# A RETROSPECTIVE EVALUATION OF THE EFFECTIVENESS OF AVERSIVE CONDITIONING ON GRIZZLY BEARS IN PETER LOUGHEED PROVINCIAL PARK, ALBERTA, CANADA

BY

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## Abstract

Using a post hoc study design, I evaluate the effectiveness of aversive conditioning (AC) as a non-lethal management technique to reduce bear-human conflict, and ultimately reduce bear mortality. I found a decrease in developed site use by radio-collared grizzly bears in Peter Lougheed Provincial Park (PLPP) after the onset of AC. Also, wariness of collared bears increased with application of AC, both short-term and long-term. Wariness of non-collared grizzly bears also increased after application of AC. Grizzly bear mortality and relocation rates in the period after AC began decreased by half within PLPP, while at the same time increasing five-fold on adjacent lands where AC was not a commonly used tool. Finally, there was a decrease in the number of bear-related facility management actions after the onset of AC. I conclude that AC is an effective management tool to reduce human conflicts with grizzly bears and promote bear population stability.

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## Chapter One: Introduction

As human populations accelerate their expansion into bear habitat throughout North America through residential development, recreational or industrial activities, interactions between grizzly bears (*Ursus arctos*) and humans occur. In recent years, these conflicts have increased in frequency and magnitude (Conover and Decker, 1991; Conover, 1998; Messmer, 2000). The rate of encounter between humans and grizzly bears is positively correlated with grizzly bear mortality (Mattson et al., 1996). Therefore, such conflicts between humans and grizzly bears are a significant concern to wildlife managers, not only because such interactions threaten human safety and property, but also because bear mortality associated with these conflicts threatens the sustainability of slow-reproducing, wild populations of grizzly bears (Nagy & Russell, 1978; McArthur, 1979; Gilbert, 1989).

While injuries of recreationists by grizzly bears in national parks often involve campers confronted by bears that learn to associate people with food (Herrero, 1976), it is also believed that frequent, innocuous contacts between bears and people can create “problem” bears without food reinforcement (McCullough, 1982), because of habituation by bears to human presence. Habituation is defined by Thorpe (1996) as a decline in an animal’s response following repeated exposure to an inconsequential stimulus. Habituated grizzly bears have a higher mortality risk than do wary bears (Mattson et al. 1992; Gibeau, 2000; Mueller, 2001); bears inside protected areas face increased mortality risk when they are habituated or food-conditioned (Benn, 1998). This mortality is often due to management removals. In the Yellowstone ecosystem between 1983 and 1987, mortality from government management actions (i.e. the removal of conflict bears) accounted for 30 to 80 % of all grizzly bear deaths. (Knight et al, 1984, 1986). Herrero (2005) states that within the Central Rockies Ecosystem (CRE), a mix of both protected and non-

protected lands, habituation of grizzly bears increases bear mortality risk even if bears are not human-food conditioned. Habituated bears may utilize habitats near roads, trails, and developments (Jope, 1985; McLellan & Shackleton, 1989a; Olson et al. 1990). In the CRE, 85 % of human-caused grizzly bear deaths with known locations occurred within 500 metres of roads or settlements or within 200 metres of trails (Benn & Herrero, 2002). A review by Benn (1998) of grizzly bear mortality in the CRE found that human response to bear-human conflict accounted for the greatest proportion of all grizzly bear deaths throughout all jurisdictions. For these reasons, wary behaviour in grizzly bears is a trait that most managers consider desirable (Mattson, 1993).

Agencies responsible for bear management have been pressured by media and the public to consider alternatives to the traditional methods of managing “problem” bears (Hunt et al., 1988). Trapping and relocating bears has been largely ineffective in meeting long-term population management goals (Herrero, 1976; Jorgensen et al., 1978; Eager & Pelton, 1979; Miller & Ballard, 1982). Other management options have included individual removals, either through euthanasia or hunting. Euthanizing bears, while at times necessary, is not a solution for all bear-human conflict incidents, if the management goal of sustaining viable grizzly populations is to be achieved. Hunting is a form of negative conditioning that may produce wary bear populations through the chasing and possible wounding of bears, but it is problematic when applied to habituated populations since the initial high mortality rate of unwary, habituated bears may reduce grizzly-bear populations to unacceptable levels (McCullough, 1982). Thus, a need exists for an effective, non-lethal, human response to conflict between bears and humans that promotes bear survival while simultaneously reducing conflict rates with people.

Aversive conditioning is a relatively new method of managing habituated or food conditioned bears, and is derived from learning behaviour theory; conditioning, either positive or negative, can result in the animal associating a reward or punishment with its behavioural response to the stimulus. Non-lethal forms of negative conditioning (e.g., pain and noise stimuli), provided by non-lethal ammunition (e.g. bean bags, rubber bullets, cracker shells) and Karelian Bear Dogs have been recognized as possible alternatives to deal with habituated bears (McCullough, 1982) and reduce bear-human interactions (Matthews et al., 2006). In fact, Benn (1998) recommended bear conditioning programs in the CRE, including the development of a Karelian Bear Dog program in Canada. Wildlife agencies have typically used AC to haze bears out of developed sites (areas with some form of infrastructure regularly used by people such as campgrounds, day use areas, private residences, restaurants, and information centres), but generally with no consistent application of the negative stimulus due to limited staffing and resources for conditioning teams. Carrie Hunt, a bear conflict specialist and founder of the Wind River Bear Institute (WRBI), has been delivering AC programs for government agencies throughout North America for more than ten years. She believes that operant conditioning techniques delivered in a consistent manner combined with securing attractants increases the effectiveness of the conditioning lesson given to bears (Hunt et.al 1988, Hunt 1997; Hunt 2003). WRBI has applied these techniques, which they call Bear Shepherding, using Karelian Bear Dogs and noise and pain stimuli, to teach bears to recognize and avoid humans and their personal space or developed site “boundaries” (Hunt, 1997).

Many benefits to both bears and people could result from successful AC programs. Such benefits may include increased economic returns through reduction of property damage and reduced closures of privately run facilities such as campgrounds; improved public safety;

increased recreational opportunities through fewer facility closures; increased wariness of bears and subsequent reduction of human-caused grizzly bear mortality and relocations; and lastly greater awareness of bear-human conflict-related issues through increased media exposure and education.

My goal is to evaluate the effectiveness of AC as a non-lethal management technique to manage "problem" grizzly bears in developed sites managed as "food secure land" (areas that have effective bearproof waste management systems in place and have no recent history of bears obtaining unnatural food rewards from people).

My research question is five-fold:

**i) Do radio-collared grizzly bears use developed sites on food secure lands more or less frequently after the onset of AC?**

$H_{01}$ (Null hypothesis): Radio-collared grizzly bears use developed sites on food secure lands at a similar or greater frequency after the onset of AC.

$H_{a1}$ (Alternate hypothesis): Radio collared grizzly bears use developed sites on food secure lands less frequently after the onset of AC.

**ii) Is it possible to change the response behaviour of grizzly bears to humans using AC techniques?**

$H_{02:}$ Bear wariness will not increase when AC techniques are employed.

$H_{a2}$: Bear wariness will increase as AC techniques are employed.

**iii) Does AC reduce grizzly bear mortality and relocation rates?**

$H_{03}$: The application of AC does not reduce bear mortality and relocation rates.

$H_{a3}$: The application of AC reduces bear mortality and relocation rates.

**iv) Does AC reduce the number of bear management actions (posted closures and warning signs) within facility areas?**

$H_{04}$: The application of AC does not reduce the number of bear management actions within facility areas.

$H_{a4}$: The application of AC reduces the number of bear management actions within facility areas.

**v) Does the presence of natural food in developed sites change the effectiveness of AC?**

$H_{05}$: Bears exposed to AC show no difference in re-visit rates to developed sites during periods when natural foods are available (berry season), compared to times when they are not as available (pre-berry season).

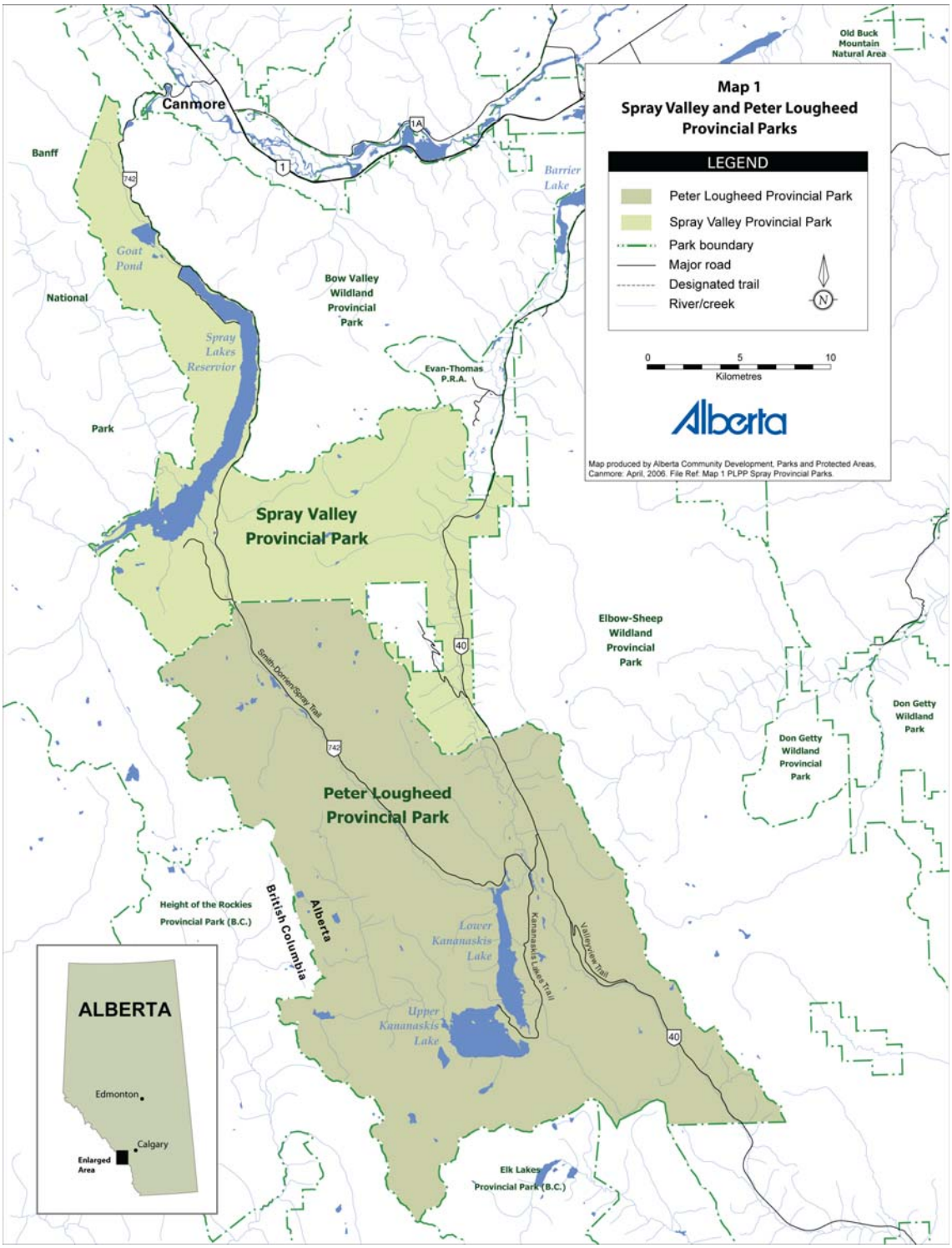
$H_{a5}$: Bears exposed to AC show an increase in re-visit rates to developed sites during periods when natural foods are available (berry season), compared to times when they are not available (pre-berry season).

## 1.1 Study Area

### *1.1.1 Geography*

The study area comprises Peter Lougheed Provincial Park (PLPP), located in the Rocky Mountains approximately 90 kilometres west of Calgary, Alberta. PLPP is a 550 $km^2$ protected area, established in 1977 as part of the larger, 4200 $km^2$, multi-use recreation area of Kananaskis Country. Several other protected areas border the park including the Height of the Rockies Provincial Park in British Columbia, Banff National Park to the west and Spray Valley Provincial Park to the north. The Elbow Sheep Wildland Park is situated to the east and Elk Lakes Provincial Park in British Columbia is located on the south boundary of PLPP (Fig. 1). Within

**Figure 1. The study area comprises lands within Peter Lougheed Provincial Park.**



the study area, monitoring was focused on the PLPP facility core which consists of seven campgrounds, two group camps, ten picnic areas, a visitor information centre, a restaurant concession, staff residences, and an overnight facility for individuals with disabilities including a main lodge and twenty-two cabins. Seventy private lots with cabins also exist along the eastern shore of Lower Kananaskis Lake. There are more than 220 kilometres of summer and winter hiking, biking, and skiing trails located in PLPP including 12 kilometres of paved bike trails in the main facility core. The Upper and Lower Kananaskis Lakes, also located in the main facility core, are the main water bodies that serve as the focal point for recreational activity in the park.

Elevation ranges from 5,000 feet at Kananaskis Lakes to mountain peaks over 11,000 feet along the Continental Divide. The area includes montane, sub-alpine and alpine vegetation sub-regions. The forest in the PLPP facility area consists primarily of lodgepole pine (*Pinus contorta*), and to a lesser degree engelmann spruce (*Picea engelmannii*) and sub-alpine fir (*Abies laciocarpa*). Buffaloberry (*Shepherdia canadensis*) is the predominant shrub in the facility core. Bog birch (*Betula occidentalis*), willow (*Salix sp*.) and sedges (*Carex sp.*) also commonly occur. Vegetation patterns have been influenced primarily by fire, logging, mining, and access development (PLPP Management Plan, 2005). The Kananaskis Lakes serve as the hub for several key watersheds that border the area. These include the Elk Valley in British Columbia, the upper and lower Kananaskis valleys, the Highwood valley, and the Smith Dorrien Valley. These river valleys are considered important local habitat and regional movement corridors for a variety of wildlife including both grizzly and black bears (*Ursus americanus*). Grizzly bears inhabit all of PLPP and have a history of utilizing the facility core, both during early spring green up and later in

the summer when buffaloberry ripens. Summer bear activity also coincides with the busiest time of the year for park visitation by people.

### *1.1.2 Human use in PLPP*

Human use in PLPP is considered high, particularly during summer months. It was the most visited provincial park for camping in Alberta in 2003, the most recent year that visitor-use statistics are available. Camping in PLPP has remained at capacity over the last ten years, averaging around 32,000 visitor nights annually, most of which occurs in July and August. Day use statistics indicate that more than 134,000 people visited PLPP in 2003, a 37 % increase since 1990. The total number of visitors, including both camping and day use visitors was estimated at more than 242,000 people in 2003 (Alberta Community Development, 2004).

### *1.1.3 Grizzly bear use in PLPP*

The grizzly bear population in the Bow River Watershed (BRW), including PLPP, grew by about four % between 1994 and 2002 (Garshelis et al., 2005). These authors also noted that grizzly bear population reproductive rates in the BRW are among the lowest of any population studied. Kananaskis Country, including PLPP, was also found to have the least amount of secure grizzly bear habitat (36 %) relative to the amount of available grizzly bear habitat when compared to other jurisdictions, including British Columbia provincial lands (50 %), Alberta provincial lands (43 %) and national parks (43 %) (Stevens, 2002). Secure habitat is identified as the percent of productive grizzly bear land where adult female grizzly bears have a low probability of encounters with people (Gibeau, 2005). The lack of secure habitat within PLPP falls far short of the target level of 68 % considered adequate by the USDA Forest Service (1990) in the Northern Continental

Divide grizzly bear ecosystem in northwest Montana.

### *1.1.4 Bear-human interaction in PLPP*

High levels of human use in the PLPP facility core combined with an existing grizzly-bear population and an abundant natural food source for bears, specifically buffaloberry during July and August, has resulted in increased interactions between bears and people. Kananaskis public safety statistics indicate that wildlife-human confrontations began to increase in the late 1980s and the number of occurrences doubled between 1990 and 1997. The majority of these incidents were bear conflict-related occurrences and of those, the majority occurred in PLPP (Duncan Pers. Com., 2006).

### *1.1.5 Managing bears and people in PLPP*

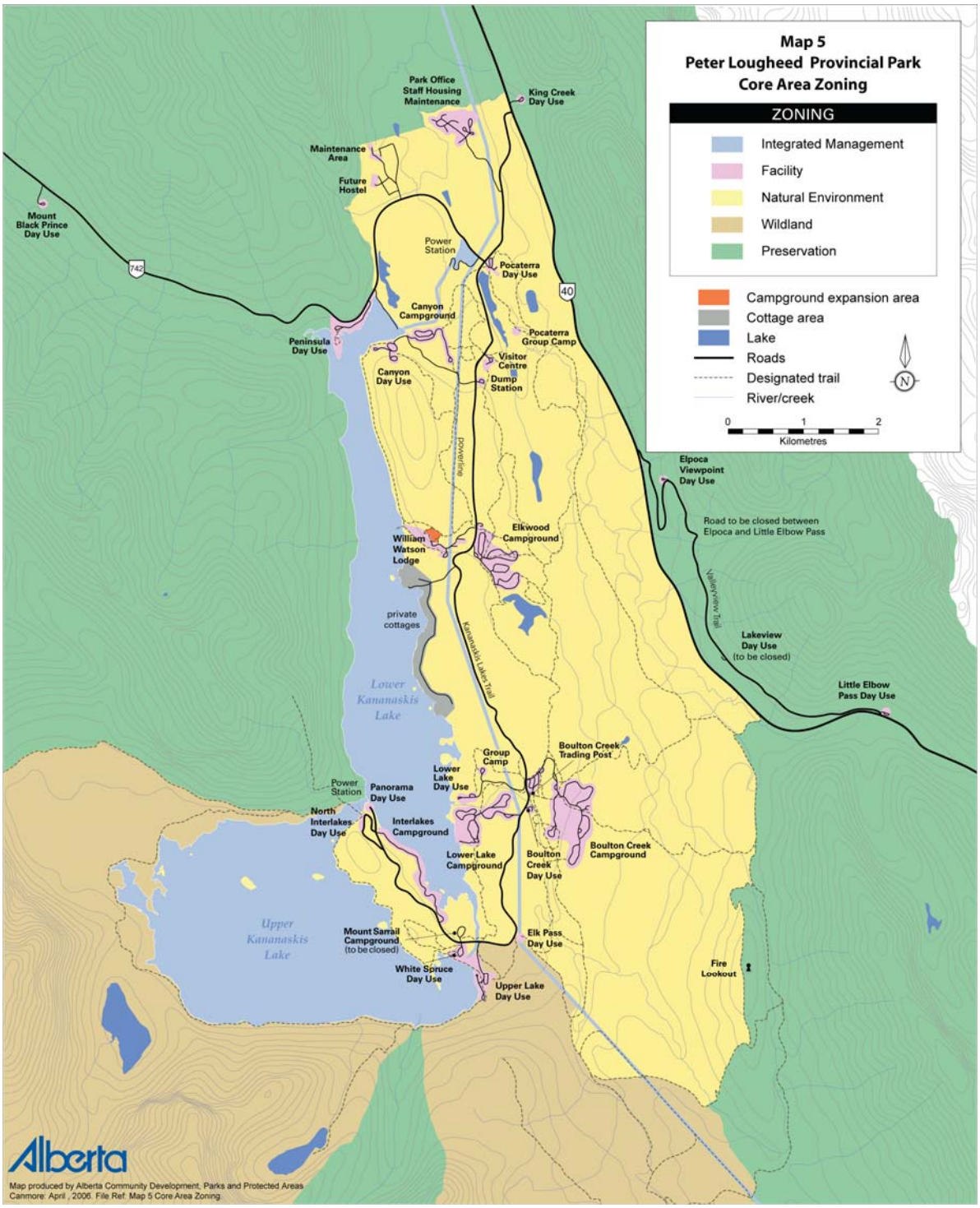
In the 1990s, wildlife managers responded to the increase in bear activity within developments by closing facilities and in rare instances, relocating bears. Lengthy facility closures in the summer due to bear activity had the potential to curtail recreational opportunities and affect private operators' economic viability in what was already a very short season (Hanna Pers. Com., 2006). Alternative management options were considered including opening some facilities later and closing others earlier in response to seasonal bear use, reducing attractants in historical trouble spots, and using AC on individual bears that were known to use PLPP facilities. In 1997, PLPP began to condition Grizzly Bear #24, a female who was known to frequent the roadside of Highway #40 with her two cubs. The conditioning was deemed successful (PLPP Summary Report 1997) and set the stage for a more formal conditioning program in the years to come. In 2000, WRBI introduced their Bear Shepherding program to Alberta wildlife managers in southern Alberta including Kananaskis Country. The WRBI protocols enhanced existing AC procedures in PLPP at

the time, resulting in a more formalized and effective process of conditioning bears (Hanna Pers. Com., 2008). The PLPP Management Plan (2006) now identifies the need to implement a formal AC program to reduce the number of bears destroyed or relocated.

The PLPP Management Plan (2006) indicates that the management intent for the park is "to maintain ecological integrity and diversity and provide opportunities for outdoor recreation, heritage appreciation, tourism or any combination of those purposes, which are dependent on and compatible with the protection of the natural values found here." The primary objective is to "preserve or enhance naturally occurring ecosystems including especially rare or uncommon species and to ensure that natural ecological processes are allowed to occur."

The PLPP Management Plan identifies management zones that recognize differences in resource values, recreation use, and landscape capability. The PLPP facility core has been designated a "Natural Environment" zone with the intent of protecting significant natural features and habitat, while accommodating trail recreation and backcountry camping. Those areas in the immediate vicinity of existing campground or day use facilities have been zoned "Facility." These areas are intended to accommodate major facility developments (i.e., campgrounds, groomed trails, day use sites, visitor centres and staff housing) (Fig. 2). It is in these facilities where the majority of bear-human interaction occurs. In contrast to many bear-human interactions, these incidents are not the result of bears obtaining unnatural foods such as garbage. In fact, researchers have described waste management in Kananaskis Country and the surrounding National Parks as "world class" (Herrero et al., 1986). Rather, bears are visiting facilities to utilize naturally occurring foods. Ironically, facility development may have played a role in contributing to the

**Figure 2. The PLPP Core Area Zoning identifies the main facilities. (PLPP Management Plan, 2006)**



abundant natural food source (i.e. buffaloberry) for bears. The nitrogen-fixing ability of buffaloberry allows it to grow in soils with low amounts of mineral nitrogen, which are common in disturbed areas (Winterhalder, 1990), such as those created during the development of PLPP facilities.

## Chapter Two: Methodology

More than 7,300 geographically referenced grizzly bear observation records were compiled from a variety of database sources, including public reports, staff observation and aversion data, and research data from the Eastern Slopes Grizzly Bear Project. Observers included government staff, Wind River Bear Institute staff, and the general public. Data from the public were collected from an Alberta government public bear sighting reporting system. These data, dating back to 1990 for both radio-collared and non-collared grizzly bears, include location and behavioural response data and more than 850 AC records. Any records that did not contain pertinent data were omitted. A summary of the database structure is outlined in Appendix A. Conditioning methods used on bears have changed over time in PLPP since its inception in 1997. However, beginning in 2000 in PLPP, WRBI Bear Shepherding techniques (Hunt 2003) have consistently been applied by AC teams. Grizzly bears were initially collared for research purposes in the mid 1990's, and some of those bears became candidates for conditioning at that time because of their use of developments and habituation to people. Since 2002, a number of grizzly bears, regardless of age or sex, were radio-collared strictly for the purposes of conditioning. All of these bears were fitted with conventional VHF radio-collars or ear tag transmitters. A senior Conservation Officer or the lead WRBI field technician validated location and behavioural data prior to it being entered into a database. Because of the difficulties inherent in post-hoc study design, sample sizes varied for different types of analyses. All estimated parameter values are followed by their associated Standard Error (S.E.) For a summary of radio-collared grizzly bear monitoring and AC records refer to Appendix B.

**Research Question #1**: **Do radio-collared grizzly bears use developed sites on unnatural food secure lands more or less frequently after the onset of AC?**

Bear locations, as they pertained to development use, were obtained by a combination of public reports, staff sightings and, in the case of radio-collared bears, ground telemetry. In the majority of cases, individual radio-collared bears were confirmed to be in developed sites through confirmed visual sightings by staff. If a radio-collared grizzly bear could not be confirmed to be in a developed site, the record was not included in the radio-collared grizzly bear data set used for this analysis.

Because it was not possible to collect data on bear visitation rates prior to the initiation of AC, I examined how the annual frequency of visitation to developed sites changed as bears were exposed to increasing numbers of AC events. A repeated-measures regression was used to examine the relationship between the frequency of bears returning to developed sites and time since the onset of AC. The repeated measures design accounted for within-subject (i.e. each bear) correlations, so that each bear received equal weight in the analysis. Only those bears subjected to more than one year of AC were considered for analysis. A sample of five bears (GB #24, GB #47, GB #48, GB #80, and GB #81) was used in this analysis. Data were transformed using a square root transformation because untransformed values were not normally distributed (Appendix C). In addition, bears with increasing trends of site use were removed from the analysis to determine if there was a significant decrease in site use trends for the remaining bears as AC increased over time. This was justified on the basis that AC is not considered appropriate for every bear but that AC can change the behaviour of enough bears to have a positive impact on the population.

**Research Question #2: Is it possible to change the response behaviour of grizzly bears to humans using AC techniques?**

I tested the hypothesis that grizzly bears subjected to conditioning would change their behaviour over time from a *Negative* response (non-retreat) to a *Positive* response (retreat) when approached by humans, i.e. they would become more wary of people. Response behaviour data were categorized as *Negative* or *Positive* based on how a bear responded when approached by people. Typical scenarios for these approaches included vehicles stopping to observe roadside bears and hikers, bikers or campers observing bears near campsites or trails. Bear-response type categories from the available databases included *Aware, Indifference, Unaware, Retreat, Retreat to Cover,* and *Close Distance*. For the purposes of this report, these categories were further separated into *Negative* and *Positive* responses.

The *Negative* response category includes *Aware, Indifferent,* and *Close Distance* behaviour responses. *Aware* responses occurred when the bear was aware of the observer's presence, indicated by the bear looking up or watching the observer but not moving away. *Indifferent* responses occurred when the bear was aware of the observers' presence but the behaviour of the bear did not change as the observer approached (e.g. when people or vehicles are in close proximity to the bear, the bear acknowledges the people's presence yet continues to feed). *Close Distance* responses were those where the bear responded by approaching the observer.

The *Positive* response category included those responses where the bear increased distance between itself and the observer. These types of responses included the categories *Retreat* and *Retreat to Cover*. A bear was considered to *Retreat* when it was aware of the

observer's presence and increased distance between itself and the observer as the observer approached. In this case, the bear did not go into cover and continued to be seen by the observer. *Retreat to Cover* occurred when a bear was aware of an observer's presence and increased distance between itself and the observer as the observer approached. The bear moved into cover and could not be seen by the observer. Two categories included in bear response data, *Unaware* and *Unavailable,* were not included in the analysis. An *Unaware* response occurred when the bear was not aware of the observer's presence. *Unavailable* refers to data that are incomplete and no determination could be made of the bear's response upon approach by the observer. Separate analyses were conducted for radio-collared and non-radio-collared bears. Data from non-collared grizzly bears were analysed as a group since they could not be consistently identified as unique individuals.

Non-collared grizzly bears

I tested the hypothesis that non-collared grizzly bears subject to AC would change their behaviour from a *Negative* response to a *Positive* response over time when approached by people. A segmented regression was used to examine longitudinal data (Muggeo, 2003) to identify the onset of a change in grizzly bear behaviour to human encounter (PLPP, 1990-2005). The independent variable for this test was 'year' (1990-2005), coded as 1-15. Data for 1996 were unavailable. The dependent variable was the count of active responses in each year. A significant change in the slope would indicate a change in the relationship between time (years) and the proportion of active responses after the identified break-point. The strength of this analysis is that it spans the time before and after AC was employed by managers, therefore providing a "control" period when no AC was occurring prior to 1997. This was not possible for data collected for radio-collared bears, since no data on these

animals could be collected prior to collaring. Twenty percent (680 of 3640) of the non-collared grizzly bear behavioural response records were incomplete with no behavioural responses noted.

Radio-collared grizzly bears

An individual radio-collared bear's behavioural response to humans was examined on both a short-term (seasonal) and long-term (annual) basis to examine the timeframe over which bears responded to AC. Roughly 20 percent (300 of 1500) of observation records did not have a behavioural response category included. These missing data are distributed throughout the study period and are not expected to weight one particular response type more than another.

i) Short-term (seasonally)

A repeated measures logistic regression was used to test for an increase in *Positive* response behaviour as conditioning progressed over the course of a season. The sample was composed of ten bears with one or more years of data (Bears GB #24, GB #47, GB #48, GB #80, GB #94, GB #95, GB #98, GB #100, GB #103, GB #104). The sample unit is the individual bear. The repeated measures logistic regression accounts for the varying numbers of years of data for each bear.

ii) Long-term (annually)

A repeated measures logistic regression was used to examine the relationship between bear response upon human encounter (*Positive* versus *Negative)* and the number of AC events since the onset of conditioning. A minimum of ten observations was necessary for data from an individual bear to be included, resulting in a sample size of ten bears (GB #24, GB #47, GB #48, GB #80, GB #94, GB #95, GB #98, GB #100, GB #103 and GB

#104).

**Research question #3: Does AC reduce grizzly bear mortality and relocation rates?**

Human-caused grizzly bear mortality and relocation data were obtained from Alberta Sustainable Resource Development (ASRD) between 1985 and 2006 and from Eastern Slopes Grizzly Bear Project data between 1994 and 2004. Human-caused mortality includes any known grizzly-bear mortality that occurred as a direct result of human actions including wildlife agencies euthanizing problem bears, research-related deaths, self-defence kills, bears legally and illegally killed, and highway related deaths. Relocations included both short distance and long distance actions. Human-caused grizzly bear mortality and relocation incidents between 1987 and 1996, the ten year period prior to conditioning, were compared to similar data for the ten-year period after conditioning began, between 1997 and 2006, to determine whether there was a decrease in the number of human caused grizzly bear mortalities or relocations. These data were also compared to mortality and relocation data collected concomitantly on lands situated adjacent to PLPP lands where AC was employed inconsistently, if at all, to determine whether there was reduced mortality and relocation rates in PLPP. Lands adjacent to PLPP refer to the four main watersheds bordering PLPP: the Kananaskis, Highwood, and Spray valleys in Alberta, and the Elk valley in British Columbia.

**Research Question #4: Does AC reduce the number of bear management actions (posted closures and warning signs) within facility areas?**

I tested the hypothesis that the number of management actions (i.e. posted closures and cautions in developed sites) would be reduced over time as a result of conditioning. A segmented regression was used to identify any change in the annual frequency of

management actions in PLPP between 1990 and 2006. The independent variable for this test was year (1990-2006), coded as 1-17. The dependent variable was the total number of management actions in each year.

**Research Question #5: Does the presence of natural food in developed sites change the effectiveness of AC?**

While reviewing the data, there appeared to be a disproportionate amount of grizzly bear activity in developed sites during the berry season compared to the preberry season. I was curious to test whether the presence of natural foods in developed sites changed the effectiveness of AC.

I therefore compared radio-collared grizzly bear visitation rates to developed sites in pre-berry (den emergence to July 15) and berry (July 16 to den up) seasons. A revisit to a developed site was identified as any return to a development after a conditioning event regardless of whether it was the developed site where conditioning initially occurred or not. This was based on the idea that bears would learn to recognize any development with vehicles, tents, picnic tables, and buildings as being a “no-go zone” and avoid all such developments accordingly (Hunt et al., 1988). An exact Wilcoxon signed rank test was used to compare the mean and median number of revisits of radio-collared grizzly bears after AC was initiated in a developed site in both pre-berry and berry seasons. This non-parametric equivalent of the paired-sample t-test was used because the data did not fit a normal distribution.

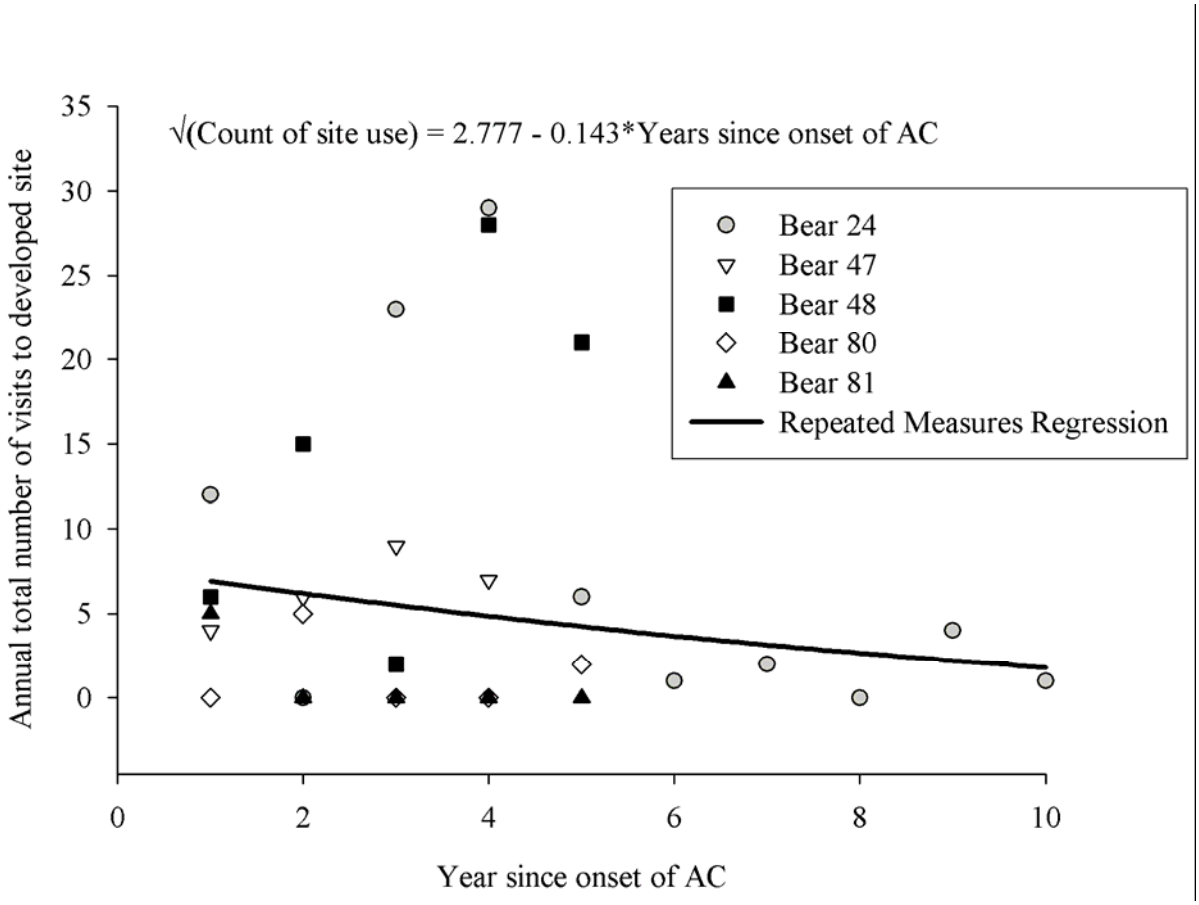
## Chapter Three: Results

Seventy-five % (9 of 12) of radio-collared grizzly bears using PLPP developed sites between 1997 and 2006 were female (GB #24, GB #39, GB #47, GB #48, GB #80, GB #81, GB #94, GB #103, GB #104). Sixty-seven % (eight of twelve) of radio-collared grizzly bears were subadults when they were initially collared and subjected to their first year of AC. Three of these subadult bears were males (GB #95, GB #98, GB #100). During the first year of conditioning, subadult bears used developed sites at a higher frequency rate (n= 8, average: 12.3 visits) than adult grizzly bears (n= 4, average: 7.3 visits) and male bears used developed sites at a higher frequency rate (n=3, average: 21.7 visits) than female bears (n=9, average: 6.3 visits) (Appendix D).

**Research Question #1: Do radio-collared grizzly bears use developed sites on unnatural food secure lands more or less frequently after the onset of AC?**

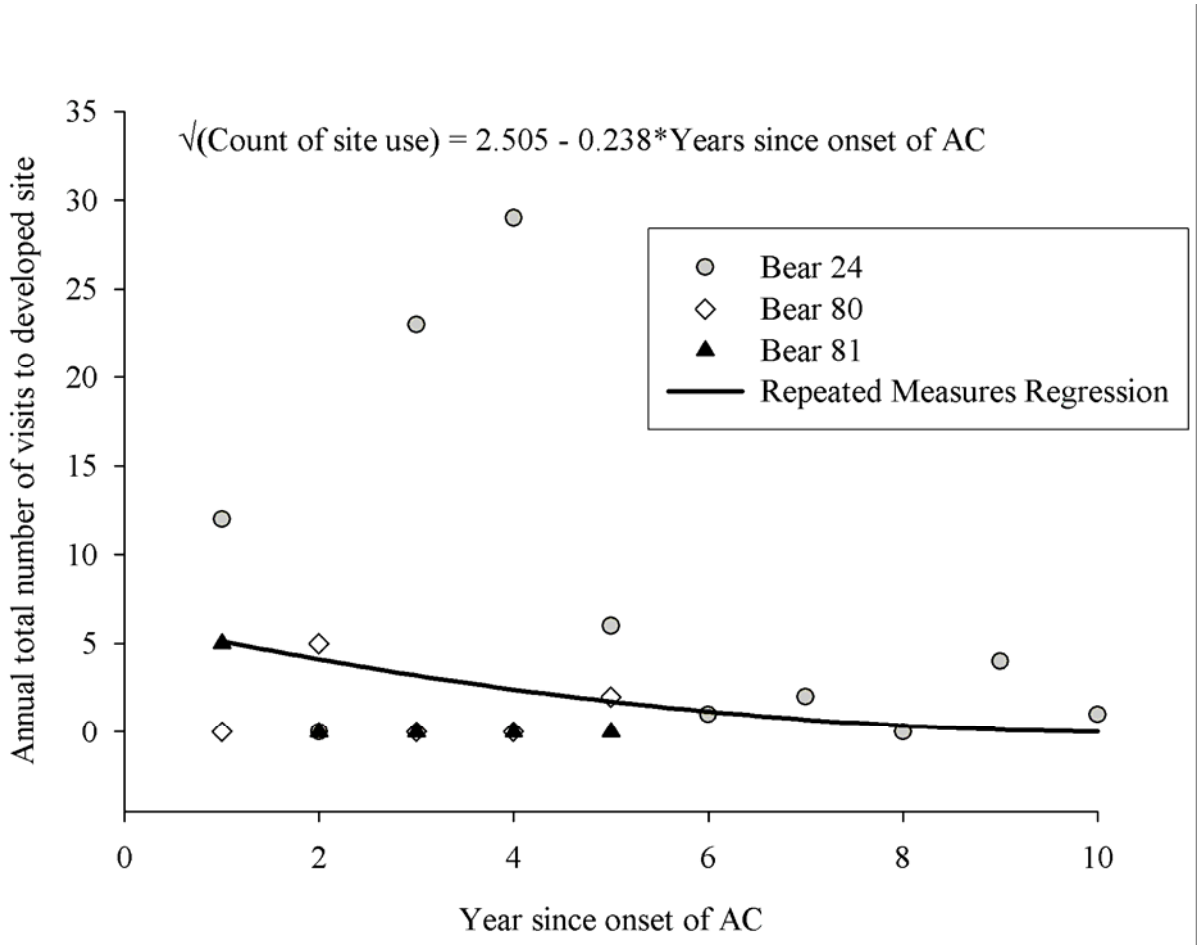
There was a decreasing trend (-0.1 ± 0.1 visits/ year) in the annual frequency of developed-site use by radio-collared grizzly bears in PLPP, though it was not significant ($t = -1.3$, $df = 23$, $p = 0.2$; see Fig. 3). Three of the five bears analyzed (GB #24, GB #80, GB #81), all female, reduced their annual visitation rate to developed sites progressively after the onset of conditioning. Two additional female bears (GB #39 and GB #94) only had two years of data and were excluded from the regression analysis. They also showed a reduction in annual visitation rates.

**Figure 3. The total number of visits annually to developed sites in PLPP by radio-collared grizzly bears between 1997 and 2006 was variable after successive years of AC. (Figure shows untransformed values for ease of interpretation)**




When the bears with increasing trends of site use (GB #47 and GB #48) were removed from the analysis, the result was still not significant at the alpha = 0.05 level, although nearly so (-0.2 ± 0.1 visits/ year; t= -2.1, df=16, p=0.05; See Fig. 4).

**Figure 4. Removing bears with increasing trends of developed site use (GB #47 and GB #48), after successive years of AC between 1997 and 2006 did not result in a significant decreasing trend of site use by the remaining radio-collared grizzly bears. (Figure shows untransformed values for ease of interpretation)**



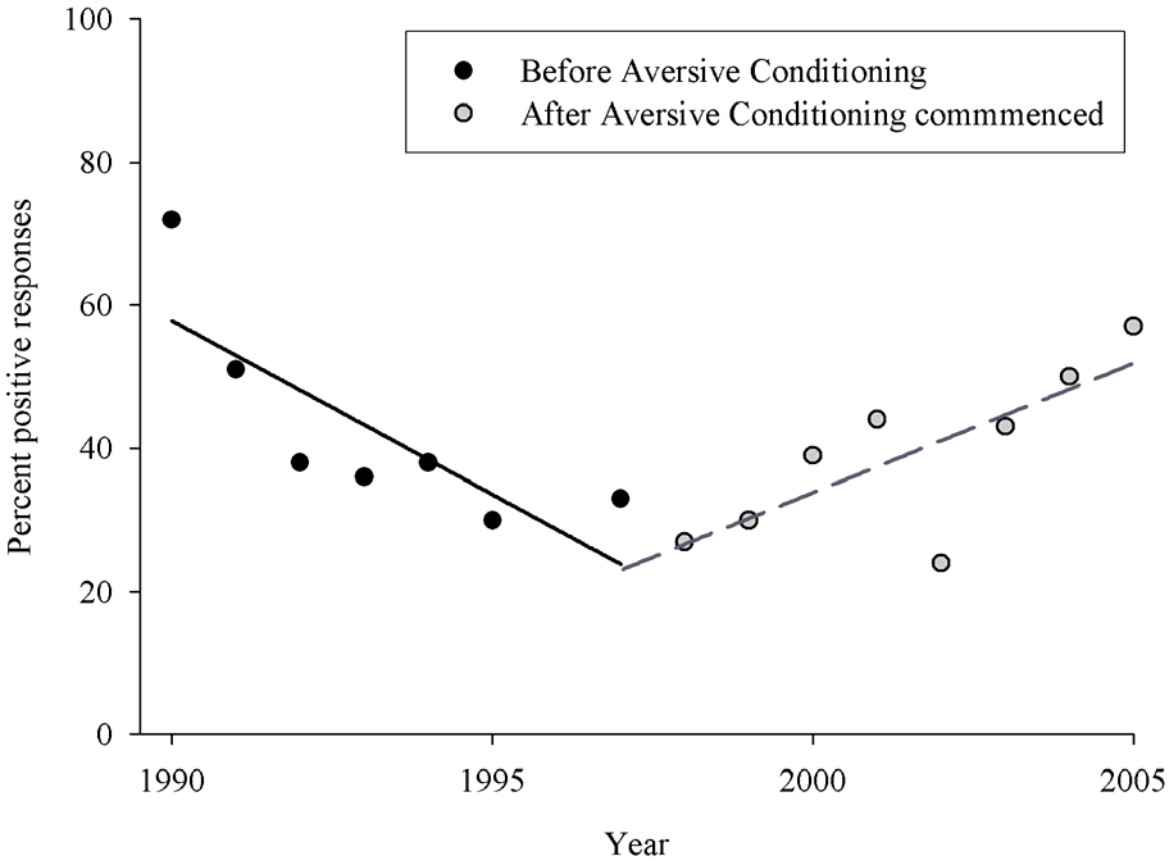

Ninety-one % (10 of 11) of radio-collared grizzly bears subjected to AC returned to developments one or more times after their first conditioning event. Only one bear, GB #81, did not return to a development since her initial conditioning in 2002, despite subsequent radio tracking for four years. Seventy-one % (five of seven) of radio-collared grizzly bears that had been conditioned for multiple years (GB #24, GB #47, GB #48, GB #80, GB #81) avoided developments for periods of up to one year or more after being conditioned.

**Research Question #2: Is it possible to change the response behaviour of grizzly bears to humans using AC techniques?**

Non-collared grizzly bears

Prior to the initiation of AC, bears appeared to be showing signs of habituation as demonstrated by a decrease in the likelihood of a *Positive* response over time on approach by humans. Between 1990 and 1997 the likelihood of *Positive* response behaviour of non-collared grizzly bears decreased from 72% to 30%. Once AC was initiated, *Positive* response behaviour increased from 33% (1998) to 57% (2005). A statistical breakpoint was identified between years 1997 and 1998 (7.3 ± 0.9), essentially the point in time when aversive conditioning commenced in PLPP. The slope of the line before 1997 is negative *(-5.7* responses/ year ± *1.6*), and significantly different from 0 ($t = -3.6$, $df = 11$, $p=0.004$). In contrast, once conditioning began, bears became more wary, as defined by an increase in the likelihood of a *Positive* response to humans. The slope after the onset of conditioning (i.e. after 1997) is positive (9.3 responses/ year ± 2.03; $t = 4.6$, $df = 11$, $p<0.001$) (Fig. 5).

**Figure 5. The change in % *Positive* response to human presence in non-collared grizzly bears in PLPP began to increase after the onset of AC in 1997.**

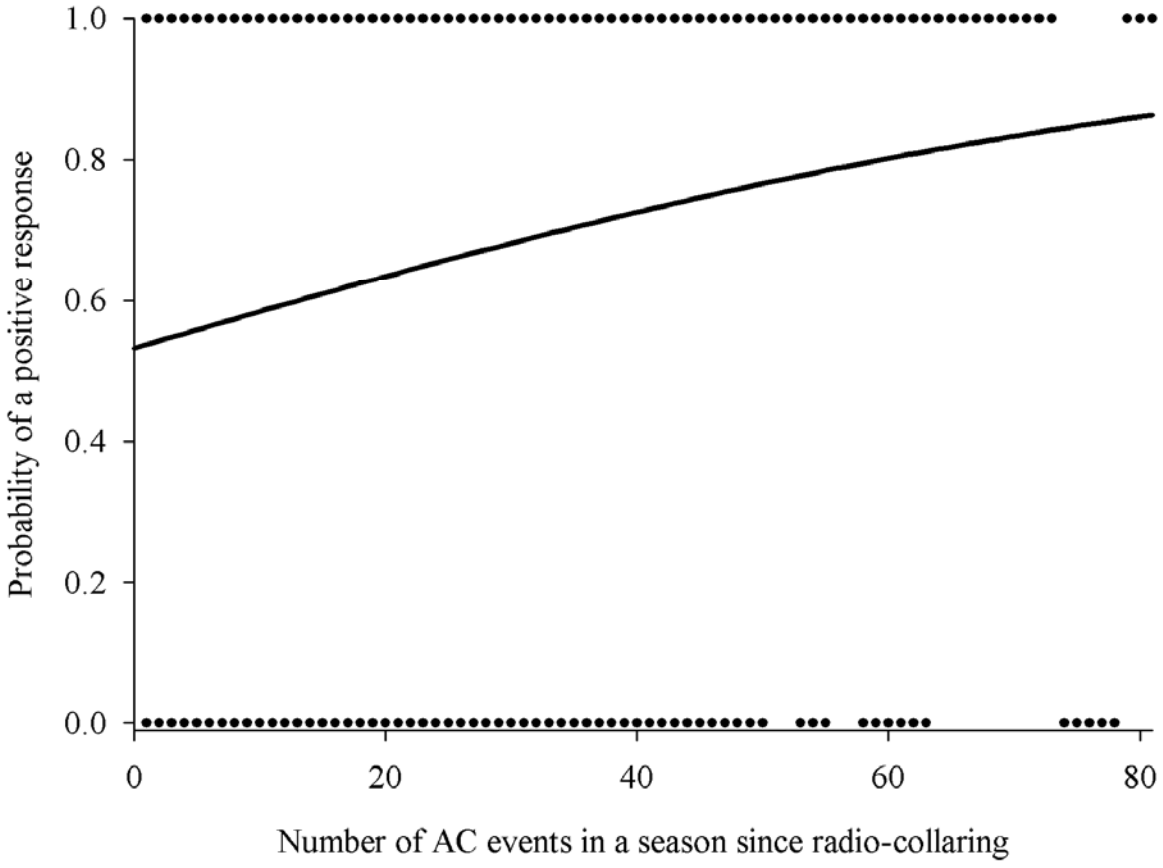



Radio-collared grizzly bears

i) Short-term (seasonally)

The probability of a positive response is 0.5 (n = 10) during the first AC event of the season. After 81 AC events (the maximum that any bear received in one season), the predicted probability of a positive response is 0.9. The likelihood of a *Positive* response increased significantly as exposure to AC events increased (= 1/(1+e^-(0.1+0.02*Number of AC events in a season; $z=4.7$, $p<0.001$) (Fig. 6).

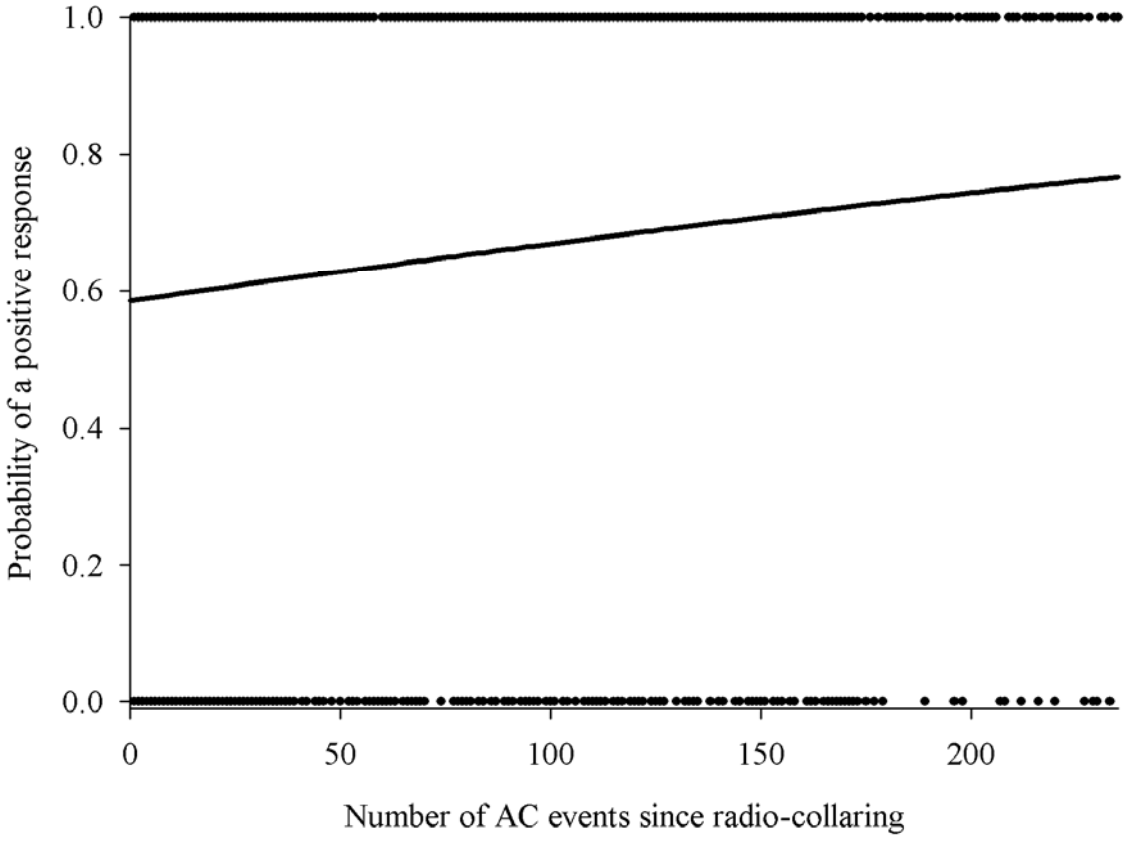
**Figure 6. Probability of *Positive* responses of radio-collared grizzly bears as AC is delivered over a season, 1998 to 2006. (Sample points represent a grizzly bear response to one AC event; Positive (1.0) or Negative (0.0))**




ii) Long-term (annually)

The probability of a positive response is 0.6 (n = 10) at the first AC event. After 235 lifetime AC events (the maximum that any bear received), the predicted probability of a positive response is 0.8. Over multiple years of AC, the likelihood of a Positive response by radio-collared grizzly bears increased significantly as exposure to AC events increased (Fig. 7; z=2.5, p=0.01).

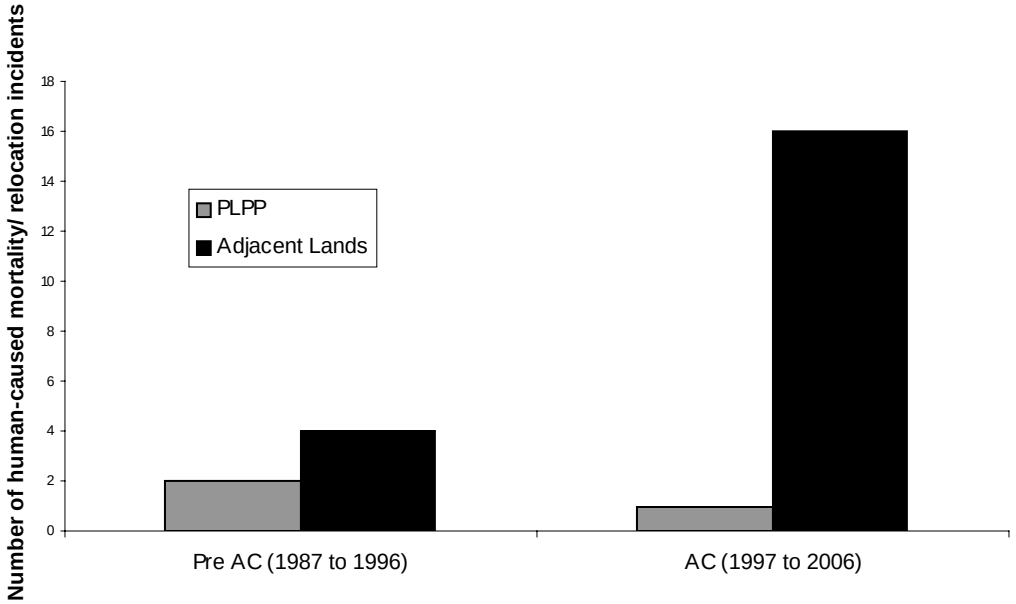
**Figure 7. Probability of *Positive* responses of radio-collared grizzly bears in PLPP after onset of AC (AC), 1997 to 2006 (Sample points represent a grizzly bear response to one AC event; Positive (1.0) or Negative (0.0))**




**Research question #3: Does AC reduce grizzly bear mortality and relocation rates?**

In the decade prior to AC, the number of grizzly-bear mortalities and relocations in PLPP was two. Outside of PLPP, on adjacent lands, mortality and relocations totalled three during the same period. In stark contrast, in the decade following the initiation of AC in PLPP, mortality and relocation rates decreased to one in PLPP, while increasing five-fold, from three to sixteen incidents on adjacent lands (Fig. 8). For a specific breakdown of mortality and relocation incidents refer to Appendix F.

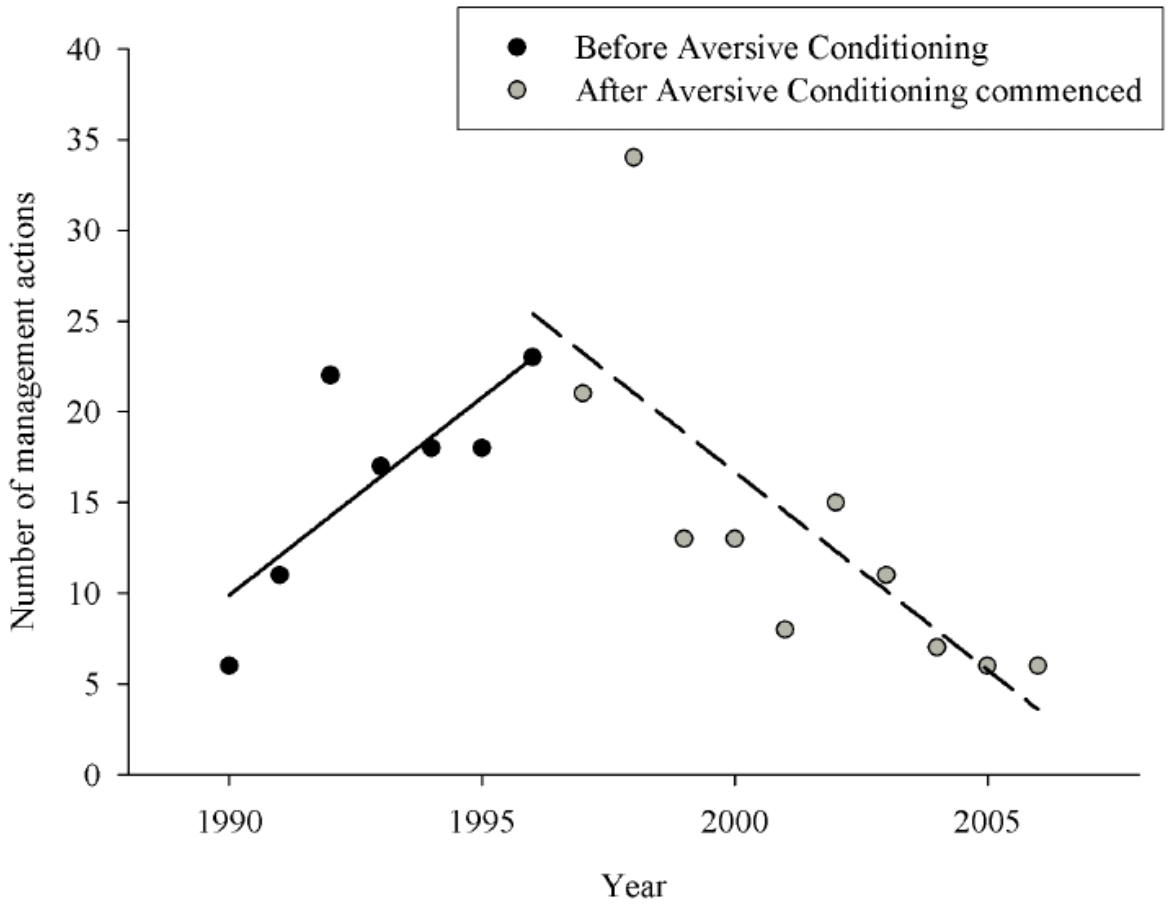
**Figure 8. Human-caused mortalities and relocations in PLPP decreased between pre- AC (1987 to 1996) and AC (AC) (1997 to 2006) while increasing during the same periods in lands adjacent to PLPP.**




**Question #4: Does AC reduce the number of bear management actions (posted closures and warning signs) within facility areas?**

Prior to the initiation of AC, bear related management actions increased from 6 (1990) to 23 (1996). Once AC was initiated, management actions decreased from 21 (1997) to 6 (2006). The trend in frequency of management actions was significant as evidenced by a change in the significance of the slope at 8.3 ± 1.2 years i.e. between 8 and 9, or years 1997 and 1998. The slope of the line before the breakpoint is positive (1.8 management actions/ year ± 0.8), and significantly different from zero ($t = 2.2$, $df = 13$, $p<0.05$), indicating an increase in management actions over time prior to the onset of AC in 1997. The slope after the breakpoint, i.e., after 1997, is negative (–4.2 management actions/ year ± 1.1) and significantly different from zero ($t = –3.9$, $df = 13$, $p< 0.01$), indicating that management actions decreased significantly over time after the onset of AC (Fig. 9).

**Figure 9. Bear-related management actions in PLPP began to decrease after the onset of AC in 1997.**




**Research Question #5: Does the presence of natural food in developed sites change the effectiveness of AC?**

There were more revisits after an AC event during the berry season (Median 18.0) than during the pre-berry season (Median 3.0), though this difference was not significant (Exact Wilcoxon signed rank test, $v = 15$, $p = 0.06$; see Table 1).

**Table 1. The median/ mean number of annual revisits to developments by radio-collared grizzly bear between 1997 to 2006 are greater during the berry season**

| Grizzly Bear | Years Conditioned | Pre-berry Median | Pre-berry Mean | Berry Median | Berry Mean |
|---|---|---|---|---|---|
| 24 | 8 | 0 | 0.125 | 0 | 2.25 |
| 47 | 5 | 0 | 0.8 | 1.0 | 1.4 |
| 48 | 5 | 0 | 0.6 | 11.0 | 9.4 |
| 80 | 4 | 0 | 0 | 0 | 0.25 |
| 94 | 2 | 1.5 | 1.5 | 15.5 | 15.5 |
| Average | | 3.0 | 2.33 | 18.0 | 20.33 |

## Chapter Four: Discussion

### Research Question #1: Do radio-collared grizzly bears use developed sites on unnatural food secure lands more or less frequently after the onset of AC?

Although the decreasing trend in the frequency of developed site use by radio-collared grizzly bears was not statistically significant, from a population perspective (i.e. across bears), it was not an unexpected result. Not all bears are expected to respond to conditioning in the same way (Hunt, 1984; Gillin et al., 1994). Other studies indicate that bears may return even after being conditioned from sites (Stenhouse, 1982; Hunt et al., 1988). On the other hand, five of seven grizzly bears, all female, (GB #24, GB #39, GB #80, GB #81 and GB #94) demonstrated a negative trend in developed site use after experiencing AC. Similar reductions in site use using the application of taste deterrents has also been observed with free ranging polar bears near bait stations (Miller, 1980) and in campgrounds in Yosemite National Park (Hastings et al., 1980).

Given the low reproductive rate of grizzly bears in the Bow River Watershed, and the recognition that habituation of grizzly bears increases mortality risk (Herrero et al. 2005), avoidance of developed sites by five female grizzly bears and their subsequent survival in the population is an indication that the use of AC as a bear management tool can have a positive impact at the population level. The importance of focusing management efforts on preserving female grizzly bears in the population to achieve long-term stability has the support of many bear experts. Herrero (2005) believes that AC of habituated females in the CRE, applied since 1997, has been fundamental in keeping them away from areas where they could get into trouble such as campgrounds and roadsides, thus minimizing their mortality. He speculates that AC is an essential management tool for achieving high survival rates of adult female grizzly bears in developed landscapes with high mortality risk.

In contrast to the five bears who decreased their use of developments, two bears, GB #47 and GB #48, both adult females, increased their use of developments after the onset of AC. GB #47 has not been radio-collared since 2003 but it is believed that she has not frequented the PLPP facilities much since that time; this cannot be confirmed (Hanna Pers. Com., 2007).

According to Gillin et al. (1994), individual variability in bear response to AC depends on a variety of factors. This includes level of habituation, level of food conditioning, sex and age, breeding status, physical condition, natural food availability and whether bears receive unnatural food rewards during conditioning. The intensity of conditioning may also play a role in how bears use developments; intensive conditioning early on could result in bears learning more quickly (Hunt, 2005). A proper analysis of conditioning intensity levels warrants more study.

That conditioning may not work on every bear highlights the importance of evaluating the effectiveness of conditioning work on individual bears on a regular basis. This includes ensuring that proper conditioning techniques are used as consistently as possible. If conditioning is determined to be ineffective on a particular bear, based on excessive site use or improper response behaviour (i.e. aggressiveness to the public or conditioning teams), it may be necessary to implement alternative management options including an intensified conditioning program, facility closures, relocation or destruction. This approach allows AC to be utilized efficiently on those bears that are most likely to respond positively to the conditioning work.

Although the sample size is small, there appears to be a bias in the age class of bears using developed sites in PLPP. Two thirds of the radio-collared grizzly bears using developed sites in PLPP were subadult bears. In addition, their frequency of site use was generally higher than that of adult bears (Appendix 4). This is consistent with previous studies, which have shown that subdominant bears utilize suboptimal habitat at higher rates compared to dominant bears

(Mattson et al., 1987; McLellan & Shackleton, 1988; Gibeau, 2000). Where bear densities are high, they will disperse to areas unoccupied by more dominant bears (Van Horne, 1983). Mueller (2001) and Christian (1970) determined that subadult bears may compete with other grizzly bears or people as a result of this dispersion. Young bears may use developed sites even when subjected to conditioning if dominant bears are present in surrounding areas and local food availability is good (Hunt et al., 1988). Thus, subdominant bears are more vulnerable to habituation (Gunther, 1990), which can lead to high mortality rates (Meagher and Fowler, 1989; Mattson et al., 1992; Pease and Mattson, 1999). Over the last 20 years, subadult mortality and relocation rates within PLPP and lands adjacent to PLPP accounted for 64 % (14 of 22) of known human-caused mortality and relocations (Appendix F).

Temporal biases in how data were collected may have impacted results. Monitoring and conditioning data are biased to daytime hours. Because of this, night time activity at developed sites is currently unknown. If bears are accessing developed sites at night, it could result in "neutral" learning, a situation that can increase a bear's tolerance to developed sites and as a result, people (Hunt, 2003; Smith et al, 2005). This may decrease the effectiveness of an AC program delivered only in the day. The frequency of site use is further complicated by a number of factors in and around PLPP developments. The boundary between developed sites and acceptable areas for bears is not always well defined or obvious from a bear's perspective. Often during a conditioning event, the closest natural hiding cover is located inside developments. This can result in bears entering developments unknowingly or, in the case of conditioning, lingering within the development longer than desired. For these reasons, caution must be used when interpreting developed site use results.

Future analyses need to address weaknesses inherent in this post hoc design analysis. Research questions should be formulated before the collection of data. Secondly, statistical power is lacking. Power depends largely on three things: the size of the effect, sample size, and variability among subjects. Small effect sizes and significant variability among individual bears requires a larger sample to see significant increases in power. A power analysis will help to determine the minimum sample size needed given a certain expected effect size and variance among subjects. It is equally important to have bears monitored long enough for trends to be observable. Ideally, it would be beneficial to have a control group of bears that utilized developed sites for some time prior to being subject to conditioning. For public safety reasons, this may be difficult to achieve.

Further, incorporating GPS tracking technology would be a useful component of future studies as it would provide information on existing data gaps such as locating bears when roadside telemetry cannot, frequency of night time developed site use, and detailed movement routes of bears in and around developments.

**Research Question #2: Is it possible to change the response behaviour of grizzly bears to humans using AC techniques?**

Non-collared grizzly bears

There was a decrease in *Positive* response behaviour of non-collared grizzly bears between 1990 (72 %) and 1998 (29 %). This was followed by a gradual increase in *Positive* responses beginning in 1999 (30 %), shortly after the conditioning program started, continuing to 2005 (57 %) when the last recordings were compiled (Appendix 5). A literature search revealed no studies pertaining to AC of unmarked or non-collared bears. There is, however, a precedent for AC on unmarked Bighorn Sheep (*Ovis canadensis*). AC, carried out in southern Alberta by

Fish and Wildlife Officers using Karelian Bear Dogs, has been effective in reducing highway mortality of Bighorn Sheep (Clarke Pers. Com., 2008).

An explanation for the increase in wariness of non-collared grizzly bears is that over time grizzly bear numbers slowly increased, as did human use levels. The availability of natural foods (buffaloberry) increased in the PLPP facility area due to the increase in soil and vegetation disturbance caused by facility development. Bears adapted to the newly created environment and, thus became more tolerant to foraging near people. As the conditioning program developed further, more resources were dedicated to specific AC work. The improved effectiveness of conditioning non-collared grizzly bears that resulted may have contributed to the gradual increase in *Positive* responses between 1999 and 2005.

Because non-collared grizzly bears cannot be identified individually, it is possible that one bear could weight data in favour of a particular behavioural response type. This possible bias, while not expected to change the result significantly, does reduce confidence in the results. The gradual increase of wary behaviour over time may have occurred even more rapidly had AC been delivered on a more consistent basis during the initial years of the AC program.

Radio-collared Grizzly Bears

Radio-collared grizzly bears became more wary with AC over the short term (seasonally) and long term (annually). These findings are consistent with research carried out under controlled, laboratory-based conditioning experiments, where it has been shown that animals can learn lessons rapidly (Rescoria, 1988, Garcia, 1974). Bears also learn from other bears and are capable of learning from a single experience (Gilbert, 1977). In a field setting, however, studies related to behavioural change on bears using pain stimuli (rubber bullets) have produced mixed

results (Stenhouse and Cattet, 1983; Hunt, 1984; Derocher and Miller, 1986; Dalle-Molle and Van Horne, 1989). Two recent studies, one involving European brown bears (Raul et al, 2003) and another involving black bears in Nevada (Beckmann et al., 2004) concluded that the use of AC was not effective in deterring bears from developed areas. The availability of unnatural foods, an issue in both of the latter studies, likely reduced the effectiveness of AC (Gillin et al. 1994). In contrast to these study areas, PLPP has excellent unnatural food management and bears almost never obtain unnatural food rewards. They do, though, obtain rewards in the form of natural foods that are present in PLPP developed sites. Despite the presence of natural foods, AC was shown to be effective in this case; wariness increased from the beginning of the season at den emergence to the end of the berry season when natural foods are most abundant. Additionally, the number of conditioning events per bear in Europe (Raul et al. 2003) and in Nevada (Beckmann et al. 2004) was relatively low, averaging one to two events per year for one to three years. Radio-collared grizzly bears in PLPP have been monitored and conditioned for longer periods of time, averaging 15 conditioning events per year per bear for one to ten years.

The positive relation between AC and bear wariness in PLPP may also be related to the manner in which the delivery of conditioning was conducted. Animals learn best by punishment conditioning if certain criteria are met including consistent, immediate, intense delivery by a variety of personnel (Domjan, 1996). In this study, once bears were radio-collared they were conditioned whenever they attempted to enter developed sites for periods of up to ten years by a variety of officers and contract staff. The conditioning techniques used were developed over many years of fieldwork by organizations like WRBI with a relatively high level of consistency. The conditioning process was always delivered by yelling first, followed by pain (i.e. bean bags and rubber bullets) and noise stimuli (i.e. cracker shells) and with a dog barking whenever

possible. This is consistent with research that identifies the importance of auditory association with pain related conditioning (Garcia and Koelling, 1966). Varying percentages of annual *Positive* responses occurred; the highest (88 %) occurred in 2001 with three adult radio-collared grizzly bears that had been conditioned for multiple years. The lowest percentage of *Positive* responses occurred in 2004 (57 %) and 2006 (59 %) when there were eight radio-collared grizzly bears that were being conditioned (Appendix E). Both of these years had the greatest number of newly radio-collared grizzly bears, three in each year, all of which were subadults. It is possible that bears received more consistent conditioning in 2001 when there were fewer bears to monitor, and responded more favourably to AC as a result. Bears that receive multiple years of AC may respond better than bears being conditioned in their first year. This suggests that first year AC recipients (subadult bears) may respond differently than multi-year recipients (adult bears), a phenomenon supported by Hunt (1984). Future research could address this aspect.

Also, conditioning teams collected the majority of radio-collared grizzly bear behavioural data; bear behaviour data involving members of the public may not be as well represented. If bears respond differently to conditioning teams compared to the public, as suggested by local officers (Hanna Pers. Com., 2007) and other studies (Stenhouse, 1983; Hunt, 1997), then a particular response behaviour may occur more often with conditioning teams than the public; there are likely to be more *Positive* responses from bears when approached by conditioning teams. If this is the case, bears do seem to still be learning a *Positive* behaviour though possibly with one group of observers (officers) more than another (public). It is not possible to confirm this with the data available.

Missing data identified in the Methodology can be improved by recording behaviour data fields more consistently through time. Uncollared grizzly bears, many of them subadults,

continue to use the PLPP facility area. Radio-collaring more of these bears and tracking them for a longer period of time could increase sample size. This would result in a more even distribution of AC events over time and increase the statistical power of the data analyses.

**Research question #3: Does AC reduce grizzly bear mortality and relocation rates?**

In comparison of pre and post AC periods (10 years each), human-caused grizzly bear mortality and relocations decreased from two to one within PLPP lands. In stark contrast, the number of mortalities and relocations in lands adjacent to PLPP, where AC was employed inconsistently at best, increased five-fold from 3 to 16 during the same time periods. Other studies have shown similar reductions in mortality due to the implementation of AC (Clark et al., 2003) and where AC was part of a larger bear conflict program (Schirokauer & Boyd, 1998). Reducing mortality through the use of AC has also occurred by increasing public awareness on issues of bear-human conflict concerning unnatural foods. In one instance, this has resulted in one group in Nevada acquiring bearproof garbage containers (Beckmann et al., 2004). Securing attractants in this way can reduce the number of incidents of bears obtaining unnatural foods – a factor directly attributed to bear mortality (Benn, 1998).

The nature and management of human use within and outside of protected areas may be an alternate explanation for differences in mortality and relocation rates in the two areas. Incidents that result in human-caused bear mortality or relocation include legal and illegal hunting, self-defence, highway accidents, and management related removals resulting from bears injuring people, livestock depredation, or obtaining unnatural foods such as animal feed and garbage. While many of these types of incidents can and do occur in both protected and non-protected lands, some are more likely to occur outside of protected areas because of the nature of

human land use outside of parks. For example, it is more likely for bears to die from legal hunting and self-defence kills outside of protected areas because it is illegal to hunt or carry firearms in most parks in North America. The chance of bears obtaining unnatural food rewards is likely greater outside of protected areas due to increased availability of unnatural foods such as fruit trees, livestock and pet feed, birdfeeders and the lack of bear proof waste management systems in non-protected lands in contrast to many protected areas where these concerns are not present. The difference in initial mortality and relocation rates may be further explained by the fact that protected areas such as PLPP have systems in place to manage and reduce bear-human conflict These include effective waste management, education and bear reporting programs and in some areas, the presence of an AC program. Even if areas adjacent to PLPP had these systems in place (and many do not) it would still be difficult to manage for other types of mortality that occur outside of protected areas including self-defence kills, illegal hunting, and management removals as a result of livestock depredation.

Even if managing bears and people within PLPP is less complex than on non-protected lands, several factors suggest that mortality and relocation rates in PLPP would have followed a similar, though possibly less dramatic, trend as that which occurred on adjacent lands. There has been an increase in the grizzly bear population in the Bow River Watershed between 1994 and 2002 (Garshelis et al., 2005) along with increases in human use within PLPP over the last 15 years (Alberta Community Development, 2004). In addition, research has shown that subadult male and female grizzly bears, the primary recipients of conditioning in PLPP, are prone to interaction with humans in the Bow River watershed (Mueller, 2001). These factors suggest that an increase in interactions between people and bears would likely occur in PLPP, thus increasing

the potential for conflict and the risk of human-caused mortality or relocation. In fact, mortality and relocation rates have decreased.

This suggests that AC has been a leading cause for the difference in mortality and relocation rates. These differences, a decrease by half in mortality and relocation rates within PLPP compared to a substantial increase in adjacent lands, can have significant population impacts, particularly on a species as slow in reproducing as grizzly bears. These results suggest that the implementation of similar complimentary programs to the ones that exist in PLPP into areas adjacent to PLPP may help to reduce mortality and relocation rates on those lands. In order to further validate these results, it would be beneficial to continue collecting mortality and relocation data as it relates to the overall grizzly bear population estimates and the AC program within the study area and in lands adjacent to PLPP.

**Research Question #4: Does AC reduce the number of bear management actions (posted closures and warning signs) within facility areas?**

Management occurrences increased over time prior to AC commencing, from a low of six occurrences in 1990 to a high of 34 in 1998. Since 1998, there has been a decrease in management actions, from 13 occurrences in 1999 to six in 2005. A literature search revealed no other studies that considered how AC affects the management of facilities, yet the economic benefits of the AC program cannot be ignored.

In the early 1990's, when grizzly bears were rarely seen, facilities were closed when bears were reported to be using an area. This approach in conjunction with a public education program and effective garbage management has reduced bear problems in other protected areas (Martinka, 1974; Herrero, 1976; Meagher, 1980; Hastings et al., 1981). This was considered acceptable at

the time in PLPP as the numbers of closures were rare. As bear activity increased into the mid 1990's so did the frequency of facility closures, which became less acceptable to the public, campground contractors and managers. By the late 1990's, alternate methods of managing bears in facilities were implemented, including using AC to move radio-collared grizzly bears out of developments in a timely fashion. The result was fewer facility closures. As the AC program evolved along with other complementary programs such as public education, attractant removal, and the bear reporting system, more bears were radio-collared and conditioning resources increased, including the use of WRBI and their Karelian Bear Dogs. This allowed bears to remain in the system and facilities to remain open. Since many grizzly bears using developed sites are now radio-collared, their movements have become better understood and more predictable resulting in more effective delivery of AC. The result is an effective process for preventing radio-collared grizzly bears from actually entering developments in the first place and pushing both radio-collared and non-collared grizzly bears out of developments when necessary. Additionally, the sight of conditioning teams in developed sites, complete with KBDs, serves as a reminder to park visitors that bears are nearby. This encourages visitors to adopt "best practices" while in bear country such as reporting bear sightings, securing attractants, making noise, and carrying bear spray while hiking.

As noted earlier, the numbers of bears and people have both increased in the study area. It would not be unreasonable to expect an increase in bear-human interactions as a result, justifying an increase in facility-related management actions. Surprisingly, and perhaps a testament to the shift in the paradigm of bear-management techniques, this has not been the case. The decrease of management actions since the onset of AC suggests, at least in part, success of the conditioning program. That said, there are other factors that may affect the number of facility closures in a

given year. Annual changes in natural food availability will invariably change levels of bear activity within PLPP facilities; berry crop failures in facility areas would likely mean less bear activity in facilities and therefore fewer facility closures. Human-use levels may also vary year to year due to weather conditions; cold rainy weather will often deter park users from visiting. Special events, such as the G8 World Leaders conference in 2002 limited human use in some areas of the Kananaskis Valley. Facilities may close for other reasons, eliminating human use and resulting in an "artificial" reduction in management actions. For one week in August, 2003 the public was prohibited from entering PLPP and other public lands between the Trans Canada Highway and the United States border due to extreme fire hazard. None of the aforementioned factors occur regularly, nor are they typically long in duration. As such, they are not expected to have a large impact on the results.

It would be beneficial to continue collecting data within PLPP regarding closures and warnings and the reasons for them to determine if existing trends continue or not. This may better define the relationship between management action trends and the AC program.

**Research Question #5: Does the presence of natural food in developed sites change the effectiveness of AC?**

Natural food availability (seasonal and long-term) in developed sites likely plays a role in dictating how often bears use developed sites. More than 90 % (10 of 11) of radio-collared grizzly bears revisited a development after being subjected to conditioning from within a developed site. The median/ mean number of annual revisits for radio-collared grizzly bears "within season" was greater during the berry season (18/ 20 revisits) than in the preberry season (3/ 2 revisits). Other studies suggest that bears will return to sites they have been conditioned

from to obtain natural food rewards in the form of carrion (Stenhouse, 1983; Derocher and Miller, 1986), or berries and nuts (Gillin et al., 1994). This suggests that the drive for bears to return to sites to acquire food, even after being conditioned, can be high if the food source is available and deemed important enough. There has been general consensus with people carrying out AC on bears; to conduct it effectively, unnatural attractants must be secured (Hunt 1983, 1985, and 2003). With this in mind, seasonal natural food availability and variation likely play a key role in determining how often and when bears return to developments after AC. If developed sites within the PLPP facility zone had less natural food available to bears, via mechanical removal of buffaloberry, the frequency of site use will likely decrease. Consideration should be given to ensuring there is no net loss of food for bears when removing natural foods from developed sites so that overall population capacity is maintained. This could be achieved by forest thinning projects in secure areas, which can open up forest canopies, and encourage buffaloberry growth.

I defined a revisit as a return to any development regardless of whether it was the developed site where conditioning initially occurred or not. I did not examine how often bears returned to the development in which they were initially conditioned, based on the concept that bears would generalize their avoidance response to avoid any site (Hunt et al, 1988). I suspect that a review of the data to determine whether bears returned to the same developed site they were conditioned out of would likely result in a further decrease in frequency of developed site use relative to the existing analyses. This deserves further study.

It would be helpful to know whether bears are travelling or feeding in developed sites. As discussed earlier, food rewards are an important factor in determining effectiveness of AC. A bear feeding within developments increases the chance of an interaction with the public because

they are typically in the developed sites longer than bears simply travelling through. Existing data do not make this differentiation. The use of technology, in the form of pedometers attached to radio-collars, would identify whether animals stop to feed or are travelling through a site.

The longer bears remain in developments, the longer the reward from natural foods and the greater the chance they could opportunistically access unnatural foods. Bears found feeding on natural foods inside a development may justify closing the facility, or alternatively, removing that particular food source. Removing natural foods would have the added benefit of reducing the amount of natural hiding cover that presently exists in developed sites. A lack of hiding cover may allow bears to better recognize developed site boundaries and move to the closest cover available; outside of the development. Further study is required to determine if this does occur.

## Chapter Five: Conclusion

From the outset, the intent of AC has never been to save each and every bear, but rather to attempt to reduce levels of bear-human conflict to a point where the population of grizzly bears is sustainable. As evidenced by my findings, AC can be an effective means of reducing the visitation rates of individual bears to developed sites and increasing bear wariness in areas where unnatural foods are secured. Increased visitation by bears to developed sites during periods when natural foods are abundant suggests that an integrated program that includes facility closures or the removal of natural attractants from developed sites in combination with an AC program may help to further reduce developed site use from present levels. Increasing wariness and reducing bear-related facility closures has the potential to ensure continued, safe recreational opportunities are available for the public. Low reproductive rates and minimal secure habitat in PLPP suggest that programs that limit human-caused mortality and relocations, such as AC, are beneficial.

Regular, detailed evaluation of AC that measures the effectiveness of all components of the program is essential. Evaluation should not be based on any one component alone; multi-year trends of developed site use and individual bear behaviour change needs to be considered collectively before conditioning is deemed successful or not. An ongoing review of sex and age class data and mortality and relocation rates may shed light on how these factors are affected by a formal conditioning program. A more consistent approach to data collection needs to occur, minimizing the gaps that currently exist in the database. For this to occur, staff need to participate in formal training sessions at the beginning of each season. These sessions would ideally illustrate weaknesses in current data, thereby justifying the need to collect standardized data consistently amongst all field staff. Until complete, these data gaps will reduce the

confidence level of data collected making an accurate evaluation of the conditioning program that much more challenging.

Lastly, AC is meant to be one of several tools that can be used together to effectively manage bear-human conflict. The chances for success are likely reduced if any one tool is used in isolation. The implementation of complementary programs such as attractant management and public education combined with existing conditioning programs will only help ensure bears and people are managed as effectively as possible, bringing us one step closer to realizing the goal of living with bears in a more sustainable fashion.

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## Appendix A: Database Field and Definitions

| | |
|---|---|
| **Bear ID** | Radio-collared grizzly bear (GB #24), |
| | Non-collared grizzly bear, |
| | Bear (bear species unknown), |
| | Unknown (animal species unknown) |
| **Age** | Young of Year (0-1 year), |
| | Subadult (2-5 years), |
| | Adult (6+ years) |
| **Sex** | Male, |
| | Female, |
| | Unknown |
| **Cubs** | Yes, |
| | No |
| **Season** | Preberry (den emergence to July 15), |
| | Berry (July 16 to den up) |
| **Date** | dd/ mm/ yr |
| **Location** | Frontcountry campground, |
| | Day use area, |
| | Road, |
| | Backcountry, |
| | Backcountry campground, |
| | Unknown |

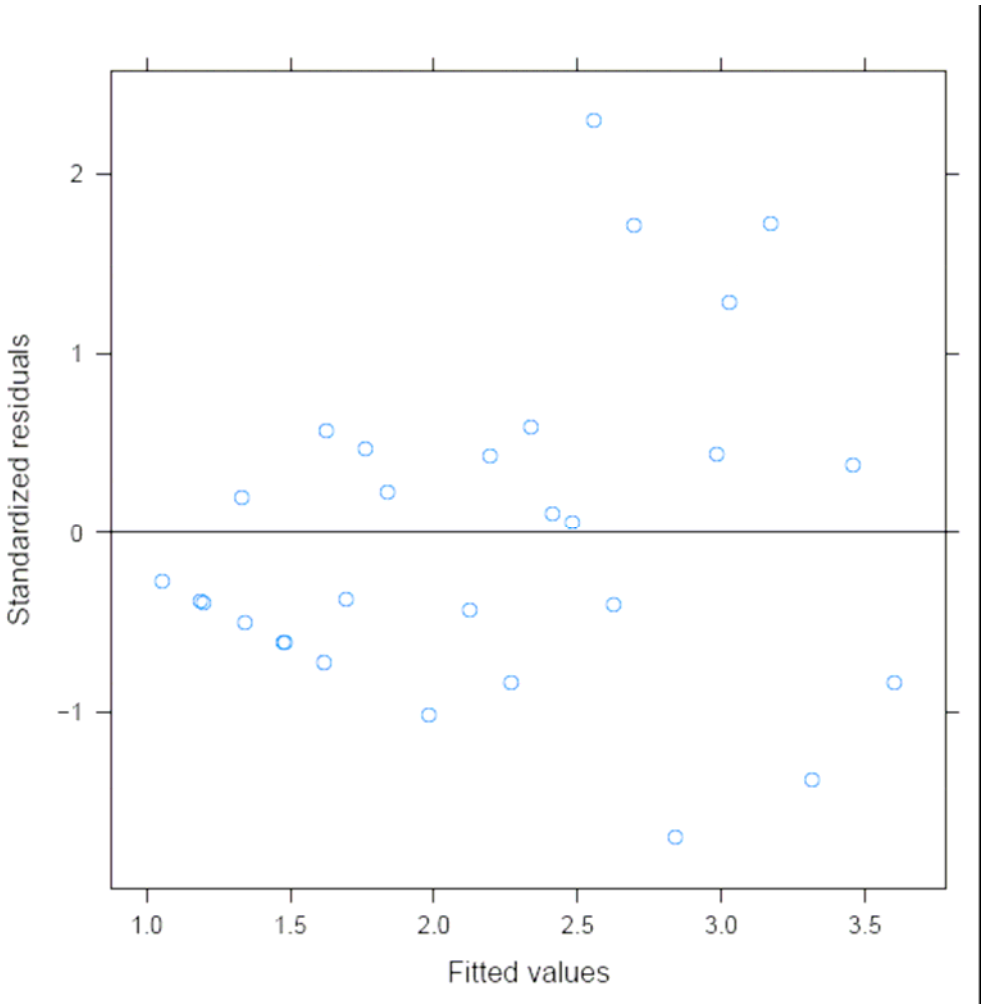
| | |
|---|---|
| **Response Behaviour** | Positive (retreat, retreat to cover),<br>Negative (aware, indifference, close distance),<br>Not applicable (unknown) |
| **AC** | Yes,<br>No |
| **Database** | Specific database where records were originally derived (Wildlife observation, Kananaskis telemetry, AC monitoring, WRBI AC, ENFOR occurrence reporting, Eastern slope grizzly bear project |
| **Comments** | Narrative included in original records |

## Appendix B: Radio-Collard Grizzly Bear Monitoring and AC Summary 1995 - 2006

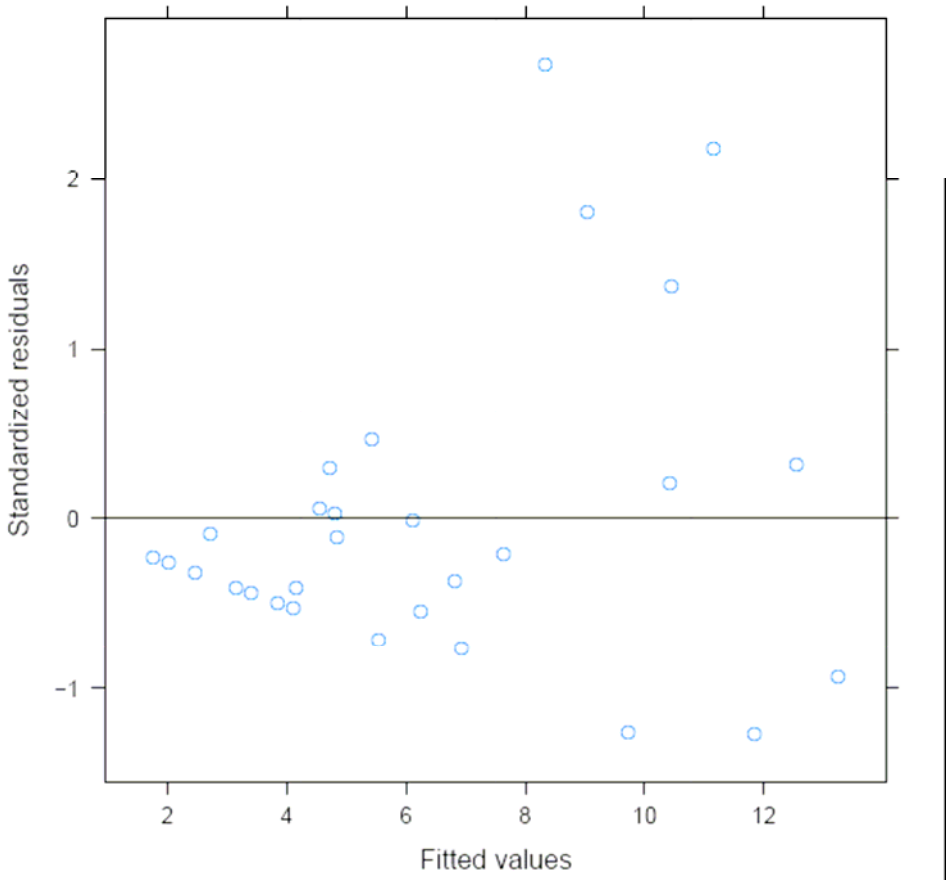
| GB ID | Sex | Age (at onset of AC) | Monitoring start date | Monitoring end date | Years monitored | Years of AC | Total AC Events |
|---|---|---|---|---|---|---|---|
| 24 | Female | Adult | 1995 | 2006 | 13 | 10 | 118 |
| 39 | Female | Subadult | 2005 | 2006 | 2 | 2 | 12 |
| 47 | Female | Adult | 1996 | 2004 | 9 | 4 | 37 |
| 48 | Female | Subadult | 1996/ 2000 | 1997/ 2006 | 8 | 6 | 149 |
| 80 | Female | Adult | 2002 | 2006 | 5 | 5 | 31 |
| 81 | Female | Adult | 2002 | 2006 | 5 | 2 | 2 |
| 94 | Female | Subadult | 2003/ 2006 | 2004/ 2006 | 3 | 3 | 165 |
| 95 | Male | Subadult | 2003 | 2004 | 1* | 1 | 50 |
| 98 | Male | Subadult | 2004 | 2004 | 1 | 1 | 12 |
| 100 | Male | Subadult | 2005 | 2005 | 1 | 1 | 32 |
| 103 | Female | Subadult | 2006 | 2006 | 1 | 1 | 4 |
| 104 | Female | Subadult | 2006 | 2006 | 1 | 1 | 6 |

GB #95 was killed by unknown causes in the spring of 2004. He had received 2 roadside AC actions in early May, 2004 and was not located after that. As a result he is considered to have been monitored for one year only.

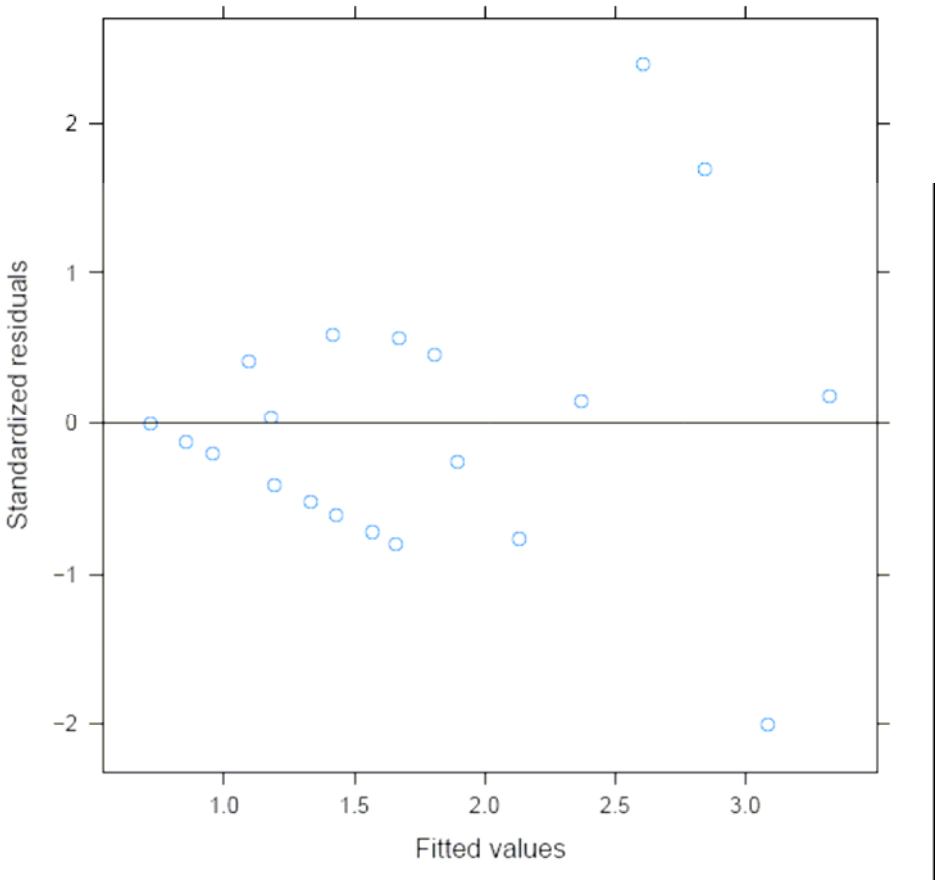
**Appendix C: Radio-collared grizzly bear site use. Methods to assess normality with and without transformed data**



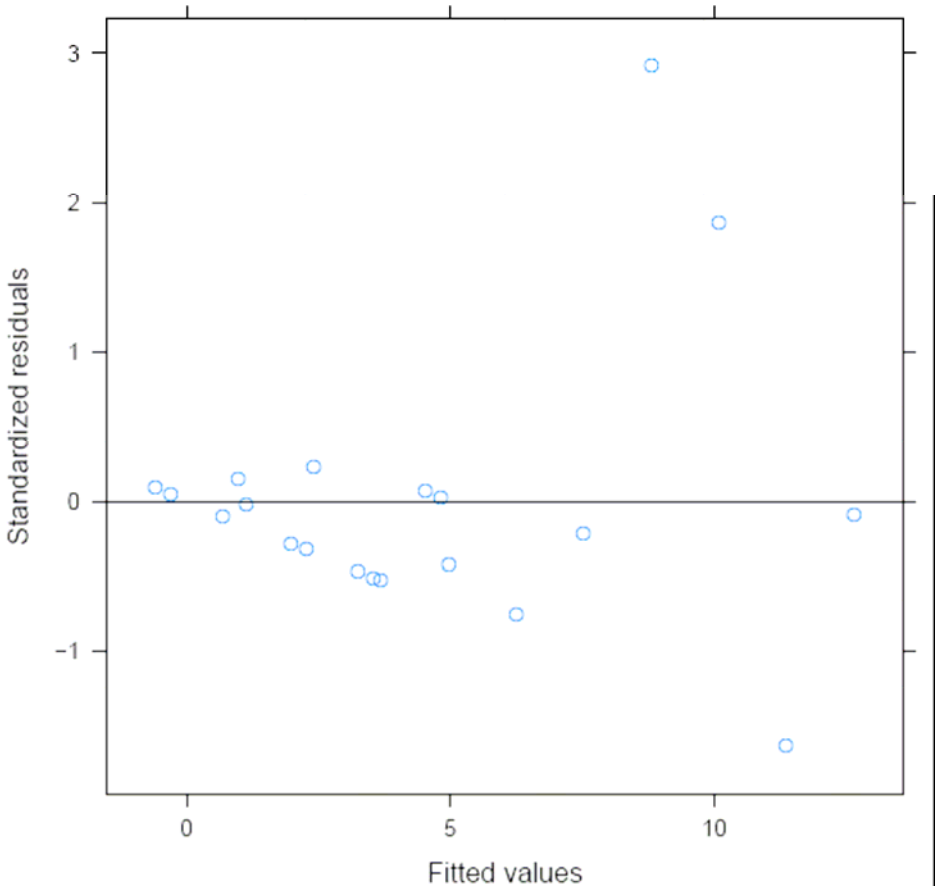

Radio-collared grizzly bear site use (GB #24, GB #47, GB #48, GB #80, GB #81) - residuals from analysis using square-root transformed data.




Radio-collared grizzly bear site use (GB #24, GB #47, GB #48, GB #80, GB #81) - Residuals from analysis using untransformed data.




Radio-collared grizzly bear site use (GB #24, GB #80, GB #81) - Residuals from analysis using square-root transformed data.




Radio-collared grizzly bear site use (GB #24, GB #80, GB #81) - Residuals from analysis using untransformed data.

**Appendix D: Developed site use by sex and age class of radio-collared grizzly bears during first year of AC**

| Grizzly Bear | First year of AC | Number of times in development during first year of AC | Age/ Sex Class |
|---|---|---|---|
| GB #24 | 1997 | 12 | Adult Female |
| GB #47 | 1997 | 2 | Adult Female |
| GB #48 | 2000 | 1 | Subadult Female |
| GB #80 | 2003 | 5 | Adult Female |
| GB #81 | 2002 | 5 | Adult Female |
| GB #94 | 2003 | 25 | Subadult Female |
| GB #95 | 2003 | 19 | Subadult Male |
| GB #98 | 2004 | 11 | Subadult Male |
| GB #100 | 2005 | 35 | Subadult Male |
| GB #39 | 2005 | 2 | Subadult Female |
| GB #103 | 2006 | 1 | Subadult Female |
| GB #104 | 2006 | 4 | Subadult Female |

## Appendix E: Grizzly bear percent Positive responses - 1997 – 2005

Non-collared

| | Negative | Positive | Total | % Positive |
|---|---|---|---|---|
| 1990 | 21 | 55 | 76 | 72 |
| 1991 | 66 | 69 | 139 | 51 |
| 1992 | 214 | 133 | 347 | 38 |
| 1993 | 228 | 130 | 358 | 36 |
| 1994 | 86 | 53 | 139 | 38 |
| 1995 | 115 | 50 | 165 | 30 |
| 1997 | 63 | 35 | 98 | 36 |
| 1998 | 131 | 53 | 184 | 29 |
| 1999 | 166 | 73 | 239 | 30 |
| 2000 | 111 | 76 | 187 | 41 |
| 2001 | 67 | 62 | 129 | 48 |
| 2002 | 63 | 21 | 84 | 25 |
| 2003 | 75 | 62 | 137 | 45 |
| 2004 | 57 | 56 | 113 | 50 |
| 2005 | 89 | 119 | 208 | 57 |
| Totals | 822 | 557 | 1379 | |

Radio-collared

| | Negative | Positive | Total | % Positive |
|---|---|---|---|---|
| 1997 | 19 | 23 | 42 | 55 |
| 1998 | 7 | 6 | 13 | 46 |
| 1999 | 14 | 14 | 28 | 50 |
| 2000 | 26 | 61 | 87 | 70 |
| 2001 | 3 | 22 | 25 | 88 |
| 2002 | 10 | 22 | 32 | 69 |
| 2003 | 68 | 125 | 193 | 65 |
| 2004 | 23 | 30 | 53 | 57 |
| 2005 | 51 | 120 | 171 | 70 |
| Totals | 221 | 423 | 644 | |

## Appendix F: Human-caused grizzly bear mortality by age and sex class within PLPP and lands adjacent to PLPP

**Human-caused grizzly bear mortality 1987 - 2006**

*PLPP Lands*

| | Bear ID | Sex | Age | Year | Mortality type | Relocation |
|---|---|---|---|---|---|---|
| **Pre AC** | Unknown | M | Sa | 1992 | N/a | Kakwa |
| **(1987 – 1996)** | Research #19 | M | Ad | 1994 | Accidental | n/a |
| | | | | | | |
| **AC** | Unknown | M | Sa | 1997 | Management | n/a |
| **(1997 – 2006)** | | | | | | |

*Land adjacent to PLPP*

| | Bear ID | Sex | Age | Year | Mortality type | Relocation |
|---|---|---|---|---|---|---|
| **Pre AC** | AFWS #21055 | M | Sa | 1993 | Conflict | n/a |
| **(1987 – 1996)** | AFWS #25161 | M | Sa | 1994 | Illegal hunt | n/a |
| | Research #21 | M | Sa | 1995 | Conflict | n/a |
| | | | | | | |
| **AC** | Research #35 | F | Sa | 1997 | Treaty Indian | n/a |
| **(1997 – 2006)** | Unknown | F | Ad | 1998 | Highway | n/a |
| | Unknown | M | Sa | 1999 | Electrocution | n/a |
| | Research #26 | F | Ad | 1999 | Self defence | n/a |
| | AFWS #42771 | F | Sa | 1999 | Treaty Indian | n/a |
| | AFWS | F | Ad | 2000 | Conflict | n/a |
| | Unknown | F | Ad | 2001 | Conflict | n/a |
| | AFWS #50495 | M | Sa | 2002 | Treaty Indian | n/a |
| | Research #68 | M | Ad | 2002 | Treaty Indian | n/a |
| | BNP | F | Sa | 2002 | Accidental | n/a |
| | Research #82 | M | Sa | 2002 | Accidental | n/a |
| | Research #69 | F | Sa | 2002 | Treaty Indian | n/a |
| | Research #97 | M | Sa | 2003 | N/a | Spray Lakes |
| | Research #70 | F | Ad | 2004 | N/a | Kakwa |
| | Research #100 | M | Sa | 2006 | Legal hunt | n/a |
| | Research #79 | M | Ad | 2006 | Legal hunt | n/a |

M – Male
F – Female
Adult (Ad) - > 5 years old
Subadult (Sa) – post independence from mother to 5 years old
Young of Year (YOY) – still with mother
(Garshelis et al, 2005)