Rates and Causes of Grizzly Bear Mortality in the Interior Mountains of Western North America

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ABSTRACT

Understanding rates and causes of grizzly bear (*Ursus arctos*) mortality is critical to their conservation. Using data obtained from 13 study areas in the Rocky and Columbia mountains of Alberta, British Columbia, Montana, Idaho, and Washington, we estimated survival rates and causes of mortalities for 388 grizzly bears radio-collared for research purposes between 1975 and 1997. We found that people killed 77–85% of the 99 bears that were known or suspected to have died while radio-collared. In jurisdictions that allowed grizzly bear hunting, legal harvest accounted for 39–44% of the deaths. Other major causes of mortality included control killing for threatening human habitation or property, self-defence, and malicious killings. The mortality rate due to hunting was higher for males than females, and subadult males had a higher probability of being killed as problem animals than did adult males or females. Adult females had a higher mortality rate from natural causes than males. The annual survival rates of subadult males (0.74–0.81) were lower than for other sex-age classes. Survival rates of adult males varied between 0.84 and 0.89 in most areas. Comparing the survival rates of females between areas dominated by multiple-use land with those dominated by parks, we found that although few bears were killed within park boundaries, survival rates appeared to be higher in multiple-use areas (0.95–0.96 vs. 0.91). The importance of well-managed multiple-use land to grizzly bear conservation should be recognized, and land-use plans developed for these areas should ensure there is no human settlement and only low levels of recreational activity. Without radiotelemetry, management agencies would have been aware of only about half (46–51%) of the deaths of radio-collared grizzly bears.

Key words: Alberta, British Columbia, grizzly bear, hunting, Idaho, Montana, poaching, problem wildlife, protected areas, survival rate, *Ursus arctos*, Washington.

Due to late maturation and a low reproductive rate, grizzly bear populations are most sensitive to a change in female survival (Knight and Eberhardt 1985, McLellan 1989, Eberhardt et al. 1994, Hovey and McLellan 1996, Mace and Waller 1998). Unlike most other large mammals, however, grizzlies are killed for a variety of reasons in addition to legal sport hunting. Understanding the causes and rates of grizzly bear mortality is fundamental to grizzly bear conservation, but because grizzly bears are difficult to capture and keep radio-collared, individual research projects rarely collect sufficient information on mortality factors to make general inferences. In this paper, we present the analysis of mortality data collated from several telemetry-based studies of grizzly bears from areas with a variety of management goals. We also estimated the proportion and types of grizzly bear deaths that would not have been recorded by management agencies unless the bears had been radio-collared.

METHODS

We analyzed data from 13 study areas in the Rocky and Columbia mountains of British Columbia, Alberta, Montana, Idaho, and Washington, collected between 1975 and 1997. Due to low sample sizes, data from several studies in geographically similar or adjacent areas with similar management goals were pooled. Study areas were the Mountain Parks, Waterton/Blackfeet, Northfork (NF) Flathead, Southfork (SF) Flathead, and Cabinet/Selkirks.

Bears were captured for research purposes and radio-collars were attached with a canvas connector that decomposed

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and allowed the collar to drop from the bear after a planned amount of time. Bears killed as problem wildlife, for defence of life or property, taken legally by hunters, and some illegal killing were reported to or investigated by conservation officers. Cause of death of other radio-collared bears was determined by investigating the site.

Mortalities were first classified as natural, human-caused, or unknown. Those classified as human-caused were further categorized by the apparent reason: 1) legal hunting; 2) malicious, when the animal was shot and left for no apparent reason; 3) management problem, when the bear was near buildings, camps, or livestock, and killed or removed by a wildlife official; 4) citizen's problem, when a citizen shot the bear for being near buildings, livestock, or a camp; 5) self-defence, when a person thought their safety was threatened; 6) poached, when the animal was hunted but killed illegally; 7) accident, such as a vehicle collision; and 8) unknown, when a radio-collar had been cut off. We also recorded suspected human-caused deaths and whether or not the management agency would have recorded the death if the animal had not been radio-collared.

Survival rates were estimated for each sex-age class using Kaplan-Meier estimator described by Hovey and McLellan (1996). We tested differences in survival rates among study area groups and sex-age classes using an unbalanced, 2-way analysis of variance (ANOVA; Montgomery 1991). Differences in mortality rates associated with different causes were analyzed as a 1-way ANOVA treating sex-age class as the design factor. Because each jurisdiction had different management goals, practices, and laws, we summarized causes of mortality by jurisdiction. Because collared bears frequently moved among jurisdictions we had to calculate survival rates for each study area group.

RESULTS

Of 388 radio-collared grizzly bears that were monitored for a total of 704.4 radio-tracking years, 90 (23%) were known to have died, and 9 (2.3%) were suspected to have died, while radio-collared. Survival rates differed among sex-age classes ($F_{3,351} = 3.89$, $P = 0.009$; Table 1), but not among study area groups ($F_{3,351} = 0.690$, $P = 0.559$). The annual survival rates of adult males, adult females, and subadult females were not different, but all were greater than the survival of subadult males.

Depending on how the 9 suspected deaths and 5 deaths from unknown causes were treated, people caused 77–85% of the grizzly bear deaths. In British Columbia and Alberta grizzly bear hunting was legal, but it was only a major cause of mortality of radio-collared bears in British Columbia, where it accounted for 39–44% of the deaths. Ungulate hunters killing grizzly bears in self-defence, hunters mistaking a grizzly bear for a black bear (*Ursus americanus*), and malicious killing were major causes of grizzly bear deaths in Montana. Being shot or translocated by wildlife officials or shot by a citizen for killing livestock or being near homes or camps was a major mortality factor in several jurisdictions. Poachers rarely killed collared bears, there was no evidence of a collared bear dying after being wounded by a hunter, and people killed bears for unknown reasons in most studies.

Without the aid of radiotelemetry, management agencies would have been aware of 46–51% of radio-collared grizzly bear deaths and 54–66% of human-caused deaths. A large proportion of the collared bears in British Columbia were killed legally and reported by hunters, but even there the management agency would have recorded only 53–59% of the mortalities and 67–83% of the human-caused deaths.

Mortality rates due to hunting differed among sex-age classes ($F_{3,425} = 4.17$, $P = 0.006$; Table 2), with adult and subadult males having similar rates, which were higher than adult or subadult females. Mortality rates due to a combination of management and citizen control killing also differed among sex-age classes ($F_{3,425} = 4.06$, $P = 0.007$), with subadult males having a higher rate than the other 3 classes. Mortality rates from a combination of the clearly illegal categories of poaching, malicious killing, and killing for unknown reasons (collars cut off) did not differ among sex-age classes ($F_{3,425} = 1.89$, $P = 0.131$). Mortality rates from other human causes (accidents, misidentification, and self-defence) differed among sex-age classes ($F_{3,425} = 2.80$, $P = 0.040$). Adult males had a higher rate than adult females, as 5 adult males but 0 adult females were shot in self-defence. Natural mortality rates differed among sex-age classes ($F_{3,425} = 3.83$, $P = 0.010$), with adult females having a higher rate than adult or subadult males. Twelve females died of natural causes: 3 in rock or snow avalanches; 1 in a collapsed den; 5 apparently killed by conspecifics; and 3 by unknown causes.

DISCUSSION

Although grizzly bear hunting selects males over females and was permitted in some study area groups but not others, adult males had similar mortality rates in all areas. Survival rates of adult males in our study areas were similar to the 0.84 recorded in a hunted population on Chichagof Island (Titus and Beier 1994), but higher than the 0.75–0.80 recorded in the Susitna drainage of Alaska. The Susitna population was being intentionally reduced in an attempt to increase survival of moose (*Alces alces*) calves (S. Miller, Alaska Department of Fish and Game, pers. comm.).

Survival rates of adult females were similar to rates of adult males in the Mountain Parks and SF Flathead study areas and also similar to the 0.89–0.92 recorded for adult females in the grizzly bear reduction area of the Susitna drainage, Alaska (S. Miller, pers. comm.). Adult female survival rates in the NF Flathead and Selkirk/Yaak, however, were similar to that of females on Chichagof Island (0.96; Titus and Beier 1994), and

Table 1. Estimated annual survival rates of adult and subadult (excludes radio-collared cubs and yearlings) grizzly bears of each sex by groups of study areas in the Rocky and Columbia mountains, 1975–97.

Age/sex class	Study group	No. of bears	Mortalities [suspected]	Radio-years	Survival rate	SE
Adult Female						
	Mountain Parks	41	6	65.5	0.905	0.036
	NF Flathead	31	4	89.9	0.959	0.021
	SF Flathead	14	6	50.0	0.888	0.043
	Selkirk/Yaak	18	3	57.9	0.952	0.026
	Blackfeet/Waterton	14	0[2]	22.4	0.918	0.055
Combined		118	19[2]	285.7	0.926	0.006
Adult Male						
	Mountain Parks	50	7	55.8	0.891	0.038
	NF Flathead	24	4	35.1	0.887	0.054
	SF Flathead	12	3	25.4	0.888	0.062
	Selkirk/Yaak	18	5	27.8	0.842	0.066
	Blackfeet/Waterton	7	3	7.0	0.625	0.180
Combined		111	22	151.1	0.877	0.006
Subadult Female						
	Mountain Parks	14	1	17.8	0.954	0.045
	NF Flathead	25	3	46.5	0.935	0.036
	SF Flathead	18	5	35.2	0.872	0.054
	Selkirk/Yaak	10	1	9.5	0.929	0.070
	Blackfeet/Waterton	13	3	19.5	0.859	0.077
Combined		80	13	128.5	0.923	0.008
Subadult Male						
	Mountain Parks	29	8	24.6	0.742	0.078
	NF Flathead	36	5[4]	36.4	0.782	0.063
	SF Flathead	11	4	15.4	0.784	0.095
	Selkirk/Yaak	16	4	18.7	0.807	0.090
	Blackfeet/Waterton	17	3	12.1	0.798	0.106
Combined		109	20	107.2	0.801	0.007

appeared to be higher, although not statistically so, than in the Mountain Parks and SF Flathead.

The lack of difference or perhaps even higher adult female survival rates in some multiple-use landscapes (e.g., NF Flathead, Selkirk/Yaak) compared to areas dominated by protected areas (e.g., Mountain Parks) is an important consideration in developing conservation strategies. Although few collared bears died when inside park boundaries, bears had high mortality rates on the periphery. The high mortality rate along park boundaries is likely an indirect result of nearly 1 million people within a 1–2 hour drive, and approximately 43,000 residents and 28,000 hotel beds in occupied grizzly bear habitat of the Mountain Park study areas. Similarly, within the SF Flathead study area, Mace and Waller (1998) found bears with home ranges entirely within multiple-use areas had higher survival rates than bears that also used rural settlements or designated wilderness areas. We suggest that the long-term conservation value of protected areas is not only related to the amount and quality of habitat they contain and their bear management programs, but also the number and activities of people using the protected area and adjacent lands. Multiple-use lands remote from human population centres may be critical to the long-term conservation of grizzly bears, provided that they are managed for low-density human use.

Most radio-collared bears died because people killed them. Hunting was a significant factor only in British Columbia, where it accounted for less than half the deaths. It is probable that in more remote areas a higher proportion of grizzly bear deaths would be from legal hunting because, with less human settlement, control killing would be reduced (Miller and Chihuly 1987). Results from remote study areas in Alaska suggest that 78–100% of the human-caused deaths of radio-collared bears were from hunting (Schoen and Beier 1990, Smith and Van Daele 1991, Reynolds 1993, Sellers 1994).

Development and implementation of comprehensive access, recreation, and settlement plans are essential in occupied grizzly bear habitat to maintain a low density of people, particularly those who engage in activities that put bears at risk (McLellan 1990, Mattson et al. 1996, Mace and Waller 1997). Black bear and ungulate hunters killed a relatively

Table 2. Age/sex class of known mortalities of radio-collared grizzly bears that would have been recorded by the management agency. The number of additional known mortalities and suspected mortalities that would not have been detected if they had not been radio-collared are in ( ) and [ ], respectively.

	Age/sex class				
Cause of death	Adult female	Adult male	Subadult female	Subadult male	Total
Natural	(10)	0	(2)	(2)	(14)
Unknown	(2)	0	0	(3)	(5)
Human-caused					
Hunter Kill	2	10	0	4	16
Citizen Problem	0	(1)	1	1(2)[1]	2(3)[1]
Management Problem	1	3	1	5	10
Misidentification	1	0	1(3)	0	2(3)
Self-defence	0	4(1)	0	1	5(1)
Accident	0	(1)	1	0	1(1)
Poach	1	1(1)	1	2(1)	5(2)
Malicious	1(1)	(1)	(2)	(2)	1(6)
Unknown	(1)[3]	(1)	(2)[1]	(2)[4]	(6)[8]
Total: Human-caused	6(2)[3]	18(6)	5(7)[1]	13(7)[5]	42(22)[9]
Total: All Deaths	6(14)[3]	18(6)	5(9)[1]	13(12)[5]	42(41)[9]

high proportion of the radio-collared grizzly bears. Misidentification, self-defence, and problems associated with attractants such as garbage, food, and ungulate carcasses in hunting camps were often the reason for killing bears. Enforcement of existing rules about clean camping, and emphasis on techniques for hunting in grizzly bear country during hunter training courses and in regulation synopses may reduce the number of grizzly bear mortalities associated with big game hunting seasons.

Managers should incorporate appropriate estimates of unreported kills in estimates of acceptable harvest rates. These estimates, however, remain uncertain, but appear to depend on the amount of legal hunting and the degree that bears and people share habitat. In remote areas with legal hunting managers will likely be aware of >70% of the bears killed by people. In areas without legal hunting and where people commonly live, work, and recreate in occupied grizzly bear habitat, the unreported number of bears people kill is likely equal to the number reported.

See McLellan et al. (1999) for a more detailed version of this paper.

LITERATURE CITED

Eberhardt, L. L., B. M. Blanchard, and R. R. Knight. 1994. Population trend in the Yellowstone grizzly bear as estimated from reproductive and survival rates. Can. J. Zool. 72:360–363.

Hovey, F. W., and B. N. McLellan. 1996. Estimating population growth of grizzly bears from the Flathead River drainage using computer simulations of reproductive and survival rates. Can. J. Zool. 74:1409–1416.

Knight, R. R., and L. L. Eberhardt. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323–334.

Mace, R. C., and J. S. Waller. 1997. Final report: grizzly bear ecology in the Swan Mountains, Montana. Montana Fish, Wildl. and Parks, Helena, MT.

_____, and _____. 1998. Demography and population trend of grizzly bears in the Swan Mountains, Montana. Conserv. Biol. 12:1005–1016.

Mattson, D. J., S. Herrero, R. G. Wright, and C. M. Pease. 1996. Science and management of Rocky Mountain grizzly bears. Conserv. Biol. 10:1013–1025.

McLellan, B. N. 1989. Population dynamics of grizzly bears during a period of resource extraction. III. Natality and rate of change. Can. J. Zool. 67:1865–1868.

_____.1990. Relationships between human industrial activity and grizzly bears. Internatl. Conf. on Bear Res. and Manage. 8:57–64.

_____, F. Hovey, J. Woods, M. Gibeau, D. Carney, R. Mace, W. Wakkinen, and W. Kasworm. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, and Idaho. J. Wildl. Manage. 63:991–920.

Miller, S. D., and M. A. Chihuly. 1987. Characteristics of nonsport brown bear deaths in Alaska. Internatl. Conf. on Bear Res. and Manage. 7:51–58.

Montgomery, D. C. 1991. Design and analysis of experiments, 3rd ed. Wiley and Sons. New York, NY.

Reynolds, H. V. 1993. Evaluation of the effects of harvest on grizzly bear population dynamics in the northcentral Alaska Range. Alaska Dep. Fish and Game, Juneau, AK.

Final Rep., Study 4.23.
Schoen, J., and L. Beier. 1990. Brown bear habitat preferences and brown bear logging and mining relationships in southeast Alaska. Alaska Dep. Fish and Game, Juneau, AK. Study 4.17.
Sellers, R. A. 1994. Dynamics of a hunted brown bear population at Black Lake, Alaska. 1993 annual progress report, Alaska Dep. Fish and Game, Juneau, AK.
Smith, R. B., and L. J. Van Daele. 1991. Terror Lake hydroelectric project, Kodiak Island, Alaska. Final report on brown bear studies (1982-1986). Alaska Dep. Fish and Game, Juneau, AK.
Titus, K., and L. V. Beier. 1994. Population and habitat ecology of brown bears on Admiralty and Chichagof Islands. Alaska Dep. Fish and Game, Juneau, AK. Progress Rep., Study 4.22.