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Population Characteristics of Grizzly and Black Bears in West Central Alberta

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POPULATION CHARACTERISTICS OF GRIZZLY AND BLACK BEARS IN WEST CENTRAL ALBERTA

by

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ABSTRACT

Population characteristics of grizzly and black bears were determined by capturing, marking, and radio tracking bears in the Berland River area of west central Alberta during 1981-85. Trapping was conducted in prime spring grizzly bear habitat. Eighteen male and 20 female grizzly and 16 male and 16 female black bears were captured. The average enumerated post-emergence spring grizzly bear population was 37 animals, giving a density of 4.6 bears/1000 km^2 on the minimum effective trapping area. The grizzly bear population had low density, was comprised primarily of adults (63.1%), and was characterized by poor productivity (1.8 cubs/female and a reproductive interval >4 years). These data collectively suggest that the grizzly bear population was declining. This decline was considered to reflect the effects of long-term legal harvest, encroaching resource development activities, and habitat deterioration on that population.

The average post-emergence spring black bear population was 36 bears, giving a density of 5.7 bears/1000 km^2. The black bear population was comprised primarily of adults and subadults. Data on population characteristics were considered to be inadequate to give an indication of the affect of hunting on or of the relative status of the Berland black bear population.

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1. INTRODUCTION

The boreal forest in west central Alberta supports one of the few remaining populations of grizzly bears (Ursus arctos) outside of mountain habitats in the province. Pressures on this population from resource development and recreational activities have increased in recent decades. In 1980, 7,720 km^2 of this area were leased to British Columbia Forest Products (BCFP) for long-term commercial rotational cutting and reforestation. This action raised concerns about the future welfare of the population because increased regional access and altered habitats produced by logging activities could adversely affect grizzly bears and other sensitive wildlife species in the area.

Grizzly bear studies have been conducted in Alberta in the alpine-subalpine (Russell et al. 1979, Hamer et al. 1981, Hamer and Herrero 1983), boreal foothills (Nagy and Russell 1978) and boreal mixed wood ecoregions (Horejsi 1986) in Alberta. In this study we investigated the population ecology of grizzly bears in the boreal upland ecoregion in the Berland and Little Smoky rivers area in west central Alberta (hereafter called the Berland area). Specific objectives were to determine the size, density, productivity and stability of this grizzly bear population. Because grizzly bears occurred sympatrically with black bears (Ursus americanus) in the Berland area, we also obtained data on the population characteristics of black bears.

2. STUDY AREA

The study area encompassed the headwaters of the Little Smoky River and the Berland-Wildhay river system (Figure 1). The area is part of the Western Alberta Plains Geologic Region. The bedrock is upper cretaceous and tertiary sandstone and shale, and the soil is grey wooded, covering outwash comprised of sand and gravel. Elevation ranged from 1200-1800 m in the west to 900-1200 m in the central and eastern parts of the study area.

The area fell within the boreal uplands ecoregions. The climate was continental. Isotherms enclosing the area ranged from -14 to -12°C in January and 12 to 14°C in July. The mean annual precipitation was 508-559 mm and mean annual snowfall was 1.5-2.0 m. Lodgepole pine (Pinus contorta) and white spruce (Picea glauca) comprised the dominant overstory throughout most of this region, although aspen (Populus tremuloides), white spruce and black spruce (Picea mariana) dominated the northeastern portion. White birch (Betula papyrifera) was scattered in small amounts throughout. There were extensive areas of muskeg, especially along the Little Smoky River. The general forest productivity rating within the study area was 70-140 m^3/ha. Indigenous wildlife included grizzly bears, black bears, mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), wapiti (Cervus elaphus), moose (Alces alces), goat (Oreamnos americanus), wolf (Canus lupus), beaver (Castor canadensis), lynx (Lynx canadensis) and possibly cougar (Felix concolor). Feral horses (Equus caballus) also occurred in the area.

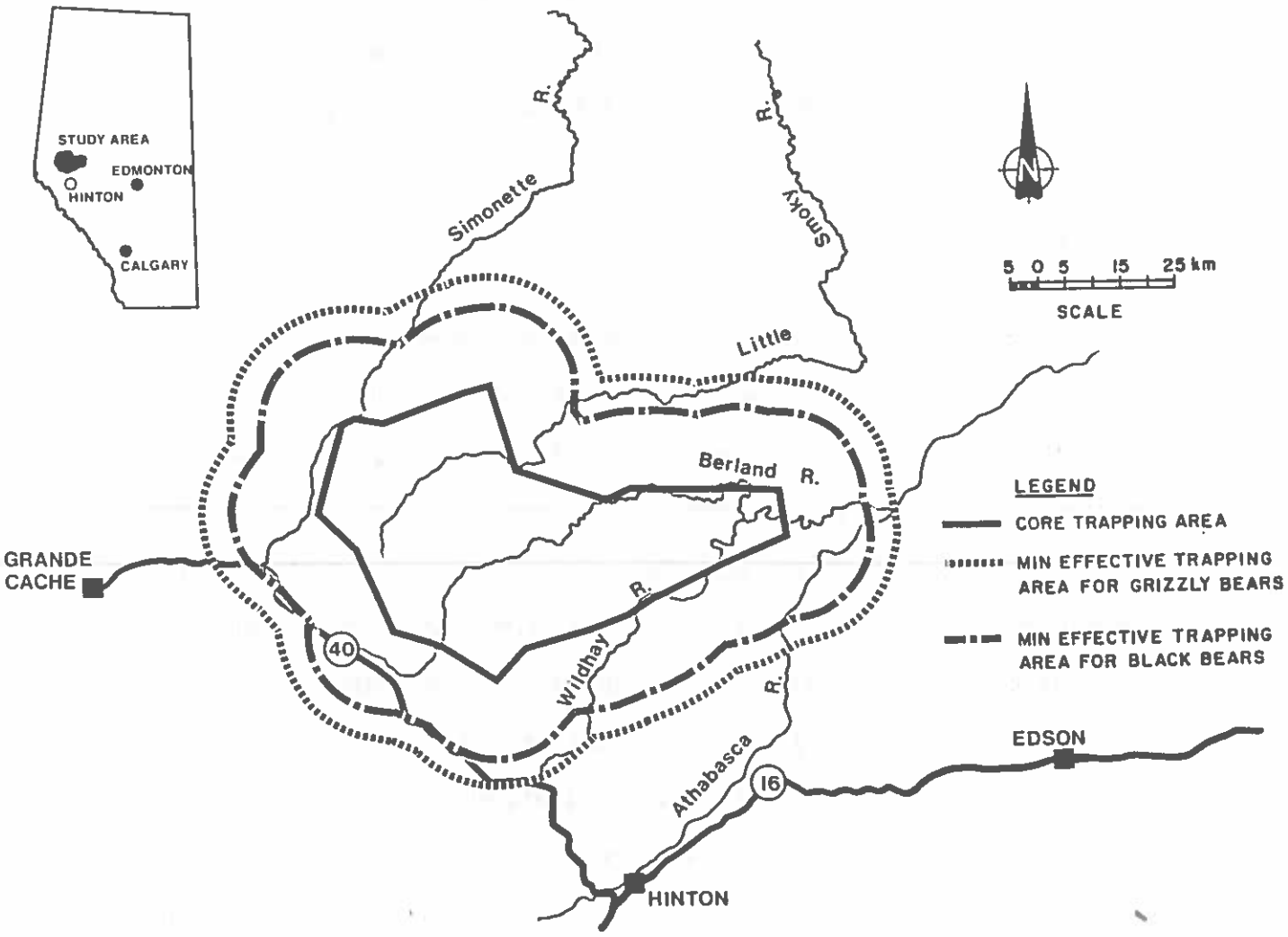

Figure 1. Location of the minimum effective trapping area for grizzly and black bears in west central Alberta.

Extensive winter seismic activity and limited development of oil and gas wells have occurred in the study area. There are irregularly located road networks resulting from petroleum extraction but ground travel is generally limited to all-terrain vehicles or on foot. Logging activities commenced on a limited scale in the western portion of the area in 1981. Much of the study area, particularly the river valleys, remain pristine.

3. METHODS

Cubbies for trapping bears were constructed in fall 1980 and spring 1981 at 35 sites considered to be prime spring grizzly bear habitat in the primary and secondary drainage valleys of the Wildhay, Berland, Little Smoky and Simonette Rivers. Additional trap sites were established in 1982 and 1983 in an effort to capture bears, particularly adult female grizzly bears with cubs, that might have used spring habitats that were less preferred than those in the major river valleys. Trapping was conducted in 1981, 1982 and 1983. A maximum of 34 to 38 trap sites were maintained each year. Trapping periods commenced each spring when adult male grizzly bears became active as estimated from climatic conditions in 1981, and by the activity of radio-collared animals in subsequent years. Trapping ceased when there was a dramatic decline (about 50% of maximum) in the frequency of bear visitations at trap sites, generally in mid-June.

About 200-250 kg of beaver carcasses or other available baits were deposited at each trap site to attract bears to baited cubbies. Bears

were captured in Aldrich leghold snares set in the cubbies or on trails leading to bait piles (Pearson 1976, Nagy and Russell 1978 and Russell et al. 1979). Each site was equipped with one or more trap activity monitoring devices (Nolan et al. 1984), most of which contained a timer (Hawley et al. 1985). The trapline was monitored and maintained on a daily basis through the use of a Bell 206 or A-Star helicopter.

Bears caught in snares were immobilized with phencyclidine hydrochloride (Sernylan, Parke Davis and Co., Brockville, Ontario) or a mixture of ketamine hydrochloride- (Parke Davis and Co.) xylazine hydrochloride (Cutter Laboratories, Inc., Mississauga, Ontario) during 1981 (Pearson et al. 1968, Addison and Kolenosky 1979), and etorphine hydrochloride (M99, Cyanamid of Canada Ltd., Scarborough, Ontario) during 1982-83. Diprenorphine (Cyanamid of Canada Ltd.) was used as an antidote for M99. The sex of the animal was recorded at capture and each animal was individually marked with a numbered white Teflon button tag (Western Industrial, Research and Training Centre, St. Albert, Alberta) in the left ear, a numbered green Alflex cattle tag (Alflex Tag Co., Culver City, California) in the right ear, and a green lip tattoo. A premolar tooth was extracted from each animal at every capture and age was determined by counting cementum annulations (Pearson 1975). Radio transmitter collars (Telonics Inc., Mesa, Arizona) were attached to 30 different grizzly bears and 8 black bears. During 1981 to 1984, an average of 25 radio tracking surveys

were conducted each year at weekly intervals during the active period, using a Cessna 185 or 337 fixed-wing aircraft.

Population parameters were calculated from data obtained at capture and through aerial monitoring of bears. For purposes of analyses, grizzly bears were divided into 5 age classes: cubs (< 1 year), yearlings (1 to < 2 years), 2-year-olds (2 to < 3 years), 3- and 4-year-olds (3 to < 5 years) and adults (> age 5 years). Black bears were divided into 3 age classes including: cubs and yearlings (0 to < 2 years), subadults (2 to < 4 years) and adults (≥ 4 years). Population size was determined as the total number of animals captured and marked on the study area plus the uncaptured young of marked females minus known mortalities. Population size was also estimated during 1982-83 from mark-recapture data using Bailey's modification of the Petersen equation (Caughley 1977). Survival rates were not calculated due to small sample sizes. Sex ratios were compared using a chi square goodness-of-fit-test (Gibbons 1985).

Estimation of population density were dependent upon the delineation of the boundaries of the study area. The area encompassed by a perimeter of trap sites (core trapping area) was approximately 2,381 km^2. We estimated the size of the area from which we were sampling bears (minimum effective trapping area) by extending the boundary of the core trapping area by the radius (20 km) of a circular area equal to the average annual home range size of adult males and adult females without young (Caughley 1977, Nagy *et al.* in prep.). Our estimate of population density was the total population of bears

divided by the minimum effective trapping area (8,140 km^2). A minimum effective trapping area for black bears of 6,335 km^2 was similarly calculated by extending the boundary of the core trapping area by 15 km.

Reproductive characteristics of female grizzly and black bears recorded during capture included the presence or absence of young, ages of young, evidence of current or recent nursing or lactation and degree of vulvar swelling. Production of young or presence of attendant males was determined by visual observation of radio-collared females. Behavioral (presence of attendant males) and physiological (evidence of vulvar swelling) characteristics were used to determine the onset and duration of the breeding season (Enders and Leekly 1941, Craighead et al. 1969). Breeding ages were determined by back-dating known ages of maternal females by ages of accompanying young. Litter sizes, dates of weaning and ages of young at weaning were determined through observation of radio-collared females. Reproductive interval was determined as the time period between successive litters.

Bear mortalities were monitored in several ways. A mortality mode on radio transmitters disclosed if a radio collar had been stationary for $\geq$ 11 hours. Immobile collars were inspected on the ground to determine the cause of the mortality signal. A reward ($100 for grizzly and $50 for black bears) was offered for the return of collars and ear tags and/or information about kills in an effort to monitor hunter harvest of radio-collared or marked bears.

4. RESULTS

4.1 Population Parameters of Grizzly Bears

Between 24 and 27 ($\bar{x}$=25) captures of grizzly bears were made each year (Table 1). A total of 38 individual bears were captured with 55% of those animals captured more than once and 6% captured up to 4 times. The average enumerated post-emergence spring population was 37 bears (range 36 to 38), giving a density on the minimum effective trapping area of 4.6 bears/1000 km^2 (range 4.4 to 4.7). Mark-recapture estimates of total population size were 36 ($\pm$7) bears in 1982 and 29 ($\pm$5) bears in 1983.

Overall, the population was comprised of 8.1% cubs, 7.2% yearlings, 7.2% 2-year-olds, 14.4% 3- and 4-year-olds, and 63.1% adults (Table 2). The sex ratio, excluding recaptures, was 18 males: 20 females. Ratios of males:females in the known population did not vary significantly ($P>0.05$) among years (Table 1) or from a 1:1 ratio.

The breeding season occurred between the first week of May and mid-August. The earliest a female was detected entering estrus, as indicated by a slightly swollen vulva, during the first week of May. A total of 5 females were observed entering estrus during the second week of May over the 3 years of trapping. Females in full estrus were all captured after 15 May. Females entering estrus were caught as late as the first week in June. Females were observed with attendant males from 01 May to 15 August. Most pairings (n=11) occurred during 01 June and 15 July.

Table 1. Numbers and sex ratios of grizzly and black bears captured in the Berland area, 1981-83.

Species and year	Number of captures	Individuals captured	New individuals captured	Total marked in population at beginning of trapping	Recaptures from previous years	Sex ratio M:F
Grizzly bears						
1982	24	19	19			10: 9
1982	25	18	9	16	9	11: 7
1983	27	18	10	22	8	7:11
1981-83	76	38	38			18:20
Black bears						
1981	7	6	6			1: 5
1982	14	11	11	6	0	6: 5
1983	24	21	15	16	6	12: 9
1981-83	44	32	32			16:16

Table 2. Age and sex structure of the Berland grizzly bear population, 1981-83 (individuals in each age class are cohorts).

Age class (yrs)	Number of animals by year of capture[a]								
	1981			1982			1983		
	M	F	T	M	F	T	M	F	T
0 - 0.9	1	1	2	-	2	4[b]	-	-	3[c]
1 - 1.9	1	1	2	1	1	2	-	2	4[d]
2 - 2.9	1	3	4	1	1	2	1	1	2
3 - 3.9	1	1	2	1	3	4	1	1	2
4 - 4.9	3	1	4	1	-	1	1	2	3
5 - 5.9	1	1	2	3	1	4	1	-	1
6 - 6.9	3	4	7	1	1	2	3	1	4
7 - 7.9	3	-	3	3	3	6	1	1	2
8 - 8.9	-	1	1	3	-	3	4	2	6
9 - 9.9	-	1	1	-	1	1	2	-	2
10 - 10.9	-	1	1	-	1	1	-	1	1
11 - 11.9	1	1	2	-	-	-	-	1	1
12 - 12.9	-	-	-	1	1	2	1	-	1
13 - 13.9	1	1	2	-	-	-	1	1	2
14 - 14.9	-	1	1	1	1	2	-	-	-
15 - 15.9	1	-	1	-	1	1	1	1	2
16 - 16.9	-	-	-	1	-	1	-	1	1
17 - 17.9	1	-	1	-	-	-	1	-	1
18 - 18.9	-	-	-	1	-	1	-	-	-
19 - 19.9	-	-	-	-	-	-	-	-	-
20 - 20.9	-	-	-	-	-	-	-	-	-
Total	18	18	36	18	17	37	18	15	38

[a]M - Males; F- Females; T - Total.
[b]Includes 2 animals of unknown sex.
[c]Includes 3 animals of unknown sex.
[d]Includes 2 animals of unknown sex.

The youngest female to show slight vulvar swelling during the breeding period was aged 2 years. One 3-year-old was in full breeding condition when captured, but did not produce young the following year. The earliest age of first known parturition was 6 years (n=2) and the oldest breeding female was 16 years (n=1). Other females were

known to have produced cubs at ages 9 years (n=1), 10 years (n=1) and 12 years (n=2). One young female was observed at ages of 3, 4 and 5 years with attendant males, but was never seen with cubs.

Seven different litters of young were observed during the 5 years of study. Young accompanying dams ranged in age from cubs to 3-year-olds. Average observed litter size was 1.6 young and was comprised of 1.8 young/litter of cubs (n=5); 1.4 young/litter of yearlings (n=5); 1.4 young/litter of 2-year-olds (n=5) and 2 young/litter of 3-year-olds (n=1). Litters with single cubs (n=2) occurred with the same frequency (40%) as litters with twins (n=2). Three of 5 (60%) of the litters with yearlings or 2-year-olds contained only one young.

There were 4 litters in which the offspring were observed from cubs to ages of weaning or mortality. Two additional litters were observed from yearling or 2-year-old ages until weaning. No individual mortalities were observed among litter mates; if mortalities occurred, the entire litter was lost.

Five adult females weaned offspring 2.5 years old and 1 female weaned offspring 3.5 years old. Two of these litters were weaned during 8-14 May. Two of the weaning females were observed the following spring. Only one of these females had produced cubs. This female weaned 2 offspring that were 3 years old in 1983 and then bred successfully that year and produced 2 cubs during 1984. Thus, her known reproductive interval was 4 years.

Two natural mortalities were documented but the causes could not be determined (Table 3). One male 2 years old was observed with its maternal female on 5 May but its radio collar was on mortality mode on 11 May. On the latter date the maternal female was observed in the

Table 3. Age and sex of known grizzly bear moralities in the Berland area, 1981-85.

Age Class (yrs)	Moralities[a]								
	Harvest			Capture			Natural		
	M	F	T	M	F	T	M	F	T
0 - 0.9	-	-	-	-	-	-	-	-	-
1 - 1.9	-	-	-	-	-	-	-	-	-
2 - 2.9	-	-	-	-	-	-	1	-	1
3 - 3.9	-	1	1	-	2	2	-	-	-
4 - 4.9	1	1	2	-	-	-	-	-	-
5 - 5.9	-	-	-	-	-	-	-	-	-
6 - 6.9	-	-	-	-	1	1	-	-	-
7 - 7.9	-	-	-	-	-	-	-	-	-
8 - 8.9	1	-	1	1	-	1	-	-	-
9 - 9.9	2	-	2	-	-	-	-	-	-
10 - 10.9	1	1	2	-	1	1	-	-	-
11 - 11.9	-	-	-	-	-	-	-	-	-
12 - 12.9	-	-	-	-	-	-	-	1	1
13 - 13.9	-	-	-	-	-	-	-	-	-
14 - 14.9	-	-	-	-	-	-	-	-	-
15 - 15.9	1	-	1	-	-	-	-	-	-
16 - 16.9	-	-	-	-	-	-	-	-	-
17 - 17.9	-	-	-	-	-	-	-	-	-
18 - 18.9	1	-	1	-	-	-	-	-	-
19 - 19.9	1	-	1	-	-	-	-	-	-
20 - 20.9	-	-	-	-	-	-	-	-	-
Total	8	3	11	1	4	5	1	1	2

[a]M- Males; F - Females; T - Total

immediate vicinity with a large male (this period was coincident with the onset of the breeding season). The subadult bear had been partially consumed and necropsy revealed puncture wounds penetrating the cranium. The subadult was presumed to have been killed by an adult male courting the maternal female. In the second instance, a 12-year-old female died between 31 July and 8 August, 1984. No lesions or shot wounds were found during necropsy and the cause of death was not determined.

In addition, natural mortalities were suspected when 2 yearlings disappeared following emergence from the winter den with their maternal female. On 6 June and subsequent aerial surveys, the maternal female was observed with a large bear (presumed to be a male because the period was coincident with the breeding season) but without the yearling offspring. The young were possibly killed by the adult male.

Five capture-related mortalities occurred (Table 3). One bear was found dead in a snare; the cause of death was not determined. Two bears died due to adverse reactions to out-dated or contaminated stocks of Sernylan, while 2 bears died of complications resulting from use of M99.

Eight males and 3 females, or 29% of the grizzly bears marked during the study, were legally harvested during 1981-85 (Table 3). The ratio of subadults:adults among harvested animals was 1:7 for males and 2:1 for females. With the exception of one adult male, all marked bears were harvested within the minimum effective trapping area.

Known mortality rates of marked bears during 3 years of capture and monitoring was 8% in 1981 (3 of 36 bears) and 1982 (3 of 37 bears) and 5% in 1983 (2 of 38 bears). Five harvest and 2 natural known mortalities occurred in 1984 and 5 known harvest mortalities occurred in 1985. Assuming a basal population of 37 bears for 1984 and 1985, known mortality rates were approximately 19% and 14%, respectively.

4.2 Population Parameters of Black Bears

Between 7 and 24 ($\bar{x}$ = 15) captures of black bears were made each year. A total of 32 individual black bears were captured (Table 1), with 22% of those animals captured more than once and 3% up to 4 times. The average enumerated post-emergence spring population was 36 bears (range 31 to 39), giving a density of 5.7 bears/1000 km^2 (range 4.9 to 6.2) on the minimum effective trapping area. Estimates of total population size based on mark-recapture data were 72 bears in 1982 ($\pm$ 49) and 46 bears in 1983 ($\pm$ 13).

Overall, the population comprised 20% cubs and yearlings, 28% subadults and 52% adults (Table 4). The greatest proportion of males captured were subadults (<5 years) while all females were aged >4 years. The sex ratio excluding recaptures was 16 males:16 females (Table 1). Ratios of males:females in the known population did not vary significantly from a 1:1 ratio during 1981-83 ($P>0.05$).

Table 4. Ages and sex structure of Berland black bear population 1981-83 (individuals in each age class are cohorts).

Age class (yrs)	Number of animals by years of capture[a]								
	1981			1982			1983		
	M	F	T	M	F	T	M	F	T
0 - 0.9	2	-	2	1	-	6[b]	-	-	3[c]
1 - 1.9	4	-	4	2	-	2	-	-	5[d]
2 - 2.9	4	1	5	4	1	5	2	-	2
3 - 3.9	3	5	8	4	1	5	4	1	5
4 - 4.9	1	1	2	3	5	8	4	1	5
5 - 5.9	-	1	1	1	1	2	2	5	7
6 - 6.9	-	2	2	-	1	1	1	1	2
7 - 7.9	-	-	-	-	2	2	-	1	1
8 - 8.9	-	1	1	-	-	-	-	2	2
9 - 9.9		3	3	-	1	1	-	-	-
10 - 10.9				-	3	3	-	1	1
11 - 11.9	-	2	2	-	-	-	-	3	3
12 - 12.9	-	-	-	-	2	2	-	-	-
13 - 13.9	1	-	1	-	-	-	-	2	2
14 - 14.9	-	-	-	1	-	1	-	-	-
15 - 15.9	-	-	-	-	-	-	1	-	1
16 - 16.9	-	-	-	-	-	-	-	-	-
Total	15	16	31	16	17	38	14	17	39

[a]M - Males; F - Females; T - Total.
[b]Includes 5 animals of unknown sex.
[c]Includes 3 animals of unknown sex.
[d]Includes 5 animals of unknown sex.

The breeding season occurred between the second week in May and mid-July. Females entering estrus were captured as early as the second week in May (n=1), but none were captured in full estrus till the second week of June (n=1). Females were observed with attendant males between 1 June and 15 July.

The earliest known age of first successful reproduction was 7 years (n=1). One 4-year-old female was in full estrus when

captured, but did not produce cubs the following year. Other females produced cubs at ages 10 years (n=2) and 13 years (n=1).

Four different litters of young were observed during the study. Litter sizes averaged 2.25 young/litter of cubs (n=4) and 2 young/litter for yearlings (n=3). Three litters were observed from cubs to age of weaning, and a fourth until they denned as cubs in the fall. Mortalities were not observed among litter mates. All young were weaned as yearlings. The reproductive interval for female black bears was not determined.

Deaths of 11 black bears were recorded during 1981-85 (Table 5). One marked bear was harvested during the trapping period (1981-83), and 8 bears or 25% of the marked bears were harvested during 1984-85. The sex ratio for harvested bears was 8 males:1 female. All harvested black bears were aged > 3 years, while the ratio of 3- and 4-year-olds to adults was 1:2. The total legal harvest could not be determined because registration of hunter kills is not compulsory. Two bears died of capture-related causes.

Table 5. Age and sex of known black bear mortalities in the Berland area, Alberta, 1981-85.

Age class (yrs)	Mortalities[a]					
	Harvest			Capture		
	M	F	T	M	F	T
0 - 0.9	-	-	-	-	-	-
1 - 1.9	-	-	-	-	-	-
2 - 2.9	-	-	-	-	-	-
3 - 3.9	1	-	1	-	-	-
4 - 4.9	2	-	2	1	-	1
5 - 5.9	1	-	1	-	1	1
6 - 6.9	1	-	1	-	-	-
7 - 7.9	1	-	1	-	-	-
8 - 8.9	1	-	1	-	-	-
9 - 9.9	-	-	-	-	-	-
10 - 10.9	-	-	-	-	-	-
11 - 11.9	-	-	-	-	-	-
12 - 12.9	-	-	-	-	-	-
13 - 13.9	-	1	1	-	-	-
14 - 14.9	-	-	-	-	-	-
15 - 15.9	-	-	-	-	-	-
16 - 16.9	-	-	-	-	-	-
17 - 17.9	1	-	1	-	-	-
Total	8	1	9	1	1	2

[a]M - Males; F - Females; T - Total.

5. DISCUSSION

5.1 Population Parameters for Grizzly Bears

The grizzly bear population in the Berland area had a low density, was comprised primarily of adults, and was characterized by poor productivity. Density estimates (4.6 bears/1000 km^2) were less than one-half of those reported for other populations in Alberta, namely unhunted populations in Banff and Jasper National Parks (Hamer and Herrero 1983, Russell et al. 1979) and a hunted population in the Swan

Hills, Alberta (Nagy and Russell 1978). In fact, density values were among the lowest reported for populations in North America (Dean 1976; Reynolds 1980; Nagy et al. 1983a, b; Mundy and Flook 1973; Martinka 1974; Reynolds 1976; and Miller and Baricello 1979). The mean litter size (1.8 cubs/female) was in the lower end of the range (1.7 to 2.4 cubs/female) reported for various regions of North America (Troyer and Hensel 1964; Hensel et al. 1969; Mundy and Flook 1973; Martinka 1974; Pearson 1975; Reynolds 1976; Craighead et al. 1974; Reynolds 1980; and Nagy et al. 1983a, b). On average, only 19% of the sexually mature females in the study area were accompanied by cubs annually, suggesting that the average reproductive interval was greater than 4 years. We feel that these data collectively suggest that the Berland population was declining. Furthermore, we feel that this decline reflects the combined affects of long-term legal harvest, encroaching resource development activities, and habitat deterioration on that population.

The Berland study area overlaps Big Game Zones (BGZ) 2, 3 and 4 where grizzly bears have been harvested under a general spring season (set between 1 April and end of first week in June) for at least 15 years. Bears in BGZ 4 are hunted under a fall bear authorization set between mid-September and 1 December. It is unlawful to hunt or possess a grizzly bear under the age of 2 years or a female accompanied by a cub under the age of 2 years. Compulsory registration of kills was instituted in 1971.

Gunson et al. (1985) provided data on the locations and causes of mortality for all known grizzly bear kills in Alberta for the period 1972-84. To identify the effects of harvest mortalities on the population characteristics of bears on the study area, kill data for bears removed within a 81 km radius (50 miles) of the junction of the Wildhay River and Pinto Creek (kill survey area) were summarized. The data were used to determine the magnitude, types, spatial distribution, sex and age class of kills made during 1972-84. Differences in the proportions of males and females in each age class were compared with a chi-square test for independence.

During 1972-84, 100 bears were removed from the kill survey area, or an average of 8 bears/year, including all mortalities (Table 6). Hunter harvest accounted for an average annual removal of 5 bears. When mortality data were considered only for 1981-84, to coincide with the present study, annual total losses were 10 bears/year, with 6 bears/year removed through legal harvest. Overall legal harvest was the greatest cause of mortality (65%) followed by illegal (15%), self-defence (9%), problem wildlife (6%) and research related (5%).

The ratio of males:females for 96 bears for which sex was recorded was 65%:35%. Sex and age were available for 83 of the bears killed (Table 7). The greatest proportion of all bears killed were adults (48%), followed by 3- and 4-year-olds (34%) and 2 year olds (18%). Significantly more adult males were harvested than adult females (62% males:38% females) ($P<0.05$) (Table 7), while the sex ratio for bears in 2-year and 3- and 4-year-old age classes did not vary significantly

Table 6. Total known kill and legal harvest of grizzly bears by Big Game Zone (BGZ) and Wildlife Management Unit (WMU) in the Berland Kill Survey Area, 1972-84[a].

BGZ	WMU	Type of mortality		
		Legal harvest	Other[b]	Total
2	354	11	6	17
	356	0	0	0
	Total	11	6	17
3	340	0	0	0
	342	1	3	4
	344	16	9	25
	346	5	3	7
	350	0	1	1
	352	10	10	20
	Total	31	26	57
4	438	5	1	6
	439	4	0	4
	440	14	1	15
	441	0	1	1
	446	0	0	0
	Total	23	3	26

[a]Data from Gunson et al. (1985)
[b]Includes removal of problem bears, accidental and research-related mortalities, illegal harvest and harvest by Treaty Indians.

from a ratio of 1:1 ($P>0.05$). For adult males, legal harvest was the greatest cause of mortality (62%), followed by self-defence (15%), problem wildlife (12%), illegal (8%) and research-related (4%) kills. Similarly for subadult males (ages < 5 years) legal harvest was the greatest cause of mortality (59%), followed by illegal (19%), problem wildlife (11%) and self-defence (11%) kills. For adult females legal harvest was the greatest cause of mortality (50%), followed by illegal

Table 7. Sex and age class for each type of mortality of grizzly bears in the Berland kill survey area, 1972-84.

Type of Mortality	Number of bears by sex and age class[1]							
	2 Years		3 & 4 Years		Adults		Overall	
	M	F	M	F	M	F	M	F
Legal	5	4	11	9	16	7	32	20
Illegal	2	-	3	1	2	3	7	4
Problem	2	-	1	-	3	-	6	-
Self-Defence	2	-	1	-	4	2	7	2
Research	-	-	-	2	1	2	1	4
TOTAL	11	4	16	12	26	14	53	30

[1]Based on data for 83 bears for which sex and age class were available (Gunson et al. 1985).

(21%), self-defence (14%) and research-related (14%) kills. Legal sport harvest was the greatest cause of mortality for subadult females (81%), followed by research related (13%) and illegal (6%). The greatest proportion of the total male kill (79%) and legal sport harvest (84%) were aged 3 and 4 years and adults ($P<0.01$). Two-year and 3- and 4-year-olds made up the greatest proportion of the total kill (43%) and legal sport harvest (65%) of females.

The sex and age classes of bears harvested in the Berland kill survey area appear to be consistent with those reported for most hunted populations. One obvious difference is the high proportion of subadult females killed. With the current hunting regulations and assuming a reproductive interval of 3 years, a female would be

protected from harvest every 2 out of 3 years of its adult life. Subadult females would not be afforded that protection until they became part of the reproductive segment of the population.

Mortality rates were estimated for data provided by Gunson et al. (1985). The total kill survey area included approximately 19,753 km^2. Assuming that bears are distributed uniformly and that enumerated population numbers reflect actual numbers, the kill survey area would support approximately 91 bears. An average of 8 bears (range 1-16) or 9% of the estimated population were removed annually from the kill survey area (including all mortalities). If mortality data are considered only for 1981-84, annual losses would be approximately 11% (range 5% in 1981 to 18% in 1984) of the estimated population. Harvest accounted for annual losses of 7% (range 0% in 1981 to 14% in 1984). This corresponded to annual mortality rates based on known kills of marked bears recorded during this study of between 5 and 8% for 1981-83, and estimated rates of between 14 and 19% for 1984-85.

A legal sport harvest of 4% is generally considered acceptable by bear managers (Lortie 1978). Reynolds (1976) reported a decline in reproductive capacity following 2 years of sport harvest at 7% of the grizzly bear population in the Brooks Range, Alaska. Dood et al. (1986) recommended a maximum total man-caused mortality rate (known and unreported) of 6% for grizzly bears in the northern continental divide ecosystem in Montana, and suggested that a 4% level of harvest would allow for population growth. Tompa (1984) recommended that the

total man-caused mortality (legal plus wounding loss and illegal kills) should not exceed 5% under the most optimal conditions in British Columbia. These studies suggest that the maximum total man-caused mortality in a grizzly bear population should not exceed 6%. In the Berland area, legal sport harvest alone accounted for average annual losses of more than 6% from estimated and enumerated grizzly bear numbers, suggesting that over-harvest has occurred. This would have contributed to the low density of grizzly bears in the Berland area.

Access to much of the Berland area was limited historically to travel on major river systems or on adjacent all-season roads. Timber harvest and oil, gas, and coal exploration and extraction activities have impacted grizzly bear populations by increasing access through the construction of roads. In fact, 75% of the grizzly bears harvested within a 50-mile radius of the centre of the Berland study area during the period 1972-84 were killed within 1 km of an all-weather road (Figure 2). Ease of access to areas adjacent to road networks has also increased through proliferation of all-terrain vehicles. As resource development activities encroach further into the Berland area, grizzly bears in more remote areas will be increasingly susceptible to harvest.

Over-harvest does not account for the low productivity observed in the Berland population. The numbers of cubs observed in the population may have been under-estimated. For example, the low mobility of cubs and the habit of females with cubs to select isolated

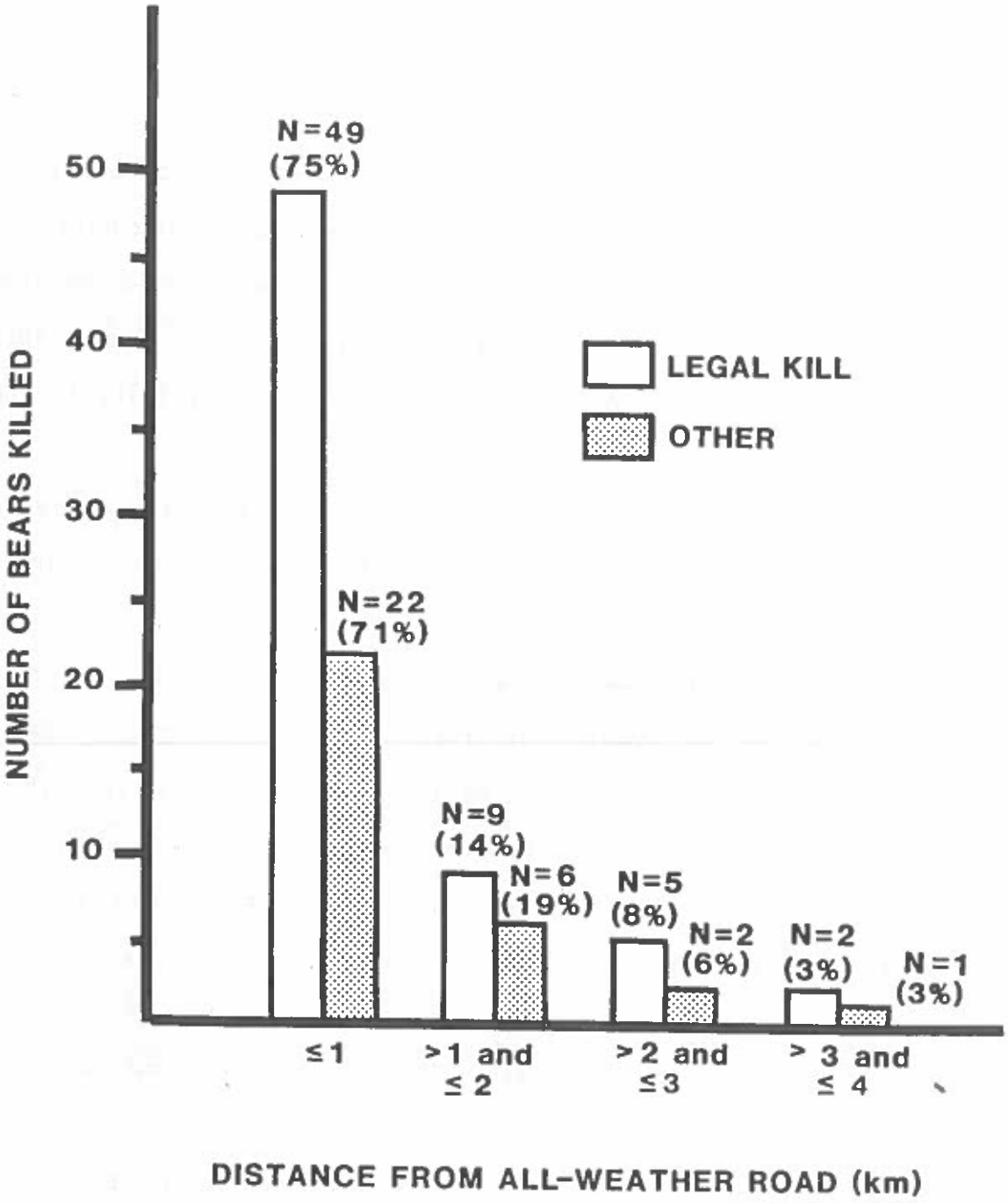

Figure 2. Number of grizzly bears killed through legal sport harvest and other actions by distance from all-weather roads in the kill survey area during 1972-84.

areas or habitats less preferred by other bears to avoid contact with conspecifics (Pearson 1975, Russell et al. 1979, Nagy et al. 1983a), could have reduced the probability of our capturing those classes of bears. However, by back-dating ages of subadults and observing females through radio telemetry, we were able to confirm annually the reproductive status of 64% to 90% of the females known to occur in the study area. We suggest, therefore, that our data closely reflected the actual productivity of the Berland population.

The low production of cubs in the Berland grizzly bear population may have been due to a reduction in breeding opportunities caused by low densities (Craighead et al. 1974). However, the productivity of grizzly bears can be high when populations occur at low density. For example, a hunted grizzly bear population on Tuktoyaktuk Peninsula, N.W.T. had one of the lowest densities reported for North America but one of the highest reproductive rates (Nagy et al. 1983b). In contrast, grizzly bears in Yellowstone National Park did not become more productive following population reductions after open-pit garbage dumps were closed. The primary difference between these two populations was that grizzly bears on the Tuktoyaktuk Peninsula had access to a stable, high-quality late summer and fall food source (arctic ground squirrels, Spermophilus undulatus) (Nagy et al. 1983b), while those in Yellowstone became nutritionally stressed because the bears were required to adjust to previously unexploited natural foods (Craighead et al. 1974). These studies suggest that the productivity of grizzly bear populations is more strongly influenced by the

availability of high-quality food resources than by density-dependent population regulatory factors.

Grizzly bears in this area were primarily herbivorous in their diets, feeding seasonally on hedysarum roots (Hedysarum alpinum), horsetails (Equisetum spp.), grasses (Graminoids), clover (Trifolium spp.), and berries (Vaccinium spp. and Sheperdia canadensis) (Nagy et al. 1987). Native mammals, such as ground squirrels (Spermophilus columbianus) and ungulates, found in grizzly bear diets in mountain regions in Alberta (Russell et al. 1979, Hamer and Herrero 1983) were conspicuously absent in diets of bears in the Berland area (Nagy et al. 1988). The study area fell on the periphery of the range of distribution of ground squirrels in Alberta, while elk, deer, and moose occurred in low numbers at the time of the study. With the exception of horsetails, the major food items consumed by grizzly bears in the Berland area occur characteristically in early seral communities where forest cover is absent or under-stocked (Hamer and Herrero 1983).

Wildfires have been suppressed under progressively intensive forest management practices in the study area since the 1930s (Murphy 1985), and most productive forest sites had advanced to mature or overmature age classes at the time of the study (Rose 1981). In Banff National Park where fire management practices were similar to those on the Berland study area, forest encroachment was occurring on seasonally important grizzly bear foraging habitats (Hamer and Herrero 1983). Where post-fire vegetation had succeeded to well-stocked

forest stands, the sites were generally unused by grizzly bears as feeding habitats (Hamer and Herrero 1983). We suggest that the quality of grizzly bear habitat in the Berland area has been eroded by forest succession, thereby reducing the productivity of grizzly bears in that area.

In conclusion, the Berland grizzly bear population was considered to be in a state of decline. The observed density, age structure, and productivity reflected the effects of long-term legal harvest, resource development activities, and habitat deterioration. Any future management plans must take into consideration the past effects of harvest, changes in regional access, and changes in habitats resulting from resource development and management activities on grizzly bear populations in that area.

5.2 Population Parameters for Black Bears

The onset and duration of the breeding season for black bears in the Berland area was similar to that reported for other regions of North America (Jonkel and Cowan 1971, Poelker and Hartwell 1973, Nagy and Russell 1978). Our limited data indicate that female black bears reached sexual maturity and first bred successfully at ages similar to those reported for other populations in Alberta (Nagy and Russell 1978, Young and Ruff 1978). Litter sizes were similar to those reported for black bears in Swan Hills, Alberta (Nagy and Russell 1978), but larger than those reported for most other regions (Erickson and Nellor 1964, Jonkel and Cowan 1971, Poelker and Hartwell 1973,

Beecham 1983). All litters were weaned as yearlings, an observation which was consistent with Nagy and Russell (1978) and Jonkel and Cowan (1971). Reproductive interval was not determined.

Density estimates of 5.7 black bears/1000 km^2 for the Berland area are low in comparison with those reported for other populations. Densities of 114 to 167 bears/1000 km^2 are commonly reported in the literature (Jonkel and Cowan 1971, Kemp 1972, Poelker and Hartwell 1973, Young and Ruff 1982). Habitats in the Berland area were similar to those in Swan Hills, Alberta, where grizzly and black bears occurred sympatrically. Black bear densities in the Swan Hills (18 bears/1000 km^2) were 3.5 times greater than those observed in the Berland area (Nagy and Russell 1978).

The low densities of black bears in the Berland area may have been a result of our study design. Trap sites were selected to maximize coverage of prime grizzly bear habitats and to capture resident grizzly bears. Black bears were captured ancillary to our primary purpose, and as a result, trap site placement may not have been adequate to give good data on black bear numbers. The wide variation between enumerated population numbers and estimates based on mark-recapture data gives support to this hypothesis.

Overall, the age composition of the Berland black bear population was similar to that of populations in Swan Hills (Nagy and Russell 1978) and Cold Lake, Alberta (Young and Ruff 1982). However, 67% of the males for which age and sex were determined in the Berland population were < 4 years. Young and Ruff (1982) reported equal sex

ratios for cub plus yearlings and adults, while those for 2- and 3-year-olds favored males in unhunted populations near Cold Lake. The ratios of males to females for a hunted population in Swan Hills were 59%:41% for adults, and 77%:33% for 2- and 3-year-olds (Nagy and Russell 1978). The disproportionately small numbers of females age <4 years and large number of males age <4 years in the Berland population was not explained, but may have been a result of inadequate sampling.

The data were considered to be inadequate to give an indication of the affect of hunting on or of the relative status of the Berland black bear population.

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