Report on Alberta Grizzly Bear Assessment of Allocation

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Executive Summary

A review of available data was undertaken to assist in management of the harvest of grizzly bears in Alberta. A small team of experts was tasked with this review under the direction of the Minister of Sustainable Resource Development. The team's goals included the review of the current model being used to allocate hunting licenses, an analysis of the available mortality data held by the department, and the identification of data needs to assist in grizzly bear management efforts.

The review found that the model currently used in predicting population size and thus the allocation of licenses is incomplete and will continue to predict exponential growth rates when this is not biologically possible. Solutions and modifications to this model are suggested that will improve the allocation of hunting licenses to prevent possible over harvest.

The mortality data used in this report is not as strong as it could be given the current registration process. Minor but important changes are possible to strengthen this data for future management needs and are outlined in this report. The ongoing maintenance and evaluation of a comprehensive database is seen as a key component of all current and future grizzly bear management efforts.

Our review of the available mortality data suggests that there are three Bear Management Areas (BMA' s) that exhibit a declining trend in the age of females in total mortalities. (units 2B, 4B and 4C). This represents a potentially serious management concern and steps to reduce overall mortality rates in these BMA's are necessary. In other BMA's a conservative legal harvest can be maintained if additional inventory work is undertaken and current habitat conditions are revisited to update our allocation formula. Further the review revealed that female bears continue to form a major component of overall total mortalities and measures to reduce this are necessary.

Problem bear management actions continue across the province, however we have identified three key areas in which ongoing and regular problems persist. Efforts should be made to work with stakeholders in these areas to reduce problem bear occurrences and department staff directed to ensure that conservation priorities are a key component of problem bear management.

Other issues concerning grizzly bear hunting are discussed and suggestions are made on approaches to resolve aspects that result in an overall increase in total human-caused mortality in the province.

We see opportunities to rectify current deficiencies in the data necessary to justify hunting license allocations. These include updating recent inventory data on this species, completing a comprehensive mortality/relocation database, and tracking landscape changes that affect the habitat carrying capacity for each BMA. In order to improve our grizzly bear management capability, additional resources are required in these areas.

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Background

In response to the assessment of the Endangered Species Conservation Committee (ESCC), which recommended the immediate closure of the grizzly bear hunting in Alberta, the Minister of Sustainable Resource Development directed the department to conduct a review to allow further consideration of this recommendation.

To conduct this review a small Grizzly Bear Technical Committee was established in July 2002 lead by provincial biologist Gordon Stenhouse. Other committee members included Dr. Mark Boyce (ACA Chair in Fisheries and Wildlife, University of Alberta) and Mr. John Boulanger (Bio-statistician - consultant, Nelson, RC.).

Our committee had the following objectives:

1. ***Review all the mortality data (sex, age, locations) and translocations (by BMA and WMU) since* 1988 *and where data exists back to* 1973 *to explore if any trends or patterns* in *mortalities are suggested that may be of management concern.*** The focus here was to determine any biological concerns relating to mortalities and translocations from a population management perspective. A key objective of the analysis was an evaluation of the data as a management tool, and an examination of how the data could be supplemented or augmented with other sources of data.
2. ***Review the current formula that Alberta Fish and Wildlife Division uses to determine BMA population values.*** This review focused on assumptions made about grizzly bear population sizes and trends for current allocation of grizzly bear hunting licenses.
3. ***Identify data needs and the resources required to ensure effective management decisions.***

The Data Set

The province of Alberta has kept systematic records of all known grizzly bear mortalities, and translocations since 1971. These records were to include the date, location, sex, type of mortality/translocation, release site locations (where applicable) and a tooth was to be submitted to the department for age determination. The process for registration of legally harvested bears requires the hunter to provide the above information to a local conservation officer who completes a registration form and submits this to department data management staff in Edmonton. In the case of translocated bears or illegal kills the responding conservation officer completes the registrations independently and forwards this information as above.

Previous summaries of provincial grizzly bear mortalities have been compiled for the period 1972-1994 (Gunson 1995), and 1988 - 1996 (Gunson 1996). Since no comprehensive grizzly bear mortality data set existed in a digital format, we spent a significant amount of effort to assemble a digital data file that incorporated historic data records (from Gunson 1995) as well as more recent annual digital department files into an amalgamated data set. Unfortunately, although each registered grizzly bear mortality or relocation should have age, sex, and location data, in a large majority of cases some of these data are not available. The largest set of missing values is age of the registered bear. Also, the common practice of recording locations by township and range provides imprecise data when one is interested in the spatial arrangement of grizzly bear mortalities.

The limitations of the available data used in this analysis are important to note and hence some conclusions reached in this document, which address age/sex composition of mortalities, should be viewed with caution as a result of these factors.

For future and ongoing management needs we feel it is important to ensure:

- All grizzly bear mortalities, relocations, and problem bears handled **must be** registered along with sex, age and precise locations (UTM's). Sufficient resources are needed to ensure that all tooth samples collected are aged in a timely fashion by a recognized laboratory.
- The maintenance of a comprehensive provincial grizzly bear mortality database must be viewed as a high priority within the Department. This database must be continually updated and data entry verified on a regular basis. Effort should be made to deal with database structure and format. Ongoing and regular communication with field staff is necessary to assess the accuracy of annual data.
- Annual summary reports are necessary to monitor the database and evaluate results relative to mortality trends.

Background on Population Assessment

In 1990 the department published a provincial Grizzly Bear Management Plan, which included the first population estimates of grizzly bears in the province. This plan divided the province into 21 Bear Management Areas (BMA's) (see figure 1) and population estimates were developed for each of these management units. These population estimates were based on habitat-specific bear densities compiled from several intensive grizzly bear research programs. The final densities and hence population estimates were modified further based on a subjective evaluation of the land surface disturbance (human impacts and activities) within a given BMA. This was done in an attempt to integrate a habitat disturbance component into these calculations. Estimated total surface disturbance at that time (1990) averaged 45%. This process resulted in the establishment of the baseline population levels for grizzly bears in Alberta.

Since 1988, the department has completed an annual update to the original 1990 grizzly bear population estimates for each BMA in Alberta. These annual estimates built on the previous years' estimate and incorporated new data on mortalities, translocations,
estimated net immigration and net natural growth (Gunson 1996). Historically in Alberta we have defined net natural growth for grizzly bears as allowable human caused mortality at 6% per year minus known mortality

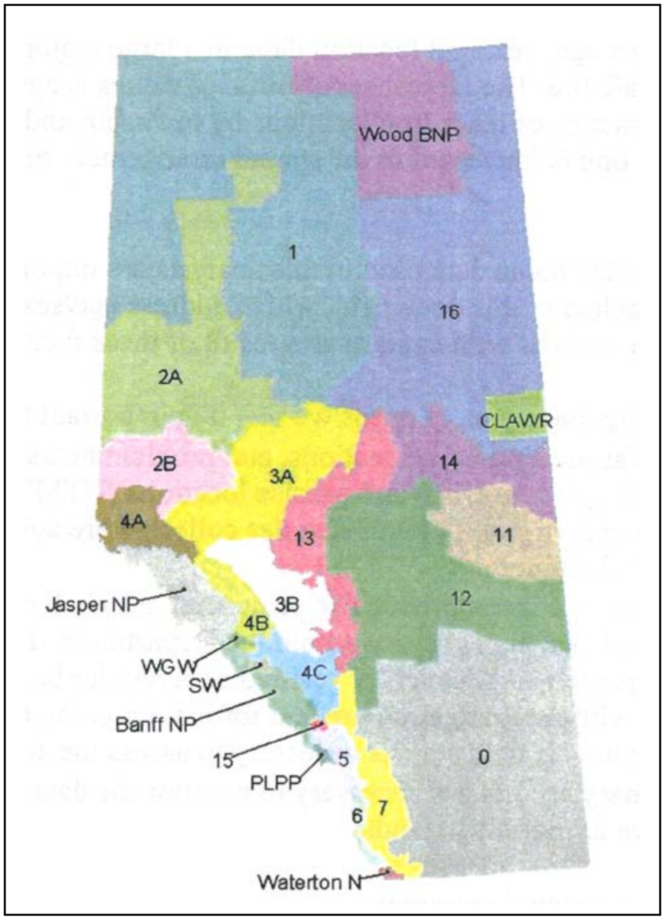

Figure 1. Bear Management Areas (BMA's) in Alberta

Comments on Current Formula and Approach used for Harvest Allocation

Table 1 presents a summary of grizzly bear population estimates for each of the provincial BMA's in Alberta from 1988-2002. The numbers presented in this table are calculations derived from the allocation formula used since 1988. Our review of these numbers and the formula itself, suggested a number of changes that would be beneficial in the approach the province uses in setting grizzly bear harvest quotas. First the current model used to estimate population size is unbounded and therefore if no harvest or human-caused sources of mortality are recorded, the population will grow exponentially without bound. This is unrealistic in terms of grizzly bear ecology, and conflicts with the spirit of habitat-based population estimates, which we believe was intended in the 1990 Alberta Grizzly Bear Management Plan.

Table 1: Number of grizzly bears estimated to occur in Alberta Bear Management Areas (BMAs) 1988-2002 (excluding national parks)

YEAR	BEAR MANAGEMENT AREA (BMA)										
	1	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**	**4C**	**6&7**	**REM****	**TOTAL**
1988	82	22	127	79	26	52	34	35	45	73	575
1989	84	18	126	85	27	46	30	22	27	71	536
1990	90	16	128	88	28	46	35	22	24	70	547
1991	90	21	136	86	29	65	43	33	47	88	638
1992	92	21	143	88	31	72	46	33	47	96	669
1993	93	21	145	97	30	82	45	28	43	102	686
1994	96	22	150	101	33	75	45	28	42	108	700
1995	102	23	158	108	33	77	44	31	46	113	735
1996	109	21	168	112	34	80	46	33	44	118	765
1997	119	17	171	108	35	78	47	35	40	126	776
1998	124	13	176	120	37	79	5C	36	31 (57*)	141	807 (833)
1999	126	10	183	124	44	83	48	37	31 (55)	147	833 (857)
2000	134	7	187	120	47	87	44	35	30 (54)	150	841
2001	14C	12	188	121	48	88	95	36	53	156	940
2002	15C	8	200	118	52	93	95	36	50	163	968

* Numbers in brackets represent revised population estimates taking into account DNA-based population density findings (Mowat and Russel 1998).
**REM = Remainder of Province including BMA 5 (Kananaskis Country), Lougheed Provincial Park, WMU 410 (bow Corridor), BMA 13 and BMA 16.
Note: Table adapted and modified from Kansas 2002.

This concern is relatively simple to rectify. First, we assume that the habitat-based density estimates allow us to calculate a carrying capacity for the landscape. Second, we use this carrying capacity, *K*, as the upper limit on population size without harvest (Table 1 b). Third, we assume that density dependence kicks in at relatively large population size consistent with Taylor (1994), suggesting a nonlinear density-dependent function. We propose to capture these assumptions with a theta-logistic model with a harvesting rate term, *h:*

$$N_{t+1} = N_t e^{\{0.058(1-[N_t/K]^3)\}} - h$$

where Nt is the grizzly bear population in a BMA in year t.

This model retains the basic elements of the current allocation formula and 1990 Grizzly Bear Management Plan but keeps the population in check relative to its habitats. The harvesting term, *h*, can be calculated using modifications to our current formula with adjustments for net translocations, net immigration, and total known mortality. Thus we use *h* = hunter kill + non-harvest mortalities - (net immigration + net trans locations).

This model is similar to the catch-limit algorithm used by the International Whaling Commission (Boyce 2000).

Table Ib: Habitat carrying capacity

BMA	1988 habitat carrying capacity (K) (bears)
1	82
2A	18
2B	127
3A	79
3B	26
4A	40
4B	28
4C	31
6 and 7	29

We also believe that change is warranted in the 25% adjustment figure of unreported mortality currently used in the harvest allocation formula. The inflation of non-harvest mortality is likely to be higher than for hunter kills because poaching and other non-harvest mortality is less likely to be reported. Based on recent research findings, we propose to add a wounding loss of 10-15%, and the non-harvest mortality should be set at a rate of 100% (see McLellan et al. 1999). Also, because relocated grizzly bears suffer increased mortality rates, we suggest the net translocations be reduced by 30%. This number should be altered as new research results become available. Overall these changes would improve the utility of this management tool and result in more realistic annual population estimates for grizzly bear populations in Alberta.

We recalculated population estimates using the new formula for 1988 to 2002 (Table 2). One problem that we encountered was that the original estimates of immigration used in calculations prior to 1998 were not available. In addition, the methodology in which immigration was estimated for each BMA (Nagy and Gunson 1990, p. 82» was not detailed enough to allow duplication of the original estimates. Given this, we set immigration to 0 for BMA's with the exception of BMA's 6 and 7 that were adjacent to the Flathead Valley, a documented potential source of dispersal (Hovey and McLellan 1986). For these BMA's net immigration was set to 2 bears per year which was the same value used in calculations with the original formula. Net immigration was set at 0 or 1 bear per year for most BMA's with the original formula, and therefore a large change in estimates should not be expected under the assumption of no immigration into BMA's. It would be useful to have a more rigorous method to estimate grizzly bear dispersals into BMA. For example, genetic methods could be used to estimate population boundaries, . and long-term movement between sub-populations.

The data presented in Figure 1 b represents a recalculation of grizzly bear population estimates using the suggested revised formula for the period 1988-2001. Estimates using the previous formula are also included for comparison purposes. By including a habitat carrying capacity (based on original values used in the 1988 baseline K variable along with the other identified changes) the annual population change does not correspond to previous calculations and the model does not indicate steady population growth in BMA's 1**,** 2B, 3A, 3B and 4A, and 6&7. The old and new formulas indicate similar population size and trends in BMA's 2A and 4C. The population size for the old formula was increased in BMA's 4B, and 6 and 7 in 1990 and 1997 therefore creating further discrepancy between population trajectories.

We emphasize, however, that the *K* value used in the new formula is one prepared for a 1988 landscape. An assumption of the new formula is that density dependant processes (such as density dependant survival, productivity, and dispersal rates) do not allow the population to exceed K (Figure 1), and therefore the estimate of K will have direct implications of population size in any BMA. One other factor that is not accounted for in this model is emigration and immigration of bears between BMA's. At this time there is no information to allow estimation of these rates. Given lack of information, the most conservative strategy is to assume minimal immigration into BMA's, therefore requiring the productivity of each BMA to offset mortality to maintain population stability.

One other important point to note is that in most BMA's the population remained stable at a level near K. One exception to this was BMA 2A which declined. This suggests that the estimated mortality did not exceed the estimated level of population increase for most BMA's.

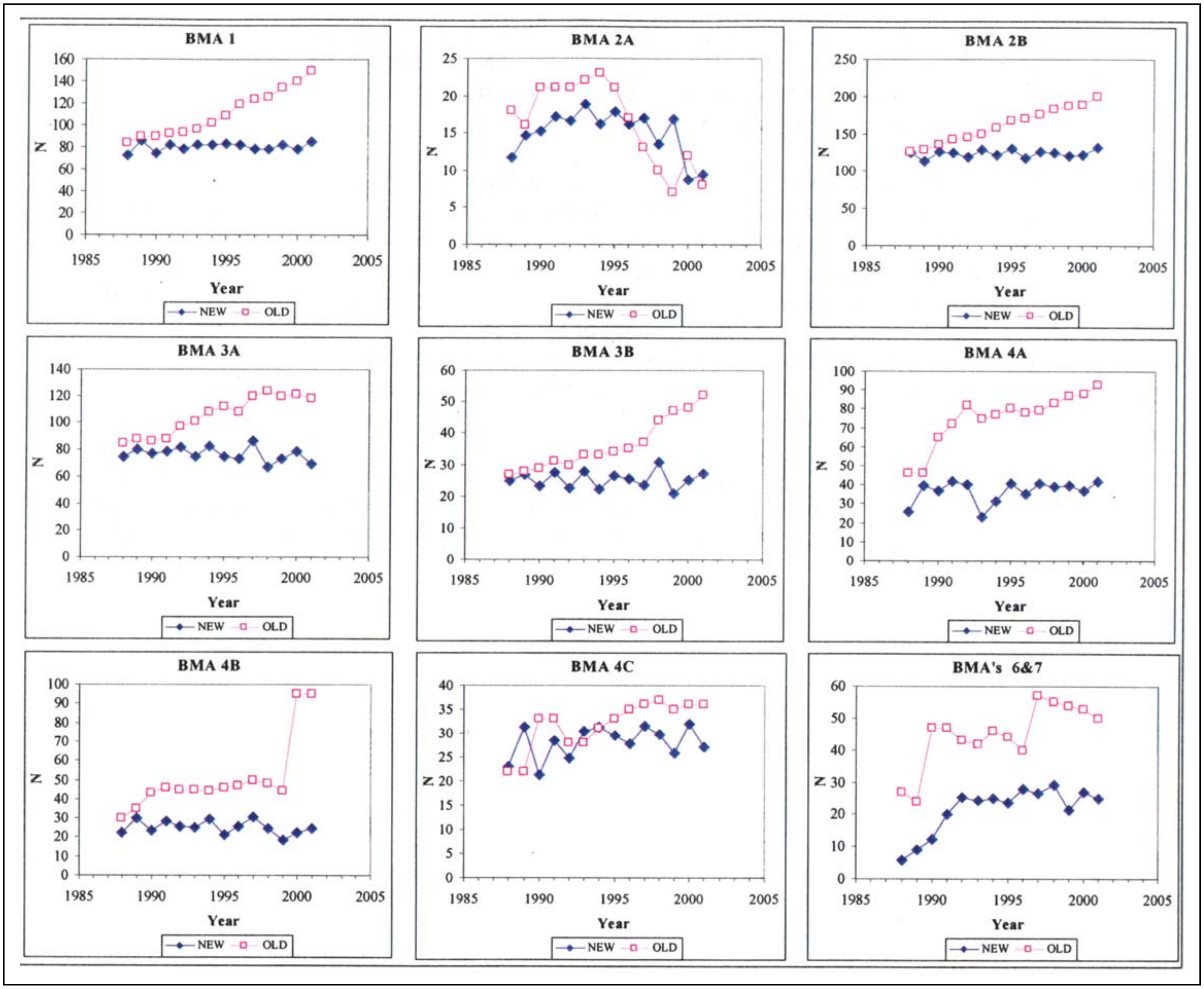

Figure lb. Estimates of population size and trend for BMA's using revised and old population models

Grizzly Bear Allocations

Year	Habitat Carrying Capacity K	A GBMA	B POP EST.	C NET TRANS.	C1 Net Trans (-30%)	D EST. NET IMM.	D1 Hunt Kill	D2 Hunt & wound (+15%)	D3 Non-hunt Mort.	D4 Unreport Nonhunt (+100%)	E Total REPT. MORT.	F EST. TOTAL MORT. D2+D4	G ALLOW. MAN CAUSED MORT. @6%/YR	H NET NATURAL GROWTH (G-F)	I JAN.2002 CAL. GRIZ. POP. New model	Old model N	J HARV (… GOAL
1988	82	1	82	2	1.4	0	3	3.45	4	8.0	7	11.5	4.9	-6.53	72.0	84	0.02
1989	82	1	72.0	0	0.0	0	1	1.15	0	0.0	1	1.2	4.3	3.17	85.8	90	0.02
1990	82	1	85.8	6	4.2	0	6	6.9	1	2.0	7	8.9	5.1	-3.75	74.1	90	0.02
1991	82	1	74.1	3	2.1	0	2	2.3	2	4.0	4	6.3	4.4	-1.85	82.1	92	0.02
1992	82	1	82.1	1	0.7	0	4	4.6	0	0.0	4	4.6	4.9	0.33	78.0	93	0.02
1993	82	1	78.0	1	0.7	0	3	3.45	0	0.0	3	3.5	4.7	1.23	81.8	96	0.02
1994	82	1	81.8	1	0.7	0	1	1.15	0	0.0	1	1.2	4.9	3.76	81.7	102	0.02
1995	82	1	81.7	1	0.7	0	0	0	0	0.0	0	0.0	4.9	4.90	82.9	109	0.02
1996	82	1	82.9	7	4.9	0	4	4.6	0	0.0	4	4.6	5.0	0.38	81.6	119	0.02
1997	82	1	81.6	3	2.1	0	2	2.3	2	4.0	4	6.3	4.9	-1.41	78.1	124	0.02
1998	82	1	78.1	0.0	0.0	0	4	4.6	1	2.0	5	6.6	4.7	-1.91	77.9	126	0.02
1999	82	1	77.9	2.0	1.4	0	0	0	2	4.0	2	4.0	4.7	0.68	82.0	134	0.02
2000	82	1	82.0	3.0	2.1	0	2	2.3	2	4.0	4	6.3	4.9	-1.38	77.8	140	0.02
2001	82	1	77.8	4.0	2.8	0	2	2.3	0	0.0	2	2.3	4.7	2.37	85.2	150	0.02
1988	18	2A	22	0	0.0	0	0	0	1	2.0	1	2.0	1.3	-0.68	11.6	18	0.02
1989	18	2A	11.6	0	0.0	0	1	1.15	1	2.0	2	3.2	0.7	-2.45	14.6	16	0.02
1990	18	2A	14.6	-2	0.0	0	0	0	2	4.0	2	4.0	0.9	-3.12	15.2	21	0.02
1991	18	2A	15.2	-1	0.0	0	0	0	1	2.0	1	2.0	0.9	-1.09	17.2	21	0.02
1992	18	2A	17.2	-1	0.0	0	0	0	1	2.0	1	2.0	1.0	-0.97	16.5	21	0.02
1993	18	2A	16.5	0	0.0	0	0	0	0	0.0	0	0.0	1.0	0.99	18.8	22	0.02
1994	18	2A	18.8	0	0.0	0	1	1.15	0	0.0	1	1.2	1.1	-0.02	16.1	23	0.02
1995	18	2A	16.1	0	0.0	0	1	1.15	0	0.0	1	1.2	1.0	-0.18	17.8	21	0.02
1996	18	2A	17.8	-4	0.0	0	0	0	1	2.0	1	2.0	1.1	-0.93	16.1	17	0.02
1997	18	2A	16.1	-4	0.0	0	0	0	1	2.0	1	2.0	1.0	-1.03	17.0	13	0.02
1998	18	2A	17.0	0.0	0.0	0	1	1.15	2	4.0	3	5.2	1.0	-4.13	13.5	10	0.02
1999	18	2A	13.5	-2.0	0.0	0	0	0	1	2.0	1	2.0	0.8	-1.19	16.9	7	0.02
2000	18	2A	16.9	0.0	0.0	0	0	0	5	10.0	5	10.0	1.0	-8.99	8.7	12	0.02
2001	18	2A	8.7	-3.0	0.0	0	1	1.15	2	4.0	3	5.2	0.5	-4.63	9.4	8	0.02
1988	127	2B	127	-1	0.0	0	2	2.3	0	0.0	2	2.3	7.6	5.32	124.7	126	0.02
1989	127	2B	124.7	5	3.5	0	1	1.15	9	18.0	10	19.2	7.5	-11.67	113.0	128	0.02
1990	127	2B	113.0	2	1.4	0	2	2.3	4	8.0	6	10.3	6.8	-3.52	125.4	136	0.02
1991	127	2B	125.4	1	0.7	0		0	2	4.0	2	4.0	7.5	3.52	124.9	143	0.02
1992	127	2B	124.9	1	0.7	0	4	4.6	3	6.0	7	10.6	7.5	-3.11	118.6	145	0.02
1993	127	2B	118.6	0	0.0	0	2	2.3	1	2.0	3	4.3	7.1	2.82	127.8	150	0.02
1994	127	2B	127.8	5	3.5	0	2	2.3	3	6.0	5	8.3	7.7	-0.63	121.6	158	0.02
1995	127	2B	121.6	3	2.1	0	1	1.15	1	2.0	2	3.2	7.3	4.14	129.6	168	0.02
1996	127	2B	129.6	3	2.1	0	5	5.75	2	4.0	7	9.8	7.8	-1.98	117.3	171	0.02
1997	127	2B	117.3	2	1.4	0	4	4.6	2	4.0	6	8.6	7.0	-1.56	125.5	176	0.02
1998	127	2B	125.5	0.0	0.0	0	3	3.45	0	0.0	3	3.5	7.5	4.08	124.6	183	0.02
1999	127	2B	124.6	1.0	0.7	0	4	4.6	2	4.0	6	8.6	7.5	-1.12	120.8	187	0.02
2000	127	2B	120.8	-1.0	0.0	0	5	5.75	2	4.0	7	9.8	7.2	-2.50	121.3	188	0.02
2001	127	2B	121.3	0.0	0.0	0	0	0	0	0.0	0	0.0	7.3	7.28	130.8	200	0.02
1988	79	3A	79	-1	0.0	0	0	0	2	4.0	2	4.0	4.7	0.74	75.0	85	0.02
1989	79	3A	75.0	1	0.7	0	0	0	1	2.0	1	2.0	4.5	2.50	80.3	88	0.02
1990	79	3A	80.3	0	0.0	0	1	1.15	0	0.0	1	1.2	4.8	3.67	76.8	86	0.02
1991	79	3A	76.8	-1	0.0	0	2	2.3	0	0.0	2	2.3	4.6	2.31	78.2	88	0.02
1992	79	3A	78.2	5	3.5	0	1	1.15	0	0.0	1	1.2	4.7	3.54	81.9	97	0.02

Grizzly Bear Allocations (cont…)

EAR ALLOCATIONS

K	L	M	historic values for m	N	O	P	Additional information	
HUNTER SUCCESS (MOST RECENT) (5 YEARS)	INTERM LIC (IxJ/K) (HARVEST RATE) /SUCCESS RATE	CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	ADJUSTED #LIC. >35% FEMALE= REDUCTION OF 0.33	# LIC. ALLOCATED (DEPENDANT ON REGIONAL REVIEW)	EST. HARVEST	Licenses alloted	Harvest
	22	10		14				
	26	10		17				
[illegible]	22	14		15				
6.6%	25	16		16				
6.6%	24	16		16				
7.0%	23	18		16				
7.4%	22	18		14				
5.8%	29	18		19				
7.2%	23	20		15				
6.3%	25	22		16				
6.8%	23	25	33.0	15			37	4
5.9%	28	26	34.0	18			31	0
7.1%	22	27	34.0	14			34	2
6.9%	25	29	36.0	16			17	2
2.3%	10	4		7				
2.3%	13	5		8				
2.3%	13	8		9				
2.3%	15	8		10				
2.3%	15	8		10				
1.8%	21	8		14				
1.3%	26	8		17				
2.3%	15	8		10				
2.3%	14	9		9				
2.3%	15	13		10				
7.3%	4	14	42.0	2			4	
6.1%	6	14	39.0	4			2	0
5.0%	3	17	41.0	2			2	0
7.9%	2	17	38.0	2			7	
3.6%	69	38		46				
3.6%	63	45		41				
3.6%	70	49		46				
3.6%	69	51		46				
3.6%	66	53		44				
3.8%	67	53		44				
4.6%	53	55		35				
4.6%	57	56		37				
7.2%	33	58		21				
8.1%	31	59		20				
9.3%	27	60	42 0	18			32	
10.3%	23	62	42.0	15			35	
13.9%	17	65	42.0	11			24	
11.3%	23	65	42.0	15			13	
3.2%	47	52		31				
3.2%	50	54		33				
3.2%	48	54		32				
3.2%	49	55		32				
3.2%	51	57		34				

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Grizzly Bear Allocations (cont…

GRIZZLY BEAR

Year	Habitat Carrying Capacity K	A GBMA	B POP EST.	C NET TRANS.	C1 Net Trans (-30%)	D EST. NET IMM.	D1 Hunt Kill	D2 Hunt & wound (+15%)	D3 Non-hunt Mort.	D4 Unreport Nonhunt (+100%)	E Total REPT. MORT.	F EST. TOTAL MORT. D2+D4	G ALLOW. MAN CAUSED MORT. @6%/YR	H NET NATURAL GROWTH (G-F)	I JAN.2002 CAL. GRIZ. POP. New model	Old model N	J HARV GOAL	(MC
1993	79	3A	81.9	0	0.0	0	0	0	1	2.0	1	2.0	4.9	2.92	74.6	101	0.02	
1994	79	3A	74.6	1	0.7	0	0	0	0	0.0	0	0.0	4.5	4.48	82.5	108	0.02	
1995	79	3A	82.5	0	0.0	0	1	1.15	0	0.0	1	1.2	5.0	3.80	74.9	112	0.02	
1996	79	3A	74.9	0	0.0	0	4	4.6	2	4.0	6	8.6	4.5	-4.10	73.0	108	0.02	
1997	79	3A	73.0	5	3.5	0	0	0	0	0.0	0	0.0	4.4	4.38	86.0	120	0.02	
1998	79	3A	86.0	2.0	1.4	0	1	1.15	3	6.0	4	7.2	5.2	-1.99	66.8	124	0.02	
1999	79	3A	66.8	0.0	0.0	0	8	9.2	1	2.0	9	11.2	4.0	-7.19	72.9	120	0.02	
2000	79	3A	72.9	-2.0	0.0	0	2	2.3	1	2.0	3	4.3	4.4	0.08	78.3	121	0.02	
2001	79	3A	78.3	0.0	0.0	0	7	8.05	1	2.0	8	10.1	4.7	-5.35	69.5	118	0.02	
1988	26	3B	26	1	0.7	0	0	0	1	2.0	1	2.0	1.6	-0.44	24.7	27	0.02	
1989	26	3B	24.7	-3	0.0	0	0	0	0	0.0	0	0.0	1.5	1.48	26.8	28	0.02	
1990	26	3B	26.8	-5	0.0	0	0	0	1	2.0	1	2.0	1.6	-0.39	23.3	29	0.02	
1991	26	3B	23.3	0	0.0	0	0	0	0	0.0	0	0.0	1.4	1.40	27.4	31	0.02	
1992	26	3B	27.4	-3	0.0	0	2	2.3	0	0.0	2	2.3	1.6	-0.65	22.5	30	0.02	
1993	26	3B	22.5	2	1.4	0	1	1.15	0	0.0	1	1.2	1.3	0.20	27.9	33	0.02	
1994	26	3B	27.9	-6	0.0	0	0	0	1	2.0	1	2.0	1.7	-0.33	22.3	33	0.02	
1995	26	3B	22.3	-1	0.0	0	1	1.15	0	0.0	1	1.2	1.3	0.19	26.5	34	0.02	
1996	26	3B	26.5	-1	0.0	0	0	0	0	0.0	0	0.0	1.6	1.59	25.6	35	0.02	
1997	26	3B	25.6	5	3.5	0	2	2.3	2	4.0	4	6.3	1.5	-4.76	23.5	37	0.02	
1998	26	3B	23.5	5.0	3.5	0	0	0	0	0.0	0	0.0	1.4	1.41	30.9	44	0.02	
1999	26	3B	30.9	0.0	0.0	0	0	0	0	0.0	0	0.0	1.9	1.85	20.8	47	0.02	
2000	26	3B	20.8	1.0	0.7	0	1	1.15	1	2.0	2	3.2	1.2	-1.90	25.2	48	0.02	
2001	26	3B	25.2	1.0	0.7	0	0	0	0	0.0	0	0.0	1.5	1.51	27.2	52	0.02	
1988	40	4A	52	0.0	0.0	0	0	0	0	0.0	0	0.0	3.1	3.12	25.9	46	0.02	
1989	40	4A	25.9	-3	0.0	0	0	0	0	0.0	0	0.0	1.6	1.55	39.6	46	0.02	
1990	40	4A	39.6	1	0.7	0	2	2.3	1	2.0	3	4.3	2.4	-1.92	36.7	65	0.02	
1991	40	4A	36.7	0.0	0.0	0	0	0	0	0.0	0	0.0	2.2	2.20	41.9	72	0.02	
1992	40	4A	41.9	6	4.2	0	2	2.3	0	0.0	2	2.3	2.5	0.21	40.3	82	0.02	
1993	40	4A	40.3	0	0.0	0	6	6.9	5	10.0	11	16.9	2.4	-14.48	22.9	75	0.02	
1994	40	4A	22.9	0	0.0	0	1	1.15	2	4.0	3	5.2	1.4	-3.78	31.6	77	0.02	
1995	40	4A	31.6	1	0.7	0	2	2.3	0	0.0	2	2.3	1.9	-0.40	40.9	80	0.02	
1996	40	4A	40.9	-2	0.0	0	2	2.3	1	2.0	3	4.3	2.5	-1.85	35.0	78	0.02	
1997	40	4A	35.0	-2	0.0	0	0	0	1	2.0	1	2.0	2.1	0.10	40.4	79	0.02	
1998	40	4A	40.0	0.0	0.0	0	1	1.15	0	0.0	1	1.2	2.4	1.25	38.9	83	0.02	
1999	40	4A	38.9	0.0	0.0	0	1	1.15	0	0.0	1	1.2	2.3	1.18	39.6	87	0.02	
2000	40	4A	39.6	0.0	0.0	0	3	3.45	0	0.0	3	3.5	2.4	-1.07	36.8	88	0.02	
2001	40	4A	36.8	0.0	0.0	0	0	0	0	0.0	0	0.0	2.2	2.21	41.9	93	0.02	
1988	28	4B	34	1	0.7	0	0	0	0	0.0	0	0.0	2.0	2.04	22.1	30	0.02	
1989	28	4B	22.1	4	2.8	0	2	2.3	0	0.0	2	2.3	1.3	-0.97	30.2	35	0.02	
1990	28	4B	30.2	0	0.0	0	2	2.3	0	0.0	2	2.3	1.8	-0.49	23.7	43	0.02	
1991	28	4B	23.7	3	2.1	0	3	3.45	0	0.0	3	3.5	1.4	-2.03	28.5	46	0.02	
1992	28	4B	28.5	0	0.0	0	0	0	1	2.0	1	2.0	1.7	-0.29	25.6	45	0.02	
1993	28	4B	25.6	0	0.0	0	2	2.3	1	2.0	3	4.3	1.5	-2.76	25.1	45	0.02	
1994	28	4B	25.1	0.0	0.0	0	0	0	0	0.0	0	0.0	1.5	1.50	29.6	44	0.02	
1995	28	4B	29.6	1	0.7	0	2	2.3	2	4.0	4	6.3	1.8	-4.53	21.1	46	0.02	
1996	28	4B	21.1	1	0.7	0	2	2.3	1	2.0	3	4.3	1.3	-3.04	25.8	47	.0.02	
1997	28	4B	25.8	2	1.4	0	0	0	0	0.0	0	0.0	1.6	1.55	30.7	50	0.02	

1

Grizzly Bear Allocations (cont…)

ALLOCATIONS

K HUNTER SUCCESS ST RECENT) 5 YEARS)	L INTERM LIC (IxJ/K) (HARVEST RATE) /SUCCESS RATE	M CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	historic values for m CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	N ADJUSTED #LIC. >35% FEMALE= REDUCTION OF 0.33	O # LIC. ALLOCATED (DEPENDANT ON REGIONAL REVIEW)	P EST. HARVEST	Additional information Licenses alloted	Harvest
3.2%	46	57		31				
3.2%	51	57		34				
3.2%	47	57		31				
2.9%	50	60		33				
2.1%	83	60		55				
2.5%	53	61	36.0	35			45	1
5.4%	27	63	35.0	18			55	8
6.0%	26	66	36.0	17			40	2
8.9%	16	67	35.0	10			31	7
3.3%	15	2		10				
3.3%	16	3		11				
3.3%	14	8		9				
3.3%	16	8		11				
3.3%	13	9		9				
4.2%	13	11		9				
4.2%	11	15		7				
6.2%	9	16		6				
6.2%	8	16		5				
4.9%	10	17		6				
4.1%	15	17	16.0	10			11	0
4.1%	10	17	16.0	7			17	0
3.1%	16	18	19.0	11			21	1
3.1%	18	18	19.0	12			25	0
3.7%	14	53		9				
3.7%	22	54		14				
3.7%	20	54		13				
3.7%	23	54		15				
3.7%	22	56		15				
7.5%	6	59		4				
9.8%	6	62		4				
13.1%	6	62		4				
18.1%	4	64		3				
16.1%	5	65		3				
15.6%	5	66	39.0	3			6	1
16.2%	5	67	40.0	3			7	1
19.8%	4	67	39.0	2			7	3
14.8%	6	67	39.0	4			5	0
7.3%	6	10		4				
7.3%	8	11		5				
7.3%	7	11		4				
7.3%	8	12		5				
7.3%	7	13		5				
10.4%	5	14		3				
8.1%	7	14		5				
8.6%	5	16		3				
8.2%	6	16		4				
8.2%	8	16		5				

Grizzly Bear Allocations (cont…)

GRIZZLY BI

Year	K (Habitat Carrying Capacity)	A GBMA	B POP EST.	C NET TRANS.	C1 Net Trans (-30%)	D EST. NET IMM.	D1 Hunt Kill	D2 Hunt & wound (+15%)	D3 Non-hunt Mort.	D4 Unreport Nonhunt (+100%)	E Total REPT. MORT.	F EST. TOTAL MORT. D2+D4	G ALLOW. MAN CAUSED MORT. @6%/YR	H NET NATURAL GROWTH (G-F)	I JAN.2002 CAL. GRIZ. POP. New model	Old model N	J HARV GOAL
1998	28	4B	28.0	-2.0	0.0	0	1	1.15	1	2.0	2	3.2	1.7	-1.47	24.9	48	0.02
1999	28	4B	24.9	-1.0	0.0	0	1	1.15	5	10.0	6	11.2	1.5	-9.66	18.5	44	0.02
2000	28	4B	18.5	1.0	0.7	0	2	2.3	2	4.0	4	6.3	1.1	-5.19	22.4	95	0.02
2001	28	4B	22.4	0.0	0.0	0	3	3.45	1	2.0	4	5.5	1.3	-4.11	24.3	95	0.02
1988	31	4C	35	0	0.0	0	0	0	2	4.0	2	4.0	2.1	-1.90	23.1	22	0.03
1989	31	4C	23.1	-4	0.0	0	1	1.15	0	0.0	1	1.2	1.4	0.24	31.4	22	0.03
1990	31	4C	31.4	-3	0.0	0	3	3.45	3	6.0	6	9.5	1.9	-7.57	21.3	33	0.03
1991	31	4C	21.3	-1	0.0	0	1	1.15	1	2.0	2	3.2	1.3	-1.87	28.4	33	0.03
1992	31	4C	28.4	0	0.0	0	5	5.75	1	2.0	6	7.8	1.7	-6.05	24.7	28	0.03
1993	31	4C	24.7	1	0.7	0	1	1.15	1	2.0	2	3.2	1.5	-1.67	30.5	28	0.03
1994	31	4C	30.5	-1	0.0	0	0	0	0	0.0	0	0.0	1.8	1.83	31.4	31	0.03
1995	31	4C	31.4	-1	0.0	0	1	1.15	0	0.0	1	1.2	1.9	0.73	29.6	33	0.03
1996	31	4C	29.6	0	0.0	0	0	0	2	4.0	2	4.0	1.8	-2.23	27.9	35	0.03
1997	31	4C	27.9	0	0.0	0	1	1.15	0	0.0	1	1.2	1.7	0.53	31.5	36	0.03
1998	31	4C	31.0	0.0	0.0	0	1	1.15	0	0.0	1	1.2	1.9	0.71	29.9	37	0.03
1999	31	4C	29.9	0.0	0.0	0	0	0	3	6.0	3	6.0	1.8	-4.21	25.8	35	0.03
2000	31	4C	25.8	0.0	0.0	0	1	1.15	0	0.0	1	1.2	1.5	0.40	31.9	36	0.03
2001	31	4C	31.9	0.0	0.0	0	1	1.15	1	2.0	2	3.2	1.9	-1.24	27.1	36	0.03
1988	29	6 AND 7	45	0	0.0	2	3	3.45	1	2.0	4	5.5	2.7	-2.75	5.7	27	0.03
1989	29	6 AND 7	5.7	0	0.0	2	1	1.15	1	2.0	2	3.2	0.3	-2.81	9.0	24	0.03
1990	29	6 AND 7	9.0	0	0.0	2	3	3.45	1	2.0	4	5.5	0.5	-4.91	12.4	47	0.03
1991	29	6 AND 7	12.4	-3	0.0	2	1	1.15	1	2.0	2	3.2	0.7	-2.41	20.0	47	0.03
1992	29	6 AND 7	20.0	-4	0.0	2	2	2.3	2	4.0	4	6.3	1.2	-5.10	25.3	43	0.03
1993	29	6 AND 7	25.3	-2	0.0	2	2	2.3	3	6.0	5	8.3	1.5	-6.78	24.5	42	0.03
1994	29	6 AND 7	24.5	0	0.0	2	0	0	4	8.0	4	8.0	1.5	-6.53	24.9	46	0.03
1995	29	6 AND 7	24.9	-4	0.0	2	1	1.15	4	8.0	5	9.2	1.5	-7.66	23.7	44	0.03
1996	29	6 AND 7	23.7	-4	0.0	2	1	1.15	2	4.0	3	5.2	1.4	-3.73	27.7	40	0.03
1997	29	6 AND 7	27.7	-15	0.0	2	1	1.15	2	4.0	3	5.2	1.7	-3.49	26.7	57	0.03
1998	29	6 AND 7	26.7	-5.0	0.0	2	1	1.15	1	2.0	2	3.2	1.6	-1.55	29.2	55	0.03
1999	29	6 AND 7	29.2	0.0	0.0	2	3	3.45	3	6.0	6	9.5	1.8	-7.70	21.4	54	0.03
2000	29	6 AND 7	21.4	-2.0	0.0	2	3	3.45	1	2.0	4	5.5	1.3	-4.17	26.9	53	0.03
2001	29	6 AND 7	26.9	-2.0	0.0	2	3	3.45	2	4.0	5	7.5	1.6	-5.84	24.8	50	0.03
	1405																

31 (57*)
31 (55)
30 (54)
53
50

Grizzly Bear Allocations (cont…)

EAR ALLOCATIONS

K HUNTER SUCCESS (MOST RECENT) (5 YEARS)	L INTERM LIC (IxJ/K) (HARVEST RATE) /SUCCESS RATE	M CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	historic values for m CUMMULATIVE 1972- FEMALE MAN CAUSED MORTAL. +TRANS. OUT	N ADJUSTED #LIC. >35% FEMALE= REDUCTION OF 0.33	O # LIC. ALLOCATED (DEPENDANT ON REGIONAL REVIEW)	P EST. HARVEST	Additional information Licenses alloted	Harvest
7.3%	7	17	26.0	4			9	1
9.0%	4	20	27.0	3			12	1
11.4%	4	22	29.0	3			9	2
12.1%	4	24	28.0	3			16	3
13.5%	5	35		3				
13.5%	7	38		5				
13.5%	5	42		3				
13.5%	6	42		4				
13.5%	6	43		4				
16.8%	5	44		4				
15.3%	6	44		4				
17.9%	5	44		3				
16.7%	5	44		3				
15.0%	6	44		4				
18.3%	5	45	37.0	3			3	1
18.3%	4	46	37.0	3			3	0
16.7%	6	46	36.0	4			4	1
21.7%	4	46	36.0	2			4	1
11.3%	2	27		1				
11.3%	2	28		2				
11.3%	3	30		2				
11.3%	5	30		3				
11.3%	7	35		4				
12.6%	6	37		4				
11.5%	7	37		4				
11.2%	6	38		4				
13.1%	6	41		4				
15.0%	5	52		4				
16.3%	5	58	35.0	4			4	1
28.3%	2	64	36.0	1			5	3
39.3%	2	65	35.0	1			4	3
51.0%	1	66	34.0	1			4	3
	534							

Another important weakness in the harvest allocation model that we feel must be addressed is the % disturbance on the landscape, which directly affects the estimated grizzly bear population size. In the original calculations of landscape disturbance presented in the 1990 Grizzly Bear Management Plan, the procedures and methods used to make these calculations are unclear. The amount and level of landscape change in grizzly bear habitat in Alberta has changed substantially since the late 1980's and likely will continue to do so. As of this date, the amount of landscape development that has occurred has not been reviewed and included in the department's annual grizzly bear population assessment since 1990 (or in the example calculations presented in Table 2). The ESCC status report and recommendations to the Minister have clearly identified that perceived loss of habitat and pressures on existing grizzly bear habitats are key factors in the conclusions presented, thus it appears that a review and reassessment of this issue is necessary. This is not a simple *or* quick task and it has not been undertaken as part of this report. Should this be undertaken it is important to formalize this process and ensure that the analysis has statistical rigor. We suggest that a BMA with the most GIS land-use information and grizzly bear data be selected as a pilot area in which to conduct this assessment.

Our review of the data set used to determine the annual population status of grizzly bears in Alberta also pointed out one other important issue relating to model "recalibration " *or* "resetting". It appears that in the past population estimates for specific BMA's were adjusted by either a "Delphi" (expert opinion) approach of through extrapolation of research results. Although the view that "some data is better that none" and that "those in bear habitat really have a true sense of what bear populations are really doing", these are questionable practices and are not scientifically defensible. We believe that standards must be established for modifications and *or* adjustments of population numbers. In the case of extrapolation from DNA census results we suggest that, after a careful peer review of the DNA finding the numbers used are restricted to using the lower end of the 50% confidence interval. This approach ensures a conservative approach to management decisions concerning this species.

The consequences of error in population management for grizzly bears are high as this species reproduces slowly and reduced populations require many years to recover. Miller (1989) using simulation modeling showed that when reproductive rates were generous, natural mortality rates were low, and harvests were 75% of maximum sustained rates, grizzly bear populations that had been reduced by half would require >40 years to recover. Further, even when hunting rates were reduced to 50% and 0% during the recovery period, it would take 19 and 10 years respectively for populations to recover from a 50% reduction in abundance.

Summary *of* Known Grizzly Bear Mortalities in Alberta from 1997 to 2002.

Known grizzly bear mortalities in Alberta from 1997 to 2002 were analysed for this summary using comparisons among years and BMA's (Table 3). These numbers represent only known mortalities and likely should be adjusted upwards as identified previously under suggested model adjustments. Averages of the 6 years analysed were compared with the previous 8 years (1988 - 1996).

Total known grizzly bear mortalities in Alberta from all causes averaged 29.2 from 1997 to 2002 whereas the average for the period 1988-1996 was 21 bears. Total known mortalities ranged from 20 in 1997 to 38 in 1999 (Figure 2).

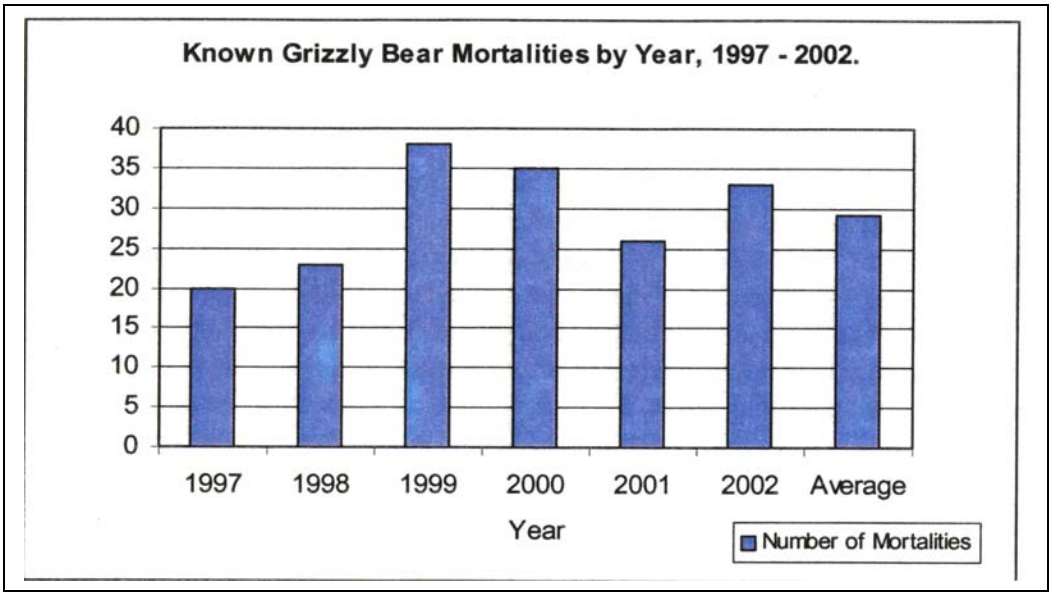

Figure 2. Known grizzly bear mortalities by year, 1997 - 2002.

When these mortalities are broken down by bear management units, GBMAs 1, 2B, 3A, 4B and 7 had relatively high mortality rates ranging from 17 to 26. GBMAs 2A and 4C had mortality rates averaged over 6-years of 14. GBMAs 3B, 4A, 5, and 6 had relatively low mortality rates of between 7 and 9 while GBMAs 12, 13, and 16 had very low mortality rates between 1 and 3 (Figure 3). Those GBMAs with high or moderate levels of mortality are in areas with large urban communities (i.e. Hinton and Grande Prairie) or extensive agricultural development in association with forested land or protected areas such as Waterton Lakes and Jasper National Parks. Those GBMAs with very low levels of mortality are in areas that are outside of or on the edge of currently identified grizzly bear range where bear densities are low. GBMA 4A has low levels of mortality, possibly due to the lack of motorized access into this area.

Table 3.Total known mortality of grizzly bears by Alberta Bear Management Areas (BMAs) 1972-2002											
YEAR	**BEAR MANAGEMENT AREA (BMA)**										
	1	2A	2B	3A	3B	4A	4B	4C	6&7	REM**	TOTAL
1972	1	0	1	5	1	6	2	2	0	0	18
1973	1	0	0	10	0	1	1	2	0	2	17
1974	2	0	2	8	1	3	1	0	7	2	26
1975	1	1	3	7	0	6	2	0	0	1	21
1976	1	2	5	10	1	8	2	6	2	1	38
1977	3	1	6	6	1	8	3	4	0	0	32
1978	0	2	6	6	1	3	4	4	0	1	27
1979	1	1	4	8	1	7	1	5	4	1	33
1980	1	1	5	4	1	11	3	11	0	1	38
1981	5	1	6	8	2	7	2	12	1	2	46
1982	3	2	11	12	1	6	2	5	5	1	48
1983	6	2	7	9	2	14	0	12	8	0	60
1984	3	1	10	7	1	15	6	6	9	1	59
1985	1	1	9	9	0	18	5	6	5	1	55
1986	3	1	10	6	0	12	6	6	7	0	51
1987	2	4	11	2	2	10	6	12	14	5	68
1988	6	1	2	2	0	0	0	2	4	0	17
1989	1	2	9	1	0	0	2	1	2	2	20
1990	7	2	6	1	1	3	2	6	4	0	32
1991	4	1	2	2	0	0	3	2	2	1	17
1992	4	1	7	1	2	2	1	6	4	2	30
1993	2	1	2	2	1	11	3	2	5	1	30
1994	1	1	5	0	1	3	0	0	2	2	15
1995	0	1	2	2	1	2	2	1	2	1	14
1996	3	3	7	6	0	3	3	2	1	0	28
1997	4	1	6	0	4	1	0	1	3	0	20
1998	4	3	3	4	0	1	2	1	2	3	23
1999	1	1	6	9	0	1	5	3	5	5	36
2000	4	5	7	3	2	3	4	1	3	3	35
2001	2	2	0	8	0	0	4	2	5	0	23
2002	2	2	2	2	1	3	8	6	5	2	33

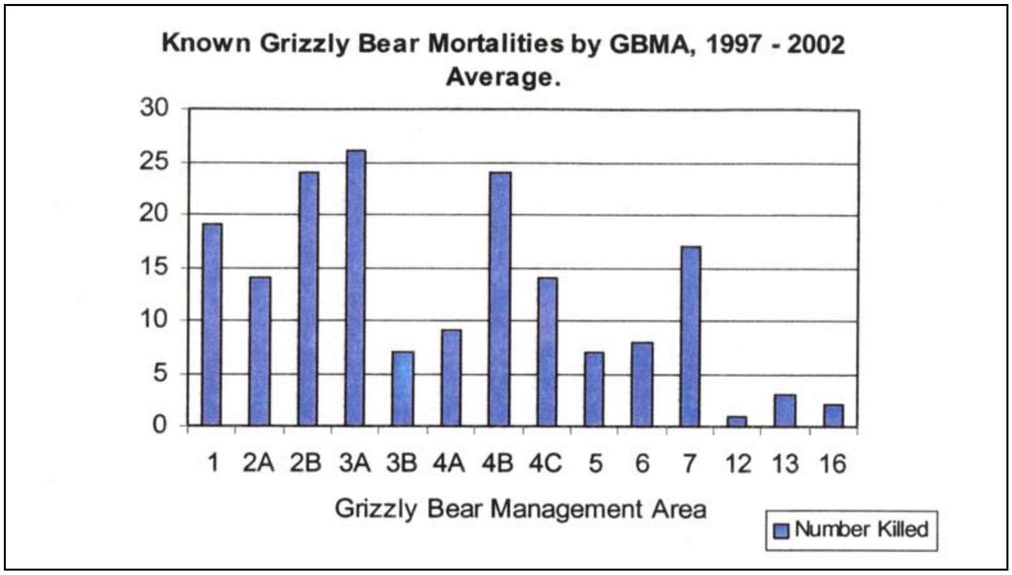

Figure 3. Known grizzly bear mortalities by GBMA, 1997 - 2002. Averaged over 6 years.

Human-caused mortality was broken down into 3 groups, legal harvest, illegal kills and other mortality (Figure 4). Other mortality included self-defence, research losses, problem wildlife, treaty Indian, and found dead. Legal harvest comprised the largest portion of mortality causes in each of the 6 years analysed, ranging from 10 in 1997 to 19 in 2000 and averaging 15.2. Those mortality causes grouped under other mortalities comprised the second most-common cause of mortality, ranging from 5 in 2001 to 14 in 1999 and averaging 8.3. Illegal kills ranged from 3 in 1998 to 9 in 2002, averaging 5.7. Again, there did not appear to be a trend, either increasing or decreasing, during the 6 years analysed.

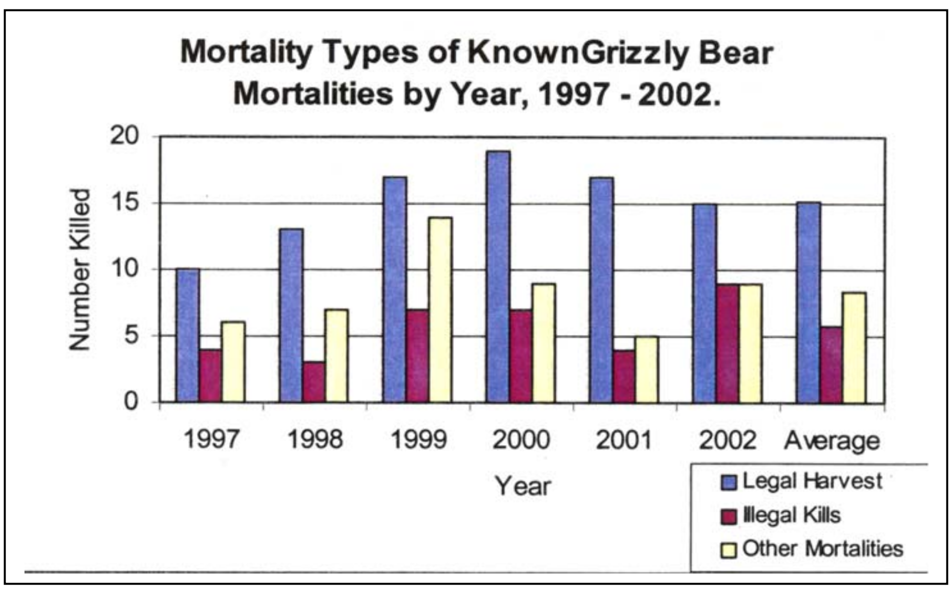

Figure 4. Mortality types of known grizzly bear mortalities by year, 1997 - 2002.

Legal harvest comprised the largest portion of known mortalities in most GBMAs (1, 2B, 3A, 3B, 4A, 4B, 4C, 6 and 7) (Figure 4). GBMAs 2B, 3A, and 4A had legal harvest greater than twice the combined mortality from all other causes. All of these GBMAs are in west central Alberta and include the Willmore Wilderness. Outside of the Willmore, these areas comprise industrial forests on crown lands with a high density of access. These areas, except the Willmore, also have the largest number of mortalities of all GBMAs. In GBMAs 2B and 3A, good access on crown lands probably attracts larger numbers of legal hunters and allows a higher success rate (1996-2000 average = 17.0% and 11.8% for GBMA 2B and 3A respectively compared with 6%, 5%, 2.6%, 0%, 7.8%, and 0% for GBMAs I, 2A, 3B, 4A, 4B, and 4C respectively. GBMA 6 and 7 combined also had high hunter success at 10.6%)). Legal harvests in these 2 units are significantly higher than the average (9.1) for all units (not including GBMA 12, 13, and 16, which are outside of or on the edge of normal grizzly bear range). Whereas illegal kills and other mortalities for these 2 units were close to average.

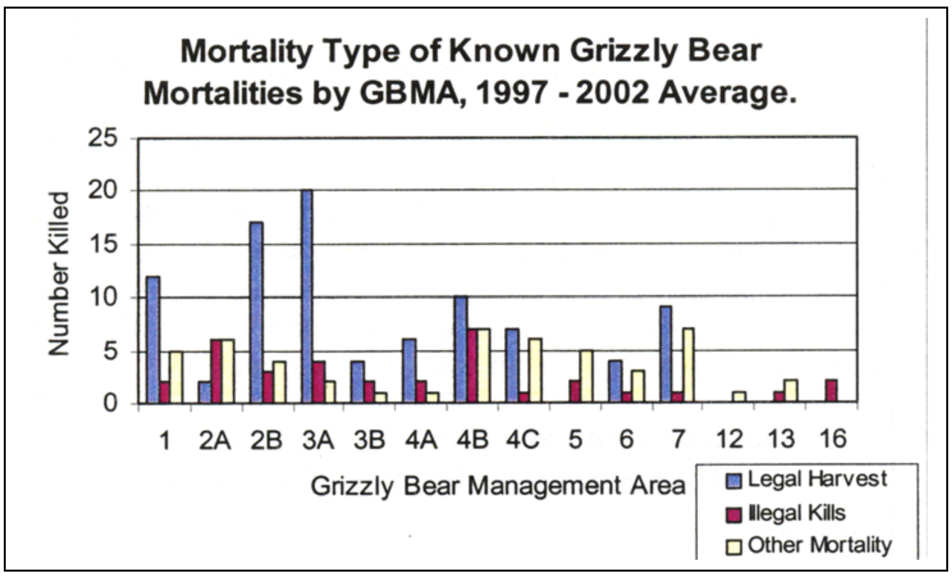

Figure 5. Mortality types of known grizzly bear mortalities by GBMA, 1997 – 2002. Averaged over 6 years.

Male grizzly bears comprised the largest portion of all known mortalities in each of the years analysed, ranging from 12 in 1997 to 23 in 2000 and averaging 17.7 (Figure 6). The female portion of the known mortalities ranged from 6 in 1997 and 2001 to 16 in 1999 averaging 10.7. In 2002, the number of dead males exceeded dead females by only 2 animals. This high ratio of females in the total human-caused mortality in 2002 is a serious management concern.

Figure 6. Gender of known grizzly bear mortalities by year, 1997 - 2002.

The ratios of male mortalities to female mortalities (males/females) ranged from 53/47 in 2002 to 76/24 in 2001 (Figure 7). The average over the 6 years was 63/37.The data did not appear to represent any trend in the ratios. The Management Plan for Grizzly Bears in Alberta has a goal of that females should not represent more than 35% of the annual and cumulative known mortality in each GBMA. The proportion of females among known mortalities exceeded the management goal on a provincial level in 1998, 1999, and 2002 although the average ratio for the 6 years was within the goal.

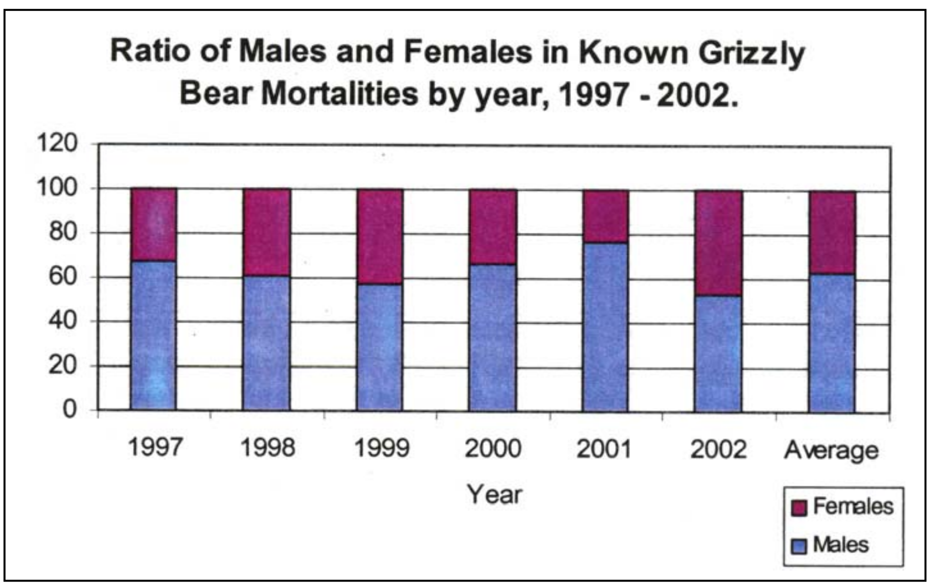

Figure 7. Ratio of males and females in known grizzly bear mortalities by year, 1997 2002.

Males comprised the largest portion of known mortalities in all GBMAs (averaged over 6 years) except 1 and 5 (Figure 8). Number of male deaths exceeded females by only 1 and 2 animals in GBMAs 4A and 4B respectively. GBMAs 12, 13 and 16 had no female mortality recorded. The mortality in these units may represent dispersing young males.

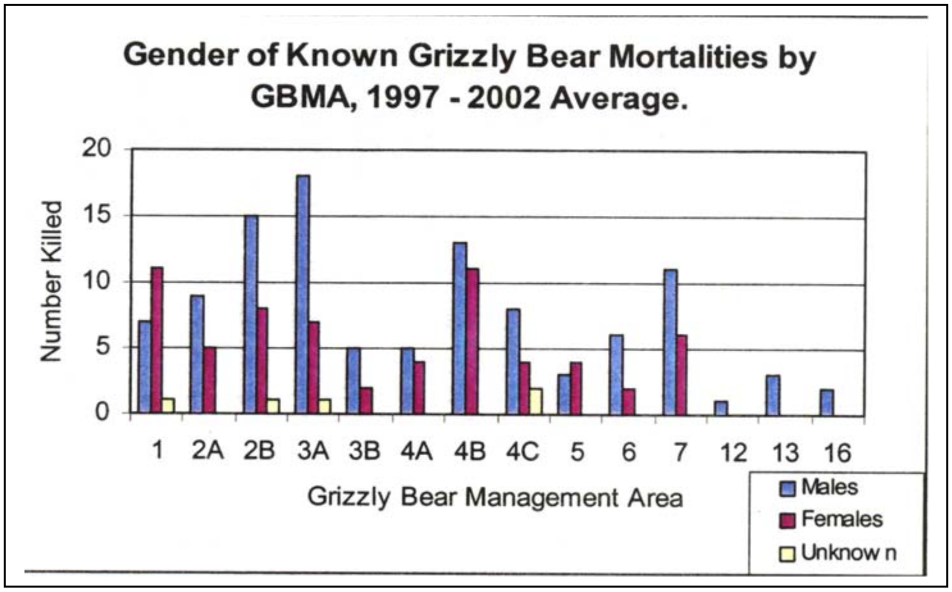

Figure 8. Gender of known grizzly bear mortalities by GBMA, 1997 - 2002. Averaged over 6 years.

Averaged over 6 years, GBMAs 1, 2A, 4A, 4B, and 5 had mortality ratios exceeding the goal of 65% males to 35% females or less (Figure 9). The ratio in GBMA 2A was only slightly higher than the goal. Ratios in GBMAs 1, 4A, 4B, and 5 were significantly greater than the goal. GBMAs 1 and 5 had ratios in which the proportion of females exceeded males (39/61 and 4,3/57 respectively). Ratios for all GBMAs (except 12, 13, and 16) ranged from 39/61 to 75/25.

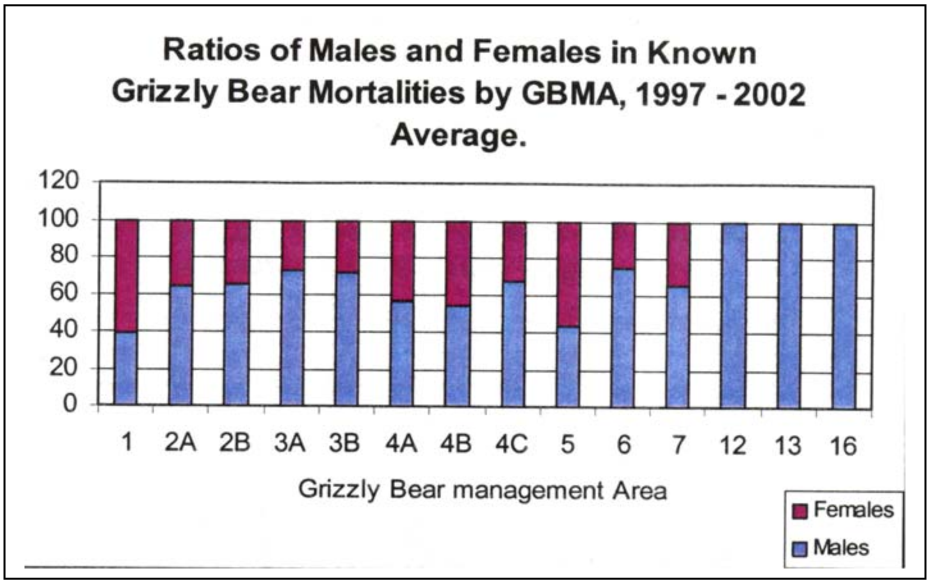

Figure 9. Ratios of males and females in known grizzly bear mortalities by GBMA, 1997 - 2002. Averaged over 6 years.

Because the loss of adult female grizzly bears has the greatest impact on population, attempts should be made to reduce the number of female grizzly bears in the total human caused mortality (Eberhardt et al. 1994). One possible method to accomplish this is to shorten the length of the hunting season because female bears are more likely to be killed during the latter part of the hunting season (Anon 1990). In addition more effort may be required by SRD staff to keep female grizzly bears within their ecosystem as part of problem bear management actions.

Additional Analysis of Age/Sex Data

Since grizzly bear mortality rates are generally considered to be low in number on an annual basis, the ability to make inferences about the population status from mortality data only is difficult (Table 3). Further, we know little about the time required for harvest (or total mortality) to impact the population's sex and age structure. In reality, the detection of bear population trend from the sex and/or age structure of harvested bears is a difficult and tenuous task. Changes in population structure indicate a change in a host of variables including food supply, reproduction, mortality or all of these.

Other data are needed to identify the source of population change. Unfortunately, obtaining actual estimates of bear numbers, densities, and trends is difficult, expensive and requires a long-term ongoing program to obtain meaningful management results. In the absence of other data sets it is important to undertake bear management strategies in a conservative manner.

In general terms, the combined use of age and sex information of harvest (and possibly all mortalities) is a stronger approach than simply using age structure alone. However, with sparse data sets encountered with most grizzly bear demographic data relating to mortalities it is often necessary to investigate the sex ratio of harvest alone. . This approach allows for a significant increase in sample size when one conducts an analysis by BMA. It is important to emphasize that when birth and death rates are constant, the sex and age composition of the population will stabilize regardless of the population trend. Therefore a population could be undergoing a serious decline (or increase) yet this may not be apparent in a review of the sex/age data of the known mortalities.

With these caveats and for the purpose of this report we have tried to identify possible trends apparent in the available data to assist in pressing management decisions.

We undertook an analysis of change in sex ratio with age over time with the Alberta grizzly bear mortality data set. One major problem we faced was the small number of grizzly bear mortalities in each BMA and that only a small proportion of dead bears were aged.

In an effort to overcome the sample size problem we elected to combine some adjacent BMA 's into single units for the following analysis (see table 4)

Table 4. Grizzly Bear Management Areas Combined for Sex/Age Analysis Purposes

1 + 16	=1
2A + 2B	=2
3A + 3B + 13	=3
4A +4B +4C	=4
5+6+7	=5

We looked at the observed change in sex ratio with age over time (Paloheimo and Fraser 1981; Fraser et al. 1982) to estimate harvest rate and other parameters. The use of this method to estimate harvest rate is controversial (Harris and Metzgar 1987) but we felt it has some utility as a trend index.

One obvious problem with this technique when applied to the current data set is sparse sample sizes in terms of number of bear mortalities and removals in each study area. In addition to pooling BMA's as noted above we also combined years to increase the sample sizes (into 4 year blocks 1986-89, 1990-3, 1994-97, 1998-2002). Sample sizes for the pooled data are shown in Figure 10 and 11 below.

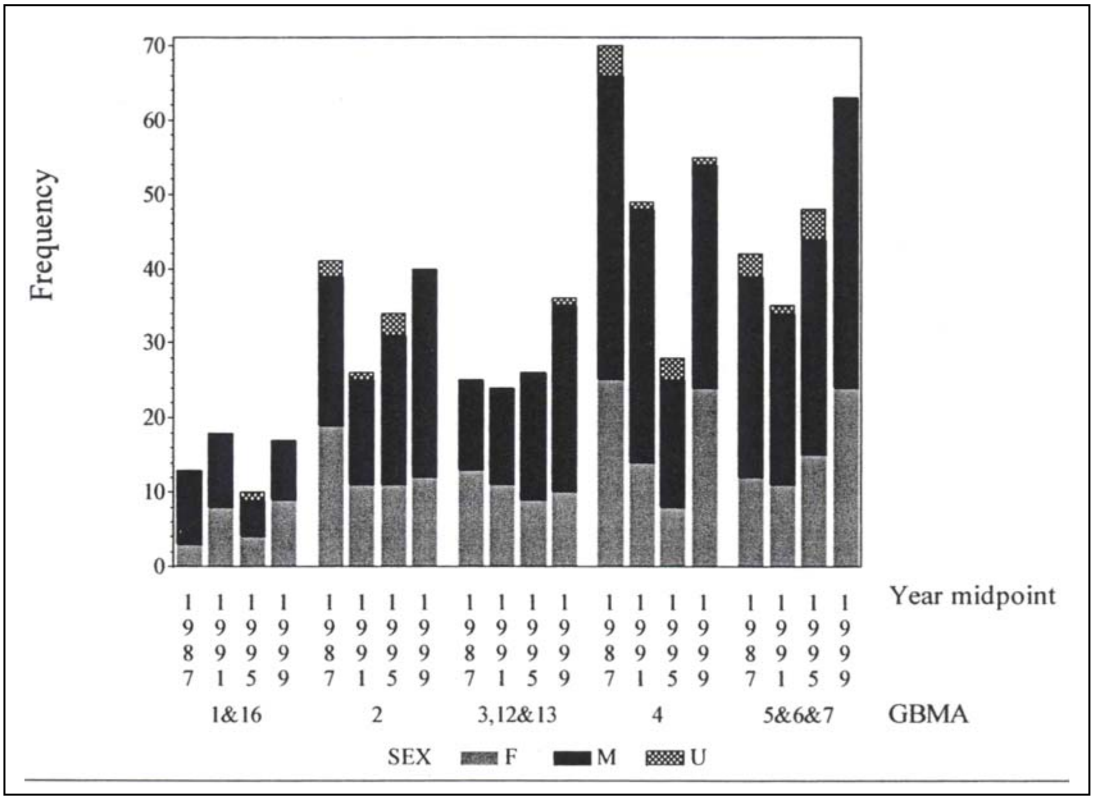

Figure 10: Frequencies of grizzly bear mortalities and removals by pooled GBMA categories and sex.

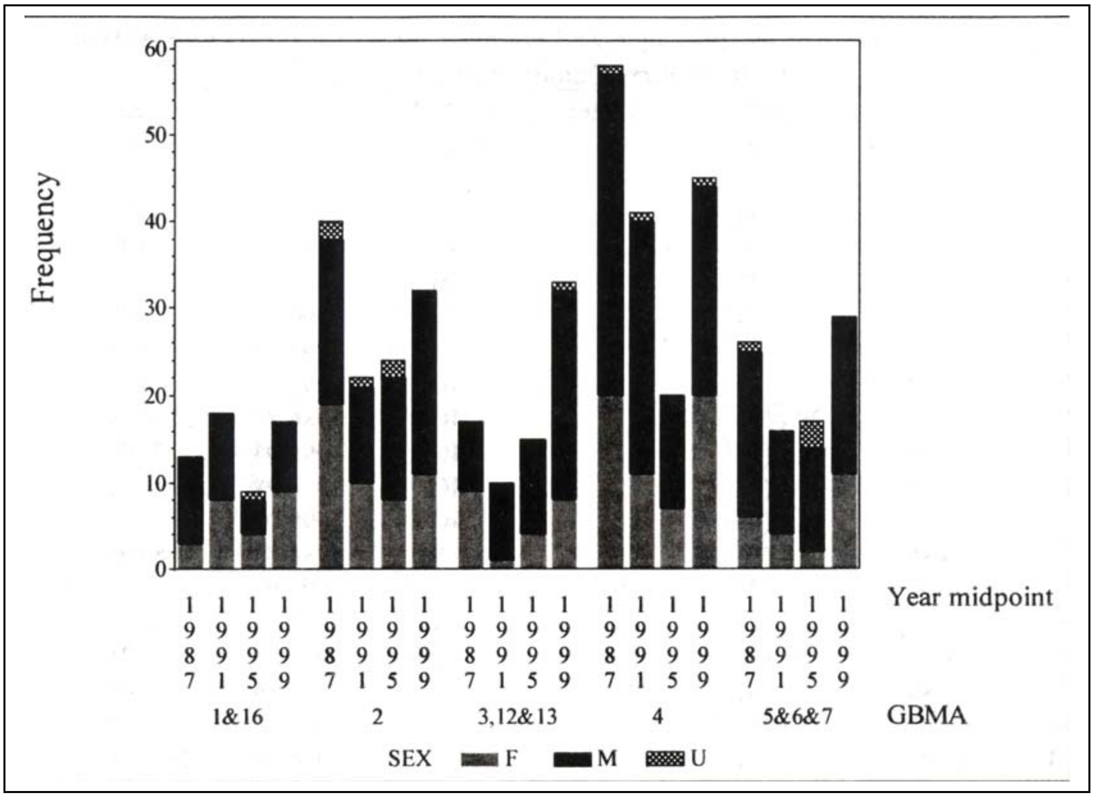

Figure 11: Frequencies of grizzly bear mortalities by pooled GBMA categories and sex.

These summary statistics suggest the greatest number of mortalities and removals occurred in grizzly bear management area 4. In addition, there was no marked change in sex ratio of harvest or removals over time.

Trends in sex and age ratios over time

We also looked at the change in median age of each sex of bear over time. The rationale behind this method is that a shift in mortalities towards younger age classes should occur if a population is being affected by harvest or other factors (i.e. habitat loss, etc). Basically, the premise would be that all the older bears are being removed (due to higher mortality rates) shifting the distribution of age to younger bears (under the assumption of a constant reproductive rate). In some cases this analysis used individual BMA's while in other cases pooling was necessary due to sparse data (Table 5). Since little difference was found between analysis using mortality data separately and the pooled with removal data as well only the pooled results are presented here.

Table 5: Frequencies of samples aged and not aged for removal and mortality data by pooled years of analysis and GBMA's.

GBMA(s)	Years	Aged[1]	Not aged	GBMA(s)	Years	Aged[1]	Not aged
1&16	1986-89	10 (2)	3	4A	1986-89	23 (8)	2
1&16	1990-93	17 (7)	1	4A	1990-93	19 (5)	0
1&16	1994-97	8 (4)	1	4A	1994-98	10 (5)	2
1&16	1998-02	14 (8)	3	4A	1999-02	6 (2)	3
2A	1986-89	6 (3)	1	4B	1986-89	15 (3)	0
2A	1990-93	5 (1)	3	4B	1990-93	8 (2)	1
2A	1994-97	11 (5)	0	4B	1994-98	5 (1)	2
2A	1998-02	11 (2)	9	4B	1999-02	17 (6)	16
2B	1986-89	29 (15)	3	4C	1986-89	22 (11)	4
2B	1990-93	16 (8)	1	4C	1990-93	17 (4)	3
2B	1994-97	18 (6)	2	4C	1994-98	5 (0)	1
2B	1998-02	15 (4)	5	4C	1999-02	7 (2)	5
3A	1986-89	14 (9)	0	5&6	1986-89	18 (6)	3
3A	1990-93	10 (3)	0	5&6	1990-93	22 (10)	0
3A	1994-97	7 (2)	3	5&6	1994-98	9 (3)	4
3A	1998-02	22 (7)	6	5&6	1999-02	6 (2)	11
3B&13	1986-89	9 (3)	2	7	1986-89	19 (4)	2
3B&13	1990-93	14 (8)	0	7	1990-93	10 (1)	2
3B&13	1994-97	13 (5)	3	7	1994-98	28 (11)	3
3B&13	1998-02	3 (0)	3	7	1999-02	40 (14)	6
				12	1999-02	0 (0)	1

[1]Sample sizes of females aged in parenthesis

Figure 12 displays the results for GBMA's in which a trend in female age over time was suggested. In review, for boxplots, the points connected by the lines are the median. The box are the 25th and 75th percentiles. The bars indicate the range of the data to a maximum of the 1.5 inter-quartile ranges. If an observation is beyond this (a suggested outlier) then a plot symbol is drawn. The inter-quartile range is the distance between the 25th and 75th percentile as indicated by the width of the box. Where no box is shown this is likely a result of spare data (i.e. 1 data point)

The y-axis is on the same scale to allow comparison in ages of bears harvested in all units. One interesting results is that very few older bears were harvested in some GBMA's (2A and 4C). The results for pooled GBMA's 1 and 16 mainly pertain to GBMA 1 since only 2 aged mortalities were present in GBMA 16.

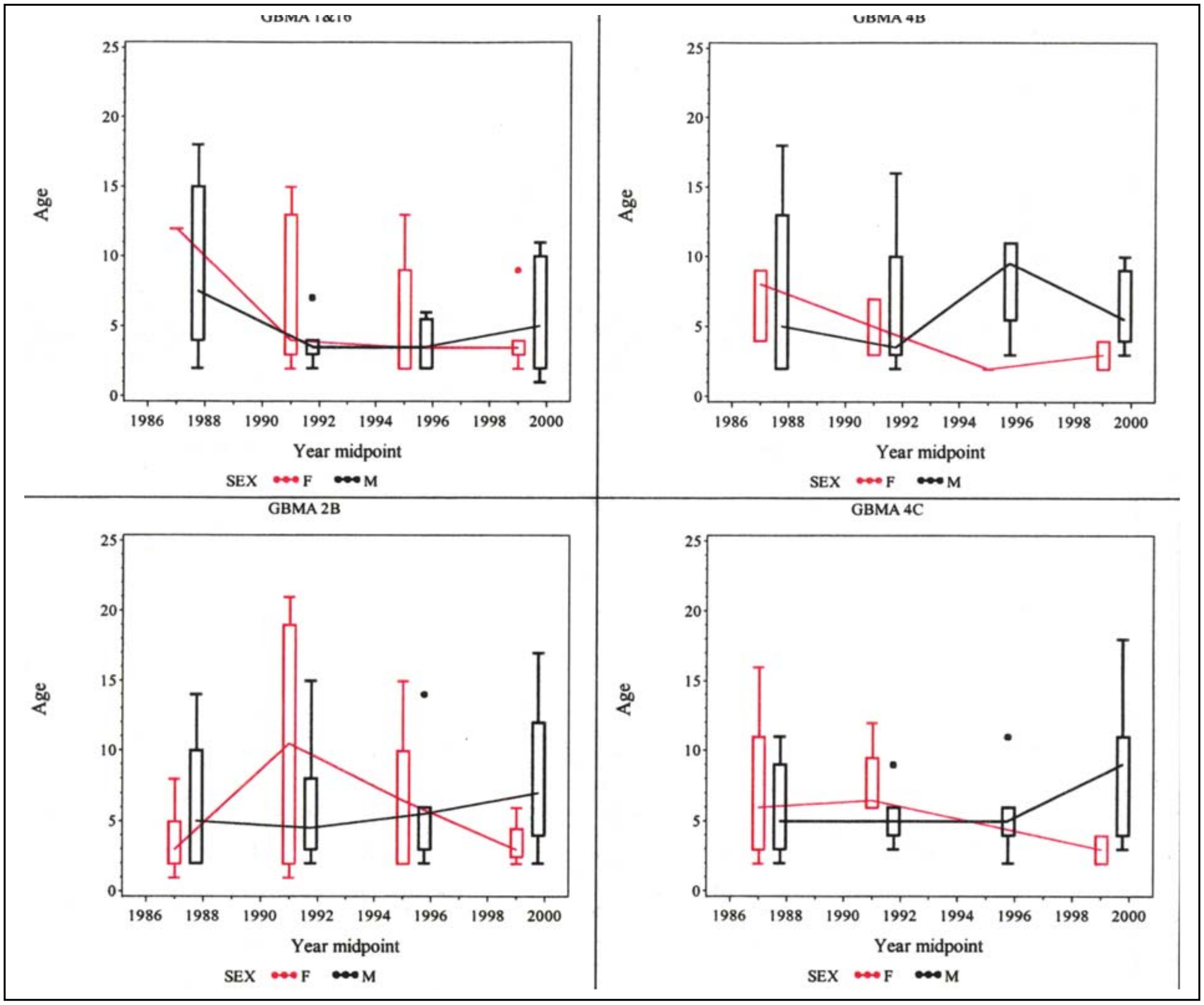

Figure 12: Boxplots of change in age and sex of bears obtained from harvest and removals. A decrease in female age over time is indicated by these figures. Axes are staggered for sexes to prevent boxes from overlapping.

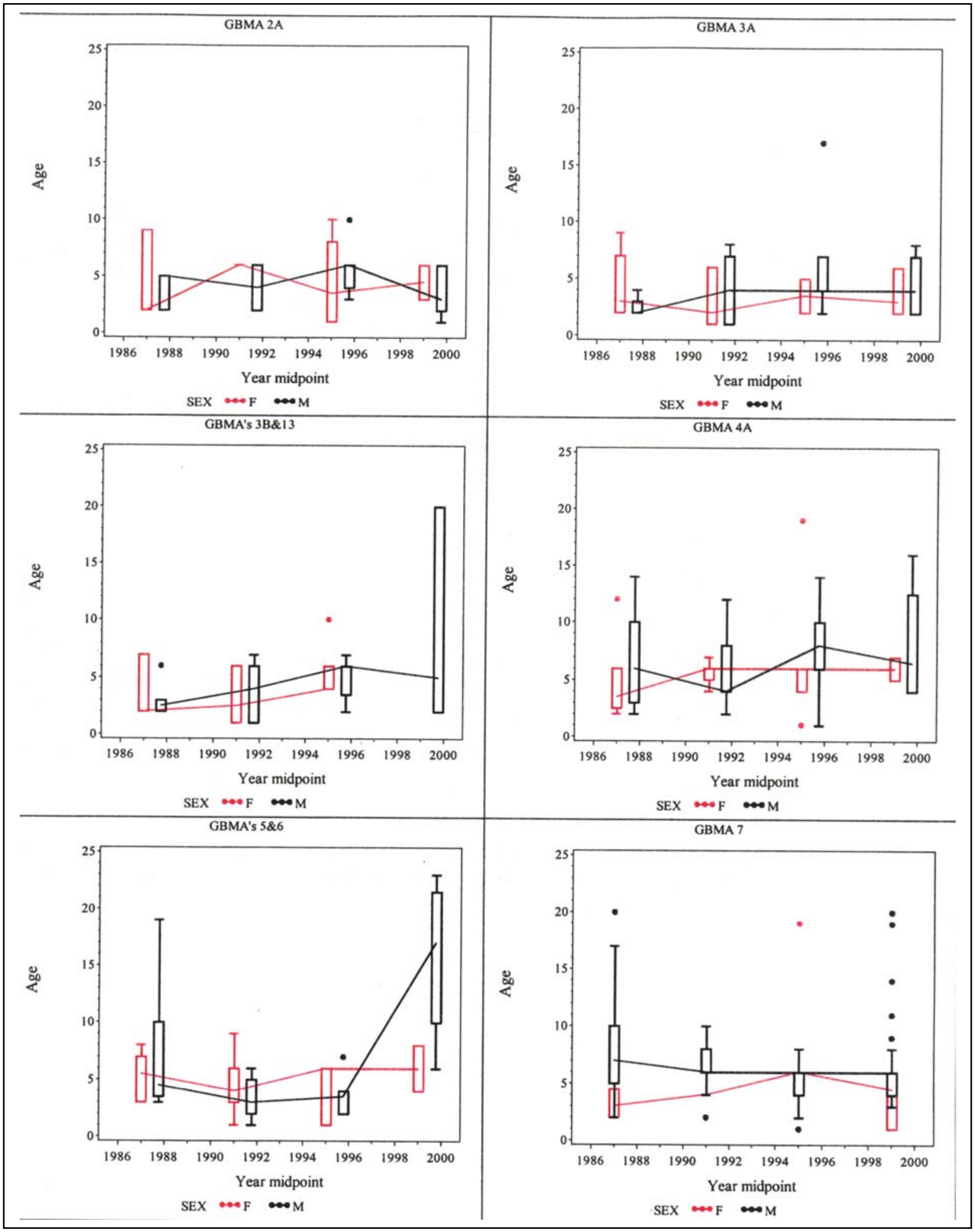

Figure 13: Boxplots of change in age and sex of bears obtained from harvest and removals. No trend in age is evident in these figures.

As previously mentioned we must emphasize that this analysis has limited power to detect changes in population status. One of the main assumptions of this analysis is that the sample of bears harvested represents a random sample of the population. This assumption could easily be violated if younger bears are more vulnerable to harvest. Recent research findings from Stenhouse and Munro (2001) clearly indicate that female bears spend more time in closer proximity to roads thus increasing their risk of mortality. **Results from this analysis suggest that BMA's (2B, 4B and 4C) which show a trend in declining age structure of female bears over time may warrant further investigation using more precise techniques. In a conservative management approach it would be prudent to take steps to reduce overall man caused mortality in these BMA's until better population inventory data is available.**

Analysis of trends in age and sex in wildlife management units that experienced high historic mortality and problem wildlife removal rates

The previous analyses considered changes in ages of bears for grizzly bear management areas. Further scrutiny has revealed that mortalities within grizzly bear management units are seldom uniform across the area (see figures A, B, C in appendix). In particular; the areas listed in Table 6 have experienced high historical (prior to 1986) and higher mortality numbers in recent years (in some cases).

Table 6: Mortalities, management removals, and frequencies of aged bears for selected wildlife management units

GBMA	WMU	Years	Aged	Not aged	Total mortalities
3A	350	1972-1986	35	8	43
	350	1986-1989	6	0	6
	350	1990-1993	6	0	6
	350	1994-1997	1	0	1
	350	1998-2002	1	1	2
2B	354&356	1972-1986	65	10	75
	354&356	1986-1989	27	3	30
	354&356	1990-1993	14	1	15
	354&356	1994-1997	15	4	19
	354&356	1998-2002	9	2	11
6 and 7	402,400,&300	1972-1986	29	5	34
	402,400,&300	1986-1989	30	2	32
	402,400,&300	1990-1993	22	1	23
	402,400,&300	1994-1997	16	5	21
	402,400,&300	1998-2002	30	4	34
2A	524	1972-1986	20	1	21
	524	1986-1989	8	3	11
	524	1990-1993	10	0	10
	524	1994-1997	6	2	8
	524	1998-2002	12	2	14

Some wildlife management units, such as 440 in GBMA 4A experienced high mortality and removal rates prior to 1986 (53 mortalities from 1972-1988), but have not experienced high mortalities past 1986 (3 mortalities) and therefore they were not considered in the analysis.

A summary of changes in distributions of age as a function of sex was conducted for wildlife management areas that had suitable sample sizes for the analysis. Unlike the previous GBMA based analysis, this analysis considers periods prior to 1986 since much of the mortality and removals occurred for many of the areas during this time period (figure 14).

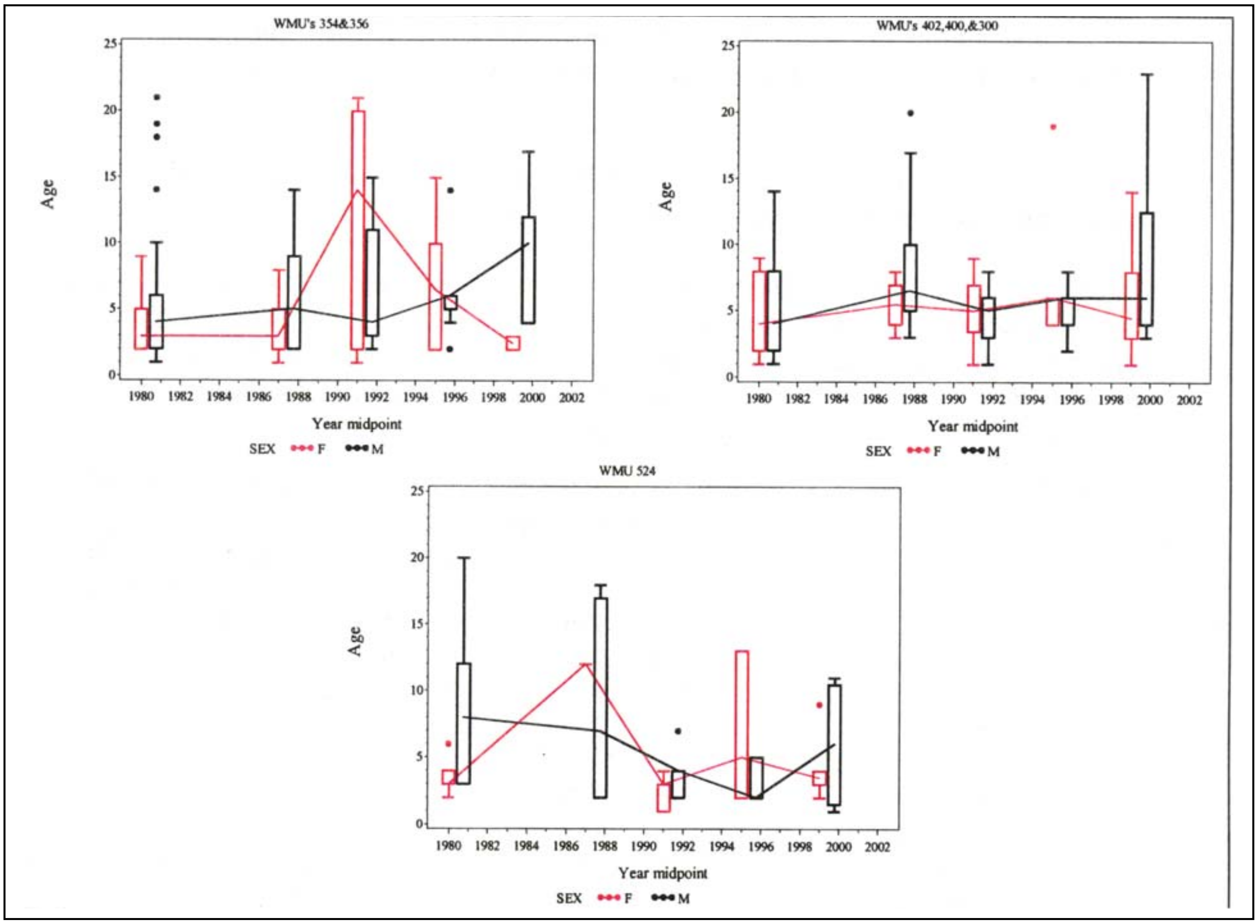

Figure 14: Changes in distribution of ages for male and female bear mortalities for selected wildlife management units. Midpoints correspond to pooled years as listed in Table 4.

A decline in age of females is potentially evident in wildlife management units 354 and 356 from 1991 - 2002; however, this may also be an artefact of sparse sample size of aged females. As with most areas, the number of mortalities declined in recent years therefore creating potential sparse sample size issues. In addition, the historic distribution of ages (1972-1986) suggests harvest of younger females, which may confound the results. No other trends are evident for other wildlife management units.

Summary of harvest and hunter success data

Table 7 provides a summary of harvest and license data for each GBMA from 19882002. A harvest bear was any bear with an LH (legal harvest) code in the mortality database. All other form of mortality are not considered in this analysis.
Table 7 shows that the number of licenses allotted is small for some GBMA's. For example GBMA's 6 and 7 had only 3-4 licenses issued after 1998 in contrast to GBMA 3A and 2B, which had many more licenses, issued. Note that the number of license issued has decreased substantially for GBMA's 4A, 4C, and 6&7.

Table 7: Summary of harvest and licenses allotted for GBMA's 1988-2002

GBMA	Statistic	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	harvest	3	1	6	2	4	3	1	0	4	2	4	0	2	2	2
	licenses	50	51	72	37	37	36	23	24	32	32	37	31	3	17	30
2A	harvest	0	1	0	0	0	0	1	1	0	0	1	0	0	1	0
	licenses	11	11	9	8	9	11	16	19	9	5	4	2	2	7	5
2B	harvest	2	1	2	0	4	2	2	1	5	4	3	4	5	0	1
	licenses	76	51	64	33	39	55	33	34	38	27	32	35	24	13	19
3A	harvest	0	0	1	2	1	0	0	1	4	0	1	8	2	7	2
	licenses	48	48	45	21	23	35	45	46	49	42	45	55	40	31	19
3B	harvest	0	0	0	0	2	1	0	1	0	2	0	0	1	0	1
	licenses	16	17	24	12	12	24	12	10	10	19	11	17	21	25	27
4A	harvest	0	0	2	0	2	6	1	2	2	0	1	1	3	0	1
	licenses	31	19	24	19	20	31	9	8	8	8	6	7	7	5	8
4B	harvest	0	2	2	3	0	2	0	2	2	0	1	1	2	3	3
	licenses	21	18	26	17	18	13	10	20	13	9	9	12	9	16	15
4C	harvest	0	1	3	1	5	1	0	1	0	1	1	0	1	1	3
	licenses	26	13	15	16	15	6	4	3	3	4	3	3	4	4	3
6&7	harvest	3	1	3	1	2	2	0	1	1	1	1	3	3	3	2
	licenses	25	18	14	14	19	11	5	5	6	5	4	5	4	4	3

Hunter success (number bears harvested/number licenses allotted) was summarized to determine if there were any dominant trends that might indicate changes in population status. For example, a decreasing harvest success rate might indicate that population's are declining making it difficult to successfully hunt bears in a GBMA. Unfortunately, many other factors can influence hunter success such as changes in access to remote areas over time and hunter skill. The problem of changing access is a particularly difficult issue. For example, a population might be declining, however, increased access would still keep hunter success high. Additional information about hunter days spent for each year might bring more resolution to this index. Given these issue the results of this analysis should be viewed with ***extreme caution***. See Miller (1989); and Garshelis (1993) for more cautions about the interpretation of harvest trends.

One other issue with hunter success data is the great degree of yearly variation, which makes it difficult to interpret raw data. For this reason, a smoothing spline routine was used to interpolate trend from data points. The spline data smoothing method can be conceptualized as a technique which undertakes non-linear regression analyses on small segments of data. It then connects the individual regression lines together in a method which optimizes the fit of each data point. This allows infinite flexibility in the shape of

relationships that splines can accommodate. The tension of the spline, which is a function of the number of data points used for each individual regression analysis, was varied iteratively to minimize noise or variance in the data set (Brown and Rothery 1993; Ellison 1993; SAS Institute 1997). The results of the spline analysis are shown along with the raw data points to allow further evaluation of trends in the data.
No apparent long-term trends are evident from this analysis. Success rate appears to be stable or increasing slightly in most GBMA' s. The actual number of licenses allotted can influence the interpretation of success rates. For example, the success rate for to be high in GBMA's 6 and 7 until 2000 when it decreases to O. However, the number of licenses allotted for the latter years of this analysis varies from 3 to 5. The low sample size of licenses allotted basically makes the estimation of success rate for G BMA' s 6 and 7 problematic at best. A similar issue is evident with GBMA 4c in which only 3 licenses were issued with 3 kills in 2002 resulting in a success rate of 1. To confront the issue we attempted to pool adjacent years, however, trends were still not evident from the data.

As mentioned earlier, data about hunter days spent would allow a better quantification of the degree of effort expended per hunter. This information might allow a better index of hunter success. In addition, changes in hunter access should be considered. For example, changes in kill locations over time might reveal if bears are being hunted in more remote areas than previous years.

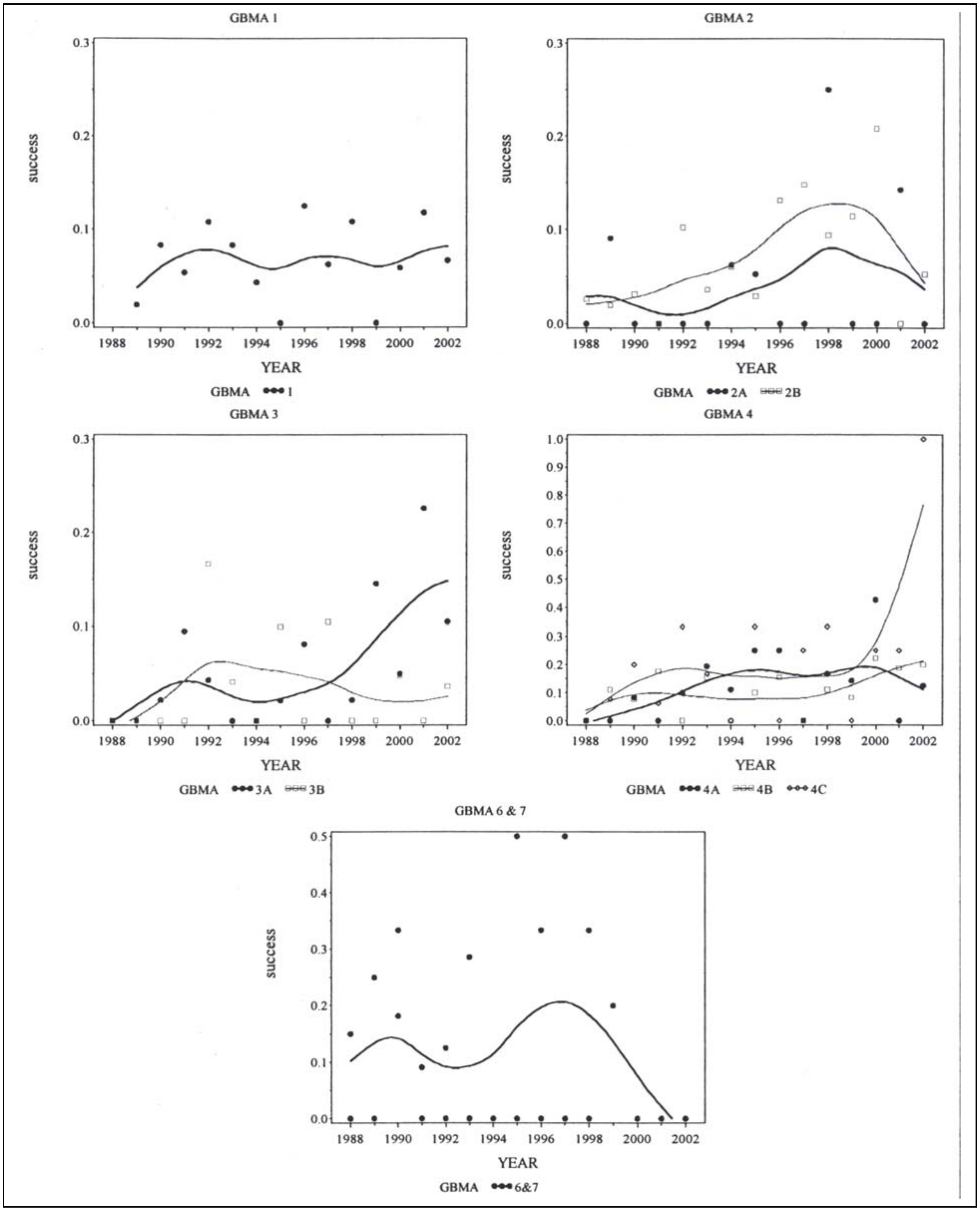

Figure 15: Trends in harvest success by GBMA. A spline smoothing routine was used to evaluate trend in the data. Raw data points are also shown.

Problem Bear Management and Relocations

As part of an overall assessment of provincial grizzly bear mortalities it is important to recognize and appreciate that problem bear management in Alberta can, and will, playa key role in the long-term conservation of this species. Figure 16 shows overall problem bear management actions (captures and relocations) for the period 1974 - 1997. Although UTM's for the period 1998-2001 were not available, the same general spatial trend was apparent in these years. This map clearly shows common geographic areas of problem bear occurrences and also identifies common areas where the department has been relocating these problem bears. There has been little or no change in the location or reasons for problem bear actions in these areas since the publication of the 1990 Alberta Grizzly Bear Management Plan. This suggests that our current management approach to bear problems in this area appears to be inadequate and that new approaches or efforts are required.

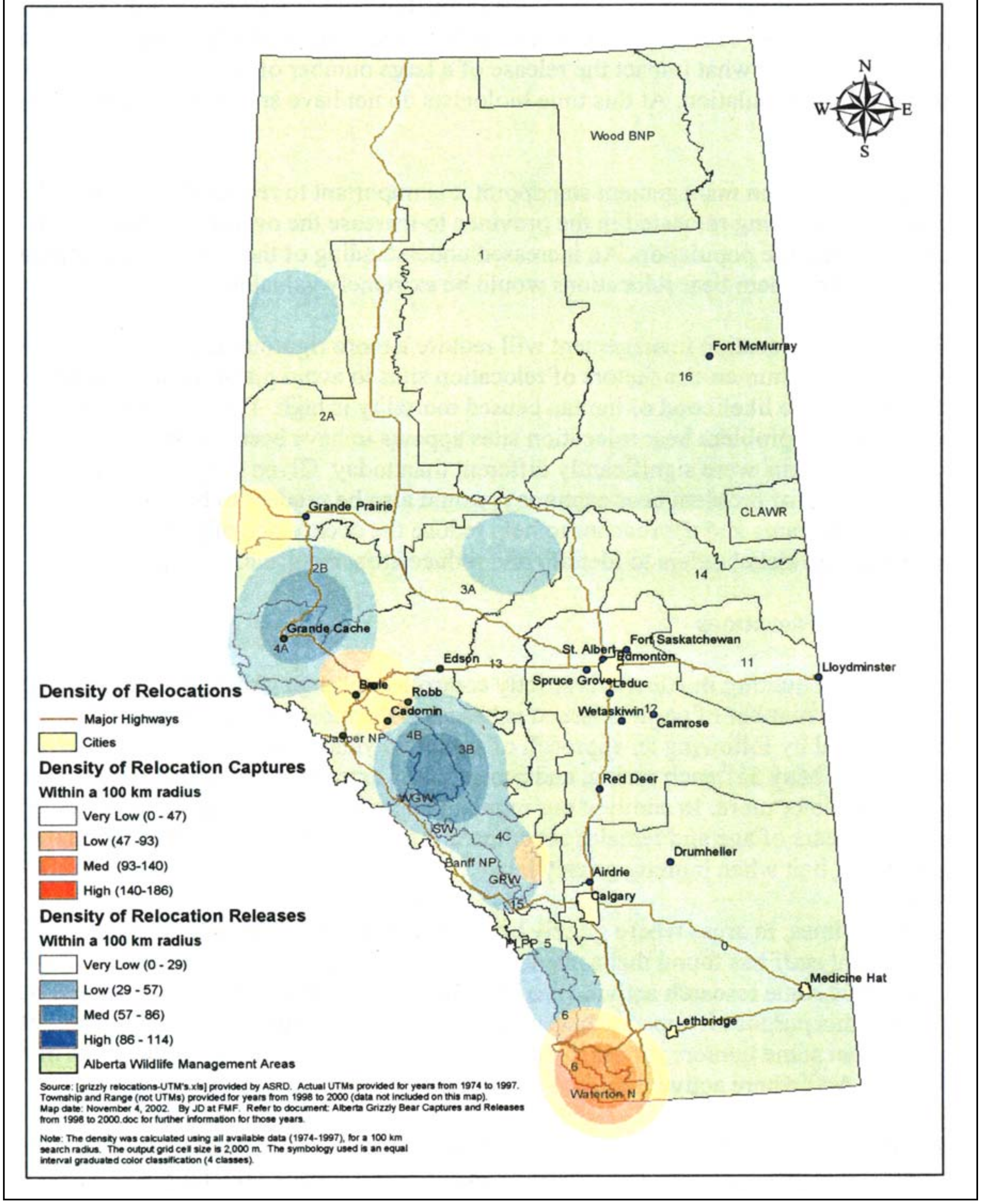

Figure 16. Spatial distribution of problem bear captures and relocations.

Historically problem bears that were relocated were treated as a loss to the BMA where they were captured and added to the BMA of relocation. This practise served the general requirements of the previous allocation formula but did not take into account either; a). the mortality rates of relocated bears (Blanchard and Knight 1996)(estimated to be at least 30%), or b). what impact the release of a large number of bears would have on the resident bear population. At this time biologists do not have an understanding of this latter issue.

From a population management standpoint it is important to reduce the number of grizzly bears that are being relocated in the province to increase the overall survival rate of this cohort within the population. An increased understanding of the survival and population impacts of problem bear relocations would be extremely valuable.

Effective translocation management will require a more rigorous assessment of habitat suitability and human-use factors of relocation sites to avoid placing relocated bears in areas where the likelihood of human caused mortality is high. The last provincial assessment of problem bear relocation sites appears to have been made in 1982 when land-use patterns were significantly different than today. Given the geographical concentration of problem bear captures it would also be prudent to have department staff develop programs and approaches to help reduce the occurrence of problem bears by working with stakeholders to identify and reduce attractants, etc.

Other Considerations

Grizzly bear hunting in Alberta is strictly controlled through a regulated draw and quota system. The number of permits issued is based on the most recent annual population estimate and by following an approach of sustained yield. Hunting is allowed between April 1 and May 31st each spring, and protection is extended to all grizzly bears part of a group of two or more. In addition our regulations prohibit the harvest of grizzlies less than two years of age and females accompanied by cubs. Hunters are also prohibited from using bait when hunting grizzly bears.

In recent times, in areas where grizzly bear research activities have been underway, department staff has found that some hunters are hunting in and around active trapping sites. Since some research activities require the capture and collaring of bears and bait is used for this purpose it appears that some hunters are benefiting from hunting near this bait. In fact some hunters appear to have entered closed areas (under Section 6.1 of the Wildlife Act) where active trap sites are present in pursuit of a grizzly bear.

As a result of this conflict, consideration should be given to closing identified BMA's where active grizzly bear trapping efforts (using baits) for research purposes, are underway.

Jurisdictions where black bear hunting takes place in habitats shared with grizzly bears have realized that this can lead to an increase in the mortality of grizzly bears. At times both black and grizzly bears can be misidentified and an illegal harvest can occur.

Alberta also faces similar challenges in having a fall black and spring black bears where grizzly bears are sometimes killed due to misidentification of this species. There have been two common approaches used in other jurisdictions to deal with this issue. First management decisions have been made to prohibit black bear hunting in management units where both black bears and grizzly bears are found. The second approach is to require all bear hunters to take and pass a formal test in which they have to correctly identify the species of bear shown in a series of photographs as recently implemented in Montana. With this approach management agencies also have the ability to review with hunters the requirements of harvest registration and review information on the collection of biological samples. Alberta would benefit from the implementation of this type of system in an effort to reduce the number of "misidentified" grizzly bear mortalities.

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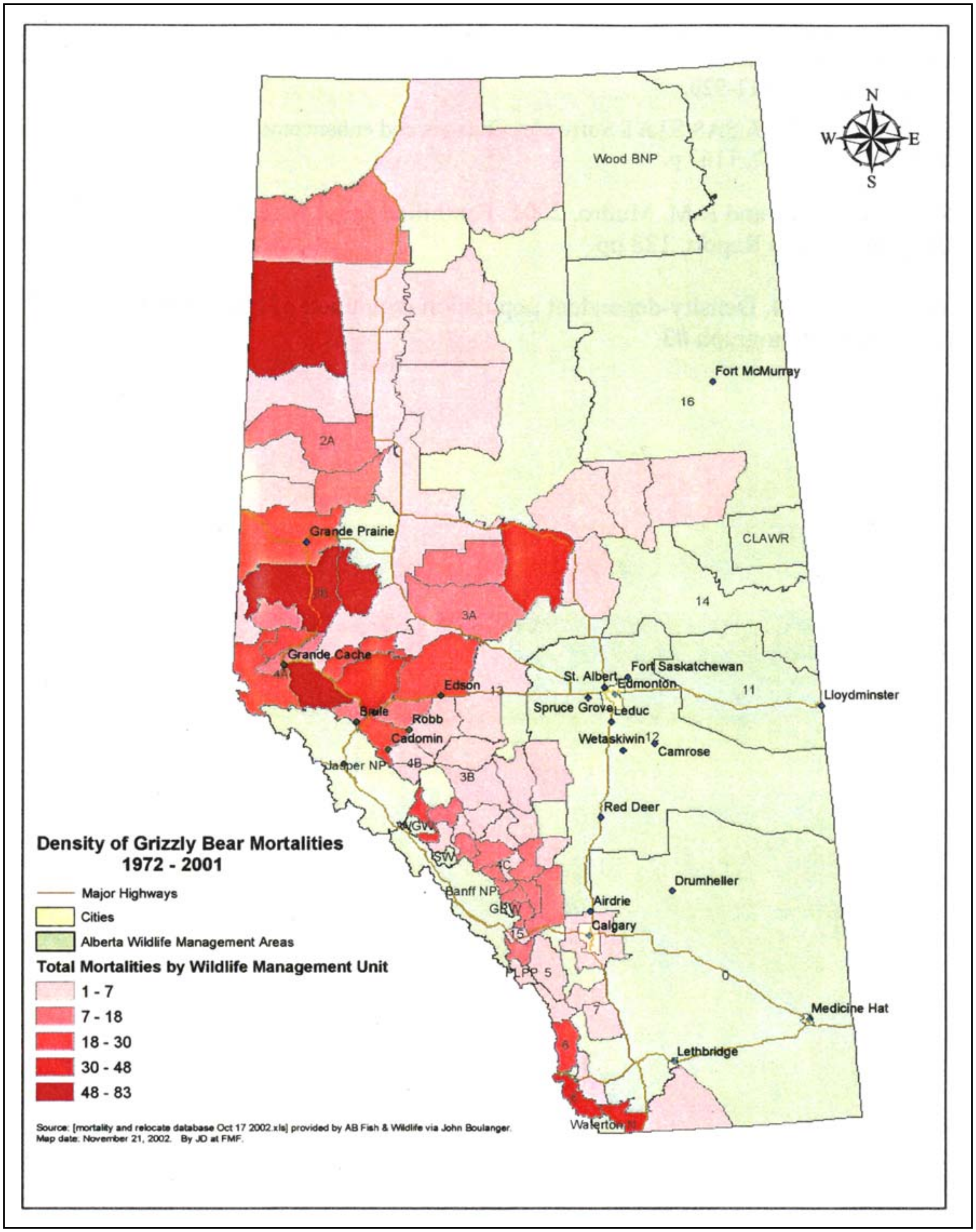
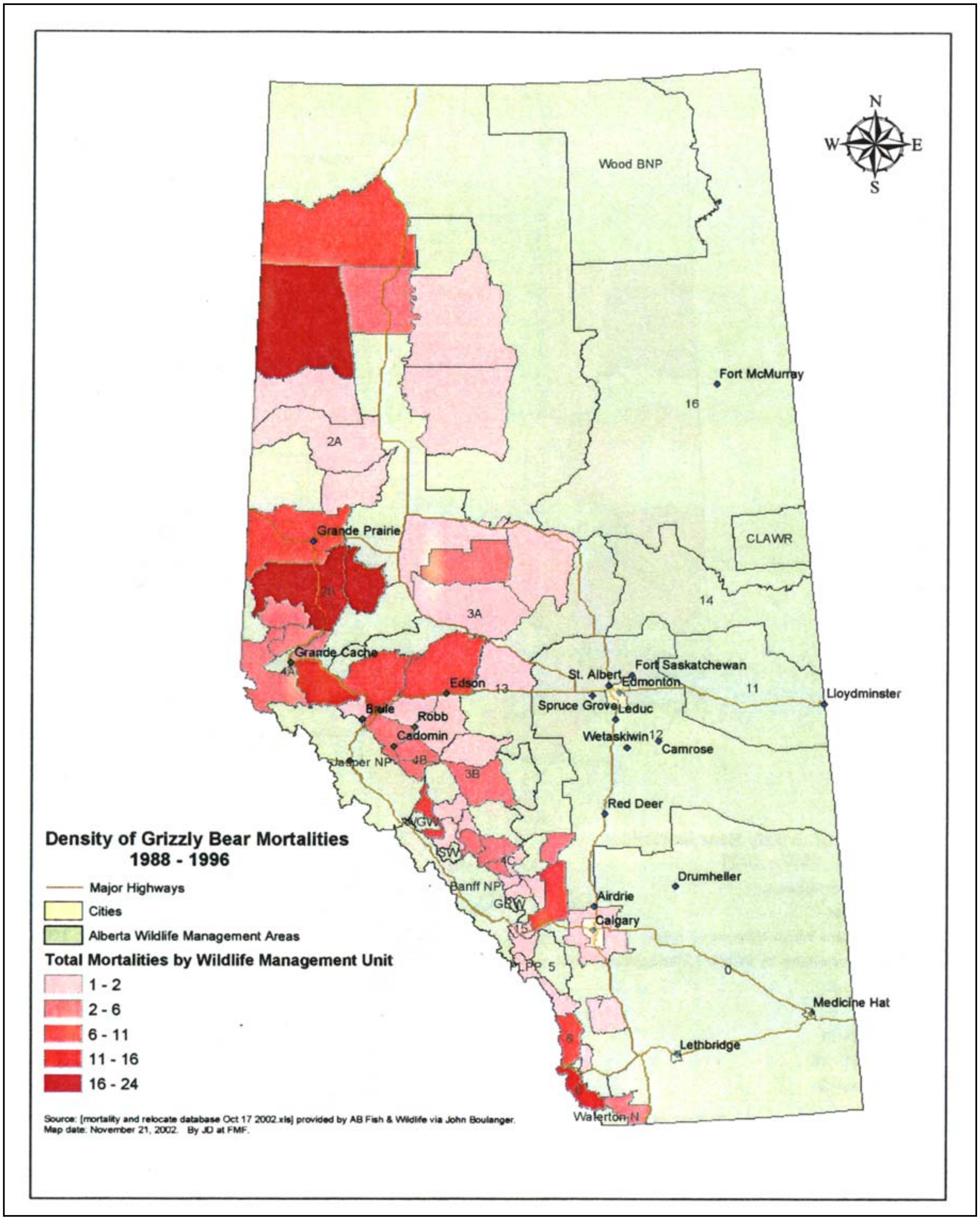
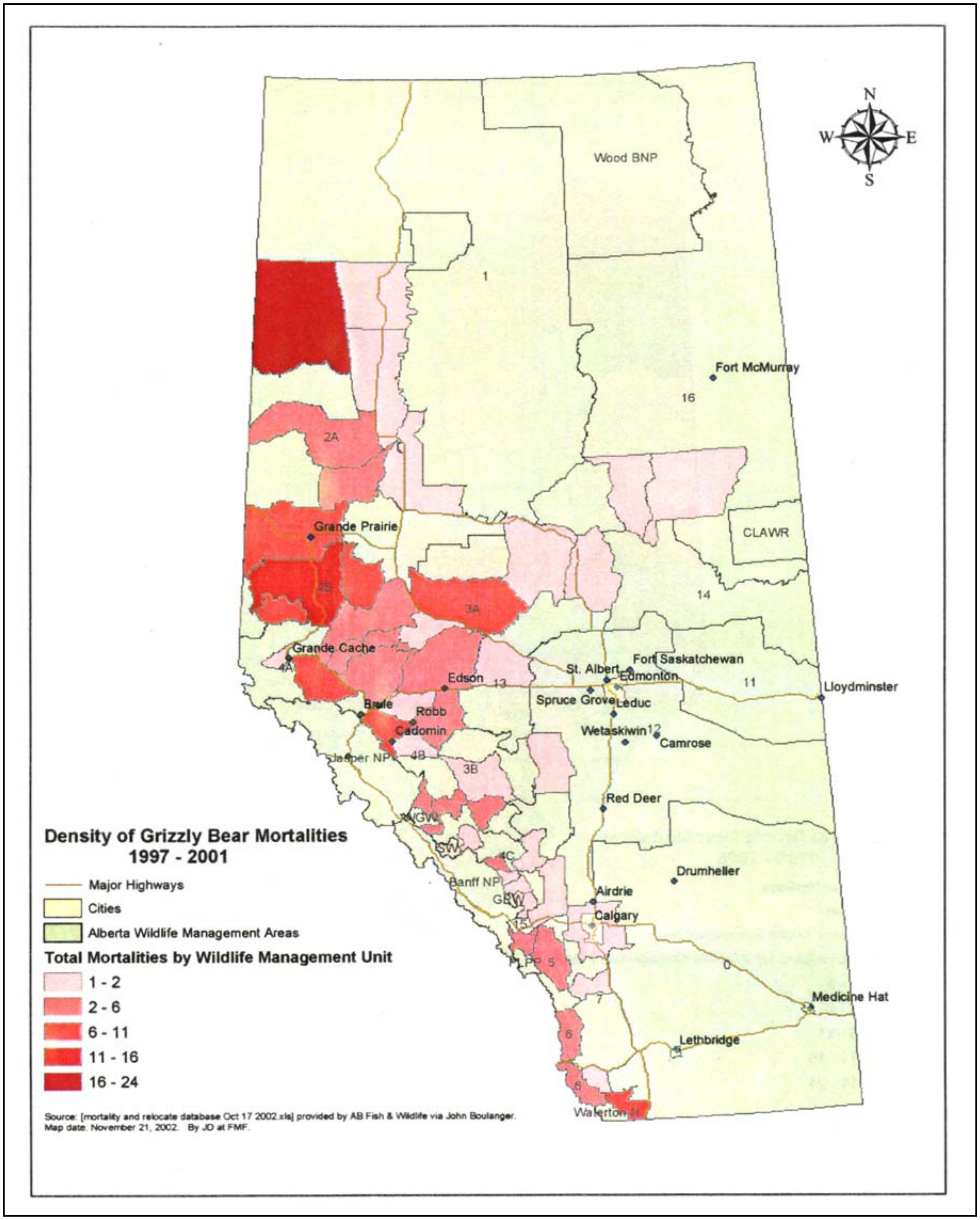

Density of Grizzly Bear Mortalities
1972 - 2001
Major Highways
Cities
Alberta Wildlife Management Areas
Total Mortalities by Wildlife Management Unit
1 - 7
7 - 18
18 - 30
30 - 48
48 - 83
Source: [mortality and relocate database Oct 17 2002.xls] provided by AB Fish & Wildlife via John Boulanger.
Map date: November 21, 2002. By JD at FMF.
N
W
E
S
Wood BNP
Fort McMurray
16
2A
Grande Prairie
CLAWR
14
3A
Grande Cache
St. Albert
Fort Saskatchewan
Edmonton
Edson
13
11
Lloydminster
Spruce Grove
Leduc
Brule
Robb
Cadomin
Wetaskiwin
12
Camrose
Jasper NP
4B
3B
Red Deer
WGW
SW
4C
Drumheller
Banff NP
GBW
Airdrie
Calgary
15
PLPP
5
0
Medicine Hat
7
6
Lethbridge
Waterton

Appendix A


Density of Grizzly Bear Mortalities
1988 - 1996
Major Highways
Cities
Alberta Wildlife Management Areas
Total Mortalities by Wildlife Management Unit
1 - 2
2 - 6
6 - 11
11 - 16
16 - 24
Source: [mortality and relocate database Oct 17 2002.xls] provided by AB Fish & Wildlife via John Boulanger.
Map date: November 21, 2002. By JD at FMF.
Wood BNP
Fort McMurray
16
2A
Grande Prairie
CLAWR
3A
14
Grande Cache
Fort Saskatchewan
St. Albert
Edmonton
Edson
13
11
Lloydminster
Spruce Grove
Leduc
Brule
Robb
Cadomin
Wetaskiwin
12
Camrose
Jasper NP
4B
3B
Red Deer
Drumheller
Banff NP
Airdrie
Calgary
Medicine Hat
Lethbridge
Waterton N

Appendix B


Density of Grizzly Bear Mortalities
1997 - 2001
Major Highways
Cities
Alberta Wildlife Management Areas
Total Mortalities by Wildlife Management Unit
1 - 2
2 - 6
6 - 11
11 - 16
16 - 24
Source: [mortality and relocate database Oct 17 2002.xls] provided by AB Fish & Wildlife via John Boulanger.
Map date: November 21, 2002. By JD at FMF.
N
S
E
W
Wood BNP
1
Fort McMurray
16
2A
CLAWR
Grande Prairie
14
3A
Grande Cache
4A
St. Albert
Fort Saskatchewan
Edmonton
Edson
13
11
Lloydminster
Spruce Grove
Leduc
Brule
Robb
Cadomin
Wetaskiwin
12
Camrose
4B
3B
Red Deer
4C
Drumheller
Banff NP
Airdrie
Calgary
5
0
Medicine Hat
7
6
Lethbridge
Waterton

Appendix C.