NORTHERN CONTINENTAL DIVIDE ECOSYSTEM

GRIZZLY BEAR POPULATION MONITORING

ANNUAL REPORT – 2012

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This annual report summarizes data collection efforts to date. It is not a peer-reviewed document, and data summaries and interpretations are subject to change.

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This Annual Report is available on the web at:
http://fwp.mt.gov/fishAndWildlife/management/grizzlyBear/monitoring.html

ABSTRACT

A program to monitor the population trend of grizzly bears in the Northern Continental Divide Ecosystem (NCDE) of Montana was initiated in 2004. The goal of this program is to estimate population trend by monitoring the survival and reproductive rates of radio-instrumented female grizzly bears. In 2012, 9 females and 5 males were captured for trend monitoring. An additional 8 independent females and 30 independent males were captured in 2012, primarily for management purposes. In 2012, 100 individual bears were radio-monitored, 36 of which were trend females. Since 2004, independent aged female survival has remained near 0.930. COY survival rate was estimated to be 0.56 and yearling survival rate was estimated to be 0.760.We documented the stable age structure of grizzly bears in the NCDE, and the proportion of the entire population that resides inside Glacier National Park. COY litter sizes were calculated for both management and trend females. An unadjusted average of 2.00 COY/litter was estimated for management females, and an unadjusted average of 1.97 COY/litter was estimated for trend females. Several new verified grizzly bear observations were obtained in areas south of the NCDE in 2012. Twenty-two known or probable grizzly bear mortalities were tallied for 2012, 4 of which were outside the 10 mile NCDE buffer.

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I. INTRODUCTION AND STATEMENT OF NEED

The grizzly bear *(Ursus arctos horribilis*) occupies over 8 million wilderness and non-wilderness acres in the Northern Continental Divide Ecosystem (NCDE) of western Montana. Notable regions within this ecosystem include Glacier National Park and the Bob Marshall wilderness complex. Grizzlies were listed as Threatened under the Endangered Species Act in 1975 for lack of information on its population status and habitat requirements. The NCDE has the largest population of grizzly bears in the lower 48 states; mean population size during 2004 was 765 bears (Kendall et al. 2009).

Managers and the public agree that information on both population size and trend is needed. Having these estimates will greatly improve our collective knowledge of grizzly bear ecology, and provide more measurable and precise information with which to judge the status of the grizzly population in the NCDE. Therefore in 2004 Montana Fish, Wildlife & Parks (MTFWP), in cooperation with other state, federal, and tribal agencies, established a team to monitor the population trend of grizzly bears in the NCDE. The purpose of this long-term program is to monitor grizzly bear survival rates, reproductive rates, and population trend by radio-monitoring female grizzly bears and their young.

II. PROGRAM OBJECTIVES

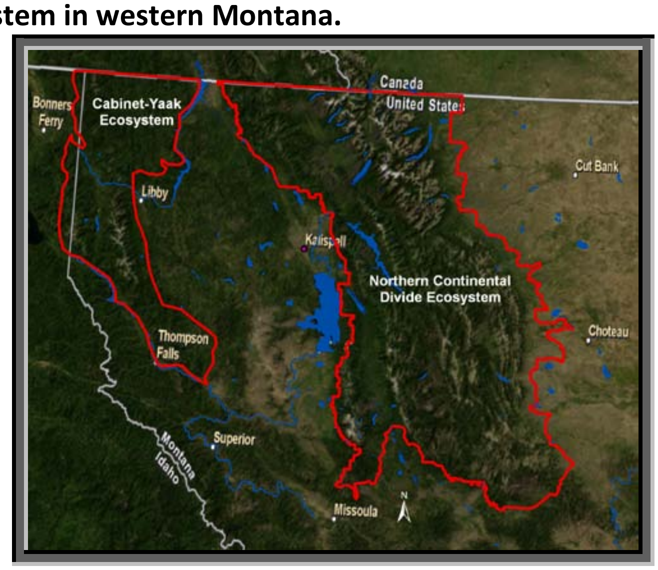
The primary objective of this program is to monitor the population trend of grizzly bears in the NCDE using known-fate estimators of survival, and documentation of reproductive rates. This will be accomplished by following the survival and reproductive rates of female grizzly bears throughout the ecosystem. Estimates of both population size and trend will be required for recovery programs in this area as dictated by the Endangered Species Act. The ultimate responsibility of the monitoring team is to collect life history and habitat data on grizzly bears in western Montana and summarize findings in a comprehensive annual report. Major population monitoring categories will initially include:

1. population trend,
2. grizzly bear survival rates,
3. grizzly bear reproductive rates,
4. grizzly bear movements and habitat selection,
5. grizzly bear distribution in western Montana,
6. mortality levels in the NCDE, and
7. level of unreported mortality.

III. GEOGRAPHIC SCOPE OF THE MONITORING PROGRAM

We monitored the population trend of grizzly bears in the NCDE of western Montana and into the Canadian provinces of British Columbia and Alberta (Fig. 1). Our primary emphasis was within the 23,136 km^2 federal recovery zone in the United States. We also captured and monitored bears up to 16 km north of the United States into Canada, which enlarged the study area to approximately 24,000 km^2. There were 2 national parks in the study area: Glacier National Park in Montana (4,081 km^2) and Waterton Lakes National Park (505 km^2) in Alberta, Canada. Portions of the Blackfeet Indian Reservation and the Confederated Salish and Kootenai Reservation occurred within our study area. Notable roadless regions outside the national parks included the Bob Marshall, Great Bear, Scapegoat, Rattlesnake, and Mission Mountain federal wilderness areas in the US. Non-wilderness areas of the NCDE were characterized by multiple-use lands under public, state, corporate, and tribal ownership. Approximately 17% of the NCDE is private land.

Fig. 1. Location of the Northern Continental Divide Grizzly Bear Ecosystem in western Montana.



V. METHODS & RESULTS

Grizzly Bear Captures 2004-2012

Methods

We captured grizzly bears using leg-hold snares and culvert traps, by helicopter darting, and in some instances, we darted and immobilized bears over baits. We followed the handling and immobilization procedures found in the Montana Animal Care and Use Committee protocols for grizzly bears and black bears (Montana Fish, Wildlife and Parks 2004). We tagged all bears subcutaneously with passive transponder tags and pulled a pre-molar tooth for age determination (Stoneberg and Jonkel 1966). Bears were radioed instrumented using standard very high frequency (VHF) neck-mounted collars (Telonics, Inc., Mesa, AZ) and VHF ear-tag transmitters (Advanced Telemetry Systems, Inc., Isanti, MN) on some bears. We used 3 types of Telonics global positioning system (GPS) collars: standard GPS (TGW-4500; Telonics, Inc.), GPS-Argos (Models TGW-3580 and TGW-3583; Telonics, Inc.), and spread-spectrum collars (SST; TGW-3690; Telonics, Inc.). Individual bears were classified as either trend (research) bears or management bears (Mace et al. 2012).

Results

Grizzly bears have been captured since 2004 for population trend monitoring. Although females were the focus of the research, males were inadvertently captured as well. Annual capture of females has varied from 10 in 2007, to 24 in 2005 (Table 1). In 2012, the team captured 14 individuals of both sexes, 9 of which were females and 5 were males (Table 1). A list of trend female bears monitored in 2012 is given in Appendix A.

Each year grizzly bears were captured in the NCDE for purposes other than trend monitoring, most of which were for management purposes. Not all of these bears, especially attendant young, were radioed. In 2012, 8 females were captured 11 times (Table 2). Thirty males were captured 37 times in 2012. Five dependent young were captured in 2012. A list of female and bears monitored for management reasons in 2012 are given in Appendix B and C.

Number of Bears Radio-Monitored; 2004-2012

Each year, grizzly bears were captured and radio-instrumented for several purposes. These included captures for trend monitoring, for management, and for other research purposes. Annual sample sizes bears radio-monitored in the NCDE varied each year from 49 in 2004 to 109 in 2009 (Table 3). In 2012, we radio-monitored 100 individual grizzly bears for varying lengths of time; 36 of which were females for population trend. Twenty-eight females were monitored for other reasons, primarily conflict management. In 2012, 36 males were also monitored (Table 3).

Survival Rates of Independent Female Grizzly Bears

Methods

The methods used to estimate grizzly bear survival rates are given in Mace et al. (2012). We generally began radio- monitoring radioed females in early April and

Table 1. The number of grizzly bear captures and recaptures in the NCDE for population trend monitoring, 2004-2012.

Capture year	Sex	Number of individuals	Number of recaptures	Total captures
2004	Female	15	1	16
2004	Male	9	0	9
2004	Total	24	1	25
2005	Female	24	1	25
2005	Male	18	2	20
2005	Total	42	3	45
2006	Female	17	1	18
2006	Male	31	4	35
2006	Total	48	5	53
2007	Female	10	2	12
2007	Male	10	2	12
2007	Total	20	4	24
2008	Female	18	2	20
2008	Male	16	0	16
2008	Total	34	2	36
2009	Female	23	2	25
2009	Male	17	3	20
2009	Total	40	5	45
2010	Female	17	1	18
2010	Male	10	1	11
2010	Total	27	2	29
2011	Female	18	0	18
2011	Male	9	0	9
2011	Total	27	0	27
2012	Female	9	1	10
2012	Male	5	0	5
2012	Total	14	1	15

Table 2. Capture of grizzly bears in the NCDE for purposes other than trend monitoring. This includes captures for management, augmentation to the Cabinet-Yaak Ecosystem, or other research efforts, 2004-2012. Not all individuals were radio-collared.

Year	Number of individual bears captured for purposes other than trend (total recaptures)			Total individuals
	Independent females	Cubs and yearlings	Independent males	
2004	15 (20)	12 (15)	19 (24)	46
2005	8 (8)	4 (4)	12 (12)	24
2006	5 (5)	2 (2)	16 (17)	23
2007	4 (5)	5 (7)	19 (22)	28
2008	9 (12)	0	19 (21)	28
2009	13 (15)	2 (2)	23 (25)	38
2010	15 (17)	6 (6)	25 (27)	46
2011	13 (17)	10/20	15(20)	38
2012	8 (11)	5 (7)	30 (37)	43

Table 3. Total radioed sample of grizzly bears in the NCDE, 2004-2012.

Year	Radioed males (mgmt and other research)	Radioed females (mgmt and other research)	Radioed trend females	Total number radioed bears
2004	17	16	16	49
2005	14	10	31	55
2006	22	10	34	66
2007	30	11	36	77
2008	30	12	40	82
2009	47	13	49	109
2010	40	18	40	98
2011	33	25	41	99
2012	36 (4 were dep. young)	28 (7 were dep. young)	36	100

concluded in November. We estimated survival of independent females using the staggered-entry Kaplan-Meier method within Program MARK using the logit scale (White and Burnham 1999). An individual's encounter history began the month and year it was first captured and concluded the month and year it was censored or died. We coded bears as either alive, dead, or censored each month. We classified bears as alive during the denning months if we knew they were alive the previous October or November and if they emerged from dens wearing a functional radio collar. In several instances, the mortality sensor on a bear collar indicated that the bear had either died or shed its' radio collar, and we were unable to investigate the bears fate. For survival analyses then, we estimated 2 survival rates. The first rate assumed that the bear had shed it collar (censored) while the second estimate assumed the bear had died. We estimated survival rates for independent sub-adult (2-4 years old) and adult (5+ years old) females.

Annual survival rates were estimated in 6-year blocks to improve precision of estimates. Therefore, we estimated annual survival in 4 6-year blocks from 2004 through 2012. Annual survival rates were estimated in 2 ways. We first estimated survival for all females in the NCDE. In the second estimate, we excluded those females annually whose home range was entirely within Glacier National Park.

Results

Entire NCDE Population. For 3 6-yr blocks, the fate of 1 subadult female remained undetermined, thus lowering survival rates when the individual was considered dead. The survival rate for subadult trend females was lowest ($\bar{x}$ = 0.841) during the 2004-2009 block of data (Table 4) and improved to either 0.911 or 0.955 for the 2007-2012 block of data. The number of adult females used to estimate annual survival varied from 66 to 76 individuals. Adult female survival remained near 0.94 across all 6-year blocks. When the age classes were combined, survival generally remained near 0.930 (Table 4). The cause of deaths for trend females is given in Table 5.

Table 4. Survival rates of all trend females using a 6-year running average.

Running average Period	Age class	*n* individuals	*n* dead	Months monitored[a]	Annual survival rate			
					Estimate	-95%	+95	SE
2004-09	sub	25	3	209	0.841	0.606	0.948	0.084
	ad	66	6	1261	0.944	0.882	0.975	0.022
	Combined	83[b]	9	1470	0.929	0.869	0.963	0.023
2005-10	sub	28	2	267	0.914	0.713	0.978	0.058
	ad	73	8	1443	0.935	0.876	0.967	0.022
	combined	91	10	1710	0.932	0.878	0.963	0.021
	combined	91	10+ (1)	1710	0.925	0.870	0.958	0.021
2006-11	sub	28	2	264	0.913	0.711	0.978	0.059
	ad	74	8	1577	0.941	0.886	0.9701	0.020
	combined	90	10	1841	0.937	0.885	0.966	0.019
2007-12	sub	28	1	262	0.955	0.740	0.994	0.044
	ad	76	9	1697	0.936	0.882	0.967	0.021
	ad	76	9 +(1)[c]	1697	0.930	0.873	0.961	0.022
	combined	95	10	1896	0.939	0.890	0.967	0.020

a. Includes months bears were in winter den.

b. The number of individuals in the combined age classes monitored may not be the sum of subadults and adults, as some individuals transitioned from subadult to adults during course of period.

c. Number in parentheses is number of individuals whose fate was unresolved.

Table 5. Cause of death for 15 radioed trend bears used in the calculation of female survival rates; 2004-2012.

Cause of death	Number of mortalities of trend females
Management removal	1
Defense-of-life	2
Illegal	3
Vehicle	0
Train	0
Natural	2
unknown	7

Cub and Yearling Survival

Methods:

Survival of dependent young was calculated using the nest survival routine in Program MARK (White and Burnham 1999) following the methods of Dinsmore et al. (2002) and further explained in Mace et al. (2012). To accomplish this, it is necessary to ascertain the first and last dates that COYs and yearlings of each litter were observed. From these dates, 3 survival periods are determined; that of COYs, the denning period, and the period when young were yearlings. Using the data from 2004-2012, the length of the COY period was 211 days, the denning period was 154 days, and the yearling period was 212 days (total of all 3 periods = 577 days). Two survival estimates were made for each ageclass of dependent young; the daily survival rate (DSR) and the annual survival rate. DSR rates in Program MARK were converted to annual rates for COYS as: $DSR^{\wedge 211}$, and for yearlings as: $DSR^{\wedge 212}$.

Results:

We monitored the survival of 142 COY and yearlings from 2004-2012 (Table 6). Approximately 30% of COY died, whereas 22% of yearlings died. Mean annual survival for COY was calculated as 0.555. For yearlings, mean annual survival was calculated as 0.762 (Table 7).

Table 6 . Sample sizes and number of dead COY and yearlings of trend females; 2004-2012.

Age class	n monitored	Dead	% Dead
COY	77	23	0.298
Yearling	65	14	0.215
Total	142	37	0.260

Table 7. Survival rates of trend female COY and yearlings; 2004-2012.

Age class	Survival statistic			
	Estimate	S.E	-95% CI	+95% CI
COY:				
Daily rate	0.9972111	0.0056	0.9958693	0.9981178
Annual rate	0.555[a]	0.0056	0.416[a]	0.671[a]
Yearling:				
Daily rate	0.9987162	0.0049	0.9973085	0.9993881
Annual rate	0.762[b]	0.0049	0.567[b]	0.878[b]

[a] For COY, annual survival rate = daily rate^{211}.
[b] For yearlings, annual survival rate = daily rate^{212}.

Stable Age Structure of Grizzly Bears in the NCDE

Knowledge of the age structure of the grizzly bear population in the NCDE is necessary for management. The proportion of individuals of each age and sex cannot be ascertained directly from field data such as physical captures or from examination of genetics data from hair-traps or rub-trees. In the case of physical capture, as is used for population trend monitoring in the NCDE, age and sex classes are not captured in the same proportion as they exist in the population. Cubs and yearlings are under-represented in the capture sample, and sub adults are over-represented relative to the stable state estimates. For genetic tagging data using hair samples collected at rub-trees or hair-trap (Kendall et al. 2009), it is not possible to determine the age of individuals.

There is a method to estimate the age structure of the population from vital population rates and population trend; the calculation of stable state population structure (Lotka and Sharpe 1911). A closed population that has experienced constant age-specific birth and death rates over a long period can be shown to also have a constant proportion of individuals in each age/sex class, thus a stable state (Seber 1982).

The stable age structure of grizzly bears in the NCDE was estimated in program RISKMAN (Taylor et al. 2001) using the vital reproductive rates, and cub and yearling female survival rates from Mace et al. (2012). Program RISKMAN uses a life-table approach to modeling structure. Specific input variables used in RISKMAN are given in Table 8. Independent male survival was set at 0.850 (Mace and Roberts 2012). The survival rates of independent sub-adult (2-4 years old) and adult (5+ years old) females were pooled at 0.936 for these analyses. For the entire male and female population, age-specific proportions are given in Table 9, and for each sex separately in Table 10. From these analyses, we estimated that 58.2% of the male population was independent bears, and 68.6% of the female population was independent-aged in the entire NCDE population (Table 11). These estimates of independent bears were used to calculate sustainable mortality levels of males and females.

Table 8. Program RISKMAN input variables to estimate grizzly bear stable state population for the NCDE.

Program RISKMAN input variables	Value used to estimate grizzly stable state population
Preferences:	-Research/stochastic, trails = 1000 -no parameter/environmental uncertainty -normalize male and female structure
Species definition:	-annual -no hunting season -covariance of recruitment and survival rates -maximum age = 27 -age of 1st adulthood = 5 -maximum litter size = 3 -minimum age of 1st reproduction = 4 -maximum age of reproduction = 27
Individual survival rates; males	-age 0 = 0.612, se= 0.108 (Mace et al. 2012) -age 1 = 0.682, se= 0.132 (Mace et al. 2012) -age 2-27 = 0.850, se= 0.055 (Mace and Roberts 2012)
Individual survival rates; females	-age 0 = 0.612, se= 0.108 (Mace et al. 2012) -age 1 = 0.682, se= 0.132 (Mace et al. 2012) -age 2-27 = 0.936, se= 0.079 (Mace and Roberts 2012)
Recruitment:	-probability of 1 cub = 0.103[a] -probability of 2 cub = 0.524[a] -probability of 3 cub = 0.373[a] -mean litter size = 2.27, se = 0.18 (Mace et al. 2012) -proportion with litters = 0.322, se = 0.051 (Mace et al. 2012) -assume 50:50 M:F sex ratio for cubs at birth

[a] Proportions of 1, 2, and 3 cub litters varied somewhat from Mace et al. (2012) to achieve a mortality-adjusted cub litter size of 2.27.

Table 9. Stable state proportions of the grizzly bear population. Stable state proportions were based on a population of 1000 individuals using program RISKMAN.

Age	Age-specific proportion of entire population	
	Male	Female
0 (cub)	0.115	0.115
1	0.068	0.068
2	0.044	0.044
3	0.036	0.039
4	0.029	0.035
5	0.024	0.032
6	0.019	0.028
7	0.016	0.025
8	0.013	0.023
9	0.010	0.020
10	0.008	0.018
11	0.007	0.016
12	0.006	0.015
13	0.005	0.013
14	0.004	0.012
15	0.003	0.011
16	0.002	0.009
17	0.002	0.008
18	0.002	0.008
19	0.001	0.007
20	0.001	0.006
21	0.001	0.005
22	0.001	0.005
23	0.001	0.004
24	0.000	0.004
25	0.000	0.004
26	0.000	0.003
27	0.000	0.003

Table 10. Summary of grizzly bear stable population states for each sex separately as derived from program RISKMAN.

Age	Age-specific proportion of male population	Age-specific proportion of female population
0 (Cub)	0.276	0.198
1	0.162	0.116
2	0.105	0.076
3	0.086	0.068
4	0.07	0.06
5	0.057	0.055
6	0.046	0.049
7	0.038	0.043
8	0.031	0.04
9	0.025	0.035
10	0.02	0.031
11	0.016	0.028
12	0.013	0.025
13	0.011	0.023
14	0.009	0.02
15	0.007	0.018
16	0.006	0.017
17	0.005	0.014
18	0.004	0.013
19	0.003	0.011
20	0.003	0.01
21	0.002	0.009
22	0.002	0.008
23	0.001	0.007
24	0.001	0.007
25	0.001	0.006
26	0.001	0.006
27	0.001	0.005

Table 11. Comparison of grizzly bear population structure from three data sources.

Sex and age class of population	Data Source		
	Stable state structure from program RISKMAN[a]	Kendall et al. 2009	Mace et al. 2012
% females in population	58.2%	61.2%	na
% males in population	41.8%	38.8%	na
% of males 2+ years old (independent)	56.4%	na	na
% of females 2+ years old (independent)	68.6%	na	69%[b]

[a] Tabulated from Table 3.

[b] From Leslie-matrix projections to stable state projections using Microsoft Excel (Microsoft, Redmond Washington, USA) and the add-in PopTools (PopTools version 3.1, www.poptools.org, accessed 02 Feb 2010).

Proportion of grizzly bear population using habitats outside of Glacier National Park

Introduction and Methods

We were interested in estimating the proportion of grizzly bears that inhabited habitats outside of Glacier National Park. This is an important statistic for long-term mortality management outside of the Park. The NCDE was divided into 2 main areas; Glacier National Park where the use of discretionary mortality would be very limited, and the remainder of the Ecosystem where most mortality has historically occurred.

To address this issue, we used home ranges from radio-instrumented female grizzly bears, and DNA detections at rub-trees for the period 2009-2011 (Kendall, USGS unpublished data; email to C. Servheen dated 5 July, 2012). Location data on radioed females were obtained as a part of the NCDE Grizzly Bear Trend Monitoring Program.

For the radioed sample of females, we examined the home ranges of those individuals that lived within and directly adjacent to Glacier National Park. We did not include bears captured and radioed during human conflict situations. For each individual and year, we used the telemetry coordinates and calculated the standard radius (km) of each bears annual home range (Harrison 1958, Single and Roseberry 1989). The standard radius was calculated as $D_i = \sqrt{((x_2-x_1)^2+(y_2-y_1)^2)}$. Using GIS, we then buffered the boundary of Glacier Park using this radius. Each female was categorized as having a home range that was 1) 100% within Glacier Park, 2) 100% outside of the park but within the buffer, or 3) bears whose home range straddled the Park. For these females, we determined the percentage of telemetry points within and outside Glacier Park.

We then evaluated the individual male and female grizzly bears that were detected at through DNA at rub-trees to ascertain the proportion of individuals in 3 geographic zones. These zones were: 1) a buffer zone that was the average home range radius extending outside the Park boundary plus a home range radius that extended inside the Park boundary, 2) the internal portion of GNP not within the buffer zone, and 3), the area of the NCDE outside the buffer surrounding the Park (Fig. 2). The proportions of males and females detected in each zone were then determined.

Results

Home Range Location Relative to GNP. We evaluated 76 home ranges of 34 females that lived in or adjacent to Glacier Park. Home ranges were developed for the period 2004-2011, and individual females had between 1 and 6 annual home ranges within the sample. Most home ranges (59%) straddled the Park boundary (Table 2). Home range diameters were, on average, smallest for bear that lived 100% within the Park, and largest (mean = 6.07 km) for females that straddled the Park boundary. For the pooled sample, the average home range radius was approximately 5 km. A sample of multi-annual female home ranges that straddle the GNP boundary is shown in Fig. 3

DNA Rub-tree Detections Comments by K. Kendall (USGS) regarding the results of the distribution grizzly bear detections at rub-trees are as follows. "The proportion of bears detected in each zone was similar for hair traps and bear rubs in 2004. The proportion of bears outside of GNP and the buffer was consistently higher 2009-2011 than in 2004. This is consistent with preliminary analysis of trend data from bear rub monitoring suggesting that the population inside GNP increased slightly or was stable 2004-2010 and the population outside GNP increased at a higher rate. We sampled all of habitat in the NCDE thought to be occupied by grizzlies in 2004, which extended beyond the Recovery Zone boundary. The proportions in the table do not include 21 individuals detected in 2004 and 16 individuals detected in 2009-2011 whose average locations were outside the Recovery Zone boundary. Obviously, if these bears were included, the proportion of the population occurring outside the park would be higher. We did not sample in Canada so we had no detections in the buffer north of the border."

For females, 75% of the individuals were detected in either the 12 km buffer around the Park or in the remainder of the NCDE (Table 13). This is the assumed proportion of the independent female population in the NCDE that either do not use the Park or move between the Park and non-park habitats.

For males, 79% of the individuals were detected in either the 12 km buffer around the Park or in the remainder of the NCDE (Table 13). This is the assumed proportion of the independent male population in the NCDE that either do not use the Park or move between the Park and non-park habitats.

Table 12. Home range radius size for bears living 100% outside GNP, 100% inside of GNP, and for those bears whose ranges straddled the Park boundary.

Female home range relationship relative to Glacier Park	Radius of home range (km)				
	Mean	-95% CI	+95% CI	*n*	SE
100% In GNP	2.799	2.289	3.308	21	0.244
100% Out Of GNP	4.645	3.515	5.775	10	0.499
Straddle Park Boundary	6.070	5.044	7.096	45	0.509
All Groups	4.979	4.273	5.684	76	0.354

Table 13. Proportion of males and females detected by DNA at rub-trees in different zones within the NCDE (Kendall, USGS, unpublished data).

Area of the NCDE	% of population detected at rub-trees in each zone
FEMALES	
GNP Core	24%
12 km buffer around GNP[a]	16%
Remainder of NCDE[b]	59%
a +b	75%
MALES	
GNP Core	22%
12 km buffer around GNP[a]	18%
Remainder of NCDE[b]	61%
a +b	79%

Fig. 2. Location of 3 geographic zones used to judge the proportion of the male and female grizzly bear population that use non-park habitats; Core GNP, a 12 km wide buffer (6 km internal to park boundary, and 6 km outside the boundary), and the remainder of the NCDE.

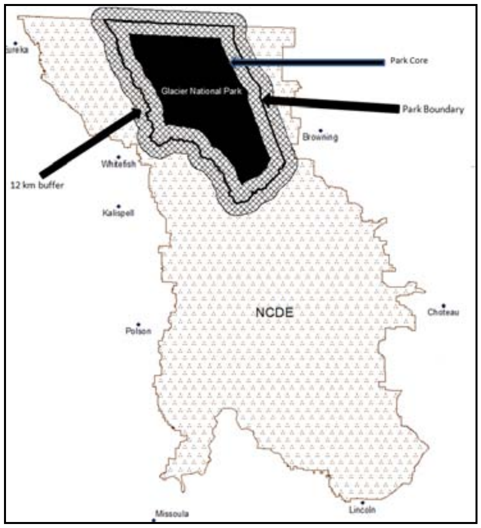
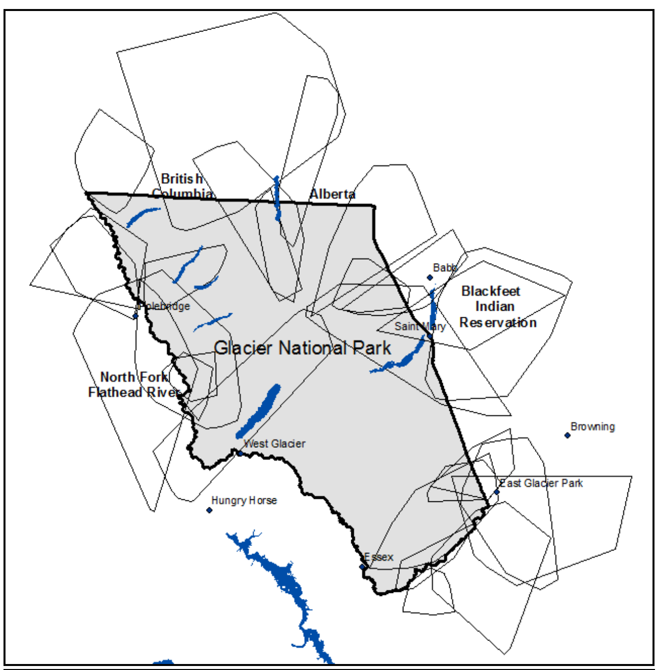


Fig. 3. Female grizzly bear convex polygon home ranges (multi-annual) relative to Glacier National Park, for those females who used both Park and non-park habitats; 2004-2011.



Grizzly Bear Reproduction

Methods

We determined the reproductive status of each adult female visually during aerial and ground telemetry sessions. We conducted observation flights in early spring, as weather allowed, to ascertain which females had dependent offspring and the number of offspring per litter. We adjusted the litter size to account for mortality of COY's prior to the first visual observation using data from Mace and Roberts (2012). We documented a 54 day period between the mean day of COY litter observations the earliest date was date of observation during which mortality could have occurred. The COY survival rate for this 54 day period was calculated as $0.99750^{54} = 0.874$. The adjusted number of individual COY was then calculated as: (*n* COY/0.874) = adjusted *n* COY. The adjusted COY litter size was then calculated as: *n* COY/n litters.

Results

We monitored 42 trend and management adult females in 2012, 16 of which did not have young (Table 14). Forty-eight dependent young (aged 0.5- 2.5) accompanied the 27 remaining adults; most were mothers with 2 COY (cubs-of-year). One litter of 3 COY was observed in 2012. A summary of the reproductive status for each female is given in Appendix D.

COY litter sizes were calculated for both management and trend females. An unadjusted average of 2.00 COY/litter was estimated for management females, and an unadjusted average of 1.97 COY/litter was estimated for trend females (Table 15).

Table 14. Observed litter sizes of research and management adult females in 2012. The status of 4 adults were not determined.

Litter size/age	*n* adult females of a given litter size	*n* dependent young
adults with no young	16	0
1 coy	4	4
2 coy	7	14
3 coy	1	3
1 yrling	1	1
2 yrling	6	10
3 yrling	1	3
1 2-yr-old	2	2
2 2-yr-old	3	8
3 2-yr-old	1	3
total	42	48

Table 15. COY litter sizes for management and trend females. Litter size estimates are prior to calculation of adjusted litter size.

Female type	Coy litter size statistics				
	Mean	-95% CI	+95% CI	*n*	s.d.
Mgmt female	2.00	1.75	2.22	27	0.555
Trend female	1.97	1.81	2.12	64	0.616

Genetic Sampling Effort

We have three different situations in which we can collect hair for DNA analysis. The first is when we capture a bear for trend monitoring research, conflict management or Cabinet-Yaak augmentation program. The second is when we have a mortality of a grizzly bear that is reported by the public or found by telemetry. The final circumstance is to collect hair samples at conflict sites or found during trapping. Genetic matches informs us of individuals that may have lost their identifiable markers. The identifiable markers consist of ear tags, avid chips, and lip tattoos. We can also have a record of a bear that was at conflict sites but never captured before.

Results

In 2011 we sent 123 hair samples in for genetic analysis (Fig. 4). We detected 69 individual bears of which 37 were males and 32 were females. We detected 22 new individual bear that had never been detected. We had four interesting matches from the 2011 DNA analysis that helped us identify bears we had already had a life history on.

We captured a female grizzly bear in the Puzzle Creek drainage for the Trend Monitoring program that the DNA matched to a bear captured in 2005 in the Puzzle Creek drainage. We know that she was born in 1991 and she had a cub of the year with her during her 2011 capture.

We had a female with two cubs of the year captured at a conflict site in the Lake Blaine area killing pigs. The female was removed and the cubs were sent to a zoo. The female was confirmed by DNA as an individual that was captured as a cub at a management site near Lake Blaine in 2006.

We identified a bear that was hit by the train west of Marias Pass to be a bear that was captured on the Blackfoot Indian Reservation earlier that year.

Bear 153 originally trapped on the BIR in 1994 and 1996 was at a conflict site West of Valier. She would be 24 years old.

We identified 15 individuals from opportunistic samples that had been captured and marked and one individual that was new to our genetic database.

We had two samples that the DNA returned a different sex then was reported in the field. One was from a capture and the other was mortality.

Fig 4. Distribution of DNA samples in the NCDE, 2011.

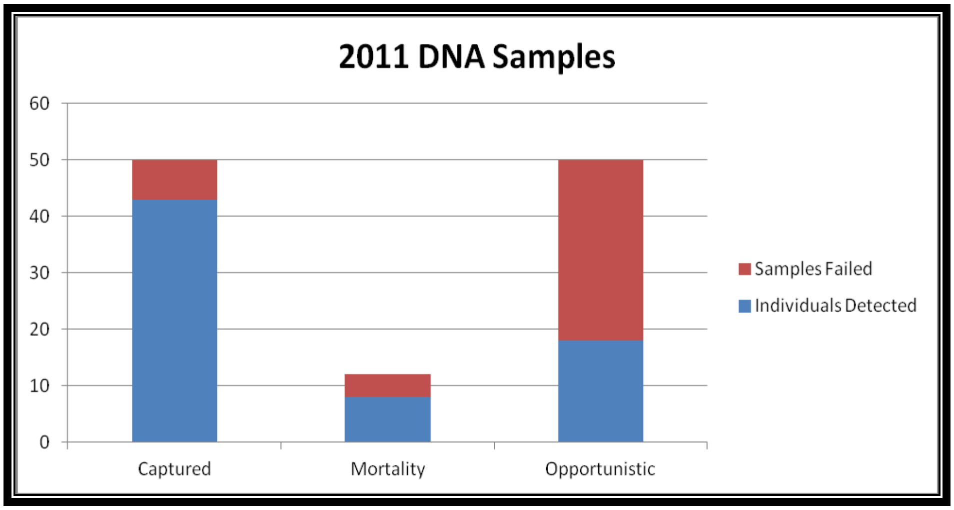
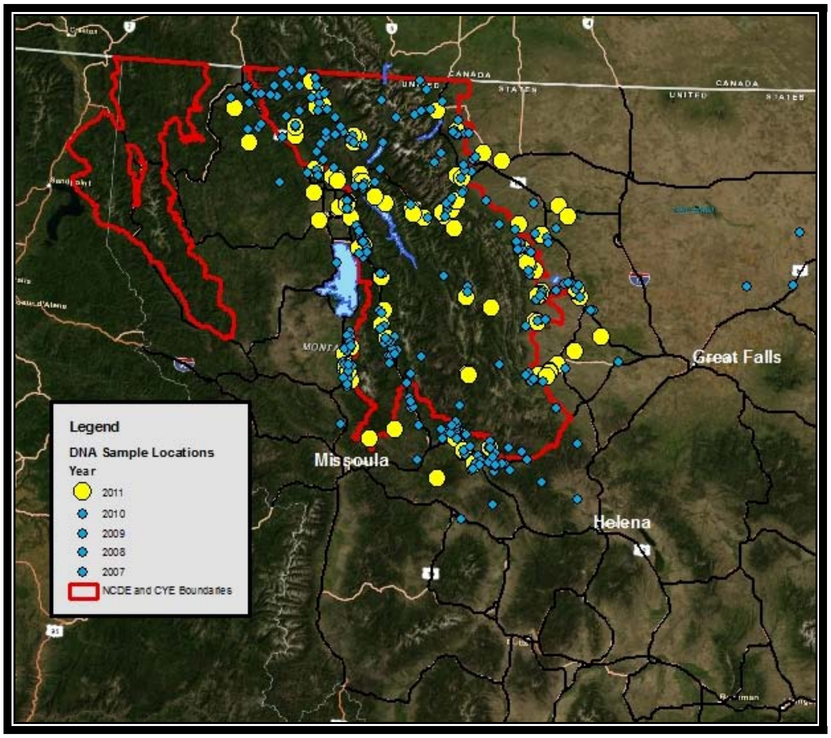


Fig 5. Location of DNA samples by year in the NCDE.



Bear Distribution Outside of the NCDE Recovery Zone

Methods

Grizzly bear data from males and females were used to assess the distribution of bears in and adjacent to the NCDE recovery zone from 1999-2011. Data used included the location of mortalities and captures, telemetry locations from research and management bears, and sites where bears were detected by DNA in 2004 (Kendall et al. 2009). Mortality, capture, and telemetry data were stored in a database managed by Montana Fish, Wildlife and Parks. Primary telemetry data sets used were those of Waller (2005) for the Middle Fork Flathead River/Glacier National Park area, those of Mace and Waller (1997) for the Swan Mountains, and bears monitored for estimating population trend (this study). Management bears monitored by MTFWP and both tribes (Blackfeet Indian Tribe and the Confederated Salish and Kootenai Tribe) were also included in analyses. Several females that were trans-located from the NCDE to the Cabinet-Yaak Ecosystem for purposes of population augmentation were also included. These data were placed on a 10 x 10 km grid overlaying western Montana and the NCDE recovery zone. Grid cells that were occupied by a bear location were highlighted in ARCMAP, and we distinguished cells occupied by males from those of females.

Grid size was based on estimates of the daily movement distance of male grizzly bears over the active season. We used a sample of 10 males equipped with gps collars to estimate the average distance (km) moved per day. There was a relationship between the number of locations per day, and the distance moved. We determined that dates with >12 locations produced similar results. We had data for 692 days from these 10 males, and the mean distance moved per day was 10.01 km (SE = 361.83, 95% CI= 9.38 – 10.81 km).

Results

Between 1989 and 2012, grizzly bears were documented outside of the NCDE recovery zone boundary in all cardinal directions (Fig. 6). We obtained grizzly bear distribution information for 355 **(**35,500 km^2) that either intersected the NCDE recovery zone boundary or were outside of the boundary. The number 10 km x 10 km cells outside the NCDE used by males only, or by females only were 59 (5,900 km^2) and 71 (7,100 km^2) respectively. We documented both males and females in 138 cells (13,800 km^2). Fifty-nine cells (5,900 km^2) were occupied by unknown sexes of bears. In general, male grizzly bears were observed further from the NCDE boundary than females.

In 2012, several observations were made that helped understand the expanded distribution of grizzly bears. Observation #1 was a grizzly bear track photographed in the Sleeping Child drainage of the Sapphire Mountains south of Missoula Montana (Fig. 7). The 2rd observation (Fig. 8) was of a grizzly bear photographed approximately 17 km southeast of Deer Lodge Montana. An interesting movement of a subadult female was also detected in 2011. This bear moved from the Mission Mountain area south into the Rattlesnake Wilderness area just north of Missoula Montana (Fig. 9).

Fig. 6. Distribution of grizzly bears adjacent to the NCDE federal recovery zone (1989-2012) based on telemetry data, mortality data, and DNA detections in 2004 (from Kendall et al. 2009). Occupancy was based on presence within 10 km^2 grid cells.

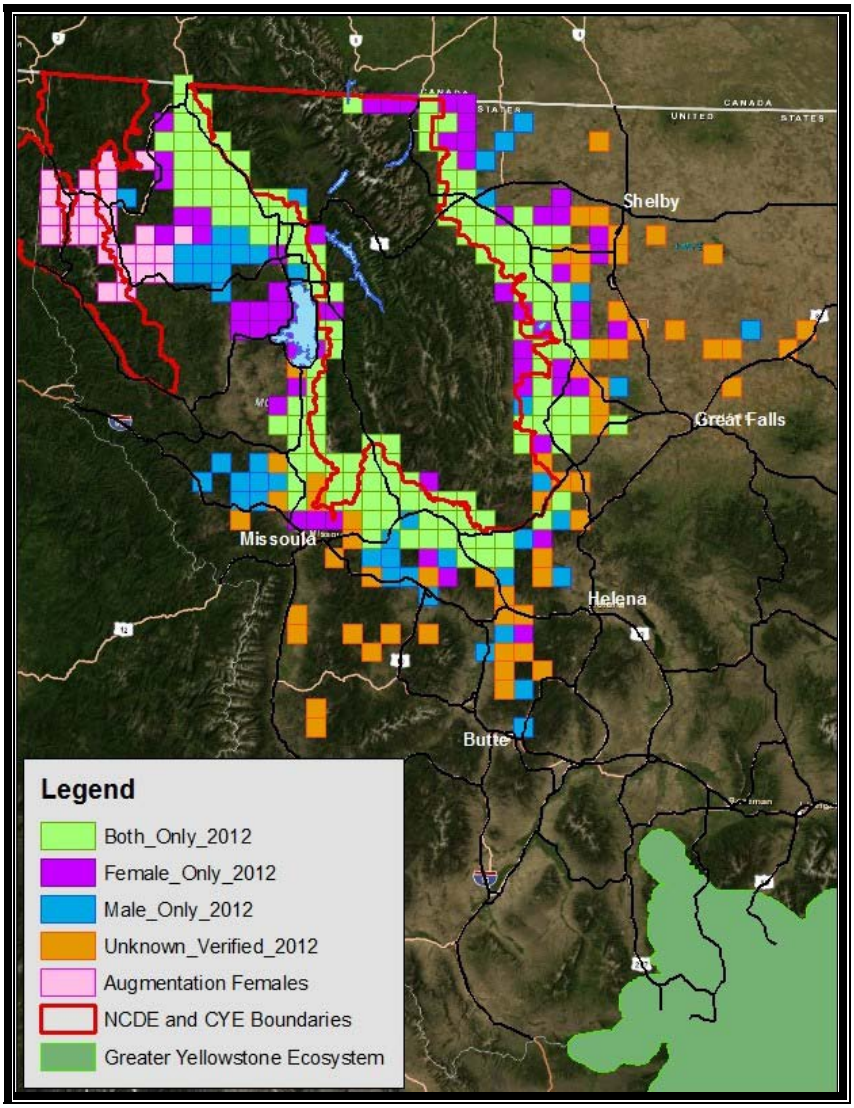
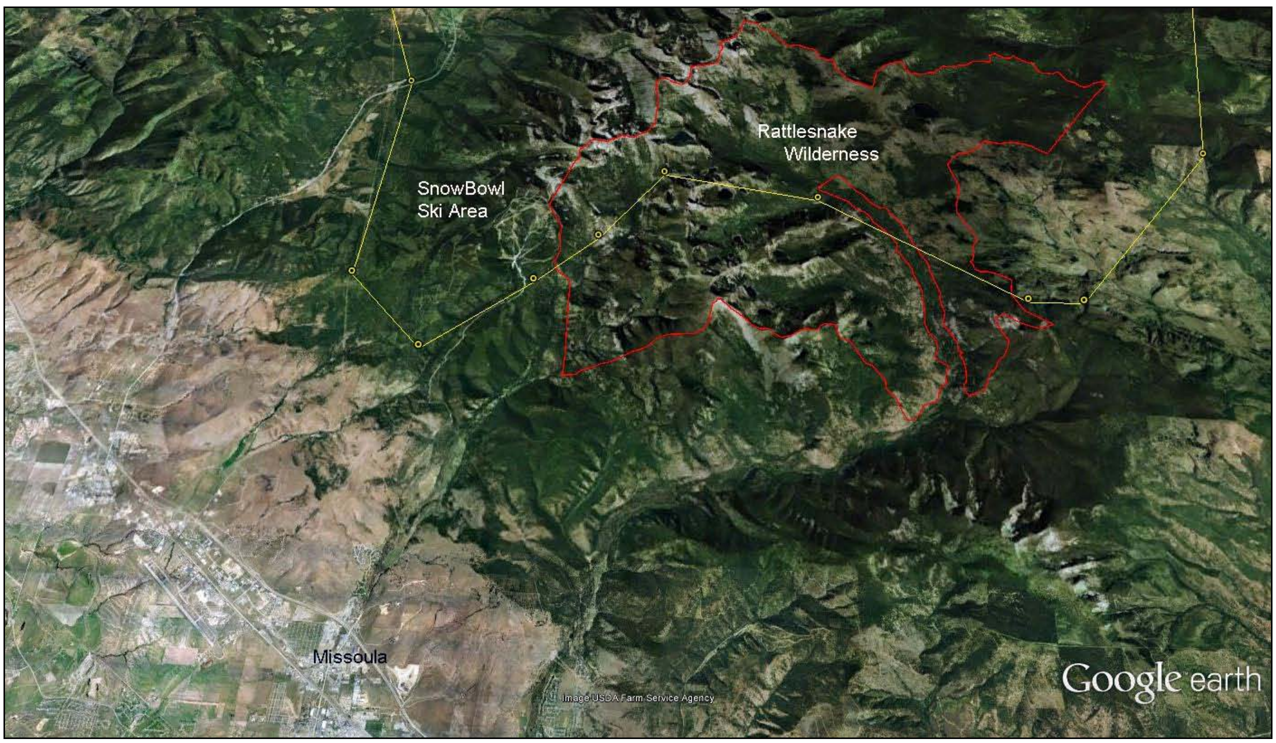


Fig. 7. Photograph of verified grizzly bear track taken in early October in the Sleeping Child Creek drainage, Sapphire Range, Montana.

Fig. 8. Photograph of grizzly bear photographed in April, 2012 in the Electric Peak Area.

Fig. 9. Telemetry locations (yellow) of sub adult female # 018112314 that traveled through the Rattlesnake Wilderness (red) Area, north of Missoula, at southern extreme of the NCDE, October 2011. Bear generally traveled from east to west.



Grizzly Bear Mortalities in the NCDE; 2012

Twenty-two known or probable grizzly bear mortalities (Fig. 10) were tallied for 2012 for all sexes and ages (Table 17, Appendix E.), 19 of which were either independent-aged or age were unknown. Four mortalities were recorded outside of the 10 mile NCDE Recovery Zone buffer, 2 of which were yearlings. Eighteen mortalities occurred within the 10 mile buffer, 2 of which were COY (Table 17).

Within the 10 mile buffer, 4 independent females and 9 independent males died in 2012. Three of these 4 female mortalities were caused by the public, whereas 5 of 9 independent males were management removals for various causes. For independent bears, regardless of relationship to 10 mile buffer, 11 of 13 deaths occurred on private lands by citizens protecting property or in defense-of-life. Marked grizzly bears that died in 2012 are provided in Table 18.

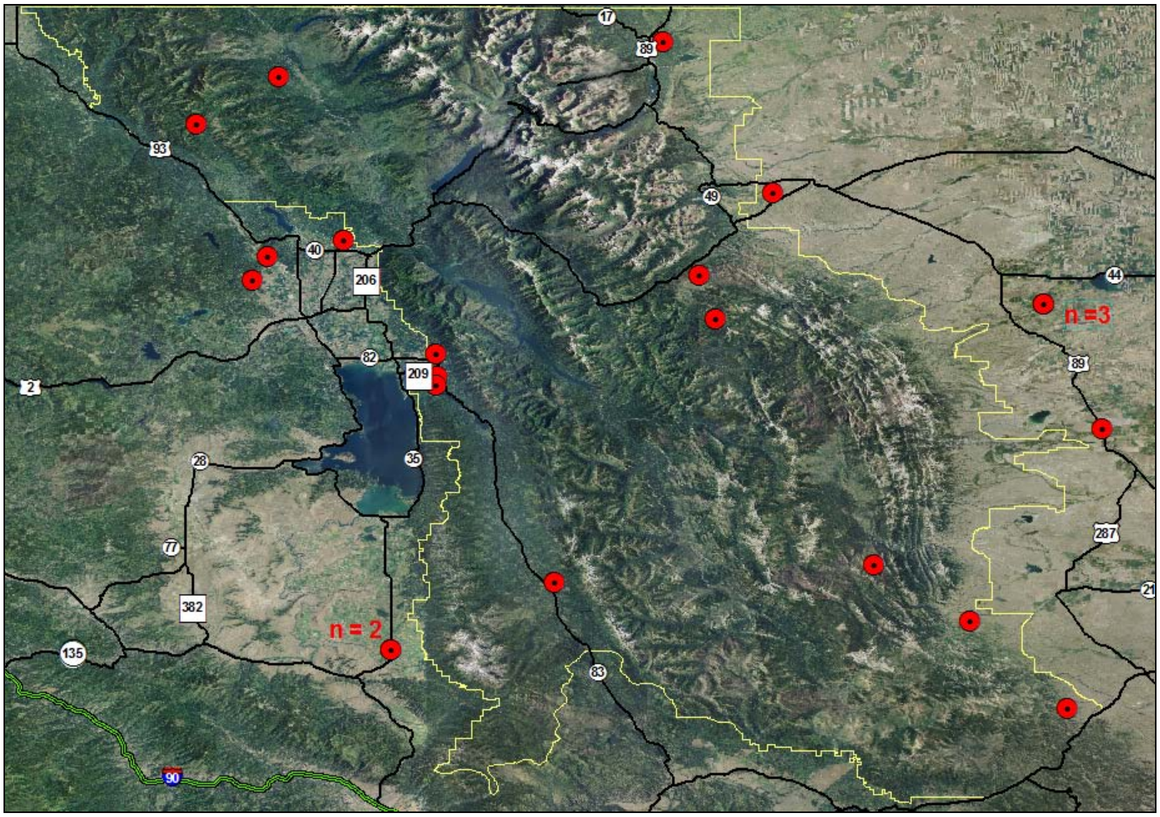
Table 17. Known and probable grizzly bear mortalities in the NCDE; 2012.

Sex	Mortality Cause	*n* in relationship to 10 mile NCDE recovery zone buffer Inside	Outside	Row total
Female				
	Public_Poached_maliceous	1	0	1
	Mgmt_Removal_augmentation	1	0	1
	Public_Private_Land_defense-of-property	1	0	1
	Public_Private_Land_defense-of-property_fowl	1	0	1
	Public_Private_Land_defense-of-property_ukn	0	1	1
Male				
	Mgmt_Removal	1	0	1
	Mgmt_Removal_augmentation	1	0	1
	Mgmt_Removal_Anthropogenic_Foods_habituation	1	0	1
	Probable man-caused_pending	1	0	1
	Public_Private_Land_defense-of-property	1	0	1
	Public_Private_Land_defense-of-property_fowl	1	0	1
	Public_Hunting_denfense-of-life	1	0	1
	Public_Private_Land_defense-of-life	0	1	1
	Automobile	2 (1=coy)	0	2
	Mgmt_Removal_Cattle	2	0	2
Ukn				
	Natural	1 (coy)	0	1
	Automobile	1	0	1
	Public_Hunting_denfense-of-life	1	0	1
	Public_Private_Land_denfense-of-property	0	2 (yearlings)	2
Column total		18	4	22

Table 18. Summary of marked grizzly bears that died in 2012.

Avid	Sex	Mortality date	Mortality Cause
36336542	M	3/29/12	Mgmt_Removal_Cattle
36554875	F	8/7/12	Mgmt_Removal_Augmentation
39851084	F	8/12	Public_Private_Land_denfense-of-property
55575613	M	10/14/12	Public_Private_Land_denfense-of-property_Fowl
55577360	M	7/23/12	Public_Private_Land_denfense-of-property
55583567	F	10/11/12	Public_Private_Land_denfense-of-property_Fowl
72118101	M	7/6/12	Mgmt_Removal_Augmentation
79572342	M	9/5/12	Mgmt_Removal_Anthropogenic_Foods_habituation
81605621	M	7/25/12	Mgmt_Removal_Cattle
93608813	M	8/31/12	Mgmt_Removal
107596012	M	4/23/12	Public_Private_Land_denfense-of-life

Fig. 10. Location of 22 known or probable grizzly bear mortalities in the NCDE, 2012.



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Appendix A. Fate of 35 radioed trend monitoring females in the NCDE; 2012.

Bear	Country	Area	Fate-2012
Pam	Canada	BC	alive
238	Canada	BC	alive
263	Canada	flathead	alive
28288097	US	Middle Fork	alive
36335046	US	East Front	alive
36547826	US	Glacier Park	alive
36553583	US	Glacier Park	alive
39838052	US	East Front	alive
39851084	US	East Front	dead
39893282	US	East Front	censor
51586884	US	South end	alive
55579532	US	BIR	alive
55582310	US	BIR	alive
55587346	US	N.F.Flathead	alive
55588533	US	South end	alive
55597781	US	South end	alive
55601006	US	Glacier Park	alive
55601314	US	Middle Fork	alive
64054290	US	South end	alive
76553865	US	East Front	alive
79050043	US	S.F.Flathead	alive
79570382	US	N.F.Flathead	unresolved
81278277	US	BIR	alive
81289085	US	BIR	alive
81600578	US	N.F. Flathead	alive
81602889	US	Bob Marshall	alive
93612012	US	Bob Marshall	alive
93638000	US	Swan/Missions	alive
97630806	US	N.F. Flathead	alive
97632856	US	Middle Fork	alive
97636103	US	Middle Fork	alive
107561271	US	S.F.Flathead	alive
107565854	US	Glacier Park	censor
107587034	US	Glacier Park	censor
123456789	US	Swan/Missions	alive

Appendix B. Fate of 28 radioed management females in the NCDE; 2012.

Bear	Area	Fate-2012
81279261	BIR	alive
55586851	Swan Valley	alive
82018000	Flathead Valley	alive
36336335	Martin City	alive
81288378	BIR	alive
36558792	Flathead Valley	alive
36320266	Salish	alive
55596108	Middle Fork	alive
14592298	Flathead Valley	alive
55580075	Flathead Valley	alive
36554875	Middle Fork	alive
39890026	East Front	alive
39844862	East Front	alive
39864592	East Front	alive
39881622	East Front	alive
39888030	East Front	alive
93550102	Eureka	censor
176568302	Coram	censor
95636784	North Fork	censor
18087605	FIR	censor
18112314	FIR	censor
55598849	Swan	censor
55577095	Swan Valley	censor
55583567	North Fork	dead
97794282	Flathead Valley	unresolved
64033127	FIR	unresolved
36558355	Salish	unresolved
40001042	East Front	unresolved

Appendix C. Fate of 42 male grizzly bears in the NCDE; 2012.

Bear	Type	Area	Fate-2012
84525524	mgmt_research	S.F.Flathead	alive
55586863	research	Rattlesnake	alive
97605021	mgmt	East Front	alive
76590799	mgmt	East Front	alive
97772298	mgmt	Flathead Valley	alive
36555039	mgmt	Flathead Valley	alive
55589362	mgmt	North Fork	alive
81279597	mgmt	BIR	alive
97768563	mgmt	Flathead Valley	alive
55579327	mgmt young	Flathead Valley	alive
637	mgmt young	East Front	alive
81289083	mgmt	BIR	alive
81278368	mgmt	BIR	alive
81279303	mgmt	BIR	alive
55581815	mgmt	Columbia Falls	alive
55588863	mgmt	BIR	alive
79569304	mgmt	Flathead Valley	alive
79572342	mgmt	South end	alive
39840563	mgmt young	East Front	alive
79559635	mgmt	Flathead Valley	alive
79594295	mgmt young	Flathead Valley	alive
79579797	mgmt	Flathead Valley	alive
39838520	mgmt	East Front	alive
39873809	mgmt	East Front	alive
39878634	mgmt	East Front	alive
79560581	mgmt	East Front	alive
79559313	mgmt	South end	alive
72554630	mgmt	Glacier Park	alive
36311260	research	Glacier Park	alive
36558090	mgmt	Flathead Valley	censor
55599290	mgmt	Swan	censor
18075381	research	FIR	censor
18127622	research	FIR	censor
55597360	mgmt	Flathead Valley	censor
55577360	mgmt	Flathead Valley	dead-radioed
107595339	research	Glacier Park	non-radioed_death
81605621	research	East Front	non-radioed_death
93608813	mgmt_research	East Front	non-radioed_death
36336542	mgmt_research	South end	non-radioed_death
55575613	mgmt	Flathead Valley	non-radioed_death
72118101	augmentation	North Fork	non-radioed_death
39847528	mgmt	East Front	unresolved

Appendix D. Reproductive status of trend females and management females radio-monitored in the NCDE; 2012.

Bear Id	2012 reproductive status
Pam	none
238	none
263	ukn
637	subadult
14592298	2_2yrolds
18112314	subadult
28288097	no yearlings observed
36320266	subadult
36335046	none
36336335	subdult
36547826	kicked off 2 yr olds
36553583	2 yrlings, lost 1
36554875	subadult
36558355	subadult
36558792	subadult
39838052	1_COY
39844862	1_COY
39851084	2_yrlings
39864592	subadult
39881622	subadult
39888030	none
39890026	3_yrlings, dispersed
39893282	1 coy
40001042	unknown
51586884	none
55577095	none
55579532	none
55580075	subadult
55582310	none
55583567	1_2yrold
55586851	1yrling, dead in Sept
55587346	none
55588533	subadult
55596108	subadult
55597781	subadult
55598849	subadult
55601006	subadult
55601314	subadult
64033127	subadult
64054290	none
76553865	2 coy
79050043	2_coy, 1 dead
79557267	2_yrlings
79570382	2_coy
81278277	ukn
81279261	ukn
81288378	2_yrlings
81289085	none
81600578	1 coy, dead
81602889	3_2yr old
82018000	1_2yrold
93550102	2_coy
93612012	2_2yr olds (kicked off?)
93638000	2_coy
95636784	3_coy
97630806	none
97632856	none
97636103	2 coy, lost 1
97794282	2_yrlings
107561271	lost 2 coy
107565854	none
107587034	none
123456789	2_yrlings

Appendix E. Summary of 22 known or probable grizzly bear mortalities in the NCDE during 2012.

Mortality #	Month	Day	Avid Tag	Ageclass	Estimated age	Real age	Sex	Cause	Certainty	Relationship to NCDE Recovery zone	Relationship to 10 mi buffer
NCDE_2012_1	3	29	36336542	adult			M	Mgmt_Removal_Cattle	Known	inside	inside
NCDE_2012_2	4	23	107596012	adult		5	M	Public_Private_Land_DOL	Known	outside	outside
NCDE_2012_3	5	5		adult	8		M	Automobile	Known	outside	inside
NCDE_2012_4	5	8		subadult	2		F	Public_Private_Land_DOP	Known	outside	inside
NCDE_2012_5	7	6	72118101	subadult	2		M	Mgmt_Removal_Augmentation	Known	inside	inside
NCDE_2012_6	7	23	55577360	subadult	2		M	Public_Private_Land_DOP	Known	inside	inside
NCDE_2012_7	7	25	81605621	adult			M	Mgmt_Removal_Cattle	Known	outside	inside
NCDE_2012_8	8	8		ukn			Ukn	Automobile	Probable	inside	inside
NCDE_2012_9	8	31	93608813	adult			M	Mgmt_Removal_ukn	Known	inside	inside
NCDE_2012_10	9	5	79572342	subadult			M	Mgmt_Removal_Anthropogenic_Foods_habituation	Known	outside	inside
NCDE_2012_12	9	20		coy		0.5	M	Automobile	Known	outside	inside
NCDE_2012_13	10	6		adult			F	Public_Poached_maliceous	Known	inside	inside
NCDE_2012_14	10	11	55583567	adult			F	Public_Private_Land_DOP_Fowl	Known	outside	inside
NCDE_2012_15	10	14	55575613	subadult	2		M	Public_Private_Land_DOP_Fowl	Known	inside	inside
NCDE_2012_16	10	21		subadult	4		M	Public_Hunting_DOL	Known	inside	inside
NCDE_2012_17	8	7	36554875	subadult		3	F	Mgmt_Removal_Augmentation	Known	inside	inside
NCDE_2012_18	9	21		ukn			Ukn	Public_Hunting_DOL	Probable	inside	inside
NCDE_2012_19	11	15		coy		0.5	Ukn	Natural	Known	inside	inside
NCDE_2012_20	11	15		AD			M	Probable man-caused_pending	Known	inside	inside
NCDE_2012_21	8		39851084	AD			F	Public_Private_Land_DOP_ukn	Known	outside	outside
NCDE_2012_22	8			yrling		1	Ukn	Public_Private_Land_DOP_ukn	Known	outside	outside
NCDE_2012_23	8			yrling		1	Ukn	Public_Private_Land_DOP_ukn	Known	outside	outside