly bear mortalities, 30(26%), 58 (50%), and 28 (24%) took place in the pre-berry, berry (mid-July-late September), and post-berry seasons. Thirty-two of 35 (91%) illegally killed grizzly bears and 20 of 24 (83%) bears killed in self-defence occurred during spring and fall hunting seasons. PW mortalities were spread throughout the year. However, 24 of 42 (57%) and 32 of 42 (76%) bears killed by management actions (PW) took place during the berry season and peak tourist season (June through September) respectively. Both highway mortalities occurred during the berry season.

BRITISH COLUMBIA SUMMARIES

There were 397 records of known human-caused grizzly bear mortalities and three deaths of unknown cause on BC provincial lands from 1976–2002 (Table 4). There were no translocation records available. The average annual number of human-caused mortalities for the 27 year period, 1976–2002 was 14.7 bears/year with the highest number of deaths occurring from 1988–90 (61 mortalities; 20.3/year) and 1994–96 (86 mortalities; 28.7/year; Figure 5). There were only 2 grizzly bear deaths recorded in 1976, possibly due to poor reporting or recording of grizzly bear mortalities during this first year of record keeping. The one mortality in 2001 reflects the implementation of a one-year moratorium on grizzly bear hunting.

Table 4. Causes and number of grizzly bear mortalities, and percentage of known human-caused mortality type, 1972–2002, in the BC study area of the Central Rockies Ecosystem, 1976–2002.

	No. of mortalities			Percentages of known		
KILL TYPE*	1976-1989	1990-2002	1976-2002	1976-1989	1990-2002	1976-2002
LH	145	175	320	86	77	81
PW	15	48	63	9	21	16
IL	9	5	14	5	2	4
unknown	2	1	3			
total	171	229	400			

* LH legal harvest, PW management kill, IL illegal kill

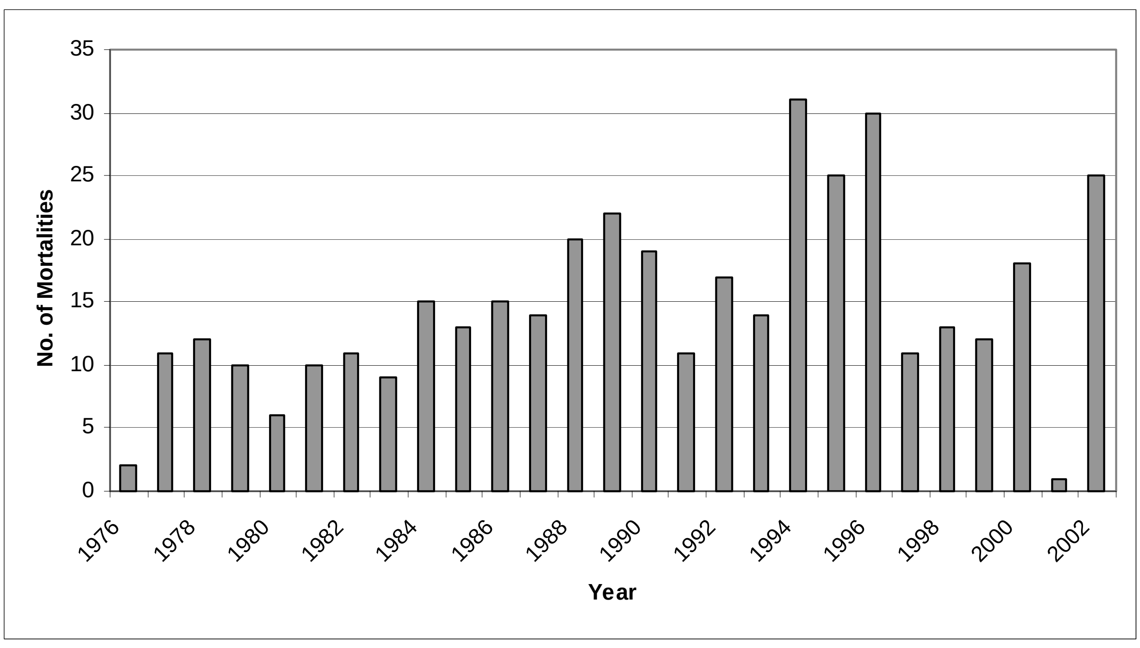

Figure 5. Known human-caused grizzly bear mortalities by year in the BC study area of the Central Rockies Ecosystem, 1976–2002 (n=397).

Legally killed grizzly bears (LH) accounted for 81% (n=320) of all known human-caused mortalities followed by management kills/removals (PW 16%) and illegally killed bears (IL 4%). There was insufficient detail in the BC mortality database to examine the contributing factors that led to non-hunting grizzly bear mortalities.

Sex and Age Analysis

Records showed the sex, age and cohort of 396, 329 and 327 grizzly bears that died (all causes) (Table 5). The overall male:female ratio of dead bears was 65:35. Adult males accounted for 37% of bears killed followed by subadult males (28%), adult females (16%) and subadult females (15%). Seventy-three records had either no sex or age data.

Thirty-one percent of the LH (n=319) and other hunting-related (IL, n=15) mortalities were independent female bears. Females accounted for 65% of management kills throughout the entire period of analysis (9/15, 1976–89; 31/47, 1990–2002).

Table 5. Numbers and percentages of human-caused grizzly bear mortalities by sex, age and cohort in the BC study area of the Central Rockies Ecosystem, 1976–2002.

SEX	1976-1989	1990-2002	1976-2002	1976-1989	1990-2002	1976-2002
male	114	144	258	67	63	65
female	55	83	138	33	37	35
unknown	2	2	4			
total	171	229	400			
AGE	1976-1989	1990-2002	1976-2002	1976-1989	1990-2002	1976-2002
dependent	5	9	14	4	5	4
subadult	61	81	142	44	42	43
adult	72	101	173	52	53	53
unknown	33	38	71			
total	171	229	400			
COHORT	1976-1989	1990-2002	1976-2002	1976-1989	1990-2002	1976-2002
dependent	5	9	14	4	5	4
subad male	38	53	91	28	28	28
subad fem	21	28	49	15	15	15
ad male	52	70	122	38	37	37
ad fem	20	31	51	15	16	16
unknown	35	38	73			
total	171	229	400			

British Columbia Spatial and Temporal Analyses

Ninety percent (9872 km^2) of the BC study area was in suitable grizzly bear foraging and denning habitat as classified by the elevation cut off. Zones of influence occupied 37% of the BC study area and 42% of the area of suitable grizzly bear habitat. Mortalities were not randomly distributed on the landscape. Fifty-six percent (208 of 369 with accurate locations) of human-caused grizzly bear deaths occurred within buffers along roads and trails compared to 34% of the sample of random points. This clumping of mortalities within the zones of influence was significant (G=49.791, df=1, P=1.719 x 10^{-12}). Fifty-three percent and 4% of mortalities occurred along roads and trails respectively.

Of 161 bears killed outside of ZOIs, 152 were hunting related (149 LH, 3 IL) and 9 were management kills/removals. Area-concentrated kills occurred at Elkford, Windermere, upper Elk Valley, Blaeberry River, Luxor Creek, Palliser River, Moose Creek, upper Albert River, White River, Blackwater Creek and Bush Arm (Figure 6).

Since 1989, the average annual mortality increased to 17.6 deaths/year (n=171) from 12.2 deaths/year (n=229) during the early analysis period. This was the result of an increase in both LH (10.3 –13.5 deaths/year) and PW (1.1 – 3.7 deaths/year) mortalities during 1990–2002. Deaths of independent female bears (all human causes) increased slightly as a percentage of total mortality (30% to 31%) although the annual number of female mortalities increased from 2.9/year during the 1976–89 period to 4.5/year in the 1990–2002 period.

The female percentage of legally harvested bears was 30% through both analysis periods.

Elevational Analysis

In the BC study area, 369 mortality locations ranged from 700–2900 m (2280–9450 ft) (Figure 7) and 87% occurred below 2100 m (6850 ft). Treeline averages about 2250–2360 m (7330–7700 ft) along the western slopes of the Rocky Mountains.

Seasonal Analysis

Of 77 dated non-sport grizzly bear mortalities, 19 (25%), 45 (58%), and 13 (17%) took place in the pre-berry, berry (mid-July-late September), and post-berry seasons. All 14 illegally killed grizzly bears died during spring and fall hunting seasons. PW mortalities were spread throughout the year. However, 43 of 63 (68%) and 45 of 63 (71%) management kills/removals took place during the berry season and peak tourist season respectively.

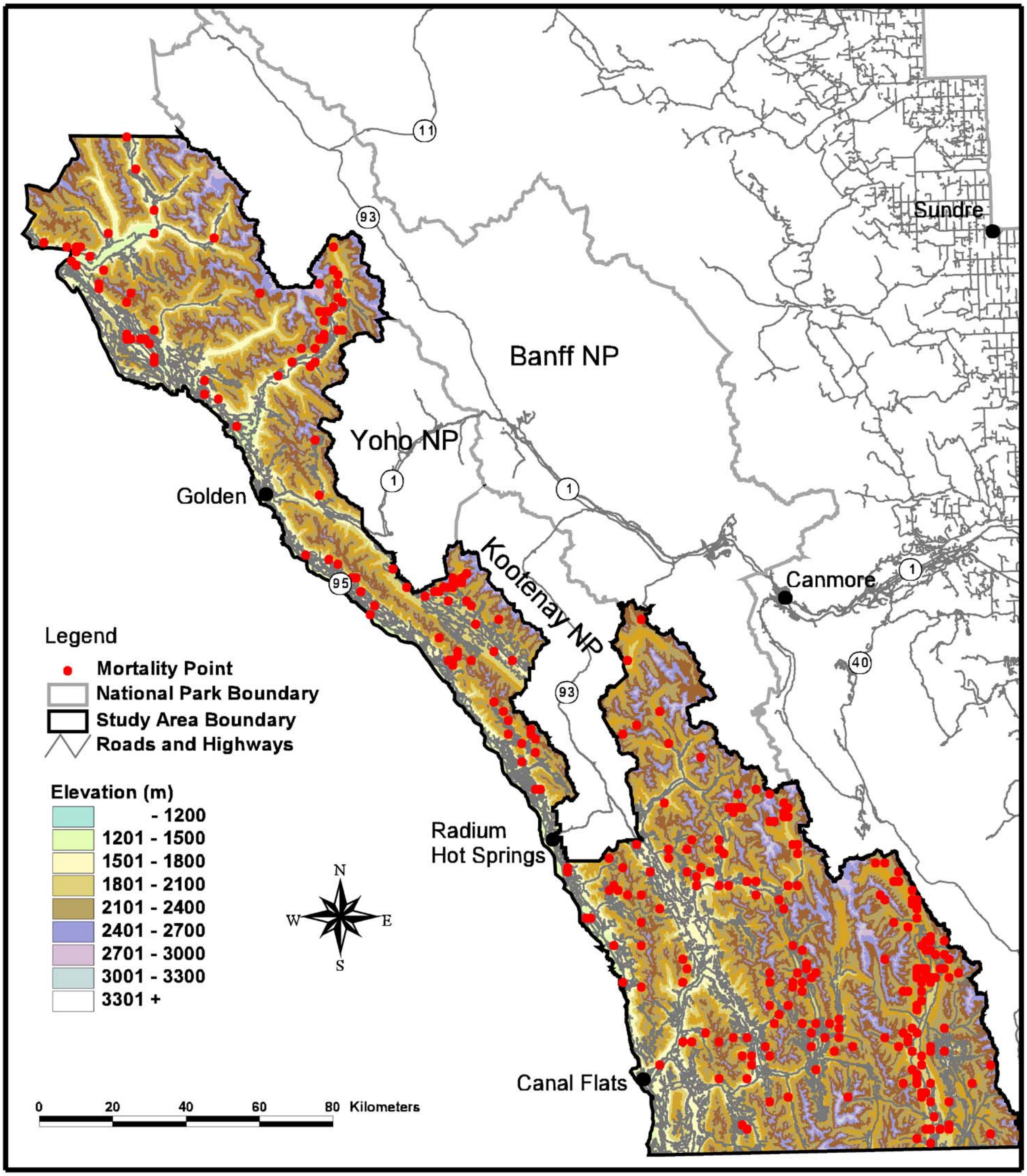

Figure 6. Grizzly bear mortality locations in the BC study area of the Central Rockies Ecosystem, 1976–2002.

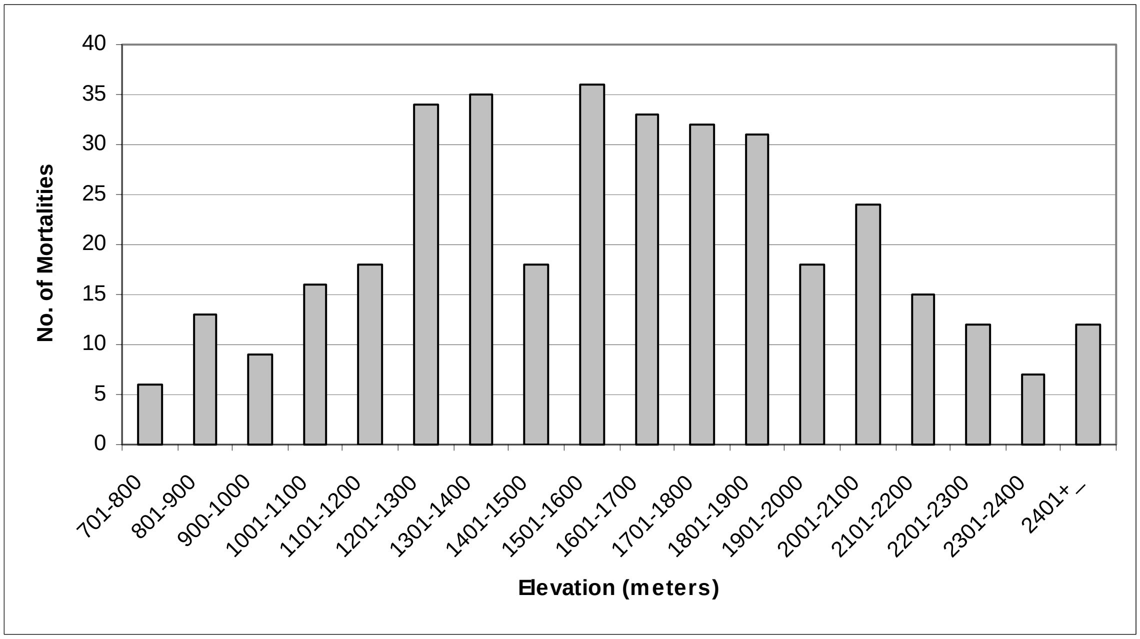

Figure 7. Elevations of grizzly bear kill locations in the BC study area of the Central Rockies Ecosystem, 1976–2002 (n=369).

DISCUSSION

Human-caused mortality has been the predominant way that grizzlies have died in the CRE, including jurisdictions with grizzly bear and ungulate hunting (portions of Alberta and BC), with ungulate hunting but no grizzly bear hunting (portions of Alberta and BC) and without any hunting (Banff and Yoho National Parks, Benn and Herrero 2002). The 229 recorded human-caused grizzly bear deaths in the Alberta study area and 397 in the BC portion of the CRE were considered to be the minimum number from 1972/1976–2002. As the potential number of unreported kills is difficult to accurately estimate, they were not factored into these analyses. McLellan *et al*. (1999) noted that management agencies would have only detected between 45 and 51 percent of the human-caused mortalities of a radio-collared bear sample. The Alberta Fish and Wildlife Division added 25% of the total reported mortality to compensate for unreported kills. In their assessment of Alberta harvest allocation, Stenhouse *et al*. (2003) recommended adding 10-15% for wounding losses and setting the unreported mortality rate at 100% of the non-harvest mortality. The BC Ministry of Wildlife, Lands and Parks uses 2% of the population estimate for unreported mortality in grizzly bear population units (GBPUs) where bear-human conflicts are common and 1% in other GBPUs (Peek *et al*. 2003). They note the potential for a high female portion of this unreported mortality, based on a reported 42% of the unreported kill of a sample of radio-collared bears being female (McLellan *et al*. 1999). Banci (1991) estimated unreported mortality at between 25-100% of the total known kill in BC.

Alberta

The number of grizzly bears killed in the Alberta study area declined slightly between the 2 periods of analysis. This was mostly attributable to the implementation of limited entry hunting, which resulted in a 32% drop in legally harvested grizzly bears. In contrast, the mortality types related to the presence of food and garbage attractants increased substantially on provincial lands with and without grizzly bear hunting, even with greatly improved food and garbage management, informative science-based public education regarding bear-human conflict and more protective management policies.

The growing population base of Calgary, Canmore and other rural Alberta communities has led to increased development (industrial, recreational and rural residential) pressures and the increased killing of grizzly bears that become attracted to developments and people’s activities, especially when there is the opportunity for a food reward for the bear. Relative to GBMAs in most other regions of the province (Stenhouse *et al*. 2003), with the exception of 1988, grizzly bear mortality for Grizzly Bear Management Areas (GBMAs) in the Alberta portion of the CRE from 1988 to 2002 was low south of the Bow River (no hunting) to moderate north of the Bow River (hunting permitted). Garshelis *et al*. (2005) calculated vital rates for grizzly bears trapped in the Bow River watershed portion of the CRE, 1994–2002. Even with the low reproductive capacity of this local population, and the high proportion of females killed in Banff National Park (Benn and Herrero 2002), the 95% survival rate (5% mortality rate) for adult female grizzly bears indicated a probable positive growth rate. However, during 2003–2004 the best available data showed significantly decreased survival rates, 88% for 2003, and 71% for 2004, suggesting population decline during these more recent periods (Chapter 5.2, this report).

Sex and Age Analysis

The composition of females in the harvest and total mortality was within the recommended 35% of the kill over the entire 1972–2002 period. However, this was extremely variable from year to year and area to area. Although detecting trends from analysis of age and sex structure in the kill is controversial (Harris and Metzgar 1987), analyses by Stenhouse *et al*. (2003) suggested a declining trend in the age of females in the total mortality in BMA 4C (north of the Bow River in the CRE).

Stenhouse *et al*. (2003) also noted that more females than males were killed in GBMA 5 (Kananaskis Country) during the 1997–2002 period. As non-harvest mortality types are non-selective for sex, female mortality may exceed sustainable levels during some years and cumulatively present a risk to the population. A series of years, such as apparently occurred in the Bow River Watershed during 2003–2004, with high female mortality could affect the tenuous positive growth rate (Garshelis *et al*. 2005) for many years. Adult females may preferentially use habitats near people, presumably to avoid adult males (Mattson et al. 1992). Thus, they are prone to habituation to humans and attraction to human food and garbage, increasing their mortality risk relative to males in these contexts and their potential for being destroyed or relocated as "problem" animals (Mattson et al. 1987). Craighead *et al*. (1995) described this dynamic in the Yellowstone Ecosystem.

Spatial and Temporal Analyses

Legally hunted grizzly bears accounted for the highest number of mortalities north of the Bow River. Kills related to hunting by Treaty Indians and ungulate hunters dominated south of the Bow River, followed closely by management kills/removals that increased substantially after 1987.

The results of interviews with Alberta grizzly bear hunters and wildlife managers in Alberta with respect to where bears were killed, and subsequent analysis of data thus generated, revealed that most grizzlies died close to human access. Spatial analyses showed a clumping of mortalities along roads and trails, and high concentrations of kills along certain drainages. North of the Bow River, where grizzly bear hunting is permitted, most mortalities occurred along trails, remote from motorized roads. This pattern was also observed in other jurisdictions of the CRE (Chapter 5, this report), and in other populations (Mattson et al. 1987, Mace et al. 1996, McLellan and Shackleton 1988a). Roads and trails improve access for hunters and poachers (McLellan and Shackleton 1988a), and increase the potential for negative bear-human encounters (McLellan and Shackleton 1988b). Thomas et al. (1976) determined that the number of hunters reaching hunting blocks decreased with distance from trails, roads and camping sites.

A small sample of mortalities showed that adult and subadult males were the main cohorts killed outside of the ZOIs. Adult males often dominate the backcountry habitats, farthest from human activities (Mattson et al. 1987). Subadult males may be more available in the backcountry during the spring hunt, as they may disperse widely in search of vacant home ranges (Bunnell and Tait 1985, McLellan and Shackleton 1988b).

Resource selection function analyses of ESGBP mortality data for the Alberta portion of the CRE by Nielsen *et al*. (2004) showed that subadult males were killed both remote from and close to access features. They suggested that during the spring hunting season, grizzly bears were further from access or hunters accessed more remote areas. However, they did not include seismic lines and modeled at a scale (30 m resolution) that probably failed to identify many horse and quad accessible trails (Scott Nielsen, Department of Biology, University of Alberta, Edmonton, Alberta, personal communication). Also, bears frequent valley bottom areas during the spring due to snow cover at higher elevations. In this regard, Nielsen *et al*. (2004) found a positive correlation between mortalities and proximity to water. In this part of Alberta most drainages are accessible by some form of road or trail.

Elevational Analysis

We found that grizzly bears died at relatively low elevation near human developments, and in areas with easy access. All mortalities occurred below the alpine ecological zone. Roads, trails, and developments are almost always placed in valley bottoms, often fragmenting riparian habitats. Similarly, concentrations of kills at settlements and along roads and trails occurred throughout the Central Rockies Ecosystem (Benn 1998) and in other grizzly bear populations (Mattson et al. 1987, Nagy et al. 1989, Mace et al. 1996). Gibeau and Herrero (1998b) showed that human use and developments caused a reduction in the amount of secure habitat for grizzly bears, and as previously mentioned, roads and trails increase the potential for bear-human encounters (McLellan and Shackleton 1988a). Increased access to the backcountry has been shown to alter bear behavior (McCullough 1982, Jope 1985), increase bear-human conflicts (Dalle-Molle and Van Horn 1989), increase the number of grizzly bear removals (Martinka 1982, Leonard et al. 1990), and displace certain cohorts, such as females with young (Mattson et al. 1987, Gilbert 1989).

Mortalities at the lowest elevations in the Alberta study area coincide with ranching and agricultural land uses outside of the forest reserves and in the lower reaches of valleys on crown land. The main causes of grizzly bear death in these areas are the result of management control and illegal activities.

Seasonal Analysis

We found that a high proportion of mortalities occurred during the berry season. Mid-July to early October is the time when grizzlies in the Central Rockies Ecosystem feed primarily on buffaloberry (*Shepherdia canadensis*) at lower and mid elevations, often along roads and in close proximity to people.

British Columbia

Legal harvests accounted for a large majority of mortalities in the database. Limited entry hunting was introduced in 1982 as a way to regulate the distribution of hunters across the landscape and prevent area-concentrated kills, however area concentrated kills remain a concern (Chapter 6.6, this report). Population studies in the Flathead River and Revelstoke areas showed larger population sizes than previously thought, and with positive growth rates (Bruce McLellan, BCMOELP Forest Service Research Branch; Guy Woods, BCMOELP Senior Wildlife Biologist; personal communication). Thus, more permits were allocated (50% increase in 1989; Simpson *et al*. 1995) to maximize the harvest within the target of 4% of the population estimate.

The number of grizzly bears killed in the BC study area increased between the 2 periods of analysis, primarily because of the large number of LH mortalities. Management kills also increased in the 1990–2002 period, even with improved food and garbage management. A spike in PW mortalities occurred in 1994–95 was probably the result of the 1994 closure of several landfills in southeast British Columbia. Bears losing such a food source, often seek food around other human developments and settlements (Mattson et al. 1992, Craighead et al. 1995, Bennett 1996). The number of grizzly bears removed from the ecosystem due to management control was likely higher by some unknown number of translocations than are recorded here. Teske (1994 in Simpson *et al*. 1995) noted that in the Kootenay region of BC of which our study area is a part, wildlife control led to “larger than normal numbers of relocations of grizzly bears”.

The high percentage of mortalities occurring in road buffers reflects the large amount of backcountry roading in BC. These roads are predominantly forestry and mining roads.

Sex and Age Analysis

The female portion of the harvest and overall mortality remained around the recommended 30% of the kill over the entire 1972–2002 period. However, management kills claimed a high proportion of females throughout the entire period of analysis. This pattern was also seen in Alberta and the adjacent national parks (Benn and Herrero 2002). As previously described, females may use habitats near people, increasing their risk of habituation to humans and thereby their risk of being killed in management actions (Mattson et al. 1987).

Elevational Analysis

The majority of mortalities occurred below treeline. Although we believe the same realtionship exists as in Alberta, elevations in the BC study area are less accurate than in the other jurisdictions due to the coarse resolution of mortality locations (±1000 m).

Seasonal Analysis

We found that a high proportion of mortalities occurred during the berry season. As in Alberta, Mid-July to early October is the time when grizzlies in the BC portion of the Central Rockies Ecosystem feed primarily on berries. In BC there are diverse berry feeding opportunities. In addition to buffaloberry (*Shepherdia canadensis*), berries in particular of the genus *Vaccinium* occur at lower and mid elevations, often along roads and in close proximity to people.

CONCLUSIONS AND RECOMMENDATIONS

Hunting, human intolerance, inadequate management of access and food attractants, and ongoing recreational and industrial development continue to be important contributing factors to grizzly bear mortality in the Alberta and BC portions of the Central Rockies Ecosystem. Significant steps have been taken by managers in all jurisdictions to reduce human-caused grizzly bear mortality. However, bear hunting, which occurs in a large portion of the CRE, is based on crude population estimates usually without confidence intervals. This combined with the mortality risk associated with human food and garbage attractants and extensive roading presents a risky dynamic for the sustainability of the CRE grizzly bear population. By considering the following recommendations, aimed at reducing potential conflicts between humans and grizzlies, human-caused grizzly bear mortality and the potential for human injury can be reduced.

The results of the above analyses and those from previously published research on mortality in grizzly bear populations throughout North America, allowed us to reach the following general conclusions, and to make recommendations with respect to managing grizzly bear mortality in the Central Rockies Ecosystem. These conclusions and recommendations are based on the following three assumptions:

- the databases represent the minimum number of grizzly bear kills/removals;
- the stated goal of management agencies in Alberta and BC is to maintain or enhance the current population size and distribution of grizzly bears; and
- the recreational hunting of grizzly bears is an acceptable practice provided it is scientifically demonstrated to not cause population decline.

Conclusion 1: A high proportion of all grizzly bear deaths throughout all jurisdictions in the CRE were the result of human actions. Managing grizzly bear mortality entails managing human activities in grizzly bear habitat. We conclude that land use that considers the needs of grizzly bears requires interagency planning and management at a regional scale. This includes:

1. all jurisdictions developing the same reporting methods and conventions for recording accurate and complete mortality and relocation data;
2. dedicating funds to ensure that staff have the ability to collect data (e.g. aging from teeth) in a timely fashion (in the past age and sex information have been inconsistently recorded);
3. recording accurate (UTM) locations in order to conduct future spatial analyses (in Alberta information has been recorded at the scale of a section of a township and in BC to ± 1000m);
4. increasing funding for research and application regarding aversive conditioning techniques;
5. continuing to use more hard (aversive conditioning) on-site releases or within home range relocations;
6. making the practice of closing public areas during periods that bears (especially females and family groups) are known to use them more widespread; and
7. continuing to improve educational programs regarding living and recreating safely in bear country.

Conclusion 2: This analysis was based on the recorded (minimum) number of mortalities/relocations. Unreported mortality has been calculated at 46–51% and up to 100% of known mortality (McLellan et al. 1999). We recommend:

1. increasing the 25% adjustment figure for unreported mortality in Alberta by adding in a factor for wounding losses of 10-15% of legally killed bears and 100% of non-harvest mortalities (McLellan *et al*. 1999, Stenhouse *et al*. 2003); and
2. committing to increasing levels of enforcement in areas with a history of vandalistic and illegal grizzly bear killing.

Conclusion 3: Within the BC portion of the CRE where hunting is permitted, harvest and total mortality appear to have been within acceptable parameters (Peek et al. 2003). In Alberta it is less clear whether sustainable hunting mortality has been attained (declining trend in age of females in total mortality, Stenhouse et al. 2003). These conclusions are, however, contingent on the population estimates used. Self-defense, illegal, and mistaken identity kills by ungulate and black bear hunters account for a large percentage of grizzly bear deaths in some regions of the CRE. We recommend:

1. increasing the level of commitment to developing and using science-based population assessment techniques with confidence intervals;
2. continuing to closely monitor harvest and total mortality, and adjust hunting permit allocations accordingly;
3. where hunting (bear and ungulate) is permitted, creating No Shooting Zones around high human use areas, and along high use roads to reduce the killing of habituated grizzlies by hunters and other people with guns who encounter these bears at close range; and
4. requiring hunters going into grizzly bear habitat to show a proficient understanding of bear identification, behavior, and safety.

Conclusion 4: Most management control mortalities occur where bears are attracted to human food and garbage, livestock and feed, and this has been associated with a high proportion of females in the kill. We recommend that effective legislation and enforcement be enacted to ensure that:

1. all concessionaires in the parks and provinces secure all food attractants and that this is regularly inspected;
2. all remaining public and commercial landfills and other garbage storage and transfer facilities are bear proofed with appropriate safeguards, preferably electric and chain link fencing;
3. all back country users (campers and hunters) be required to secure food attractants including feed for stock and carcasses;
4. agency personnel continue to assist landowners in reducing livestock-bear conflicts; and
5. the predator compensation program be improved. Fair compensation for loss to landowners exercising good husbandry techniques will instill tolerance for bears on their land.

Conclusion 5: Spatial analyses clearly showed that most grizzlies died within a narrow zone along roads and trails, and around human settlements. Yet, roads and major developments continue to be constructed in grizzly bear habitat and remain open to the public. We recommend:

1. collecting more detailed access-related (type of access route and method of travel, distance of kill from nearest access, presence of human and natural food attractants near the access route) and location information (UTM coordinate) with each grizzly bear mortality;
2. regulating access into high quality grizzly bear habitat through quotas and/or road closures, particularly in areas with past concentrations of mortality; and
3. committing to no new roads into the remaining secure grizzly bear habitats, and requiring the decommissioning of industrial roads at project termination.

Conclusion 6: Temporal analyses of the mortality data, as conducted in this project, are snapshots in time. We recommend:

1. repeating temporal analyses every five years, or when updated population estimates are available, to assess changing management strategies, and other events that affect grizzly bear survival.

The CRE will face increasing pressure from human activities as nearby urban and rural populations grow (Chapter 13, this report). As the CRE grizzly bear population exists at a low population density and has a low reproductive potential, it is vulnerable to increased mortality risk with the greater exposure to people. Thus, there will be an ongoing need to fund scientific research into accurately estimating population size and better understanding the effects of human presence and access into grizzly bear habitat. Finally, until accurate population estimates are available, we recommend a conservative approach by reducing overall human-caused grizzly bear mortality. This approach would be enhanced by integrating the above recommendations into regional planning and management policy.

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