NORTHERN CONTINENTAL DIVIDE ECOSYSTEM

GRIZZLY BEAR POPULATION MONITORING

ANNUAL REPORT – 2013

Monitoring Team Cooperators:

Montana Fish, Wildlife & Parks

U.S. Fish and Wildlife Service

U.S. Forest Service

National Park Service, Glacier National Park

Parks Canada, Waterton Lakes National Park, Alberta

Blackfeet Tribe

Confederated Salish and Kootenai Tribes

Foothills Model Forest, Alberta

British Columbia Ministry of Forests

Prepared By:

Richard D. Mace, MTFWP
Lori L. Roberts, MTFWP

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.

Suggested Citation: Mace, R. and L. Roberts. 2013. Northern Continental Divide Ecosystem Grizzly Bear Monitoring Team Annual Report, 2012. Montana Fish, Wildlife & Parks, 490 N. Meridian Road, Kalispell, MT 59901. Unpublished data.

Core Field Team Members:

D. Carney, Blackfeet Tribe
S. Courville CSKT
J. Jonkel, MTFWP
R. Mace, MTFWP
M. Madel, MTFWP
T. Manley, MTFWP
B. McLellan, British Columbia Ministry of Forests
G. Stenhouse, Foothills Model Forest, Alberta
L. Roberts, MTFWP
J. Waller, NPS
E. Wenum, MTFWP

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 2013, 19 females and 13 males were captured for trend monitoring. An additional 9 independent females and 11 independent males were captured in 2013, primarily for management purposes. In 2013, 78 individual bears were radio-monitored, 40 of which were research females. Since 2004, independent aged female survival has averaged near 0.955, and we found no difference in survival rates between adult and subadult females. Several new verified grizzly bear observations were obtained in areas east and south of the NCDE recovery zone boundary in 2013. Thirty-three known or probable grizzly bear mortalities were tallied in the NCDE in 2013, 31 of which were inside the 10 mile NCDE mortality buffer.

TABLE OF CONTENTS

LIST OF APPENDICES

Page

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

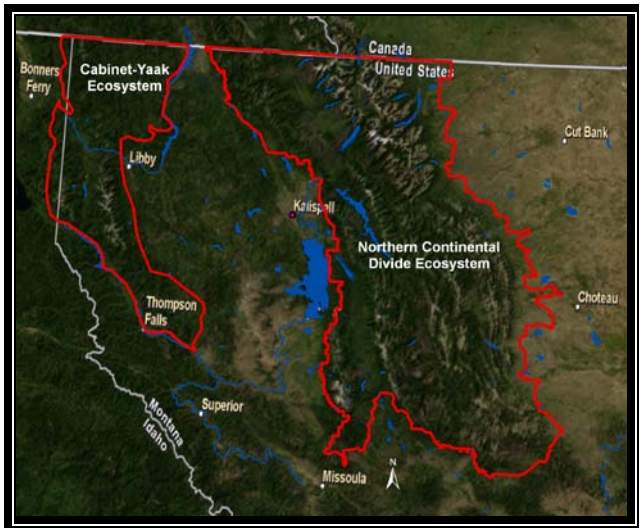
The primary objective of this program is to monitor the population trend of grizzly bears in the NCDE using known-fate estimators of survival, and documentation of reproductive rates. This will be accomplished by following the survival and reproductive rates of female grizzly bears throughout the ecosystem. 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. levels 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 2004-2013

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 research bears or management bears (Mace et al. 2012).

Results

Grizzly bears have been captured for population trend monitoring since 2004. Although females were the focus of the research, males were inadvertently captured as well. Annual capture of females has varied between 10 and 24 individuals (Table 1). In 2013, the team captured 32 individuals of both sexes, 19 of which were females and 13

were males (Table 1). A list of research female bears monitored in 2013 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 2013, 9 females were captured 10 times (Table 2). Eleven males were captured 13 times in 2013. Four dependent young were captured in 2013. A list of female and bears monitored for management reasons in 2013 and the fate of males are given in Appendix B and C.

Number of Bears Radio-monitored; 2004-2013

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 of bears radio-monitored in the NCDE varied each year from 38 to 98 (Table 3). In 2013, we radio-monitored 79 individual grizzly bears for varying lengths of time; 40 of which were females for population trend. Nine females were radio-monitored for other reasons, primarily conflict management. In 2013, we monitored 29 males (Table 3).

Table 1. The number of grizzly bear captures and recaptures in the NCDE for population trend monitoring, 2004-2013.

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
2013	Female	19	0	19
2013	Male	13	1	14
2013	Total	32	1	33

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, 2004-2013. 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
2013	9 (10)	4 (0)	11 (13)	24

Table 3. Total number of bears with radio telemetry locations each year in the NCDE, 2004-2013. Table does not include radioed bears for which no locations were obtained during the year.

Year	Radioed males (mgmt and other research)	Radioed females (mgmt and other research)	Radioed research females	Total number radioed bears
2004	13	13	12	38
2005	6	6	29	41
2006	11	5	32	48
2007	23	8	34	65
2008	30	10	37	77
2009	35	15	43	93
2010	27	18	36	81
2011	38	24	36	98
2012	31	21	35	87
2013	29	9	40	78

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 classified females as belonging to either a "research" or "conflict" sample adopting the definitions and methods of Schwartz et al. (2006). We defined females first captured and radioed-collared at a site intended for research as "research females." Females first captured and radioed-collared by bear managers at a bear-human conflict site were termed "conflict" females, whether or not they were positively implicated as having caused the conflict. A conflict bear could become a research bear if later captured at a research site. Conversely, research females captured at a conflict site retained their place as a research bear if wearing a functional radio collar at time of conflict capture. Research females whose collars had either failed or dropped off, and who were later captured at a conflict site, were reclassified as conflict bears.

We generally began radio- monitoring radioed females in early April and concluded in November. An individual's encounter history began the month and year it was first captured and concluded the year and month radio telemetry information ceased. We classified the fate of each bear monthly as either: alive, dead, censored, or undetermined. Censored bears were those who either shed their collars or whose collars exhibited evidence of failure. A bears fates was classified as undetermined when the mortality sensor on the radio collar indicated that the bear had either died or shed its' collar, but were unable to verify the fate. We did not routinely monitor bears while in their winter dens. However, 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.

We estimated the annual survival of independent females using the known-fate routine within Program MARK and the logit scale (White and Burnham 1999). The fate of each individual was recorded for each month and year it was radio-monitored and we use the 1/12 time-step (0.0833333) as described by Haroldson et al. (2006).

We used several individual and temporal covariates when model building in Program MARK. Females were classified (age) as either subadults (2-4 years old) or adults (5+ years old). Several females were known to produce cubs at age four and were therefore classified as adults at age 3. We used the individual covariates "% gnp" and % west" for research females. These covariates were defined as the percentage of total telemetry locations per year within the boundaries of Glacier National Park (GNP) and the percent of locations on the west side of the Continental Divide. Survival was estimate by year (2004-2013) and we fit both linear and quadratic functions to ascertain whether there was a temporal trend in survival. The 'Dot" model was developed without either individual or temporal covariates. We used the beta confidence intervals and AIC_c scores to assess the significance of models and covariates. Beta confidence intervals that overlapped 0 were not considered significant.

For temporal covariates, we used the "model-averaging" routine in Program MARK to account for uncertainty in determining which model is correct.

Results

We monitored the fate of 39 subadult and 103 adult research females for a combined total of 2777 months (229 years) from 2004-2013 (Table 4). Ten adults and 3 subadults had a history of human conflict prior to entering the research sample. During this period 9 adults and 2 subadults died. We could not determine the cause of death in 3 cases. Of the remaining 8 deaths where cause was known, 7 were man-caused (Table 5).

The top ranking model for research females (AICc= 145.7478) was for the 'Dot' model (Table 6). Models involving individual and/or temporal covariates were not significant, as confidence intervals for beta estimates overlapped zero. Therefore, survival did not vary by ageclass, year, percent of time bears spent in Glacier National Park, nor the percent of time bears spent on the west side of the Continental Divide.

Annual estimates of survival were derived by model-averaging the temporal covariates year and linear trend (Table 7). The average annual survival rate of independent females (2004-2013) was estimated to be 0.955 (0.866-0.985) (Table 8, Fig. 2).

Table 4. Annual sample sizes of number of research females radio-monitored and monitoring effort (months) in the NCDE, 2004-2013.

Year	*n* females	Months monitored
2004	12	93
2005	29	210
2006	32	275
2007	34	314
2008	37	310
2009	44	334
2010	36	299
2011	35	322
2012	34	329
2013	40	291
Total	124	2777

Table 5. Cause of death for 11 research females in the NCDE; 2004-2013.

Cause of death	*n*
Poached_maliceous	2
Defense-of-life	2
Undetermined	3
Natural	2
Management removal	1
Vehicle strike	1

Table 6. Model results with both individual and temporal covariates for independent female survival estimates in the NCDE, 2004-2013.

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
{dot}	145.7478	0.0000	0.29313	1.0000	1	143.7464
{incept +%west}	146.8399	1.0921	0.16979	0.5792	2	142.8356
{incept + year}	146.9149	1.1671	0.16354	0.5579	10	126.8358
{incept +%gnp}	147.1280	1.3802	0.14701	0.5015	2	143.1237
{incept + age}	147.5710	1.8232	0.11780	0.4019	2	143.5667
{incept + linear}	147.7312	1.9834	0.10873	0.3709	2	143.7269

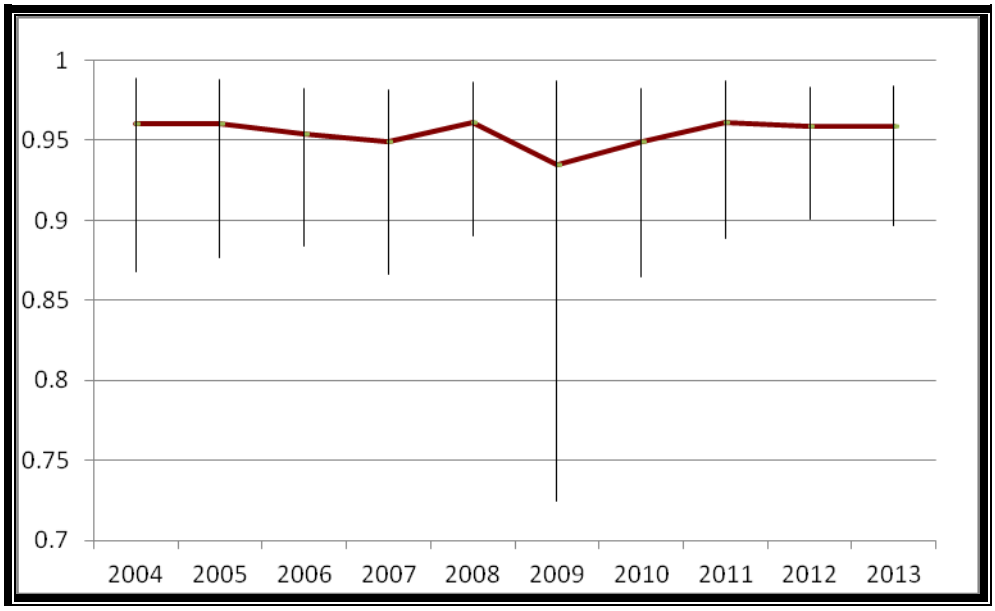
Table 7. Temporal-based models used in the model-averaged estimates of independent female survival in the NCDE; 2004-2013.

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Par.	Deviance
{dot}	145.7478	0.0000	0.51844	1.0000	1	143.7464
{incept + year}	146.9149	1.1671	0.28925	0.5579	10	126.8358
{incept + linear}	147.7312	1.9834	0.19231	0.3709	2	143.7269

Table 8. Annual survival rate estimates for research. Estimates were based on model-averaging.

Year	Estimate	SE	-95% CI	+95% CI
2004	0.960	0.025	0.868	0.989
2005	0.960	0.024	0.877	0.988
2006	0.954	0.022	0.884	0.982
2007	0.949	0.026	0.866	0.982
2008	0.961	0.021	0.890	0.987
2009	0.935	0.053	0.724	0.987
2010	0.949	0.026	0.864	0.982
2011	0.961	0.021	0.889	0.987
2012	0.959	0.019	0.901	0.983
2013	0.959	0.020	0.897	0.984
Avg	0.955	0.026	0.866	0.985

Fig. 2. Estimates of annual survival for independent-aged research females based on model-averaging; 2004-2014.



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.

Results

We monitored 40 research adult females in 2013, 36 of which were of adult age. We were not able to ascertain the reproductive status of 5 adults during the year (Table 9). Sixteen adult females did not have dependent young in 2013. All coy litters were of 2

young. We monitored the fate of a minimum of 28 dependent young during the year. A summary of the reproductive status for each female is given in Appendix D.

Table 9. Observed litter sizes of radioed research females in 2013.

Litter size/age	*n* individuals with given litter size	*n* dependent young
Unknown_adult	5	ukn
Subadult	4	0
Solitary ad	16	0
1 coy	0	0
2 coy	8	16
3 coy	0	0
1yrling	3	3
2 yrling	2	4
3 yrling	1	3
1 2-yr-old	0	0
2 2-yr-old	1	2
3 2-yr-old	0	0
Total	40	28

Stable Isotope Analysis- Dr. Justin Teisberg-US Fish and Wildlife Service

Methods

Because of the wide variation in diets of NCDE grizzly bears and the spatial breadth of the ecosystem, it is not feasible to maintain on-the-ground monitoring of availability and use of foods. Assessing assimilated diet with stable isotope analysis offers estimates of the relative dietary proportions of food groups incorporated into the animal via digestion and metabolism of energy (Hilderbrand 1996). Specifically, ratios of ^{15}N to ^{14}N ($\delta^{15}N$) become higher with increasing trophic level, allowing distinction between a plant-based, animal-based, or mixed diets of individual bears.

Hair and blood samples were collected from captured animals by federal and state managers and researchers. At time of capture, individuals were given age class, location, and management status designations. We classified bears under management or non-management status based upon a rule set adapted from Hopkins et al. (2010). One of 7 distinct ecoregions of the NCDE was assigned to the location of each capture event (Fig. 3). Samples were analyzed for stable isotope ratios to estimate the assimilated diet of each bear. Because hair and blood are metabolically active for different time periods, isotope signatures will represent the assimilated diet of the animal during the metabolically-active period of the tissue.

All blood and plasma samples were freeze-dried and ground prior to stable isotope analysis. Food items were also freeze-dried and homogenized. Hair samples were rinsed with a 2:1 chloroform:methanol solution to remove surface contaminants and ground to homogenize the sample. We weighed and sealed ground samples into tin boats for isotopic analysis (Hilderbrand et al. 1996). Isotope ratios of $\delta^{13}C$ and $\delta^{15}N$ were assessed by continuous flow methods using an elemental analyzer (ECS 4010, Costech Analytical, Valencia, California) and a mass spectrometer (Delta PlusXP, Thermofinnigan, Bremen, Germany) (Brenna et al. 1997, Qi et al. 2003).

Results and Discussion

Lab personnel sorted hair samples by underfur and guard hair. Sampled blood was centrifuged into red blood cell (RBC) and plasma portion and stored frozen until analysis. We analyzed hair from bears at 297 capture instances and blood at 128 capture instances. Adult females had significantly lower nitrogen isotope values (4.3 ± 0.24)

when compared to subadults and adult males (4.5 ± 0.22 and 6.0 ± 0.31, respectively) ($P < 0.0001$). Nitrogen signatures did not differ by year, indicating minimal fluctuation in the meat resource among the years sampled. The assimilated diet of adult males averaged 56 ± 11% terrestrial meat while adult female diets consisted of 34 ± 9% meat. On average, meat consumed by adult males in the NCDE are higher than those of male grizzly bears in the interior of the Yellowstone Ecosystem (Yellowstone males = 45%); however, NCDE adult female values are lower than their Yellowstone counterparts (Yellowstone females = 38%) (Fortin et al. 2013).

Analysis of underfur (fall growth), guard hair (summer growth), and blood indicated seasonal shifts in use of meat by grizzly bears in the NCDE. Trophic level in the fall months shifted higher, particularly for grizzly bears in the northwestern portion of the NCDE (lower Swan, lower South Fork Flathead, North Fork Flathead, and Whitefish range). On average, bears shifted from 3.5% of their diet composed of meat in the summer to 14.7% meat in the fall. Some adult females shifted to 27% meat in the fall. However, males tend to dominate this available resource in the fall. Adult male grizzly bear diets shifted from 3% to 33% meat from summer to fall in the northwest portion of the ecosystem. We suspect meat is of greater availability in the fall, primarily in the form of hunter-discarded viscera.

Nutritionally, the addition of a high protein food item to a commonly protein-deficient economy of berries allows bears to reach a target macronutrient combination, thereby maximizing rate of gain (Erlenbach et al. 2014). On the East Front, southern, and Mission Valley portions of the ecosystem, we document an opposite trend. Bears in

these areas are not necessarily limited by the amount of protein, but rather the relative contribution of carbohydrates. As berries ripen and become available, these bears appear to target a mixed diet that best exploits energy to gain mass. Interestingly, when bears in both areas (NW v. E, S, and SW of ecosystem) have protein and carbohydrates available, they arrive at similar trophic levels, as indicated by stable isotope values (Fig. 4).

On an ecosystem level, we might presume these differences are a matter of access to meat. Use of meat differed widely among ecoregions of the NCDE (Fig. 5). Bears within regions on the southwestern, southern, and eastern periphery of the ecosystem had significantly higher nitrogen isotope signatures than those in the interior or northwestern periphery of the ecosystem ($P < 0.0001$) (Fig. **6**). Estimated meat proportions of bear diets ranged from 71 ± 15% on the East Front to only 6 ± 5% in the lower Swan River and the lower South Fork of the Flathead. Female grizzly bear nitrogen signatures also differed by area (Fig. 7). Hence, economies (and diets) of bears, are extremely diverse across ecoregions of the NCDE.

Fig. 3. Northern Continental Divide Ecosystem study area and ecoregions used in analysis of assimilated diet (WNF = Whitefish Range and North Fork Flathead River; GUM = Glacier National Park and Upper Middle Fork Flathead River; LSS = Lower Swan River and Lower South Fork Flathead River; USMB = Upper South and Middle Forks of the Flathead River and Bob Marshall Wilderness; EF = East Front; MUS = Mission Mountains and Upper Swan River; RBF = Rattlesnake Wilderness and Blackfoot River). The NCDE Grizzly Bear Recovery Zone boundary is also displayed (blue outline).

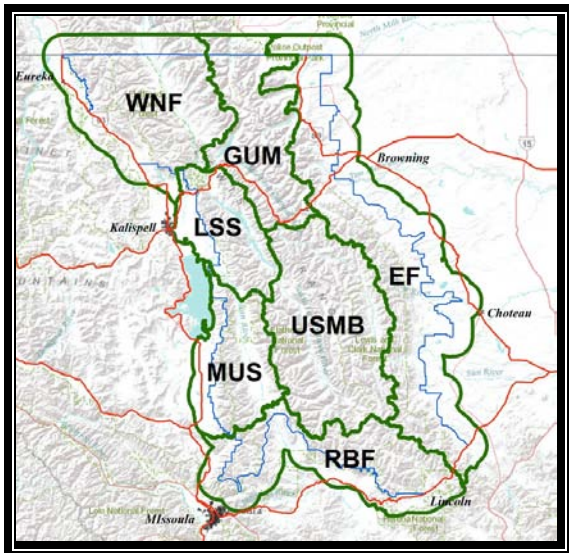


Fig. 4. Monthly δ15N signatures (2009–2012) of grizzly bears from blood samples between the northwest and east/south/southwest regions of the NCDE, ± SE. Dotted lines indicate expected isotope ratios at carnivorous and herbivorous trophic levels.

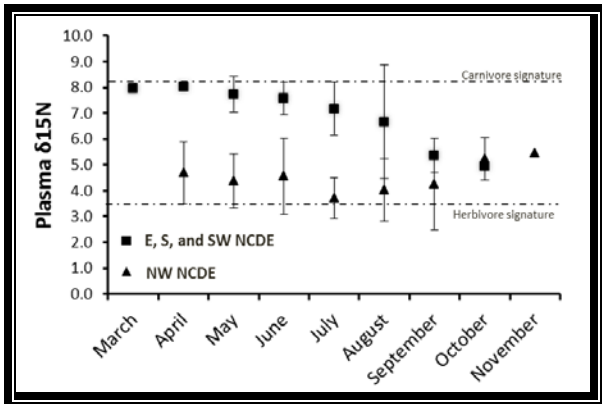


Fig. 5. Percent assimilated diet composed of animal matter for all NCDE grizzly bears for each ecoregion (± SE), 2009-2012. Values were calculated from a 2-source model (plant and animal matter). Area denotations are as in Fig. 3.

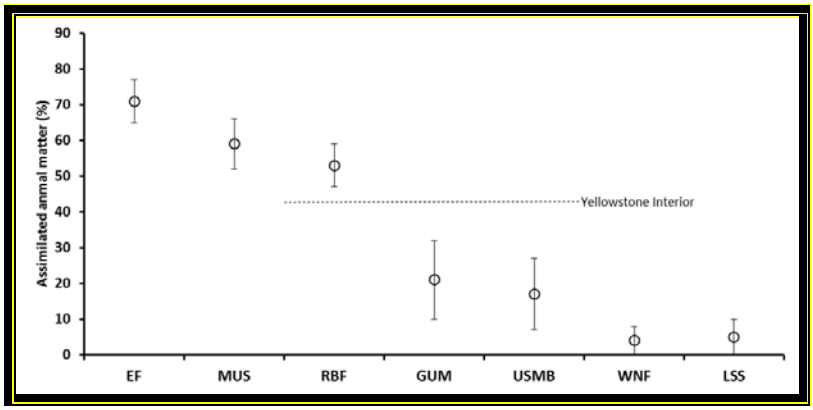


Fig. 6. Kriged surface of isotope values ($\delta^{15}N$) of guard hair from all captured grizzly bears across the Northern Continental Divide Ecosystem, 2009–2012. Higher values (hotter colors) indicate greater amount of animal matter in diets of bears. Lower values (cooler colors) indicate a greater amount of plant matter in bear diets. Sampling locations are also plotted.

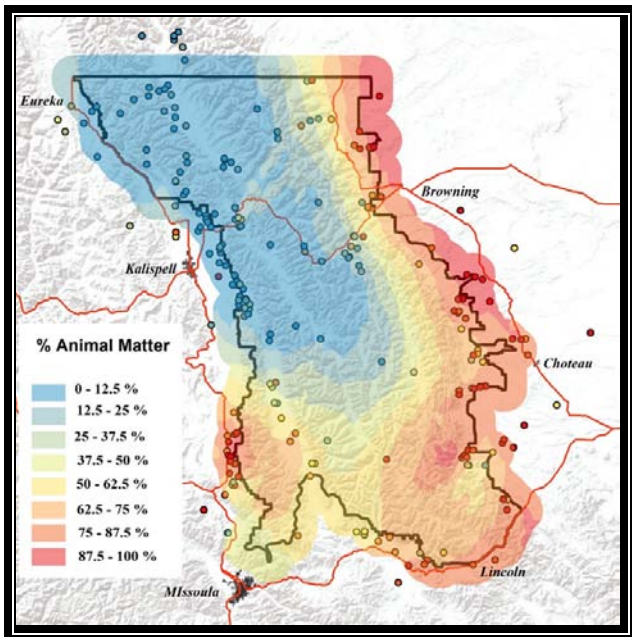
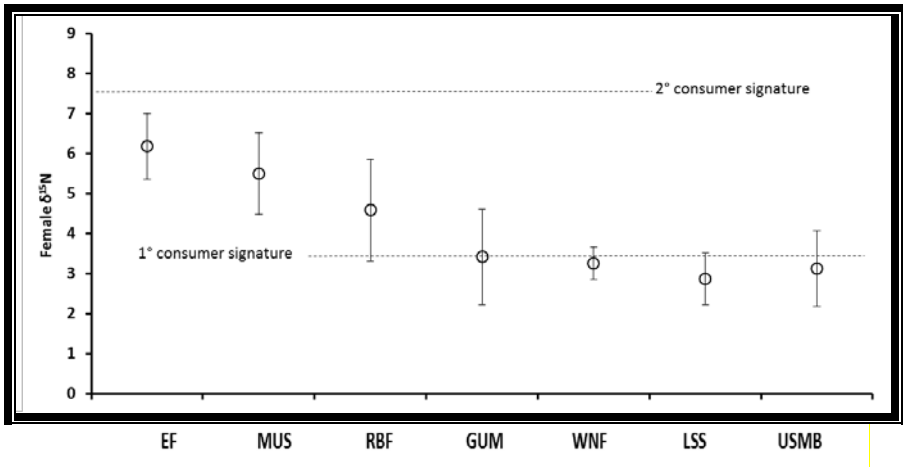


Fig. 7. δ15N signatures (2009–2012) of female grizzly bears across regions of the NCDE, ± SE. Dotted lines indicate expected isotope ratios at primary (herbivory) and secondary (carnivory) consumer trophic levels.



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

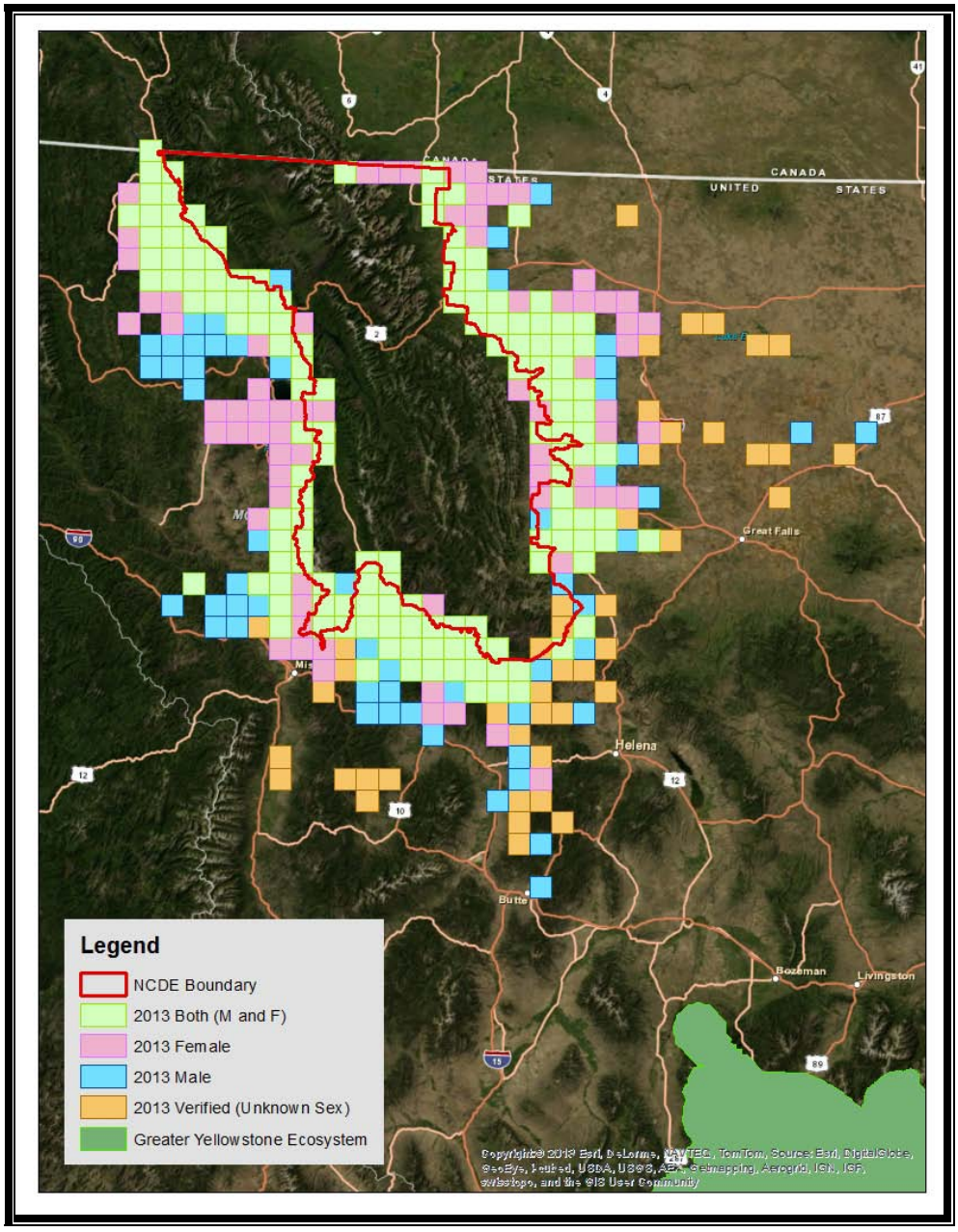
Cabinet-Yaak Ecosystem for purposes of population augmentation were also included. These data were placed on a 10 x 10 km grid overlaying western Montana and the NCDE recovery zone. Grid cells that were occupied by a bear location were highlighted in ARCMAP, and we distinguished cells occupied by males 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 2013, grizzly bears were documented outside of the NCDE recovery zone boundary in all cardinal directions (Fig. 6). We obtained grizzly bear distribution information for 312 **(**31,200 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 55 (5,500 km^2) and 72 (7,200 km^2) respectively. We documented both males and females in 140 cells (14,000 km^2). Forty-five 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.

Fig. 8. Distribution of grizzly bears adjacent to the NCDE federal recovery zone (1989-2013) 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.



Grizzly Bear Mortalities in the NCDE; 2013

Thirty-three known or probable grizzly bear mortalities (Fig. 9) were tallied for 2013 for all sexes and ages (Table 10, Appendix E), 31 of which were within 10 miles of the NCDE recovery zone. One marked female (#64033127/18095786) was killed by a property owner in southern British Columbia, Canada.

Within the 10 mile buffer, 9 independent females and 8 independent males died in 2013. Twelve dependent young were known to have died during the year. There were 11 agency removals in 2013, 6 of which were due to livestock depredations (Table 11). Six cubs were orphaned. Five mortalities were due to either poaching or malicious causes.

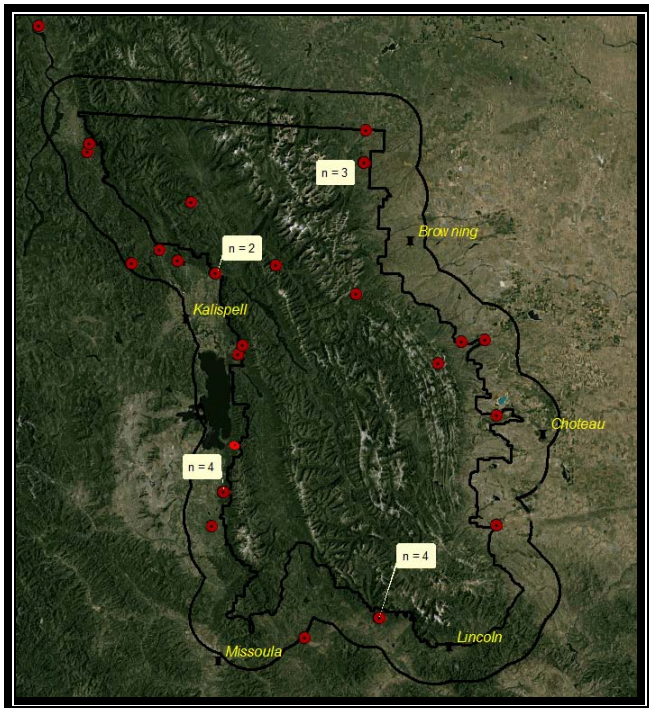
Table 10. Age and sex of grizzly bears (known and probable) that died within the 10 mile buffer of the NCDE recovery zone in 2013.

Sex	Ageclass					Total
	Subad	Ad	Coy	Yrling	Ukn	
M	6	2	1	4	0	13
F	2	7	3	1	0	13
Ukn	0	1	3	0	1	5
Total	8	10	7	5	1	31

Table 11. The cause of 31 known and probable grizzly bear mortalities within 10 miles of the NCDE boundary; 2013.

Primary Cause of mortality	Secondary cause of mortality	Gender			Total
		M	F	Ukn	
Agency Removal	Property Damage	1	0	0	1
Agency Removal	Augmentation	1	0	0	1
Agency Removal	Injury/Disease	1	0	0	1
Agency Removal	Anthropogenic Foods	0	2	0	2
Agency Removal	Livestock Depredation	4	2	0	6
Defense-of-life		1	0	0	1
Train		0	2	0	2
Automobile		1	1	1	3
Poached/Malicious		2	3	0	5
Orphaned		0	3	3	6
Natural		1	0	0	1
Undetermined		1	0	1	2

Fig. 9. Location of known or probable grizzly bear mortalities relative to the NCDE recovery zone and the 10 mile mortality buffer; 2013.



VI. LITERATURE CITED

Brenna, J. T., T.N. Corso, H.J. Tobias and R.J. Caimi. 1997. High-precision continuous-flow isotope ratio mass spectrometry. Mass Spectrometry Reviews. 16:227–258.

Erlenbach, J. A., K. D. Rode, D. Raubenheimer, and C. T. Robbins. 2013. Macronutrient optimization and energy maximization determine diets of brown bears. Journal of Mammalogy 95:000–000.

Fortin, J. K., C. C. Schwartz, K. A. Gunther, J. E. Teisberg, M. A. Haroldson, M. A. Evans, and C. T. Robbins. 2013. Dietary adjustability of grizzly bears and American black bears in Yellowstone National Park. Journal of Wildlife Management 77:270–281.

Haroldson, M.A., C.C. Schwartz, and G.C. White. 2006. Survival of independent grizzly bears in the Greater Yellowstone Ecosystem, 1983-2001. Pages 33-42 in: Schwartz, C.C., M.A. Haroldson, G.C. White, R.B. Harris, S. Cherry, K.A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences oon the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildl. Monogr. 161.

Harrison, J.L. 1958. Range of movement of some Malaysian rats. Journal of Mammalogy. 39:190-206.

Hilderbrand, G.V., S.D. Farley, C.T. Robbins, T.A. Hanley, K. Titus, and C. Servheen. 1996. Use of stable isotopes to determine the diets of living and extinct bears. Canadian Journal of Zoology 74:2080–2088.

Hopkins, J. B., S. Herrero, R. T. Shideler, K. A. Gunther, C. C. Schwartz, and S. T. Kalinowski. 2010. A proposed lexicon of terms and concepts for human-bear management in North America. Ursus 21:154–168.

Kendall, K.C., J.B. Stetz, J. Boulanger, A.C. McLeod, D. Paetkau, and G.C. White. 2009. Demography and Genetic Structure of a Recovering Grizzly Bear Population. J. Wildl. Manage. 73:3-16.

Mace, R. D., D. W, Carney, T. Chilton-Radandt, S.A. Courville, M.A. Haroldson, R.B. Harris, J. Jonkel, M. Madel, T.L Manley, C.C. Schwartz, C. Servheen, J.S. Waller, and E. Wenum. 2012. Grizzly bear population vital rates and trend in the Northern Continental Divide Ecosystem, Montana. Journal of Wildlife Management.76:119-128.

Qi, H., Coplen, T.B., Geilmann, H., Brand, W.A. and Böhlke, J.K. 2003. Two new organic reference materials for δ13C and δ15N measurements and a new value for the δ13C of NBS 22 oil. Rapid Communications in Mass Spectrometry. 17:2483–2487.

Stoneberg, R. P., and C. J. Jonkel. 1966. Age determination in black bears by cementum layers. Journal of Wildlife Management 30:411-414.

Waller, J. S. 2005. Movements and habitat-use of grizzly bears along U.S. Highway 2 in northwestern Montana 1998-2001. PhD. Dissertation, U. Montana, Missoula.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement. 120-138.

Appendix A. Fate of radioed research females in the NCDE; 2013.

Bear id	Area	Fate-2013
238	BC	alive
263	flathead	alive
11111	B.C.	alive
11032585	Swan Valley	censor
11048792	Stryker ridge	alive
11060268	Swan Valley	alive
18078025	FIR	alive
28288097	Middle Fork	censor
36335046	East Front	censor/collar fail
36547078	Hungery horse	alive
36553583	Glacier Park	censor
36554783	Glacier Park	alive
36558355	North Fork	alive
39088856	East Front	alive
51071845	East Front	alive
51586884	South end	alive
55579532	BIR	alive
55582310	BIR	DEAD
55587346	N.F.Flathead	alive
55588533	South end	alive
55588561	Middle Fork	alive
55597781	South end	alive
55599346	Middle Fork	alive
55601006	Glacier Park	censor
55601314	Middle Fork	censor
64054290	South end	alive
76361015	Glacier Park	alive
76553865	East Front	censor
79050043	S.F.Flathead	alive
79556551	BIR	censor
79557267	BIR	censor
79570382	N.F.Flathead	alive
79596617	Glacier Park	alive
81278277	BIR	alive
81600578	N.F. Flathead	censor
97630806	N.F. Flathead	alive
97636103	Middle Fork	alive
107561271	S.F.Flathead	censor
107585006	N.F.Flathead	alive
107794628	N.F. Flathead	alive

Appendix B. Fate of radioed management females in the NCDE; 2013.

Bear	Area	Fate-2013
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 male grizzly bears in the NCDE; 2013.

Bear	Type	Area	Fate-2013
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 research females radio-monitored in the NCDE; 2013.

Bear id	Reproductive status in 2013
238	solitary_ad
51071845	solitary_ad
51586884	2 coy
97636103, 84524018	1 yrling
76361015	1yrling
263	unkn
97630806	solitary_ad
107794628	at least 1 coy
107585006	solitary_ad
64054290	solitary_ad
11111	unknown
39088856, 36336617	solitary_ad
81278277	2 coy
55597781	subadult
55588533	solitary_ad
55587346	solitary_ad
55579532	2_coy
79570382	2_yrling
36558355	subadult
55588561	solitary_ad
55599346	solitary_ad
36554783	3_yrlings
36547078	2_coy
11048792	2_coy
79596617	solitary_ad
18078025	2_coy
11032585	solitary_ad
11060268	solitary_ad
76553865	2_ylings, 1dead
79050043	1 yrling
107561271	solitary_ad
81600578	solitary_ad
55601314	solitary_ad
36553583	unknown
28288097	2 coy-dead
55601006	subadult
79557267	1-2 old
79556551	subadult
36335046	unknown
55582310	2_coy_assumed dead

Appendix E. Summary of known or probable grizzly bear mortalities in the NCDE during 2013.

Date	Date accuracy	Tag #	Ageclass	Sex	Cause	Relationship to NCDE boundary	Relationship to 10 mile buffer
Fall 2013			Ukn	Ukn	Undetermined	outside	inside
04/18/2013	within a week		yearling	M	Automobile	inside	inside
05/02/2013	that day	18087605	subadult	M	Poached/Malicious	outside	inside
05/04/2013	that day	79569304	subadult	M	Poached/Malicious	outside	inside
05/12/2013	that day	39851057	adult	F	Automobile	inside	inside
05/15/2013	this spring	79594295	subadult	M	Undetermined	outside	outside
06/01/2013	that day	36320266	subadult	F	Anthropogenic Foods	outside	inside
06/20/2013	that day	39057863	subadult	M	Livestock Depredation	outside	inside
06/22/2013	that day	64033127	subadult	F	DOP	outside	outside
06/28/2013	that day	93638000	adult	F	Livestock Depredation	outside	inside
06/28/2013	that day	18074800	yearling	F	Livestock Depredation	outside	inside
06/28/2013	that day	18112362	yearling	M	Livestock Depredation	outside	inside
06/28/2013	that day	18085518	yearling	M	Livestock Depredation	outside	inside
07/25/2013	2 weeks	55582310	adult	F	Poached/Malicious	inside	inside
07/25/2013	2 weeks		Cub	Ukn	Orphaned	inside	inside
07/25/2013	2 weeks		Cub	Ukn	Orphaned	inside	inside
07/29/2013	that day		Cub	M	Natural	inside	inside
07/30/2013	that day		subadult	M	Augmentation	inside	inside
09/30/2013	that day		adult	F	Train	inside	inside
10/02/2013	that day		unknown	Ukn	Automobile	outside	inside
10/08/2013	that day		adult	F	Train	outside	inside
10/15/2013	that day		subadult	M	Undetermined	outside	inside
10/27/2013	that day	11079290	subadult	M	Injury/Disease	outside	inside
10/28/2013	that day	36558792	subadult	F	Anthropogenic Foods	inside	inside
10/30/2013	that day	11009127	adult	M	Livestock Depredation	outside	inside
11/03/2013	that day	63834064	adult	F	Poached/Malicious	outside	inside
11/03/2013	that day		Cub	F	Orphaned	outside	inside
11/03/2013	that day		Cub	F	Orphaned	outside	inside
11/03/2013	that day	97628566	adult	M	Property Damage	inside	inside
11/03/2013	that day		Cub	Ukn	Orphaned	outside	inside
11/07/2013	that day		yearling	M	DOL	inside	inside
11/09/2013	that day	76568302	adult	F	Poached/Malicious	inside	inside
11/09/2013	that day		Cub	F	Orphaned	inside	inside