QUANTIFYING BEAR POPULATIONS AND BEAR-HUMAN CONFLICTS USING NON-INVASIVE GENETIC SAMPLING IN THE KENNICOTT VALLEY OF WRANGELL-ST. ELIAS NATIONAL PARK & PRESERVE, ALASKA

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AUTHORIZATION TO SUBMIT THESIS

This thesis of James M. Wilder, submitted for the degree of Master of Science with a major in Wildlife Resources and titled “Quantifying bear populations and bear-human conflicts using non-invasive genetic sampling in the Kennicott valley of Wrangell-St. Elias National Park & Preserve, Alaska” has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

Alaska's Wrangell-St. Elias National Park & Preserve (WRST) is expecting great increases in visitation in the near future. To help accommodate visitors, the National Park Service (NPS) is developing the Kennicott Valley as a tourist destination, and plans to build a campground there. While bear-human conflicts have been common-place in the Kennicott Valley over the years, no bear study had ever been conducted in the park. This study was initiated to quantify the nature of bear-human conflicts in the valley, describe the resident bear population, and generate management recommendations to reduce the occurrence of bear-human conflicts.

We used non-invasive genetic sampling to obtain an estimate of the minimum number of black and brown bears in the valley, their distribution, and sex ratios. We also used genetic analysis on shed hair to identify individual bears involved in bear-human conflicts. Questionnaires and interviews were used to quantify and describe the nature of the bear-human conflicts.

A total of 92 bears were identified; 84 black (*Ursus americanus*) and 8 brown (*U. arctos*). Seventeen individual bears (18.5% of the total) were genetically identified as being involved in bear-human conflicts. Overall sex ratios (% male:female) for the bear population and conflict bears were 60:40 and 75:25, respectively. Local residents were responsible for 80% of reported conflicts, which were primarily caused by the widespread availability of garbage and human food. The Kennicott valley may serve as a population sink for local bear populations, particularly brown bears, due to the high quality of its natural food resources (*Shepherdia canadensis*) and human-induced mortality of bears.

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Introduction

Wrangell-St. Elias National Park and Preserve (WRST) is one of only four National Park Service (NPS) units of sixteen in Alaska accessible by the state road system. Conflicts over the loss of big-game hunting rights and visitor use issues played a major role in establishing the administrative boundaries of the park and remain a high priority resource management concern (Wright 1984). The focus of these conflicts in WRST is the McCarthy Road, a 100 km route connecting Chitina and McCarthy in the Chitina River Valley. The gravel road is a state owned right-of-way (former railroad) and passes through state, private, Ahtna Native Corporation and NPS lands. The road serves residents along the corridor and provides access for visitors to the historic communities of McCarthy and Kennecott and the park interior. Visitor services and interpretive facilities along the road are limited and maintenance problems abound. As a result, the state, in conjunction with the NPS, developed a Scenic Corridor Plan that outlines facilities and road improvements necessary to increase safety and better accommodate visitors (Alaska Department of Transportation and Public Facilities, 1997).

WRST is experiencing rapidly increasing development and visitation along the McCarthy Road and in the McCarthy-Kennecott area. The 100-bed Copper River Princess Wilderness Lodge hotel opened outside of Copper Center, near the park headquarters, in the summer of 2002. As part of the network of Princess Hotels in Alaska and their network of tours, it will greatly facilitate tourism within the park. The NPS also acquired the majority of the historic Kennecott Mill Site in the summer of 1998. As a result of these changes, the McCarthy-Kennecott area has become the focal point of road improvements, increased tourist traffic, new facilities designed to accommodate Park visitors, new residences, and private land developments. These factors have a strong potential to negatively affect the resident bear populations and to dramatically increase bear-human conflicts in the area.

The McCarthy Road, unlike the carefully controlled road through Denali National Park (Yost and Wright 2001), permits unrestricted resident and visitor access and activity. The park owns only about 52% of the land adjacent to the corridor, and thus has a limited ability to control or guide land uses (Alaska Department of Transportation and Public Facilities 2000). Littlejohn's (1996) survey found that almost 60% of WRST visitors visited the McCarthy area and almost all of them used the McCarthy Road to get there. Touring the Kennecott Mine Site is a popular visitor activity and providing visitor services in this area has long been a park priority because of its popularity (NPS 1996). Most visitors come to McCarthy-Kennecott from June-August. The current recreational opportunities for park visitors are primarily self-initiated wilderness-oriented activities along existing roads and in the backcountry. The area surrounding the McCarthy-Kennecott valley is the most popular with the park's backcountry users. Visitors can reach the area independently for sightseeing, camping, hiking, hunting, fishing, or they can use a guide for these same activities (NPS 1999b).

Reported conflicts between humans and black (*Ursus americanus*) and brown (*U. arctos*) bears have been increasing and are now a major resource management concern of the park (Carl D. Mitchell, pers. comm.). Dozens of bears, both black and brown, have been killed in the vicinity of McCarthy over the last 15 years, presumably in "defense of life and property" (DLP) (WRST files). Management problems are compounded by a lack of information on the behavior, abundance, ecology, and distribution of bears in the area. To date, there have been no studies of either black or brown bears in Wrangell-St. Elias National Park. This makes it difficult to mitigate or eliminate some of the potential conflicts between bears and human developments. Such information is needed to help the NPS better focus bear education for visitors and residents, and plan where to locate campsites or trash transfer stations to limit the potential for conflicts.

This study was initiated in 2000 by the National Park Service (NPS) in anticipation of the construction of a campground at the end of the McCarthy Road. The location of the proposed campground had been the site of unofficial camping for as long as the park had been in existence. Bear-human conflicts were reportedly increasing at this site for several years leading up to 1999, both in number and in their potential to result in serious human injury and property damage (WRST records). Many bears were also reportedly being killed in "defense of life and property" in the Kennicott Valley. As a result, the NPS commissioned this study to determine the quantity and nature of the bear-human conflicts in the area, and to develop management recommendations to mitigate their causes.

Hypotheses and Objectives

The main hypotheses of this study were:

H1: There is a relationship between visitation and bear-human conflicts
- P1: Conflicts will increase as relative numbers of visitors increase
- P2: The number of conflicts will spike in August

H2: Bear-human conflicts are associated with certain habitat types
- P1: *Shepherdia canadensis* habitat will be positively correlated with conflicts
- P2: Conflicts will be positively correlated with human developments

H3: Bears involved in conflicts are members of specific sex/age/species cohorts
- P1: Most bears involved with conflicts are young subadult males or females with cubs
- P2: Black bears are responsible for more conflicts than are grizzly bears

reside in the valley year round, with perhaps three times that number in summer. The area around McCarthy is comprised of both national park (which is open to subsistence hunting) and national preserve lands (which are open to both subsistence and sport hunting).

The study area is bounded by Fireweed Mountain on the West, Donoho Peak to the North, Bonanza Ridge and Porphyry Mountain to the East, and the Nizina River to the South. It encompasses about 315 square kilometers (121 square miles) of diverse terrain. Elevations range from 460 to 1980 meters (1500 to 6500 feet) (Figure I.2).

McCarthy often records temperatures of minus 40 degress Celsius (minus 40 degrees Fahrenheit) or lower in the winter and temperatures can reach 32 degrees Celsuis (90 degrees Farenheit) in summer. Precipitation ranges from 28 to 36 centimeters (11 to 14 inches) a year (Hunt 1996). Steep mountains, massive glaciers, extensive forests of black (*Picea mariana*) and white (*P. glauca*) spruce, and several creeks and rivers characterize the study area. Early successional plant communities are prevalent along the edge of the Kennicott Glacier and along the Kennicott and Nizina rivers which flow through the area. Plant communities of the mountainous areas gradually change from forested to subalpine to alpine as elevation increases.

The primary objectives of this study were:

1. To estimate the minimum number of bears of each species in the study area, their distribution and seasonal habitat use, the general spatial/temporal trend of habitat use, and sex ratios.
2. To document the types of bear-human conflicts in the study area.
3. To describe the biological factors which bring bears into conflicts with humans.
4. To suggest methods to minimize or avoid bear-human conflicts in the study area and recommend ways to eliminate/mitigate conditions that have a high potential to cause bear-human conflicts.
5. To assess how increased visitor use will affect bear habitat use and bear-human conflicts.
6. To create a bear-human conflict GIS database for the McCarthy-Kennecott area.

Study Area

The 5.3 million hectare (13.2 million acre) Wrangell-St. Elias National Park and Preserve was created by the Alaska National Interest Lands Conservation Act of 1980 (ANILCA). WRST is one of four contiguous conservation units (including Kluane National Park, Glacier Bay National Park, and the Tatshenshini-Alsek Provincial Park) spanning approximately 9.7 million hectares (24 million acres) in Alaska and Canada that are recognized by the United Nations as an International World Heritage Site. Altogether it is the largest internationally protected area in the world (Hunt 1996).

The study area for this project is roughly in the center of WRST between the Wrangell and Chugach mountains and is centered on the small community of McCarthy and the abandoned mining town of Kennecott (Figure I.1). Approximately 35 people

Figure I.1. Location Map

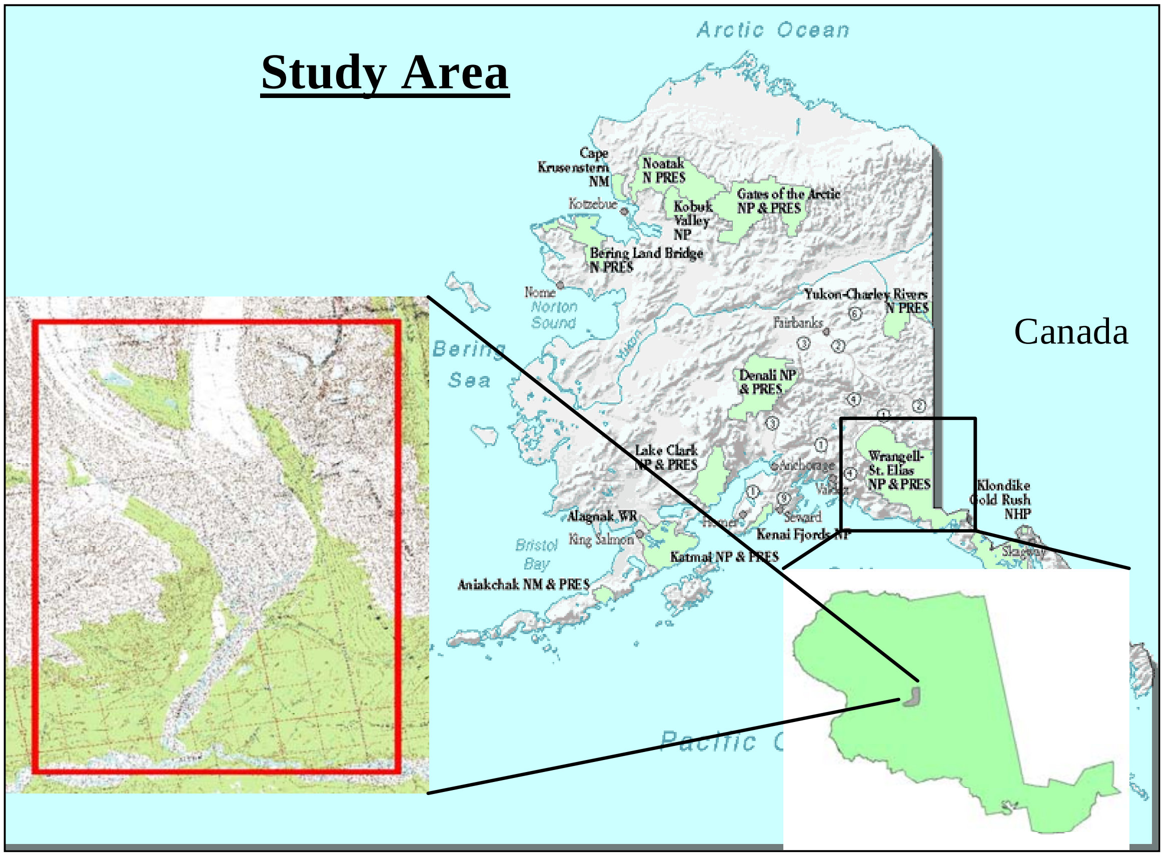


Figure I.2. Study Area Map

Table I.1. Hunter harvest of black bears for calendar years 1990-2000, Game Management Unit 11, Alaska [Modified from Tobey (1996) and Scotton (1999)].

Year	Male	Female	Unknown	Total
1990	10	3	0	13
1991	10	6	3	19
1992	7	3	1	11
1993	8	1	0	9
1994	14	4	0	18
1995	11	4	0	15
1996	11	2	0	13
1997	12	4	0	16
1998*	5	0	7	12
1999**	?	?	5	?
2000	5	4	0	9
Total 1990-1997	83	27	4	114
Avg. 1990-1997	10.4	3.4	0.5	14.3
% of total harvest (90-97)	73%	24%	3%	100%

* Sex ratio for spring only

** Spring only, sex ratio unknown

Table I.2. Hunter harvest of brown bears for calendar years 1992-1997, and by decade for 1960-1990, Game Management Unit 11, Alaska [Modified from Miller (1993), Tobey (1998) and Tobey (1999)].

Year	Male	Female	Unknown	Total
1992	4	1	0	5
1993	3	1	0	4
1994	2	4	0	6
1995	2	2	0	4
1996	1	1	0	2
1997	2	0	0	2
Total 1992-1997	14	9	0	23
% of total harvest (92-97)	61%	39%	0%	100%
Avg./year 1960's				12.4
Avg./year 1970's				16.4
Avg./year 1980's				7.6
Avg./year 1992-1997	2.3	1.5	0	3.8

The Kennicott valley lies within the State of Alaska Game Management Unit (GMU) 11. This unit covers an area of 33,080 km^2 (12,769 mi^2) and had an estimated total population of 547 brown bears in 1993 (Miller 1993). Although the harvest of black and brown bears in Unit 11 is minimal and the population is essentially unharvested (Table I.1 and Table I.2), the Kennicott valley bear population is heavily affected by human-induced mortality. Most hunter harvest in GMU 11 is by non-local hunters (Alaska Department of Fish and Game).

CHAPTER 1: QUANTIFYING BEAR POPULATIONS AND THE 'SOAPBERRY (*Shepherdia canadensis*) EFFECT' USING NON-INVASIVE GENETIC SAMPLING IN THE KENNICOTT VALLEY OF WRANGELL-ST. ELIAS NATIONAL PARK & PRESERVE, ALASKA

By James M. Wilder

Introduction

Until recently, rigorous population studies of bears in forested habitat could only be accomplished with radio telemetry (Kendall et al. 1997). Such studies usually entail intensive trapping, immobilization, handling, tagging, and frequent aerial radio tracking of bears. The presence of marked and collared bears and frequent overflights can detract from park visitors' wilderness experience (Kendall et al. 1997) and has led to conflicts over the research program at Denali National Park (Gerry Wright, pers. comm.). Radio-telemetry studies typically involve handling large numbers of bears, are quite expensive (Garshelis 1993), often involve long-term commitments, and may not produce accurate estimates of population parameters (Kendall et al. 1997). Population studies that rely on intensive and repeated physical capture may violate the basic population modeling assumption of equal catchability by inducing behavioral responses in bears to traps (Garshelis 1993), and bears occasionally die during the handling process. Recent advances in genetic techniques that allow the extraction and analysis of DNA from hair follicles and other tissue now provide a less intrusive alternative to acquire population data by providing genetic "tags" for individuals (Kendall et al. 1997).

DNA is found in two forms in mammalian cells: mitochondrial DNA (mtDNA) and nuclear DNA (nDNA). Mammals inherit their mtDNA from their mothers and their nDNA from both parents. Mitochondrial DNA is routinely used to determine species and maternal lineage (Woods and Strobeck 2000, Cronin et al. 1991). Nuclear DNA is required to identify individuals (DNA "fingerprinting"), paternity (Craighead et al. 1995), degree of heterozygosity (Paetkau et al. 1995, Strobeck and Paetkau 1994), and sex

(Amstrup et al. 1993, Hendrick and Miller 1992). Estimates of male reproductive success are also possible through DNA fingerprinting (Craighead et al. 1995). An individual's DNA fingerprint remains unchanged throughout its life, and once determined, permits positive identification of the individual in any future sample (Woods and Strobeck 2000).

Concerns with Genetic Analysis

DNA-based population studies are not without their limitations. Genetic errors can have serious effects on such metrics as genetic diversity, population structure, individual identification for population size estimation, and assessing relatedness and kinship (Taberlet et al. 1999, Waits and Leberg 2000). Paetkau (2003) described two types of genetic error that can compromise DNA-based population censuses. These are the creation of spurious individuals (scoring errors and genotyping errors) and the failure to resolve individuals (inadequate genotypes).

The rate of scoring errors depends heavily on the training, experience, and care of the person doing the scoring, and can easily be high enough to introduce considerable error into a project (Paetkau 2003). Genotyping errors (allelic dropout, 'false alleles') arise when only small sources of DNA are available, or when contaminant DNA is amplified (Miller et al. 2002). DNA extracted from hair is often at low concentrations or highly fragmented which greatly increases the probability of genotyping error (Miller et al. 2002). Amplification of this material could result in failure to amplify one allele (allelic dropout) in heterozygotes (Goossens et al. 1998, Woods et al. 1999). The failure to detect one allele of a true heterozygote can cause a locus to be misidentified as a homozygote (Goossens et al. 1998, Taberlet et al. 1999). Allelic dropout can reduce the observed heterozygosity of a population and increase the number of individuals detected

(Taberlet et al. 1999). Allelic dropout is the most common and serious genotyping error, as it is the hardest to prevent or identify (Gagneux et al. 1997, Miller et al. 2002).

Table 1.1. Definitions of genetic terms.

Microsatellite	-	Highly variable, non-coding regions of nDNA from which individual genotypes are determined.
Allele	-	One of the different forms of a specific gene that can exist at a single locus.
Locus	-	The specific location of a gene on a chromosome.

Another kind of genotyping error of concern is the production of amplification artifacts that can be misinterpreted as true alleles (Taberlet et al. 1999). If a "false allele" is generated at a homozygous locus, then the individual could be incorrectly recorded as a heterozygote (Taberlet et al. 1999). If it occurs in a heterozygote, than the presence of three ‘alleles’ should allow the detection of the error (Taberlet et al. 1996). Although these types of error occur in less than 5% of PCR’s, they may lead to erroneous genotyping and cannot be ignored (Goossens et al. 1998, Taberlet et al. 1996).

Individual genotyping using noninvasive genetic sampling can lead to a novel problem called the “shadow effect” where different individuals have identical genotypes at the limited number of loci examined (Mills et al. 2000). This results in a failure to resolve individuals. Close relatives contribute disproportionately to individual resolution problems, and must be taken into account (Paetkau 2003). One measure of the shadow effect is the probability of identity (PI). PI is defined as the probability that two animals drawn at random from a population would have genotypes which are indistinguishable from each other (Mills et al. 2000). Generally, the criteria used for accepting that two samples came from the same individual is the probability of confusing two related individuals as described in Woods et al. (1999). The largest PI values occur when genetic variation is low, and the number of animals sharing a genotype probably increases as genetic drift, inbreeding, or philopatry increases (Mills et al. 2000). The estimated PI of unrelated individuals for Kluane National Park's brown bear population (observed heterozygosity of 79% based on 8 specific loci) is approximately 1:390,000,000 (Paetkau et al. 1998), which should be similar to WRST's. By comparison, the less genetically diverse brown bears of Kodiak Island (observed heterozygosity of approximately 30%) have an estimated PI of 1:101 (Paetkau et al. 1998).

The shadow effect can be minimized by increasing the number of individual loci sampled (Mills et al. 2000). With seven independent loci or more, the PI becomes very small and problems associated with the shadow effect are likely to be minimized (Mills et al. 2000). The shadow effect will tend to negatively bias population estimates, and positively bias survival estimates because the mortality of an individual could be disguised by its surviving "shadow" (Mills et al. 2000).

In a population with little genetic variation, increasing the number of loci analyzed can increase the chances of obtaining a unique fingerprint for an individual (Woods et al. 1999). Additionally, the greater the number of alleles per locus, the better the resolution of the individual DNA fingerprint (Woods and Strobeck 2000). However, the probability of observing a genotyping error in a multilocus genotype will increase as the number of loci analyzed increases (Waits et al. 2001). Therefore, some reasonable balance must be sought between the benefits of diminishing the shadow effect and the dangers of increasing genotyping error by increasing the number of loci examined.

Another source of potential genotyping error in DNA-based population censuses are mixed samples, where hairs from more than one individual are contained in the same sample. However, this problem is of minimal importance with diverse populations when looking at more than three loci because it is likely to be detected by observing three or more alleles at a single locus.

Field biologists can help to lower genotyping errors by improving the quality of the samples they submit to the lab. This can be accomplished by collecting samples as soon after the animal leaves them as possible and by employing sound methods of dry sample storage (i.e., storing samples in airtight containers of silica desiccant) after sample collection (Taberlet et al. 1999, Roon et al. 2003).

Paetkau (2003) recommends that biologists intending to use noninvasive genetic sampling should develop sufficient expertise in genetic techniques to understand the lab protocols to be used, and should discuss points of protocol in detail with the lab that will process the samples. It is essential for field biologists to scrutinize the data returned to them from the lab for possible errors. Error rates can be evaluated by including samples from known individuals with samples submitted to the lab for analysis (Woods et al. 1999). While some errors will evade even the most careful scrutiny of results, genotyping errors should be near zero if due care and rigorous lab protocols are followed (Paetkau 2003).

Concerns with Non-invasive Genetic Sampling

Some disadvantages of using noninvasive DNA-based methods include the relatively high cost of sample processing and analysis and the limited availability of facilities and expertise to perform the analyses. An important consideration when using this method is that it does not yield important demographic data such as age structure and individual health/reproductive condition that can be obtained using conventional methods (Schwartz et al. 1998). Additionally, the quantities of DNA obtained with noninvasive genetic sampling may not be large enough for more than one genetic study. Little, if any, DNA may remain for future analysis (Taberlet et al. 1999).

Bears are unlikely to be randomly sampled based on age or sex using only hair traps (Mowat and Strobeck 2000, Kendall et al. 2002). Mace and Waller (1997) tested capture biases of grizzly bears using baited camera stations and found that adult males had the highest capture probabilities and females with cubs the lowest. Mowat and Strobeck (2000) suggested the same biases occurred in their hair trap data. This is more likely due to movement patterns, social dominance, and cohort-specific behavior rather than to sampling biases of the hair sampling technique itself (Mowat and Strobeck 2000, Kendall et al. 2002). In addition, a population census using scent lures may be biased by potentially luring bears to trap sites from outside the study area. However, hair traps are logistically easier to use than traditional trapping procedures, they allow more than one animal to be caught per trap, do not need to be checked as often, require less training of personnel, and eliminate the loss of animal ‘tags’ (Kendall et al. 2002). Non-invasive genetic sampling has been used in numerous studies of black bears (Paetkau 2003) and brown bears (Woods et al. 1999, Mowat and Strobeck 2000, Poole et al. 2001, Boulanger et al. 2002, Kendall et al. 2002).

The three main objectives covered in this chapter are: 1) to estimate the minimum number of bears of each species in the study area, their distribution and seasonal habitat use, the general spatial/temporal trend of habitat use, and sex ratios; 2) to document the biological characteristics of individual black and brown bears involved in conflicts with humans; and 3) to assess hair trapping field techniques.

Methods

Non-Invasive Genetic Sampling

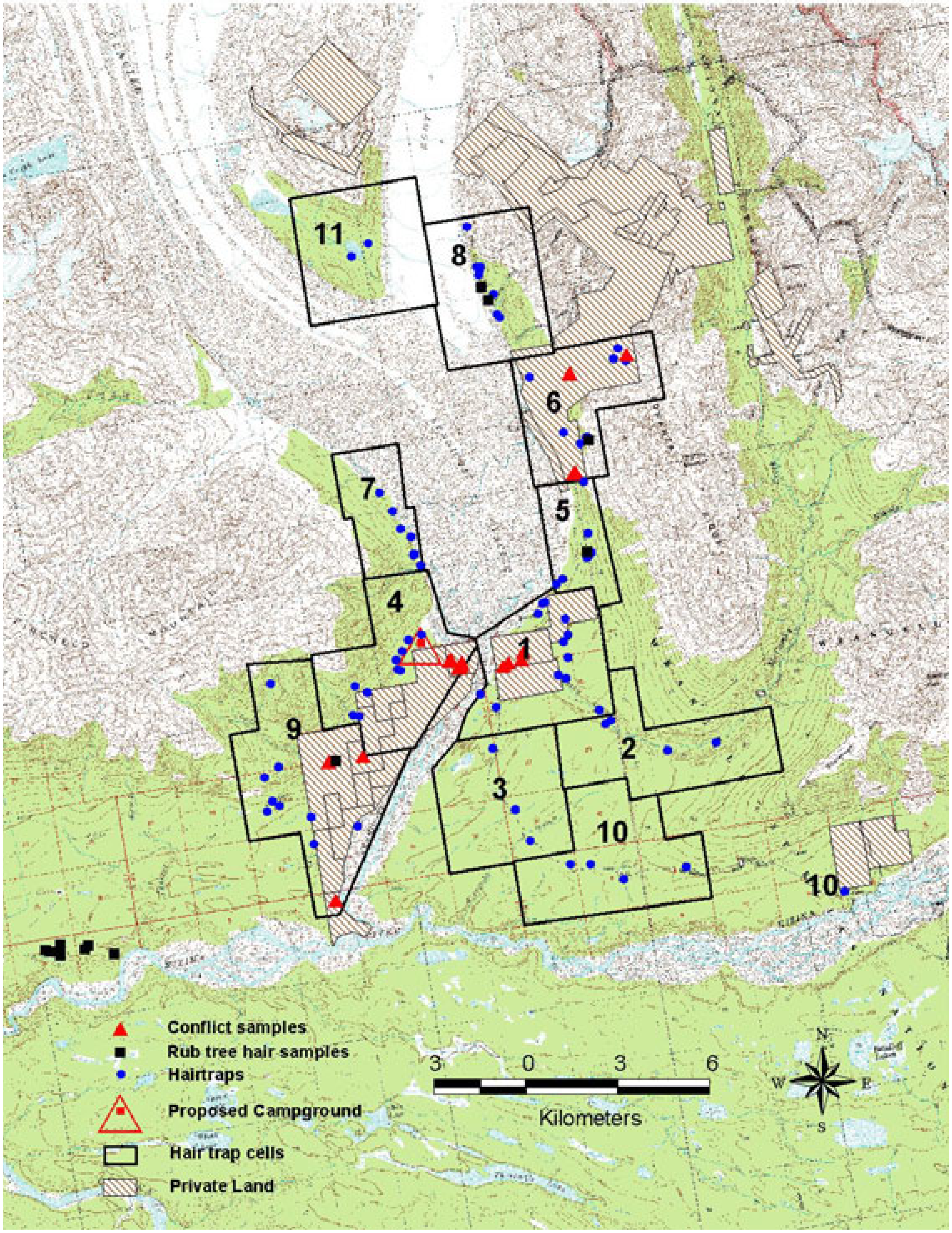
Hair Traps

I collected hair samples from "hair traps," rub trees, dead bears, and bear-human conflict sites. Hair trapping methodology was based on procedures originally developed in Canada by Woods et al. (1999). In setting hair traps, I originally planned to use the trapping web described by Anderson et al. (1983) for trapping small mammals. I felt that this design would maximize my chances of capturing bears in the area surrounding McCarthy. The geography and scale of the study area, however, ultimately prohibited this design. Instead the study area was divided into 11 cells to disperse sampling efforts in the study area. The cells closest to McCarthy were made slightly smaller than those on the outer perimeter of the study area (7.8 km^2 to 14.2 km^2) to facilitate a higher density of trap sites closer to this point of interest. Because smaller cells increase the probability of capturing individuals, cell sizes were no larger than an adult female's home range size (Bruce McLellan, pers. commun., Mowat and Strobeck 2000). All of the cells in this study were much smaller than the home range sizes reported for other bear studies in Alaska and the Yukon (Table 1.2). Although some landowners allowed us to set traps on their land, the prevalence of private property in cells 1,4,6, and 9 limited the actual area in which I could set traps in these cells (Figure 1.1).

Table 1.2. Bear density and home range studies in Alaska and the Yukon.

Location of Study	Species	Density Observed	Home Range Size	Author/Year of Study
Middle Susitna River	Black	77-103/1000 km^2		Miller et. al. 1997
Kenai Peninsula	Black	165-378/1000 km^2		Miller et. al. 1997
Susitna River	Black	89.7/1000 km^2		Miller et. al. 1987
Upper Susitna River	Black		234 km^2 (male) 200 km^2 (female)	Miller and McAllister 1982
Middle Susitna River	Brown	20-30/1000 km^2		Miller et. al. 1997
Upper Susitna River	Brown	24/1000 km^2		Miller and Ballard 1982
Denali National Park	Brown	32/1000 km^2		Dean 1987
Kluane National Park	Brown		1003 km^2 (adult males) 1281 km^2 (sub-adult males) 122 km^2 (adult females) 153 km^2 (sub-adult females)	McCann 1998

Figure 1.1. Location of hair trap cells, private property, and hair samples collected at hair traps, rub trees, and conflict sites; 2000-2001.



Field techniques for bear hair-trapping were modeled after the bear study in Glacier NP conducted by the University of Idaho and the USGS-BRD (Kendall et al. 2002). Hair traps are approximately square enclosures constructed by running a single strand of barbed wire (approximately 27 meters in length) around several trees at a uniform height approximately 50 cm above ground level. The barbed wire used for the traps was 2-strand, 4 point, with 15-cm between barbs. Terrain irregularities were filled in with woody debris to ensure that the wire was a uniform height above ground level. The center of the trap was baited with a liquid scent (a mixture of approximately 430 mL rotten fish fluid, 430 mL rotten cow blood, and 140 mL glycerin mixed with Sodium Citrate as an anticoagulant) splashed on a pile of decaying wood piled at the center of the trap. A piece of orange flagging was tied in the center of each trap to act as a visual attractant (Woods et al. 1999). I used a different concentrated scent lure as an additional attractant for each trapping session. These were commercial trapping scents (I used aged honey, raspberry oil, shellfish oil, skunk oil, beaver castoreum, fermented egg flesh, fennel oil, bacon grease, fish oil, and loganberry oil) which were poured into a perforated film canister full of "trapper's wool" and suspended by string in the center of the trap. I also hung warning signs around the trap to alert passersby. The coordinates of all traps were recorded with a GPS unit.

I maximized capture probabilities by setting traps in areas of heavy bear sign and by following the progression of natural food utilization. In general, sites were located in low elevation riparian areas early in the trapping season, and moved to higher elevations as green-up progressed. I also made an effort to trap around berry patches as berries ripened. Traps were set a minimum of 500 meters from trails, homesites, campgrounds, and other areas of human development (Figure 1.1).

Trap sites were checked and hair samples collected approximately 14 days after they were established. Latex surgical gloves were worn to prevent contamination of samples. Clumps of hair on individual barbs were treated as a single sample and were collected using flame-sterilized tweezers or forceps. A flame was then passed under each barb from which a sample was taken in order to sterilize it before the wire was reused at another site. Samples were placed in self-sealing envelopes and given a unique number consisting of hair trap cell, trapping session, date, and sample number. Envelopes were stored in a re-sealable plastic bag with silica desiccant until mailed to the lab for genetic analysis. Traps were relocated within the cells after each 14-day trapping session. Some traps located in areas of heavy bear sign or along heavily used game trails were reused in subsequent sessions.

Three 14-day trapping sessions were conducted over the summer of 2000 with ten hair traps set per session, one trap per cell (the first hair trap was set on June 26). Two additional traps were set in a fourth trapping session from August 22nd to September 7th for a total of 32 traps. In 2001, 46 hair traps were set. The first was set on June 12 and the last trap was dismantled on September 22.

Rub Trees and DLP Bears

Hair samples were also opportunistically collected from rub trees and their locations were recorded with a GPS unit (Figure 1.1). When possible, bears that were killed in “defense of life and property” (DLP) or by hunters in the surrounding National Preserve lands were examined to obtain data on species, sex, and general physiological condition (i.e., contents of stomach, amount of fat on the animal, visible wounds, and condition of teeth). A premolar was collected from DLP bears for aging, and tissue/hair samples were taken to serve as “known” control samples for evaluating error rates in the DNA analysis (Woods et al. 1999).

Hair Trap Sampling Design

Because of the size of the study area, access considerations, lack of personnel, and time constraints it was not possible to meet the assumptions necessary to estimate density. For example, the assumptions of geographic and population closure, equal distribution of trapping effort, and equal probability of survivorship could not be met (Lancia et al. 1996). Instead, I sought to gather data for a minimum population count.

Density and home range size estimates from bear studies in Alaska and the Yukon (Table 1.2), along with knowledge of the study area were used to estimate the probable number of bears residing in the study area. For example, given the amount of vertical habitat (Jonkel and Cowan 1971) and the large amount of productive early successional habitat along the glacier and river edges, I determined that my study area is probably more productive than that along the Middle Susitna River; therefore bear densities should be higher than reported in studies for that region. Conversely, more abundant precipitation on the Kenai peninsula probably produces better quality bear habitat than the area around McCarthy and bear densities there should be somewhat higher. Taking these factors into consideration I expected black bear densities in the study area to be between 100-200/1000 km^2, or .25-0.5/mi^2. Similarly, I expected brown bear densities in the McCarthy area to be similar to those found along the Middle Susitna of 20-30/1000

km^2, or $.05-.07/mi^2$ (Miller et al. 1997). Using these estimates, I hypothesized that 30-60 black bears and 6-8 brown bears resided in the study area.

Genetic Analysis

In order to effectively identify individuals using genetic sampling, the population of interest must contain a reasonable amount of genetic variation (Mowat and Strobeck 2000). Based on the assumption that the bear population in WRST is as heterogeneous as the bear population in Kluane, it was determined that DNA analysis at 6 microsatellite loci would be more than enough to identify individual bears in my study area. Genetic variation is likely to be similar in the two areas based on the huge areas of relatively pristine contiguous habitat between both parks, which should facilitate gene flow. According to Paetkau et al. (1998), the main factor affecting genetic diversity appears to be connectedness to larger populations.

DNA analysis of hair samples was conducted in the Laboratory for Ecological and Conservation Genetics under the guidance of Dr. Lisette Waits at the University of Idaho. Only hairs with visible roots underwent genetic analysis. DNA was extracted from all samples with visible roots using QIAamp™ tissue kits (Qiagen Inc.). The number of roots per extraction ranged from 1 – 15. Species identification was performed by amplifying a 145 - 165 base pair region of the mitochondrial DNA control region that has a 13 - 20 base pair deletion in brown bears relative to black bears (Shields and Kocher 1991, Murphy et al. 2000). Polymerase chain reaction (PCR) primers, reaction conditions and resolution methods have been described in Murphy et al. (2000).

Because molecules of mtDNA are more abundant in cells than nDNA, using mtDNA for species identification provides a rapid screening for sample quality that consumes only minute amounts of the available DNA. Samples from which mtDNA cannot be amplified are unlikely to produce nDNA data. Therefore, the genotyping process is made more efficient and many genotyping errors avoided by eliminating these weak samples from further analysis (Woods et al. 1999). Individual identification was attempted for all samples with a positive result for mtDNA species ID PCR. A suite of six microsatellite loci (G1A, G10B, G10C, G10L, G10M, G10P) of 200 base pairs or less was used for individual identification (Paetkau et al. 1995). Brown bears and black bears have been previously surveyed across North America using these loci (Paetkau and Strobeck 1995, Paetkau et al 1998), and a large number of alleles (5 -13) have been identified. PCR conditions and ABI gel separation methods are described in Woods et al. (1999). Genotypes for each sample were determined using the Genescan and Genotyper software packages (Perkin Elmer). Any samples that contained more than 2 alleles at a locus were assumed to contain DNA from >1 individual and were excluded from further analysis.

All samples that met the criterion for unique individuals were analyzed to determine gender. Sex ID was performed by amplifying the nuclear DNA amelogenin locus using published primers SE47 and SE48 (Ennis and Gallagher 1994). The forward primer was fluorescently labeled with 6Fam, and PCR products were resolved on a 6% polyacrylimide gel using the ABI 377 system. A female bear produces one peak of ~ 242 bp. A male bear produces an X peak at ~242 bases pairs and a Y peak at ~188 bp. Sex ID was determined for all unique individuals, and samples were amplified in duplicate to minimize potential errors. All individuals with an X and Y fragment are scored as males, and all individuals with an X fragment only are scored as females.

Limiting the Occurrence of Genotyping Errors

A number of studies have documented genotyping errors when using non-invasive sampling (Taberlet et al. 1997, Taberlet et al. 1999, Goosens et al 1998, Paetkau 2003). To avoid these problems, we took the following precautions: 1) samples collected in the field were stored in a re-sealable plastic bag with silica desiccant until mailed to the lab for genetic analysis, 2) all DNA extraction and PCR set up was performed in a low quantity DNA room that is dedicated to processing bone, scat, and hair samples to avoid contamination errors, 3) all single captures were regenotyped at all loci, 4) samples with < 5 hairs were regenotyped at all loci, 5) samples that differed by only 1 or 2 alleles were identified and regenotyped at these loci, and 6) known control samples from DLP bears were submitted to estimate the rate at which errors remain after these precautionary steps were taken (Taberlet et al. 1999, Woods et al. 1999). Although a careful record of genotyping errors was not kept in 2000, error rates were recorded in 2001 for false homozygotes, false alleles, and multiple alleles.

Based on data from ongoing studies (Waits et al. 2001, Paetkau 2003), 3-4 and 4-6 loci are required to identify individual black bears and brown bears, respectively. We chose 4 or more loci as a cut off for complete genotypes because this number strikes a reasonable balance between resolving individuals without including extra loci that could unnecessarily increase genotyping errors. Once a genotype was determined for a particular sample, match probability statistics were used to test whether that genotype contained enough information to form a basis for individual recognition (Waits et al. 2001). Our standard was that the probability that another randomly chosen sibling pair ($P_{(sib)}$) would carry a matching genotype was ≤ 5% (Woods et al. 1999).

Paetkau (2003) suggests that using 6 loci for a population with a heterozygosity of > 0.7 will resolve more than 99.98% of pairs of individuals, and that for datasets containing fewer than 100 individuals, <1 error is expected, even with many incomplete (4 or 5-locus) genotypes. The chance of an error resulting in a perfect match to a genotype from another animal is extremely small. This means that all samples with a single error in their genotype will usually have unique genotypes differing from their correct genotype by a single mismatch (Paetkau 2003). If an individual is sampled more than once and genotyping error occurs, the single individual will appear as two individuals. This potential source of error was addressed by identifying samples that differ by only 1 or 2 alleles and replicating the genotyping process at these loci.

In order to provide a measure of confidence in our genetic analysis I calculated $P_{(ran)}$ (Probability of Identity, random) and $P_{(sib)}$ from my samples for both black and brown bears. To calculate $P_{(ran)}$, I averaged the $P_{(ran)}$ values for all individual bears at the highest number of loci examined (1 value used for each animal). This number represents the probability that two randomly sampled individuals would be unique at the loci examined. To calculate $P_{(sib)}$, I only considered bears which were identified from multiple samples. I then averaged $P_{(sib)}$ values for all multiple-sample individuals. The resulting value represents the probability that two first-order relatives would have identical genotypes at the loci examined.

Assessing Field Techniques

In order to determine the efficacy of field techniques, I analyzed the failure rates of hair sample analysis (species and individual genotyping) according to how many hairs were submitted for analysis. To do this, I plotted the number of hairs analyzed against the percentage of samples in each category which failed the test, and plotted a least-squares regression line to the data. I also analyzed the efficacy of leaving hair-traps in their original locations and simply rebaiting them.

Bear Distribution

I calculated the number of individual bears caught per trap day for each hair trap and plotted these values spatially in order to determine areas of high bear use. I excluded rub tree and conflict sample points from this analysis. Using Arcview, I also created a buffer of 4 kilometers radius around the proposed campground and identified the number of individual bears identified in this area to help assess its proposed location. I also mapped out the locations of all genetically identified 'conflict bears' to determine if there was any pattern with regard to their distribution.

Soapberry Effect

Soapberry is an important food item for bears in the Kennicott Valley (see chapter 2). Bears often have long-established patterns of movements to, and exploitation of, dependable sources of rich seasonal foods (Jonkel 1987). It is assumed that some bears move into the valley just prior to soapberry ripening in order to take advantage of this rich nutritional resource. In order to investigate the influence of soapberry on bear activities in the Kennicott valley, I summarized genetic data according to soapberry phenology. In 2000-2001, soapberry began ripening around July 18th and reached full ripeness on approximately July 25th.

Results

Genetic Analysis

Hair samples were collected from hair traps, rub trees, bear-human conflict sites, hunter-killed bears, and DLP bears. Of the 32 hair traps set in 2000, 31 (97%) produced samples. A total of 296 hair samples were collected in 2000, 230 of which were from hair traps, an average of 7.2 samples per trap. The remaining samples came from rub trees and bear-human conflict sites (Table 1.3). There were 46 hair traps set in 2001, of which 35 (76%) produced samples. A total of 315 hair samples were collected in 2001, 291 of which came from hair traps, an average of 6.3 samples per trap (Table 1.3). The footbridge over McCarthy Creek was washed out until mid-July 2001. Therefore it was not possible to set any hair traps south of McCarthy creek until July 19th, 2001.

Thirty-nine samples contained no roots (Table 1.3) and were discarded (6% of the total). We were able to identify species on 491 of 572 samples with roots; 30 were grizzly and 461 were black. Of 491 samples identified to species, 385 were identified to individual (i.e. unique genotype) and 106 (22%) of the samples did not yield individual fingerprints (Table 1.3). Forty-five of these samples were mixed samples. The success rate for species identification for my 2000 samples with roots was approximately 76%, and for 2001 it was approximately 94%.

All 23 known control samples (tissue/hair samples from DLP bears and hair samples from conflict sites associated with DLP bears) submitted for analysis were correctly identified by the lab. $P_{(ran)}$ values for black (n=84) and brown (n=8) bears are reported in Table 1.4, as are $P_{(sib)}$ values. A total of 22 black bears and 4 brown bears were excluded from the $P_{(sib)}$ analysis as these individuals were identified from only 1 sample each. This resulted in 348 and 16 samples being used in the analysis for black and brown bears, respectively. Expected and observed heterozygosity for my sample population are also reported in Table 1.4. PCR amplification error rates are reported in Table 1.5, and average 0.025, 0.025, and 0.009 for false homozygotes, multiple alleles, and false alleles, respectively.

Table 1.3. Summary of DNA analysis results of samples, 2000-2001. Individual bears could be identified from one or more sample source.

	Sample Source				
	Hair Trap	Rub Tree	Conflict Site	Tissue Sample[1]	Total
2000					
Total Samples	230	51	15	7	296
Samples w/roots	198	50	15	7	263
Black Species ID	145	32	7	4	184
Brown Species ID	9	1	6	3	16
Samples w/genotypes	112	24	12	7	148
Unique Black Genotypes[2]	43	10	3	2	50
Unique Brown Genotypes	1	1	3	3	4
2001					
Total Samples	291	4	20	11	315
Samples w/roots	285	4	20	11	309
Black Species ID	261	2	14	10	277
Brown Species ID	10	0	4	1	14
Samples w/genotypes	222	2	13	11	237
Unique Black Genotypes[2,3]	52	2	10	7	55
Unique Brown Genotypes	3	0	1	1	4

[1] All tissue samples were collected at conflict sites and are included in conflict site totals

[2] Total includes individuals captured at hair traps, rub trees, and or conflict sites

[3] Total includes 21 individuals captured in 2000

Table 1.4. Expected Heterozygosity (He); Observed Heterozygosity (Ho); Probability of Identity, random $P_{(ran)}$; and Probability of Identity, sibling $P_{(sib)}$; for black and brown bears in the Kennicott valley, 2000-2001.

	Black	Brown
He	0.7783	0.7627
Ho	0.7510	0.7444
$P_{(ran)}$	1:756785	1:75291
$P_{(sib)}$	1:86	1:39

Table 1.5. PCR amplification error rates at each locus, 2001.

Locus	FH	MA	FA	Error Rate/Locus
A	0.012	0.040	0.009	0.062
B	0.026	0.023	0.023	0.072
C	0.020	0.037	0.011	0.068
L	0.024	0.010	0.000	0.034
M	0.034	0.021	0.004	0.059
P	0.032	0.018	0.007	0.058
Average	0.025	0.025	0.009	0.059

FH - false homozygote
MA - multiple alleles
FA - false allele

A total of 92 individual bears (84 black and 8 grizzly) were identified from both years' samples. Twenty-one bears were identified from samples collected in both years. Four grizzly bears and 22 black bears were identified from only one sample. The data for both years indicates that 41 bears were individually identified from only one sampling event, and 51 (55%) were captured at least twice (Table 1.6). A sampling event means that a bear was genetically identified from a single hair trap, rub tree, or conflict site. For example, a bear might be identified from 5 samples at a single hair trap, but this is considered a single sampling event.

Table 1.6. Breakdown of the number of sampling events individual bears were captured in*. The number in parentheses indicates that 26 bears were identified from a single sample.

	No. of Sampling Events						
	1	2	3	4	5	6	7
No. of Individual Bears Captured	41(26)	31	10	7	1	1	1

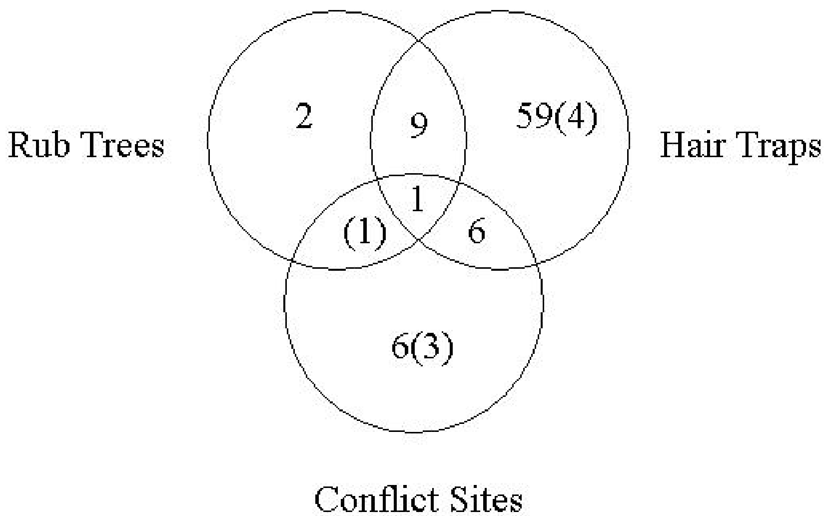
* For example, 31 bears were captured at two sampling events, and 10 bears were captured at three sampling events. A sampling event means that a bear was genetically identified from a single hair trap, rub tree, or conflict site. For example, a bear might be identified from 5 samples at a single hair trap, but this is considered a single sampling event.

Over all sample types, sex ratios (% male:female) for black and brown bears were 59:41 and 71:29, respectively (Table 1.7). We were unable to identify the sex of 7% (6 of 92) of the bears individually identified. The 483 hair trap samples with roots yielded 79 unique individuals; 75 black and 4 brown (Figure 1.2). Of these 79, gender was successfully determined for 73 of them, resulting in a male to female ratio of 55:45 (41male:33 female) for hair trap samples (Table 1.7). Seventeen individual bears were identified from 35 conflict samples with roots (Table 1.3, Table 1.7). Gender was successfully identified for 15 of these, resulting in a gender ratio of 75:25 (12 male:4 female) for bears involved in bear-human conflicts (Table 1.7). Nine bears (6 black, 3 brown) were only identified from conflict samples (Figure 1.2). Thirteen individual bears were identified from 54 rub tree samples with roots, with a male to female ratio of 62:38 (8 male:5 female) (Table 1.3, Table 1.7). Of these, 2 bears were identified by rub tree samples alone (Figure 1.2).

Table 1.7. Sex breakdown by species and method of sample collection, for samples analyzed to individual genotype, 2000-2001.

Species	Male	Female	Unknown	Percent Male:Female	Sex Ratios Male:Female
All Samples					
Black	47	32	5	59:41	1.47
Brown	5	2	1	71:29	2.50
Both	52	34	6	60:40	1.53
Hair Traps					
Black	38	32	5	54:46	1.19
Brown	3	1	0	75:25	3.00
Both	41	33	5	55:45	1.24
Conflict Sites					
Black	10	3	0	77:23	3.33
Brown	2	1	1	67:33	2.00
Both	12	4	1	75:25	3.00
Rub Trees					
Black	7	5	0	58:42	1.40
Brown	1	0	0	100:0	---
Both	8	5	0	62:38	1.60

Figure 1.2. Number of bears identified by hair traps (n=79), conflict sites (n=17), and rub trees (n=13). Bears which were caught by more than one sampling method are represented in the areas of circle overlap. For example, only one bear was identified from all three sampling methods. Brown bears are designated by numbers in parentheses.



Bear Distribution

The greatest number of individual bears were identified in the cells near the proposed campground (Figure 1.3). Two areas of apparent high bear density were discovered (Figure 1.4). A total of 50 individual bears (1 bear/km^2) were identified from samples collected within the 4 km buffer zone around the proposed campground (Figure 1.5). Sex identification was successful for 46 of these bears; 33, or 72% of them, were males.

Figure 1.3. Number of individual bears identified per cell, 2000-2001. Bears could be counted in more than one cell. Cell numbers are in black and the number of individual bears identified per cell are in red.

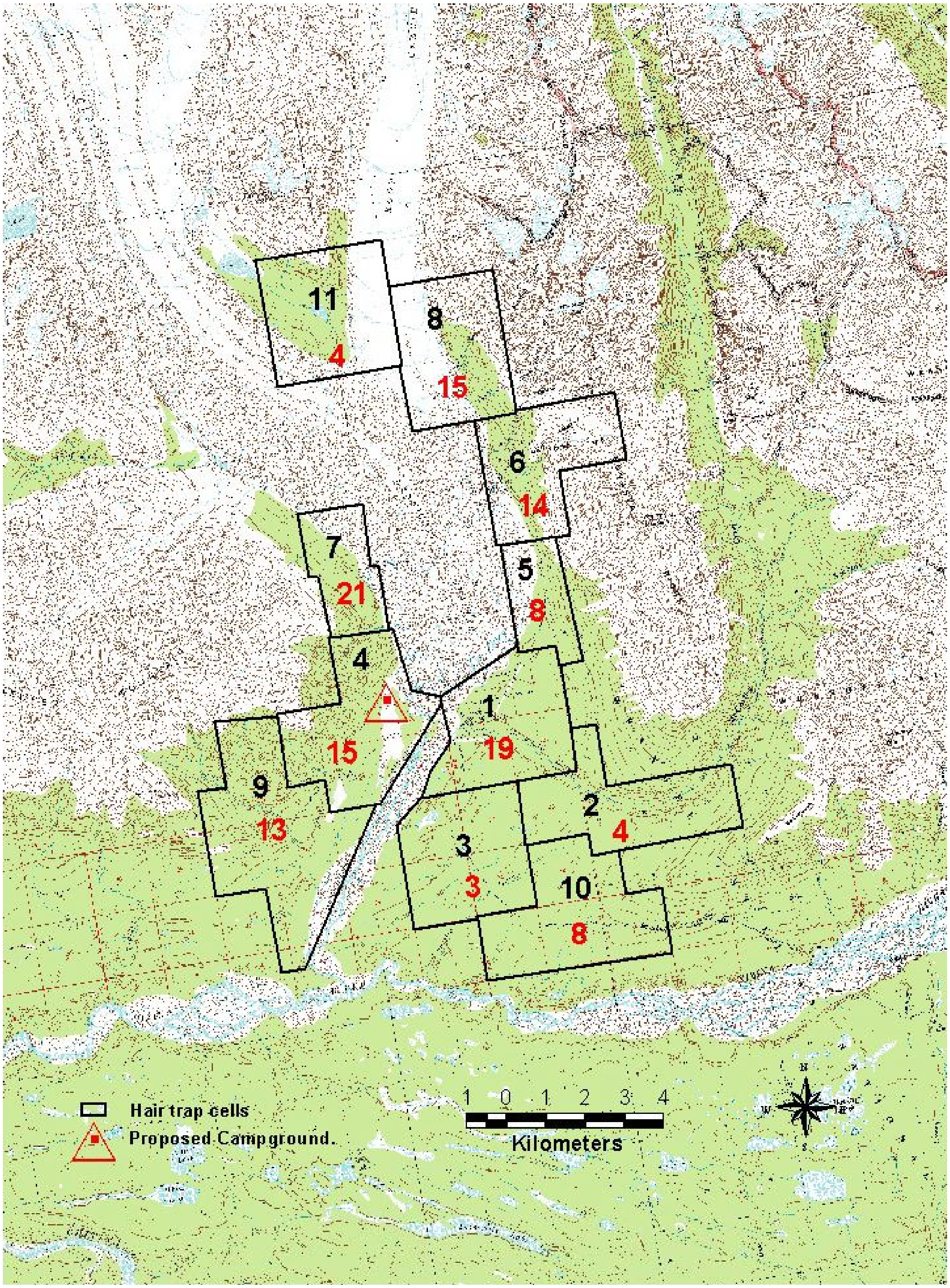


Figure 1.4. Bear densities in the study area based on bears identified from hair traps. The number of bears caught per trap day was calculated for each hair trap and color coded accordingly. Red dots indicates a high density of bears, blue medium, and black low. In order to generate Figure 1.4, rub tree and conflict sample points were excluded from the analysis.

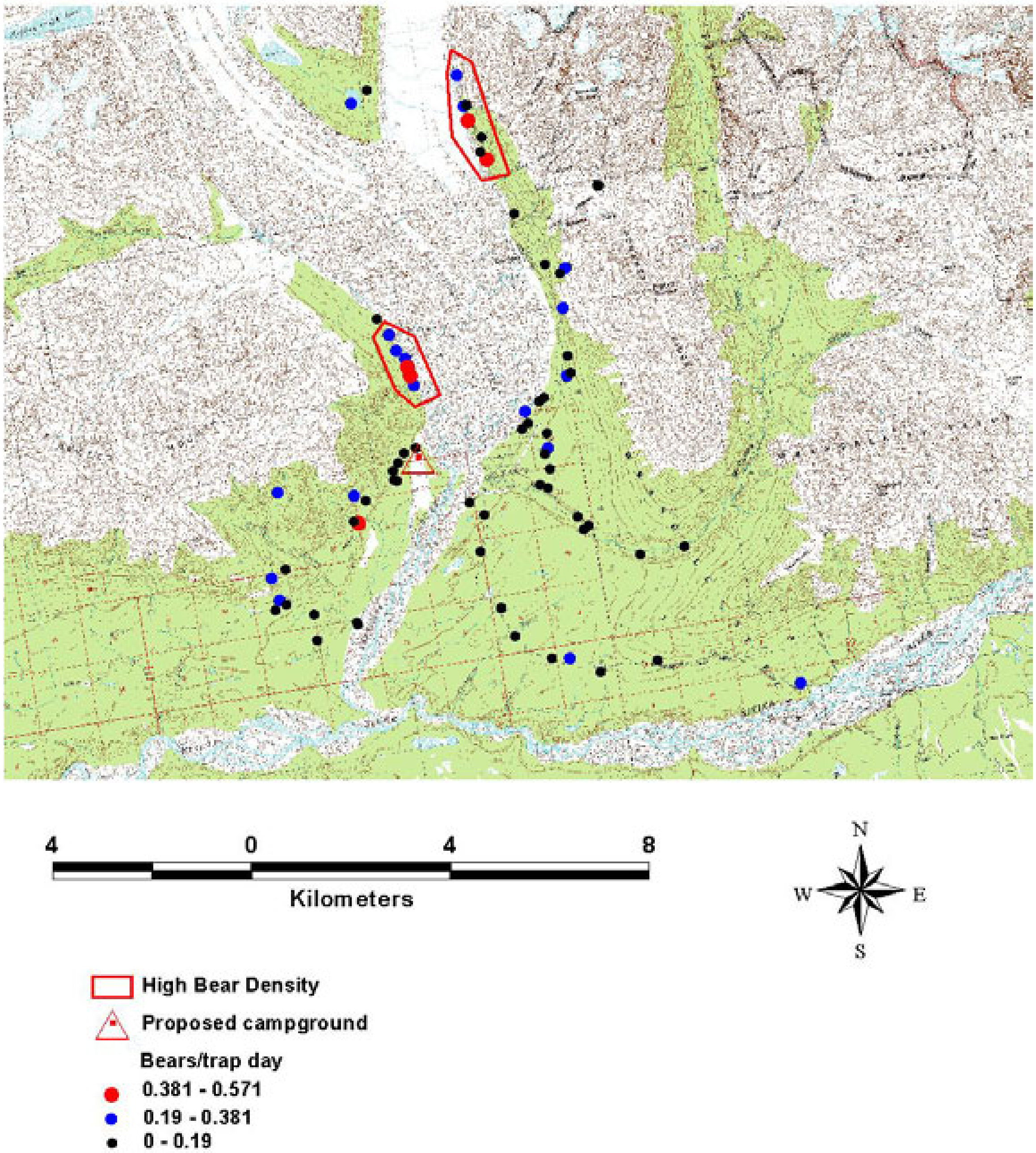
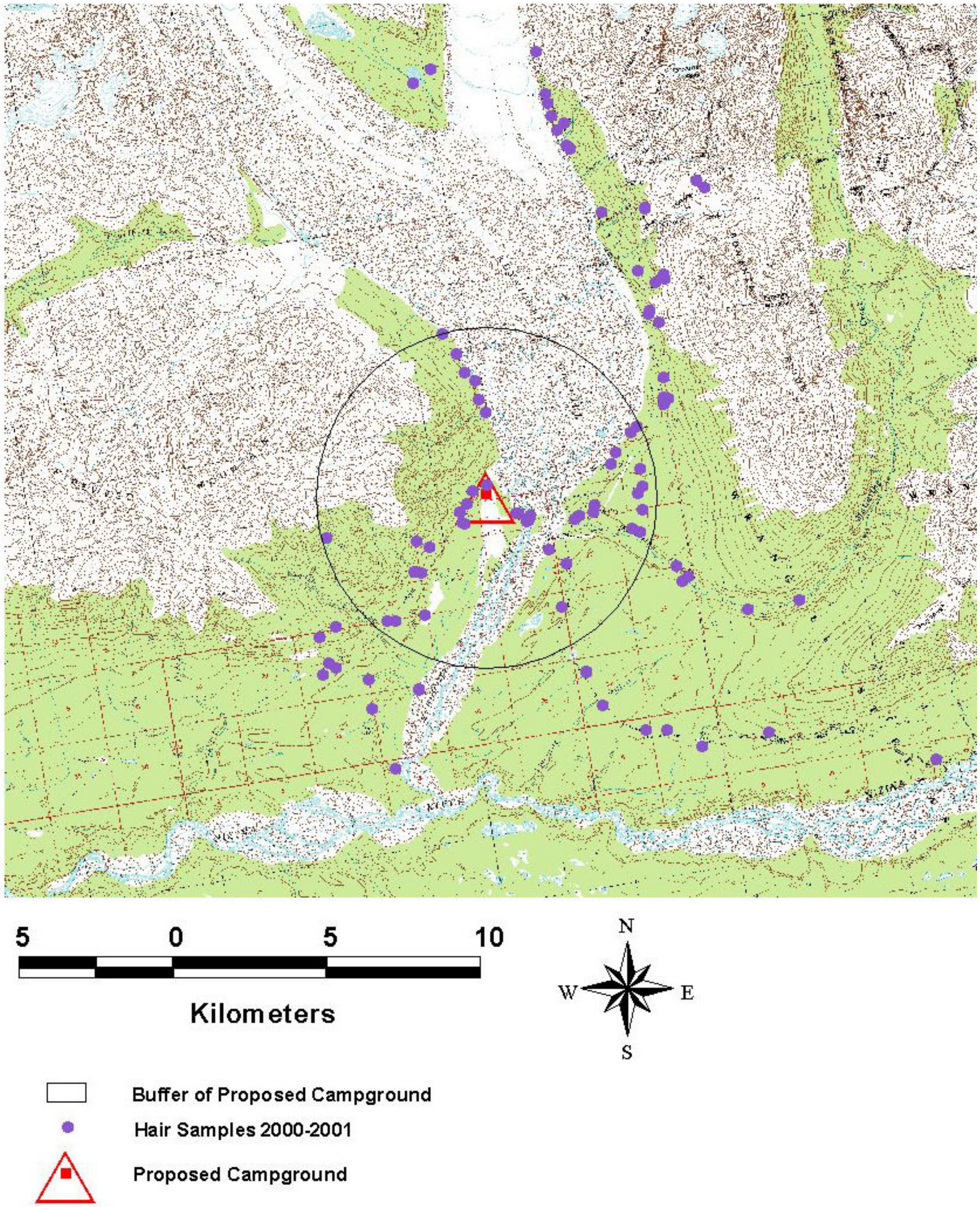


Figure 1.5. Four kilometer buffer around proposed campground. Hair samples collected from within this buffer were from hair traps and conflict sites. Fifty individual bears, or 54% of the total bears genotyped, were identified from samples collected within the 4 km buffer area.



Assessing Field Techniques

Five traps were rebaited and left in previous locations in 2001. Capture rates of new bears at reset traps ranged from 0 to 5 bears, and averaged 2.6 new bears/reset trap for the 5 traps I reset in their previous locations (Table 1.8). An average of 4.7 bears were caught at these traps during their first session. New bears identified at reset hair traps averaged 56.8% of the bears captured at these locations.

Table 1.8. Number of new bears caught per rebaited trap, 2001.

Trap #	Collection Date	# Bears Captured	# New Bears Captured	% New Bears Captured/Reset
HT010109	9/3/2001	9	9	---
HT010110	9/19/2001	2	2	100.0
HT060101	6/29/2001	1	1	---
HT060105	9/18/2001	0	0	0.0
HT070102	7/15/2001	5	5	---
HT070103	7/29/2001	7	5	71.4
HT070104	8/13/2001	8	5	62.5
HT080102	7/13/2001	4	4	---
HT080103	7/28/2001	2	1	50.0
Average for all traps		4.2	3.6	---
Average for reset traps		3.8	2.6	56.8

Of 54 rub tree samples with roots opportunistically collected in 2000-2001, 35 (65%) provided species information and 26 (48%) produced individual genotypes (Table 1.3). Genetic analysis success dropped off significantly when fewer hairs were available for genetic analysis. For my samples, failure rates for species identification when analyzing one hair, five hairs, and 10 hairs were 31%, 13%, and 7%, respectively (n=560) (Figure 1.6). Likewise, failure rates for individual genotyping when analyzing one hair, five hairs, and 10 hairs were 60%, 35%, and 10% (n=479) (Figure 1.7).

Figure 1.6. Percentage of samples which failed species identification, based on the number of hairs with roots used in the analysis, 2000-2001 (n=560;1=36, 2=22, 3=28, 4=19, 5=91, 6=30, 7=36, 8=46, 9=17, 10=235).

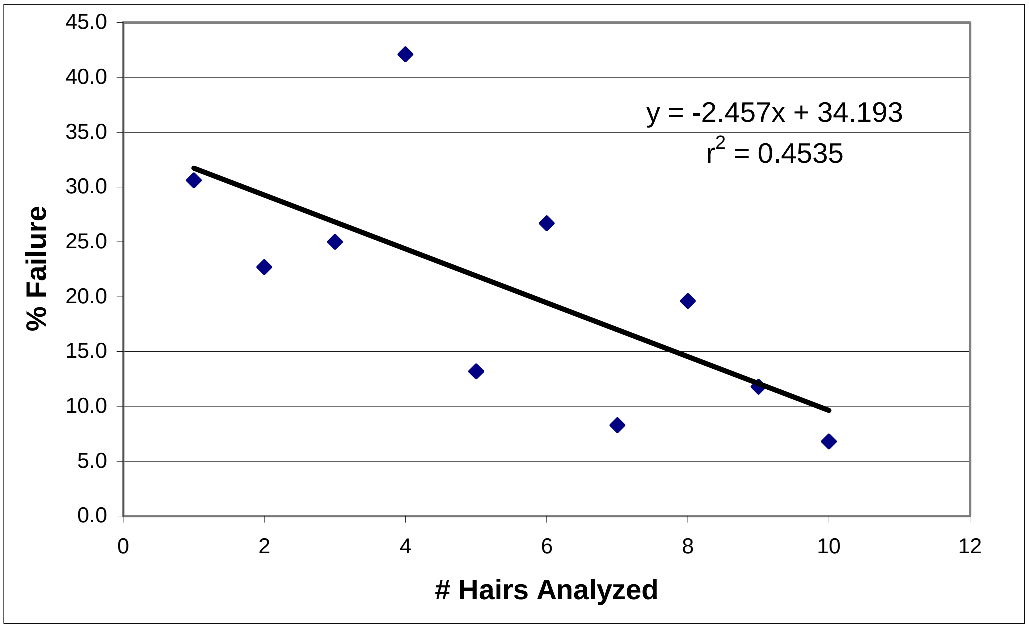
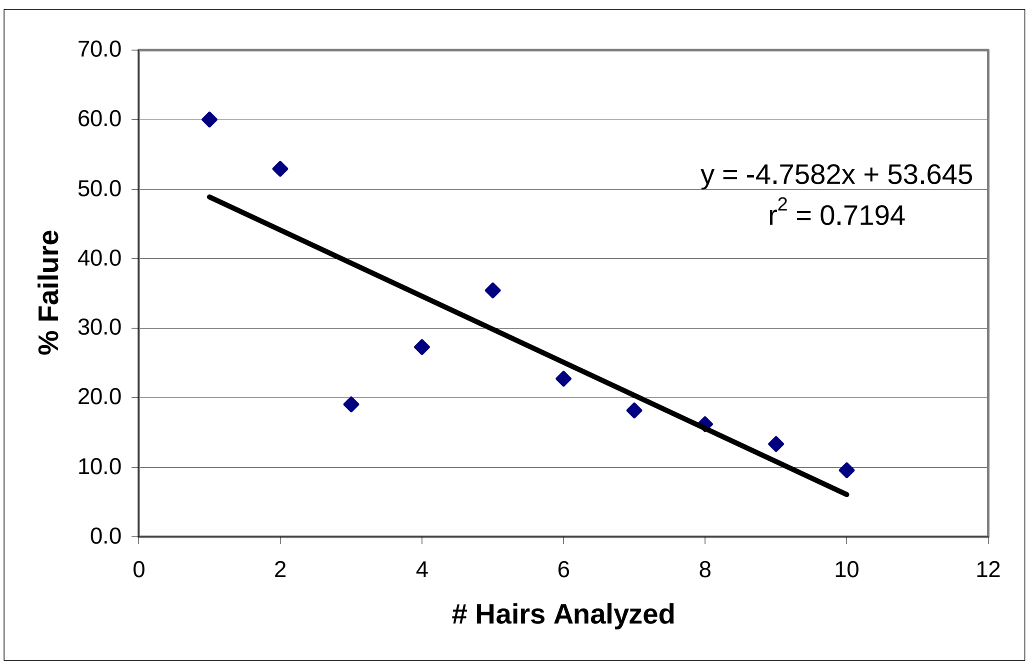


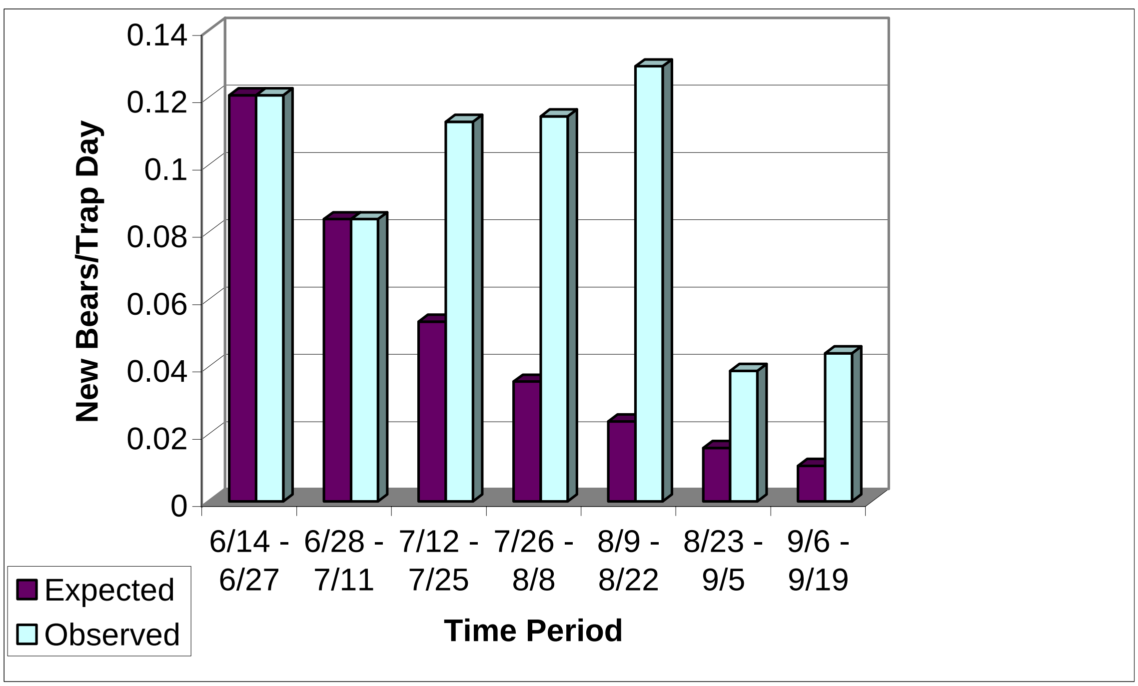
Figure 1.7. Percentage of samples which were successfully identified to species, but failed individual genotyping, based on the number of hairs with roots used in the analysis, 2000-2001 (n=479; 1=25, 2=17, 3=21, 4=11, 5=79, 6=22, 7=33, 8=37, 9=15, 10=219).



Soapberry Effect

Soapberry reached "full ripeness" on July 25th in both years. Of 41 bears which were identified from a single sampling event (Table 1.6), 31 (76%) were identified from samples collected after soapberry ripened. Figure 1.8 suggests that new bears enter the Kennicott valley as soapberry ripens, contrary to what you would expect if you assumed a closed population with a constant probability of capture for individual bears. The expected trend in Figure 1.8 is extrapolated from my first two data points.

Figure 1.8. New bears captured per hair trap day throughout the season, 2000-2001. Expected values assume a closed population and a constant probability of capture for individual bears. Data suggests that new bears enter the valley as soapberry ripens.

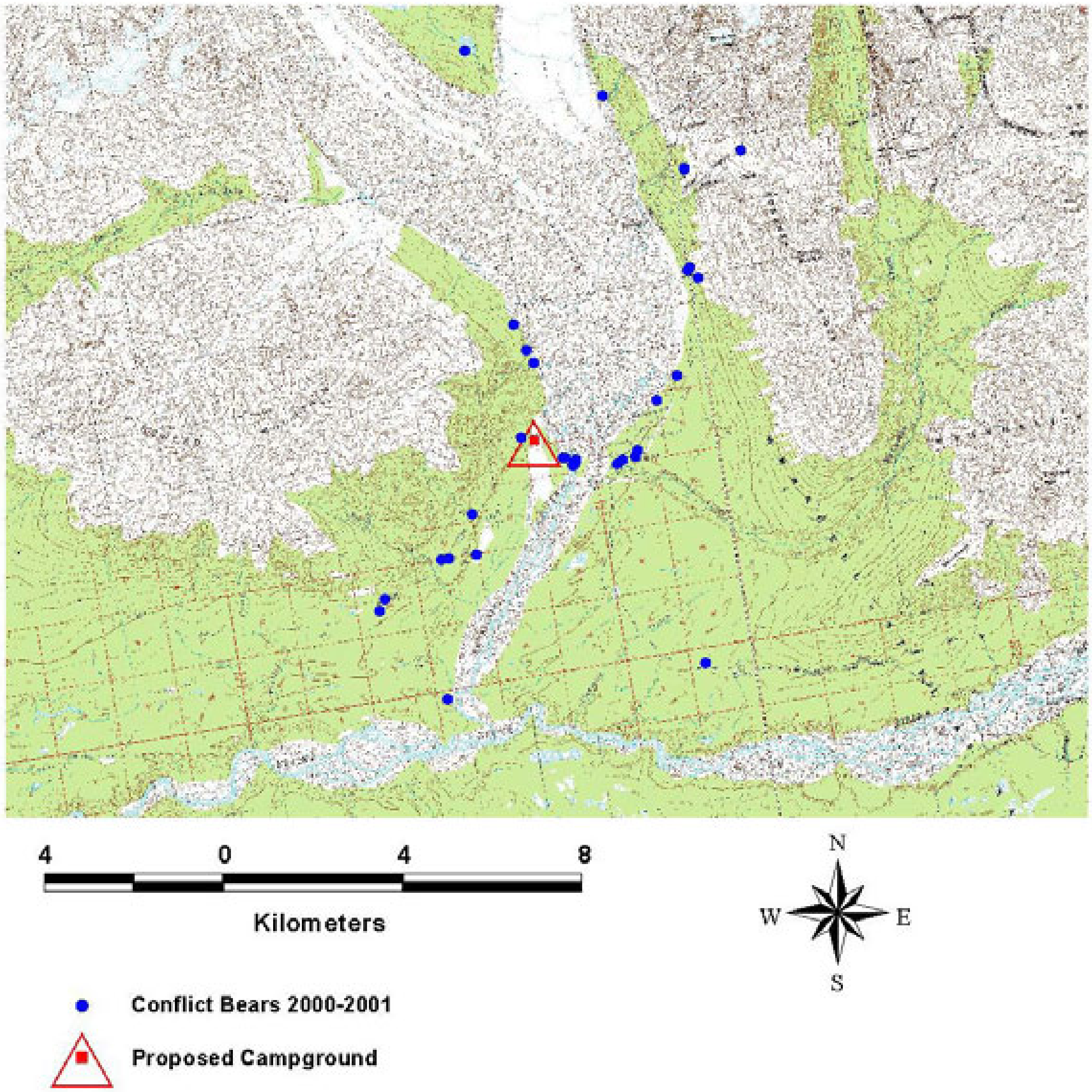


Bear-human Conflicts

I was able to use genetic analysis to identify some of the bears involved in bear-human conflicts in the Kennicott Valley. More than one sample was collected from some conflict sites. The individual bear involved was identified for 22 of 24 conflicts from which samples (n=35) were collected (Table 1.3); 17 individual bears (13 black and 4 brown) were identified from these samples (Table 1.7, Figure 1.2). These individuals represent 18.5% (17 of 92) of the total number of bears individually identified in the study area. Black bears comprised 91.3% (84 of 92) of the bears individually identified in the study area (Table 1.7), and were genetically implicated in 66.7% (16 of 24) of conflicts from which samples were collected; while brown bears accounted for only 8.7% (8 of 92) of the individual bears identified (Table 1.7), they were identified in 33.3% (8 of 24) conflict sites from which samples were collected.

When the distribution of ‘conflict bears’ is spatially mapped, they are widely distributed throughout the study area (Figure 1.9).

Figure 1.9. Distribution of conflict bears genetically identified from conflict sites, rub trees, and hair traps.



Discussion

The genetic data from this study supports two related conclusions: that soapberry is a major factor in local bear ecology, and hence the occurrence of bear-human conflicts (see Chapter 2) and that the Kennicott Valley may serve as a population sink for bears in surrounding areas, particularly brown bears.

Demography of "Conflict Bears"

The fact that 17 individual bears were identified from conflict samples (18.5% of the total number of bears individually identified in the study area) suggests that a relatively large number of bears are coming into conflict with humans in the valley, rather than just a few "problem" bears (Table 1.7). This is indicative of the many opportunities for habituation and food conditioning which currently exist in the valley, and presents a serious public safety issue for local residents and the visiting public. These figures are likely an underestimate of the true percentage of the bear population which comes into conflict with humans, as only 24 of 157 reported conflicts (Chapter 2) yielded genotyped samples. Also, the total number of bears identified represents an unknown percentage of the actual bear population using the study area.

In the Kennicott valley, an individual brown bear is much more likely to come into conflict with humans and be killed than is an individual black bear. Four of eight brown bears genetically identified in this study died by gunshot, including one female and two cubs. This is probably a consequence of resident humans' greater intolerance of grizzly bears and the bears' aggressive pursuit of feeding opportunities (Jonkel 1970, Herrero 1972, Herrero 1978, Mattson 1990). When the locations of "conflict" bears are mapped, they are found to be widely distributed throughout the study area, suggesting that the potential for conflict occurrence is not geographically limited (Figure 1.9).

“Soapberry Effect”

My data supports the idea of a “soapberry effect” on bear activities in the Kennicott valley. There are no major salmon runs into the Kennicott valley. Based on studies in neighboring Kluane National Park, terrestrial meat probably comprises between 4-15% of bears’ diets in the Kennicott valley (McCann 1997, Hilderbrand et al. 1999a). Therefore, bears in my study area are likely limited in their food choices to predominately plant matter supplemented minimally by seasonal faunal matter. Soapberry represents an important nutritional resource for local bears, particularly black bears (Chapter 2). Because smaller bears have lower total daily energy requirements than larger bears, small bears can have diets composed of more fruit than larger bears (Rode and Robbins 2000b). Therefore, the small-bodied black bear is better able to utilize soapberries, which are a rich, concentrated food resource that allows them to put on adequate fat reserves for successful reproduction and hibernation (Rogers 1976, Rogers 1987, Hilderbrand et al. 1999b).

Based on habitat in my study area and other Alaskan/Yukon bear studies, I originally estimated that the Kennicott Valley would contain a *total* of 30-60 black bears and 6-8 brown bears. In fact, we identified 84 black bears and 8 brown bears within the study area. Considering that the study area encompasses 315 square kilometers (121 square miles), this would seem to indicate a much greater density of bears than originally estimated (at least 267/1000 km^2 and 25.0/1000 km^2 for black and brown bears, respectively). However, the bears genetically identified in this study constitute a minimum population count, include two sampling seasons, and represent an unknown percentage of the actual bear population of the valley. Therefore, the actual number of bears using the valley may be higher, although, based on the intensity of my sampling effort (Figure 1.1), we can be reasonably sure that we identified the majority of bears which use the valley. This apparent high density of bears is likely a result of the Kennicott Valley being an important seasonal concentration site for bears feeding on soapberry (Craighead and Mitchell 1982, Jonkel 1987).

Because bears are active for only 5-7 months and must consume enough food during this time to sustain themselves for a full year, the major factor controlling their movements and home range size is the abundance and distribution of nutritious foods (Jonkel 1987), such as soapberry. Of 41 bears which were identified from a single sampling event (Table 1.6), 31 (76%) were identified from samples collected after soapberry ripened, suggesting that some of these bears were not occupying the valley until after soapberry was ripe. Single capture bears identified after soapberry ripened represent 34% of the bear population genetically identified. Figure 1.8 also suggests that new bears move into the valley as soapberry ripens, although some of these bears were probably present in the valley prior to soapberry ripening, and may be resident bears. Nine conflict bears were only identified from samples taken at conflict sites (Figure 1.2) after they were killed by humans after July 18th. Because these bears were only detected at conflict sites after soapberry ripened, they may not have been 'resident' bears. They likely only used the Kennicott Valley after soapberry ripened and were probably naive with respect to humans.

Assuming bears move into the valley a week before berries reach “full ripeness”, my data provide support for the hypothesis that the ripening of soapberry attracts new bears into the valley. Anecdotal evidence for a berry effect was also suggested by Strom et al. (1999) for their hair-trapping study in British Columbia. They attributed a declining capture rate through the season to a lack of productive berry patches within their study area, and speculated that bears were actually moving out of the area as berries ripened elsewhere.

Population Sink

A sink is a subpopulation in which deaths exceed births and immigration exceeds emigration (Pulliam 1988, Pulliam 1996). Sink habitats harbor sink populations (Pulliam and Dunning 1994), and densities of animals observed in sink habitats may at times be greater than that in high-quality source habitats (Van Horne 1983, Pulliam 1988). Detecting a sink can be difficult even if good demographic and dispersal data are available (Pulliam 1996). Although I have no firm data on dispersal, my genetic data suggests that the Kennicott valley may serve as a population sink for surrounding bear populations. This assertion is based on the unusual sex ratios observed in this study, the high rates of human-caused bear mortality in the valley (Chapter 2), the quality of its natural food resources, the widespread availability of human attractants (Chapter 2), and basic bear ecology.

In a dispersal sink, the source of recruitment is largely dispersing animals, which is male-biased in bears (LeCount 1982, Beecham 1983, Rogers 1987b, Kontio et al. 1998). The male-biased sex ratios observed in the Kennicott valley and the quality of its food resources provide some evidence that social hierarchies are not functioning and that it may serve as a dispersal sink for surrounding bear populations (Sargeant and Ruff 2001). If the Kennicott valley functioned as a dispersal sink, then bears in the study area would be predominately dispersing-age sub-adult males or seasonal migrants making feeding excursions from their primary range (Kontio et al. 1998). For example, social interactions often prevent subdominant animals from entering high-quality habitat. One component of high quality habitat for bears may be defined as that which provides refuge from humans (Powell et al. 1997). Adult males have been shown to actively avoid areas of human activity (Dau 1989), and adult bears, particularly males, regulate population density by controlling recruitment of sub-adults (Kemp 1976, Bunnell and Tait 1981, Young and Ruff 1982, Herrero 1983, Rogers 1983, Stringham 1983, Rogers 1987a, Rogers 1987b, Sargeant and Ruff 2001). If adult males are removed from a population, through human-caused mortality or avoidance of humans, their absence may result in an influx of dispersing sub-adult males (Kemp 1972, Kemp 1976, Ruff 1982, Young and Ruff 1982, Van Horne 1983, Rogers 1987a, Rogers 1987b), which often settle in human-occupied habitats where they are more exposed to the risks of human contact (Beeman and Pelton 1980, Garshelis and Pelton 1981, Young and Ruff 1982, Tietje and Ruff 1983).

Therefore habitat which is free from human disturbance may serve as a “source” population, and human-occupied areas as sinks. The Kennicott Valley is unusual in that it is surrounded by a large, relatively unhunted reservoir of potential immigrants (Garshelis 1994, Sargeant and Ruff 2001). In a good year, source populations produce a large excess of juveniles that emigrate and build up to high densities in sink habitats due to the absence of adult males. Because these juveniles are subdominant, there is no social interaction factor to prevent high densities in the sink habitats, in contrast to the adult-dominated source habitats (Kemp 1972, Kemp 1976, Ruff 1982, Young and Ruff 1982, Van Horne 1983). For dispersal to be advantageous, young males should seek out areas where there are few dominant males, good nutritional resources for rapid attainment of large body size, and breeding opportunities (Rogers 1987b, LeCount 1993). The Kennicott valley provides all three, due to its human-occupancy and extensive soapberry habitat.

Sinks are qualitatively different from sources in that they are unsuitable in some way for survival and reproduction (Harrison 1991). In the Kennicott valley, this is due to the human-caused mortality of bears using the area, which results in a disproportionate number of males in the population. There can be little doubt that the Kennicott valley functions as a brown bear sink, based on their high human-caused mortality rate (Chapter 2). According to Table 1.7, the sex ratio (% male:female) for all brown bear samples was 71:29, or 2.5 males to 1 female (n=7), and for hair traps samples was 75:25, or 3:1 (n=4). Although these figures should be viewed with caution due to their small sample size, they are in direct contrast to 13 brown bear studies from across North America reviewed by McLellan (1994) for which sex ratios were estimated. The average male:female ratio for these studies was 42:58. However, comparisons must be done cautiously due to a variety of methods used in their derivation (McLellan 1994). In Kluane National Park, McCann (1998) and Larsen and Markel (1989) reported that sex ratios for brown bears did not differ significantly from a ratio of 50:50 (n=59 and 19, respectively). McCann's (1998) data included all age classes of bears; he attributed the even sex ratios to their study area being a refugia from human-caused mortalities. Strom et al. (1999) reported sex ratios for grizzly bears from their hair trapping study of 36:64, or .56 males/female (n=28). Poole et al. (2001) reported sex ratios for grizzly bears from their hair trapping study of 52:48, or 1.07 males/females (n=91). Sex ratios for grizzly bears caught in hair traps set in 1998 in Glacier National Park, Montana were 46:54 (n=156)(Kendall et al. 2002). The figures for Glacier National Park also represent an unhunted population. Considering that WRST's brown bear population is essentially unharvested (Table I.2), we would also expect even or slightly female biased sex ratios in our study area. However, human-caused mortality rates account for at least 50% of the individuals genetically identified in this study, including 1 adult female and 2 cubs. Surviving grizzly bears included only one female and 3 males. Data on cub sightings (Chapter 2) provides evidence that brown bear reproduction in the valley is probably very low. Pulliam and Danielson (1991) indicate that if a study can show that local recruitment is insufficient to balance local mortality, than that is enough to show that a habitat is a sink. Based on mortality rates and the demography of the surviving grizzly bear population, we can say with much confidence that the Kennicott valley functions as a population sink for brown bears.

The sex ratio (male:female) for black bears identified from hair traps in this study is 1.19:1 (n=70), and is 1.47:1 (n=79) for all samples (Table 1.7), which is relatively high compared to other black bear populations. Initial sex ratios are generally even (Rogers et al. 1976, Rogers 1987b, Kolenosky and Strathearn 1987) and the proportion of males *decreases* with increasing age class (Rogers 1987b). This is because males have higher human-caused mortality rates than females (Kolenosky and Strathearn 1987, Mattson et al. 1987, McLellan and Shackleton 1988, MacHutchon and Smith 1990, Mattson 1990, Albert and Boyer 1991, Mattson et al. 1992), and the annual survival rate of adult females is around 80-90% in unhunted or lightly hunted populations (Kolenosky and Strathearn 1987). At 4 years of age or older, there may only be 1 male to every 3 or 4 females (Rogers 1987b).

Garshelis (1994) examined 25 black bear studies from across North America; only 3 (11%) of them reported an adult male per female (M:F) ratio greater than 1.19, and the average for all studies was 0.78 males for every 1 female. He cautions that these figures may be inflated, however, due to male-biased captures. Assuming that similar biases affected my sampling effort (Woods et al. 1999, Boulanger and McLellan 2001), the sex ratios for black bears in the Kennicott Valley appear to be more than 1.5 times as high as those summarized by Garshelis (1994). However, my sample population included all bears tall enough to leave a hair sample on a 50 cm high hair trap (1 year old or older), rather than only bears 4 years of age or older. Still, the discrepancy is likely significant as the intensity of my trapping effort and the large number of bears captured in this study suggest that I have identified a substantial proportion of the actual bear population which uses the Kennicott valley. Also, the trapping cell sizes used in my study were extremely small in comparison to the expected size of a female's home range (Table 1.2), which should have increased the probability of female capture (Boulanger et al. 2002), and reduced the effect of male-biased captures. Comparison to other black bear hair trapping studies also indicate that my sex ratios show an unusual male bias (Table 1.9).

Table 1.9. Black bear hair trapping studies in North America (unpublished data 2003).

Study Area	Sex Ratio(M:F)	Sample Size	Reference
Swan Valley, MT	0.61:1	137	Rick Mace (MT DFW&P, Pers. comm.)
New Jersey	0.71:1	82	Patrick Carr (NJ DFW, Pers. comm.)
Hoopa Valley Reservation, CA	0.69:1	160	Mark Higley (BIA, Pers. comm.)
Kennicott Valley, WRST, AK	**1.19:1**	**70**	**Wilder 2003**

The discrepancy between the ratio of males to females observed in my study and those reported by others (Garshelis 1994, Table 1.9) can be partially explained by the widespread availability of human attractants in the Kennicott valley (Chapter 2). Several authors have reported that the proportion of males at sources of garbage is higher than that found elsewhere (Rogers et al. 1976). This is explained by the larger home range sizes of males (Table 1.2, Rogers et al. 1976, Kolenosky and Strathearn 1987) which makes them more likely to encounter human attractants, and the social hierarchies which exist among bear populations (Beeman and Pelton 1980, Garshelis and Pelton 1981, Young and Ruff 1982, Tietje and Ruff 1983 Mattson et al. 1987, McLellan and Shackleton 1988, Mattson 1990).

Assuming patterns similar to those observed by Rogers (1987b) hold true for my population, the sex ratios observed in my study would indicate that an unnaturally high sub-adult male population resides in the Kennicott valley. As noted before, in a closed population, the fraction of males should decline in successive age-classes until females outnumber males, and the male age structure in most black bear populations is younger than that of females (Lindzy and Meslow 1980, Garshelis 1993). This scenario is particularly true in areas which have concentrated areas of human attractants (Rogers et al. 1976) such as the Kennicott valley (Chapter 2), where a reduced proportion of older males in the population reflects differential mortality by gunshot (Rogers et al. 1976).

Because initial sex ratios are generally even (Rogers et al. 1976, Rogers 1987b, Kolenosky and Strathearn 1987), excess males in the population must be from immigration. This influx of young males would retard the decline in the observed proportion of males in the population (Kontio et al. 1998), assuming that female mortality is not disproportionately high in the valley, which it is not, according to my data (Chapter 2).

The large number of males in the study area could further depress the proportion of females in the population. In order to increase their relative fitness and induce females to breed, immigrant males should kill cubs in their new territory (McLellan 1993, LeCount 1993, Swenson et al. 1997). Therefore, the loss of resident adult males may actually reduce cub survivorship; the female population may then also decrease because about half of the cubs born are female (LeCount 1993, McLellan 1993). This would further reduce reproductive success (Kolenosky and Strathearn 1987) and male-bias sex ratios. Thus, adult male mortality becomes additive rather than compensatory (LeCount 1993). The loss of adult females to DLP killings would further exacerbate this situation.

Although I would need quantitative data on dispersal rates in order to firmly establish that the Kennicott valley is a sink for black bears (Harrison 1991), the genetic data collected in this study lends support to the hypothesis. Because it is difficult to determine whether observed sex ratios are of biological significance or are simply artifacts of sampling design, they should be interpreted with caution. However, even the best data on population status can be ambiguous; the real art to its interpretation comes from on-site experience (Garshelis 1993). Although my data includes bears of all age-classes, it still indicates a male-dominated population out of proportion to what would be expected in a “normal” system (Rogers 1987b). Even though it is difficult to directly compare population characteristics between study areas due to differences in other conditions like food, weather, habitat, and hunting pressure, the sex ratios observed in this study are so much higher than those reported in other areas that they are likely biologically significant. They suggest that source-sink dynamics are at work and that increased human use of the valley will drive the system further in that direction.

Distribution of Bears

I initially intended to estimate bear density across the study area using kernel density estimation with hair trap points (bears caught/trap day) as the sample point. Ultimately I could not do this because my sampling effort violated the underlying premise of kernel density estimators; namely that of independent random sampling. Random sampling throughout the study area was not possible due to the size of the study area, limited resources and personnel, and the logistical problems associated with these issues. Because of this, no extrapolation from sampling points to the underlying bear distribution was made.

Bears were sampled throughout the study area; distribution of captures was non-uniform with the greatest success occurring along the glacier edge in soapberry habitat that was relatively secure from human disturbance (Figure 1.4). Hair traps with a low number of bears caught/trap day should be interpreted with caution as they do not necessarily reflect low bear densities in these areas. The two areas of ‘high observed bear density’ are natural travel corridors with major game trails paralleling the glacier edge. Both areas contain good berry habitat and are relatively secure from human disturbance.

The west side of the glacier should remain undeveloped in order to preserve secure feeding habitat for bears.

The fact that 50 individual bears, or 1 bear/km^2, were identified within 4 kilometers of the proposed campground (Figure 1.5), and that the greatest number of individual bears were identified in the cells nearest to this location (Figure 1.3), supports the idea that this area is a natural travel corridor and good berry habitat (see Chapter 2). It may also indicate that a dangerous situation exists in this area; Mattson et al. (1987) found that habituated bears account for most use within 3 kilometers of developments and Rogers et al. (1976) reported that 76% of the bears they captured in garbage dumps, campgrounds, and residential areas were males aged 1 through 7. In my study area, 72% of the bears identified within 4 kilometers of the proposed campground were male. The density of bears within the 4 kilometer buffer is approximately 10 times that reported for other interior Alaskan bear populations (Table 1.2). These facts validate the NPS decision in 2000 to relocate the proposed campground.

Field Techniques

My study has shown that resetting hair traps in the same location can be an efficient way to capture new bears if the location is good. Hair traps 070102, -03, and -04 were particularly successful as these traps were located on a heavily used game trail near major soapberry habitat on the west side of the Kennicott Glacier (Table 1.8). Only 6 of 38 bears captured at reset trap sites had been previously captured at these locations. The fact that I captured many individual bears (n=51) more than once (Table 1.6) demonstrates that bears were likely not dissuaded from investigating trap sites by not receiving a food reward from previously investigated trap sites. Strom et al. (1999) noted a similar phenomenon.

Mowat and Strobeck (2000) found that the number of hair samples collected declined and the number of identification failures increased through the course of their study in British Columbia. Consequently, they suggested minimizing this problem by finishing fieldwork by about July 15. Depending on the research questions being asked, however, this suggestion could result in a substantial proportion of the bear population being missed, particularly if animals are gathering to feed on a concentrated seasonal food resource such as soapberries. For example, in my study, 71% of bears captured in 2000 and 51% of those captured in 2001 were not identified until after soapberry ripened around July 18th (Table 1.9)**.**

I opportunistically collected hair samples of unknown age from rub trees found in the course of fieldwork with good results. Of 54 rub tree samples with roots, 65% provided species information and 48% produced individual genotypes. These samples contained enough quality DNA to provide genetic results. This would seem to indicate that opportunistically collecting samples of indeterminate age from rub trees is justifiable and can yield adequate results. However, only two bears were identified from only rub trees (Figure 1.2). This fact must be taken into account during study design. Of 13 individual bears identified from my rub tree samples, 12 were black bear (92%) and 8 (62%) were male (Table 1.7), compared to a brown:black bear ratio of 80:20 and a male:female ratio of 67:33 reported for rub tree hair samples from Glacier National Park (Kendall et al. 2002). My brown:black bear ratio likely reflects the overall bear population, however, which is dominated by black bears (Table 1.7).

Care should be taken during sample collection to ensure that hair roots are not torn from the main shaft. As in this study, latex surgical gloves should be worn when collecting samples in the field in order to prevent their contamination. This is of particular importance for determining the sex of samples collected as male human DNA can confound sex identification (L. Waits, pers. comm.).

Future studies using noninvasive hair sampling techniques to estimate population size or population density of bears should incorporate traditional mark-recapture and radio-telemetry population estimation techniques in order to compare the estimates derived from both methods. Having a radio-collared sample of the population of interest would also provide a control on individual, and more importantly, sex identification of individuals. To test for the ‘soapberry effect’, hair traps should be randomly established on a grid system (if logistically possible) in order to facilitate the spatial extrapolation of sample points to the underlying bear distributions in the study area. Longer-term studies using radio-collared animals would also provide information on bears’ preference, lack of preference, or avoidance of soapberry habitat.

Genetic Errors

The creation of spurious individuals occurs through scoring errors and genotyping errors (Paetkau 2003). PCR amplification error rates at each locus were calculated for 2001 samples (Table 1.5). Error rates were also evaluated by including samples from known individuals with samples submitted to the lab for analysis (Woods et al. 1999). The undetected rate of genetic error in my study appears to be low; 23 of 23 known control samples I submitted were correctly identified.

The expected and observed heterozygosity for my sample population (Table 1.4) provide some evidence that most cases of allelic dropout were detected (Taberlet et al. 1999), as does the fact that the lab correctly identified 100% of the control samples. They also validate our earlier assumption of an He of 79% in WRST based on data from Kluane National Park, and help validate the conclusion that the unique genotypes identified in this study represent unique individuals. To be confident that genetic recaptures represented recapture of an individual bear, we used a $P_{(sib)}$ threshold of 1:20 (.05) which was exceeded on average by my samples, which were 1:86 and 1:39 for black and brown bears respectively (Table 1.4). From this data, we can be fairly confident that the "shadow effect" was not a significant factor in our study.

Number of Hairs Analyzed

Goossens et al. (1998) found that the number of hairs used in DNA analysis directly affects the number of genotyping errors observed. They found that overall genotyping error rates using DNA extracted from one, three, and ten hairs were 14.00%, 4.86%, and 0.29% respectively. Their results were determined for alpine marmots (*Marmota marmota*), however, and may be species specific. Although I did not calculate overall genotyping error rates for this project, the percentage of samples which failed species identification and individual genotyping based on the number of hairs analyzed lends support to these findings (Figure 1.6, Figure 1.7).

Success rates for species identification typically range from 70 - 95% (Woods et al 1999, Waits, unpublished). Our overall success rate for species ID of 86% (491 of 572 samples with roots) was about the same as in Glacier National Park, where success rates were around 90% (Lisette Waits, pers. comm.). The success rate for species identification for my 2000 samples was approximately 76%, and for 2001 it was approximately 94%. I included samples with less than 5 hair roots in my 2000 samples and this probably lowered success rates (Figure 1.6, Figure 1.7). Therefore, the Glacier National Park protocol of only submitting samples with 5 or more hairs is advisable. This would cut down on the costs of DNA analysis, as fewer samples would likely have to be re-analyzed to ensure the correct amplification of alleles.

<u>Significance of baseline genetic data</u>

DNA from bear hair can be used to assess genetic diversity within and between populations, familial relationships, levels of gene flow and genetic isolation, and dispersal (Woods et al. 1999). This project provides a genetic database for bears in the Kennicott valley with baseline information on genetic diversity, individual DNA fingerprints, and sex ratios. From a law enforcement and forensic perspective, the geographic origin of bear parts can be determined with DNA analysis, as well as the species, sex, and individual (Waits et al. 1998).

<u>Management Implications</u>

There is a trend towards developing WRST to facilitate visitor use and attract tourism revenue to the state. This trend could have severe repercussions for grizzly bear populations if human activities within the park are not carefully managed. Master planning should be used to set park goals and to ensure that developments do not erode the conservation values of the park. Adequate information on grizzly bear populations, habitats, hazards, and preservation values must be incorporated at every level of park planning. Grizzly bear information should be used in overall park master planning, recreational facility design and site plans, and in trail design and location planning to avoid areas of important grizzly bear habitat.

The long-term preservation of brown bears is likely to be contingent on the preservation of wildlands that are relatively free from human disturbance (Mattson 1990), particularly at concentrated seasonal feeding areas such as the Kennicott valley. Critical resource areas which serve as seasonal concentration sites for feeding brown bears need to be identified and protected within the park. Of particular interest are salmon spawning areas. The importance of protein and lipid rich food resources (such as salmon) to the health and viability of WRST's brown bear populations cannot be overstated. These resources have a direct and profound effect on the reproductive success and health of not only individual bears, but upon bear populations as a whole (Hilderbrand 1999b). In order to adequately and proactively manage bears within WRST, data on the park's salmon resources, spawning areas, time of runs, and magnitude of runs should be collected. Salmon spawning lakes and streams should be designated as "Critical Habitat" and managed as such. Management should strive to avoid the conflicts and subsequent bear mortality that result when humans encroach upon bears' seasonal concentration sites, as documented in this study for the Kennicott valley.

Connectivity to other large areas of habitat must be maintained. One of the problems which has been identified with national parks in the lower 48 is that they are islands of habitat surrounded by a matrix of fragmented and human-dominated landscapes (Parks and Harcourt 2002). This poses serious difficulties in the management and conservation of large terrestrial mammals such as grizzly bears that are sensitive to human disturbance. Although bears are evolutionarily adapted to variable environments

(Herrero 1972, Herrero 1978), much of their resilience must have depended on the free interchange and emigration between populations (Mattson 1990). In Alaska, we have the opportunity to learn from what has transpired in the lower 48 states over the last 130 years. The habitats in Alaskan parks are only as effective as their connectivity to other large areas of protected habitat. WRST is extremely important in the long-term conservation of grizzly bears in North America as it is part of the largest internationally protected area in the world (Hunt 1996). However, the geography of the region limits the connectivity of these protected areas. Therefore, the few river corridors which connect the parks must be managed carefully to limit human impacts to resident animal populations.

Because the Kennicott valley is the “sacrificial lamb” for WRST in terms of visitation, there is little hope of completely protecting its resident bear population from human impacts. The best the NPS can do is to properly manage its lands and work with local residents to mitigate the factors which lead to bear-human conflicts (Chapter 2). The NPS should also recognize the conservation significance of the genetically diverse and healthy bear populations which reside in WRST, particularly brown bears, and manage them accordingly.

CHAPTER 2: BEAR-HUMAN CONFLICTS IN THE KENNICOTT VALLEY OF WRANGELL-ST. ELIAS NATIONAL PARK, ALASKA

By James M. Wilder

Introduction

The frequency of bear-human encounters is positively correlated with the number of resident humans in an area, the number of humans visiting an area, amount of road and trail access, amount of off-road and off-trail travel, and the occurrence and sanitation of human developments in an area (Dave Mattson, USGS-BRD, pers. commun.; Mattson 1990). There is also a direct correlation between the failure of natural food sources and the number of bear-human conflicts (Mattson et al. 1992, Rogers 1976). Bear-human conflicts do not occur randomly, but are dependent upon habitat use and site specific variables (Nadeau 1987).

Bear ecology is an important factor in bear-human conflict occurrence (Mattson 1990). Bears have to meet their nutritional requirements in the relatively short time between den emergence in the spring and winter dormancy in the fall (Jonkel 1987). The availability of high-quality food resources in late summer and fall is particularly important for the accumulation of fat by bears in preparation for winter dormancy (Farley and Robbins 1995). There appears to be a direct correlation between female bears' access to high fat, high carbohydrate food items during fall hyperphagia and their reproductive success (Elowe and Dodge 1989, Hilderbrand et al. 1999b). The quality and quantity of the bear foods in an area are positively correlated with the body size, reproductive success, and population density of bears in a given area (Hilderbrand et al. 1999b).

Soapberries (*Shepherdia canadensis*) are an important food resource for bears in the Kennicott Valley, and may influence the occurrence of bear-human conflicts. Soapberries are a rich, concentrated food resource which allow bears to put on adequate fat reserves for successful reproduction and hibernation. In the Kennicott valley, bears likely shift from a diet composed mainly of vegetation to one of mostly berries by late July. This transition period is characterized by a concurrent shift in habitat use by bears. Telemetry data from other areas indicates that grizzly bears conduct exploratory excursions for new food sources as berries start to ripen and spring vegetation senesces (McCann 1997, Nadeau 1987). In the Yukon's Kluane National Park, peak movements in August by both males and females may indicate some searching for productive food patches, including *Shepherdia* spp., *Vaccinium* spp. (blueberry), *and Empetrum nigrum* (crowberry) (McCann 1997). These are all important bear foods which are first utilized by bears in late July. Peak use of low elevations by all brown bears coincides with ripening of key forage crops such as *Oxytropis campestris, Shepherdia canadensis,* and *Hedysarum* spp. that grow along floodplains and glacial moraines (McCann 1998). The collapse of elevational segregation between adult males and females with and without cubs during the peak availability of these food sources seems to strongly suggest that they are important (McCann 1998).

There is a possibility that the Kennicott valley serves as a population sink for surrounding bear populations, particularly for dispersing sub-adult males, due to a combination of its abundant seasonal natural food resources and human occupancy. Proximity to humans may provide sub-adults and females with young an opportunity to use higher quality foods otherwise pre-empted by dominant adult males (Tietje and Ruff 1983, Mattson et al. 1987, McLellan and Shackleton 1988, Mattson 1990). Dispersing sub-adults may be less familiar with local bears and foraging options and thus more willing to use human areas as a refuge from inter- and intra- specific competition

(Mattson et al. 1987, McLellan and Shackleton 1988, Mattson 1990). The quality of the food resources within the Kennicott valley may attract bears to the area where they become habituated to humans and subsequently food conditioned. Many are ultimately killed.

Habituation is defined as the waning of a response to a neutral stimuli after repeated exposure (Whittaker and Knight 1998). For the remainder of this paper, habituation will refer specifically to bears that have become accustomed to people. Habituation is not to be confused with conditioning, which is more frequently associated with food rewards. Conditioning is learning by receiving a reward or punishment for a given response to a given stimulus (McCullough 1982). Habituated bears that eat human food or garbage become "food-conditioned." Strong evidence supports the theory that food conditioned bears are much more dangerous than unconditioned bears (Herrero 1985).

The objectives of this chapter are to: 1) document the types of bear-human conflicts in the study area; 2) describe the biological factors which bring bears into conflicts with humans; 3) suggest methods to minimize or avoid bear-human conflicts in the study area; and 4) assess how increased visitor use will affect bear habitat use and bear-human conflicts.

Methods

Visitation

I gathered data on visitation in order to investigate the relationship between visitation and the occurrence of bear-human conflicts. I placed two motion sensing road counters on the McCarthy Road at approximately mile 57, about 100 meters east of Swift

Creek. Although the road counters counted local traffic as well as visitor traffic, I felt the number of vehicles recorded should provide a rough indice of visitation to the area, as I assumed that local traffic was relatively constant for all time periods. In 2000, the road counters were in use from June 19th until September 15th. We monitored these sites for four hours at random times on 3 separate occasions to determine average occupancy per vehicle. In 2001, the road counters were in use from June 12th until September 13th. These dates corresponded to the initiation and completion of field work in 2000 and 2001. I plotted a least squares regression line to compare the relationship between the number of vehicles visiting the Kennicott valley and the number of bear-human conflicts which occurred by one week period.

Bear-human Conflicts

A conflict was defined as any case where human food, garbage, or other attractants brought bears into close proximity with humans in active search of anthropogenic foods; where bears opportunistically garnered food rewards from human encounters; where property was damaged; where bears were killed or wounded; or any encounter where bears acted aggressively towards humans. Conflicts recorded likely contributed to bear habituation to humans and increased the potential for human injury.

Standardized forms were made available to all visitors and residents who reported bear conflicts to record the details of the incident, including the date, location, habitat type, species involved, residency of the person(s) involved, likely cause, and the result. When possible, conflict sites were visited to collect bear hair for positive genetic identification of the individual bear(s) involved. Conflict sites were mapped and the people involved were interviewed, when possible, to document the factors influencing the incident. Some data were collected from second-hand sources and some were collected directly from the individual(s) involved in the conflict. Bear-human conflicts that involved residents were mostly reported by word of mouth. Whenever possible, DLP ("defense of life and property" kills) bears were examined to determine their sex, species, and physiological condition. In 2001, lower premolar teeth were extracted for age determination by cementum annuli (Marks and Erickson 1966, Stoneburg and Jonkel 1966, Wiley 1974). Data forms were also used to collect data on bear observations. The number of bear observations was plotted against the number of vehicles by one week period, and a least squares regression line plotted to describe the relationship between the two.

A GIS database was created to depict bear-human conflicts. These conflicts were mapped and roughly categorized according to the Alaska Bear Confrontation Database developed by Tom Smith of the USGS Alaska Biological Science Center (Tom Smith, pers. commun.). I used the Animal Movement extension (Hooge and Eichenlaub 1997) in Arcview to generate density contour intervals around conflict points, and assumed that this represented an underlying distribution of the probability of conflict occurrence.

Soapberry

To investigate the relationship between visitation, soapberry, and bear-human conflicts, I plotted the number of vehicles entering the valley by the number of conflicts by one week period. Conflicts were separated into categories according to whether the conflict occurred in soapberry habitat (1=soapberry habitat, 0=non-soapberry habitat) and whether the berries were ripe (1=ripe, 0=not ripe). Berries ripened by July 25th of both years. Pearson correlations were calculated for each combination of habitat and season to determine if there was good evidence for association between conflicts and habitat. I did this for the time period the road counters were in use (June 19 to September 17). I also summarized conflict occurrence by habitat, season, and residency of the human involved for the period June 19 to September 17.

I also investigated the distance between a conflict location and the nearest private development. These calculations were performed in Arcview.

Results

Visitation

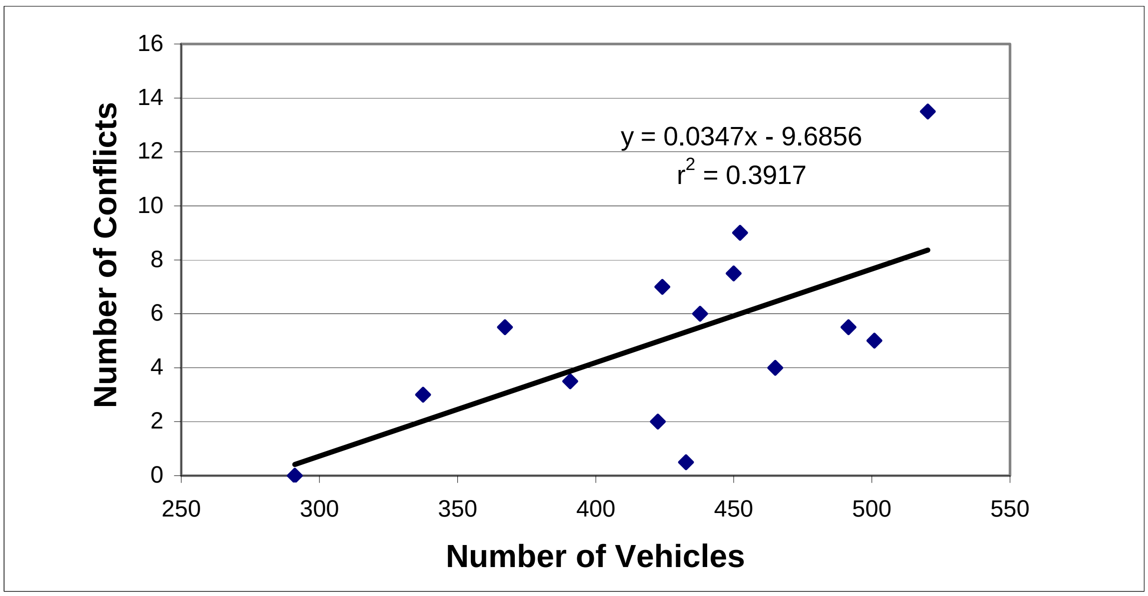
I counted approximately 5856 vehicles (average of two road counters) on the McCarthy road between June 19th and September 15th, 2000, and vehicle occupancy averaged 2 people per vehicle over three observation periods. In order to estimate total visitation, I arbitrarily assumed that 25% of the observed road traffic was local in origin. Based on this assumption, I calculated that 4392 vehicles belonged to visitors. This yields a rough estimate of 8784 visitors to the McCarthy area who arrived via the McCarthy road in 2000 during the period the counters were in use.

I counted approximately 5450 vehicles on the McCarthy road between June 12th and September 13th, 2001. Using the same assumptions as above, I estimated that approximately 4088 visitor vehicles and approximately 8176 visitors arrived in McCarthy via the McCarthy road in 2001 for the period the counters were in use.

No data are available on the number of visitors who arrived in the Kennicott valley by air. It is assumed that this source of visitation is minor compared to visitation via the McCarthy road, and follows similar temporal patterns.

The number of vehicles visiting McCarthy in 2000-2001 accounts for approximately 39% of the variation in the number of conflicts which occurred in the study area (Figure 2.1). However, in cases where the residency of the party involved in a conflict was known (resident or visitor), visitors were involved in only 20% (30 of 151) of the conflicts reported (Table 2.1).

Figure 2.1. Average number of conflicts vs. average number of vehicles by one week period; mid June-mid September, 2000-2001.



Bear-human Conflicts

There were 91 reported bear-human conflicts in the study area in 2000, and 66 in 2001 (Table 2.1). Residents were involved in 82% (68 of 83) of black bear and 65% (32 of 49) of brown bear incidents. Where the party involved in a conflict was known (resident or visitor), residents were involved in 80% (121 of 151) of the conflicts reported (Table 2.1). The most common reason for bear-human conflicts was human food, and bears received a food reward in 37% (58 of 157) of reported incidents. Cubs were involved in 6 reported conflicts in 2000, and 1 in 2001.

Garbage is a major attractant for bears in the Kennicott valley. Two black bears shot in 2000 and 2001 had garbage in their stomachs. In 2000-2001, 6 “garbage” scats were found in the study area. Bears received a food reward in 61% (23 of 38) of conflicts which involved garbage, and 28% (5 of 18) which involved burn barrels (Table 2.1). Bears are attracted to burn-barrels in search of garbage and food items which are not totally consumed by the burning process.

Table 2.1. Summary of bear-human conflicts in the Kennicott valley, 2000-2001.

	2000			2001		
	Black	Brown	Unknown	Black	Brown	Unknown
Reason for Conflict[1]						
Garbage	16	3	3	10	3	3
Human Food	16	16	5	10	0	4
Compost	10	2	0	6	0	2
Burn Barrel	6	4	1	4	2	1
Livestock[2]	8	8	4	10	1	0
Surprise	3	1	0	0	0	0
Result of Conflict[3]						
Food Reward	17	10	3	18	4	6
Physical Contact[4]	0	4	0	4	0	0
Property Damage	2	9	7	9	0	7
Bear Death[5]	5	5(1)	0	8(8)	1(1)	0
Involved in Conflict						
Resident	34	23	9	34	9	12
Visitor	5	13	3	7	2	0
Unknown	2	1	1	1	1	0
Total # of Conflicts	41	37	13	42	12	12

[1] A single conflict could have several contributing reasons assigned to it.
[2] Chickens, pigs,horses, and rabbits. Also includes pets and pet food.
[3] A result could not be attributed to every conflict.
[4] Physical contact includes bears which stood upon occupied vehicles and pawed at occupied tents.
[5] Numbers in parentheses indicate probable but unconfirmed bear deaths.

Table 2.2. Result of bear-human conflict, by residency of the person involved, 2000-2001.

Result of Conflict	Resident	Visitor	% Resident
Food Reward	51	7	87.9
Physical Contact	2	6	25.0
Property Damage	28	6	82.4
Bear Death	14	1	93.3
Total	95	20	

A result could not be attributed to every conflict. When the identity of the individual involved in a bear-human conflict was known (n=115), and a result was determined, residents were involved in a greater number of incidents where bears received a food reward, property was damaged, or where bears were killed (Table 2.2). Residents were 18 times more likely (36 to 2) to be involved in conflicts due to improper storage of garbage than were visitors. They were also twice as likely to be involved in conflicts because of human food and pet food (34 to 18 and 7 to 3, respectively) than were visitors. Visitors were more likely to experience physical contact (i.e., while in their tents or cars) with bears than were residents (Table 2.2).

When conflicts are mapped and 10% density contour intervals generated around them, it is obvious that most conflicts were centered around the end of the McCarthy road and the proposed campground (Figure 2.2). A total of 69% (109 of 157) of reported conflicts occurred within 4 km of the proposed campground. July was the most active month for bear-human conflicts in both years (Figure 2.3). Bears are attracted to human areas in the Kennicott valley for a variety of reasons (Table 2.3).

Figure 2.2. Map of bear-human conflict locations, 2000-2001. Density contours are based on 10% increments.

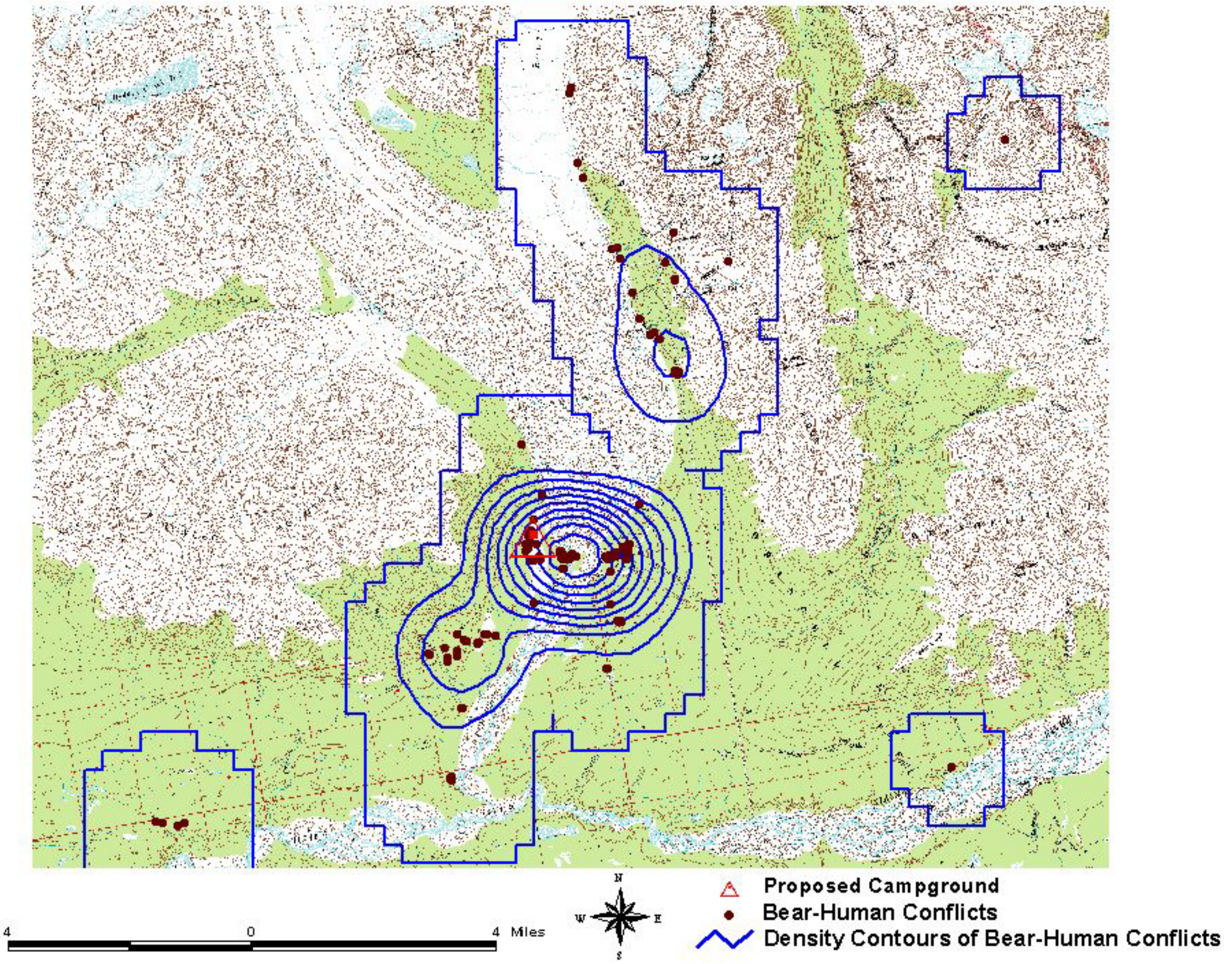


Figure 2.3. Bear-human conflicts by month and species in the Kennicott valley, 2000-2001, n=157.

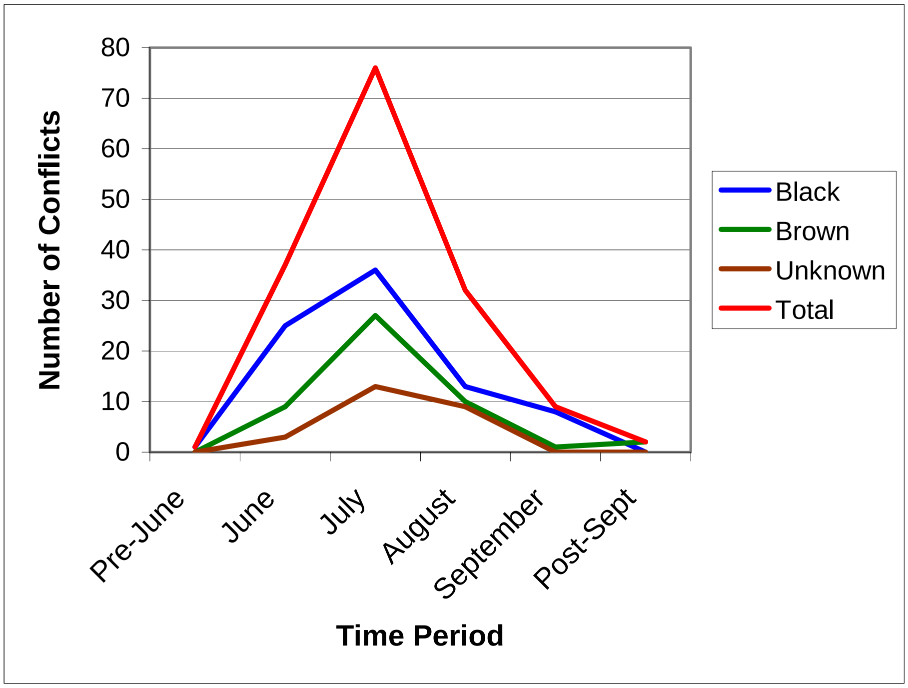


Table 2.3. Common attractants influencing bear-human conflicts around private developments in the Kennicott valley.

Human Food	Garbage		
Pouring bacon grease outside of cabins	Storing garbage on porch roofs		
Freezers on cabin porches	Storing garbage in vehicles		
Kitchens in soft-sided tents	Burn pits		
Food storage in tents	Burn barrels		
Food storage in vehicles	Unsecured garbage at businesses		
BBQ grills			
Drying salmon	Livestock and Pets		
Compost	Bird feeders	Horse feed	Pig pens
Gardens (particularly carrots)	Chickens/guineas	Dog/cat food	
	Horse droppings		

Bear Deaths and Injuries

Anecdotal information (local residents) indicates that between 1987 and 2001, at least 14, and probably 16, grizzlies were shot between Long Lake and McCarthy (4 male, 3 female, 7 sex unknown, and 2 unconfirmed). At least seven bears were reported killed in 1999 in the McCarthy area, including a female grizzly with two two-year old cubs, a single grizzly bear, and 3 black bears.

In 2000, at least10 bears (5 grizzly and 5 black) were killed in the study area. An additional grizzly bear was reported killed, but not verified (Table 2.5). One male black bear killed on September 6th, 2000 showed evidence of being wounded previously (old buckshot under its hide in the abdominal region). Two grizzly bear cubs were found dead beside the McCarthy road in August. A grizzly bear was found dead in the ice at Long Lake in October. Sex and cause of death were undetermined. No information on gender was obtainable for 3 unexamined DLP bears (incident #'s 00-080, 00-090, 00-091), and no hair samples were collected from these bears. Unfortunately, teeth were not collected from bears in 2000 for age determination.

In 2001, there were 9 confirmed bear kills and 9 other unconfirmed bear deaths in the Kennicott Valley (Table 2.6). Confirmed kills included seven male black bears, one female black bear, and one female grizzly bear. I collected hair samples from eight of the nine bears and teeth from seven of the nine; four of these were males 4 years old or younger, two were males aged 6 and 9 years, and one was a female aged 23 years. Of the nine bears killed, one was sport harvested and eight (7 male black bears and 1 female black) were DLP bears. Nine other bears were reportedly killed in or very near the study area, as follows: a black bear was reported killed in McCarthy the first week of June, a grizzly bear was reported to have been shot at Long Lake in July, a black bear was reported shot to the east (10 miles) of McCarthy in August, and six black bears were reportedly shot by hunters in the fall on the west side of the Kennicott Glacier. In 2001, 5 bears (4 black and 1 grizzly) were reportedly wounded, some intentionally (grizzly with bird shot, black bear with buckshot, and black bear with a .22). A total of 10 male bears, 5 female, and 11 sex unknown were killed by humans in the Kennicott valley from 1999-2001 (Table 2.4). These numbers include 2 female and 4 grizzly bear cubs.

Table 2.4. Summary of human-caused bear deaths by sex and species, 1999-2001. Cub deaths are designated in parentheses.

	Male	Female	Unknown	Unconfirmed
Black	8	3	5	8
Grizzly	1(1)	2	3(3)	2

Table 2.5. Reported bear kills in the Kennicott valley, 2000.

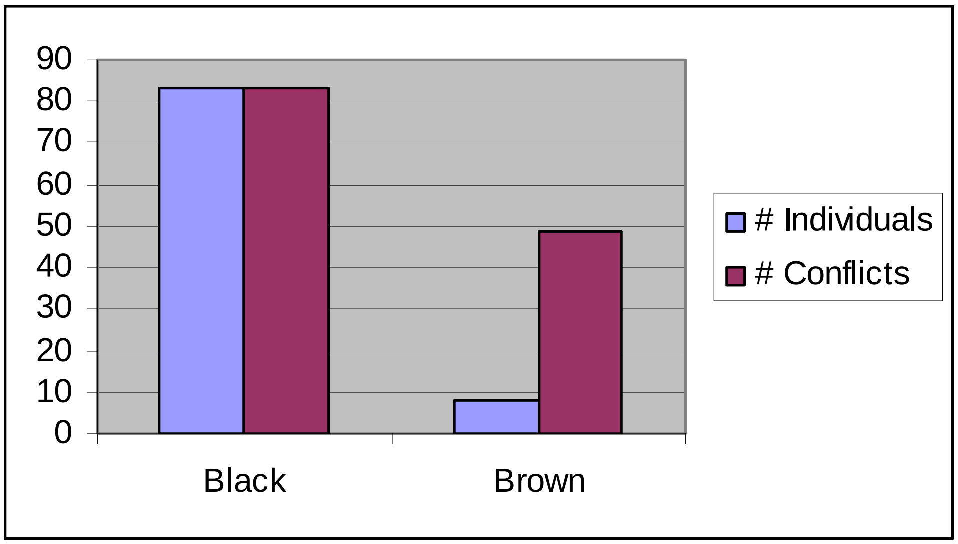
Conflict #	Species	Sex	Bear's Age	Date killed	Hair Sample
DLP Bears					
00-029	B	F	?	7/3/2000	None
00-061	G	M	?	7/16/2000	MI0600
00-079	G	M	cub	8/20/2000	MI1400
00-079	G	?	cub	8/20/2000	MI1500
00-080	B	?	?	8/24/2000	None
00-085	B	F	?	9/6/2000	MI2000, MI2100
00-087	B	M	?	9/6/2000	MI2200, MI2300
00-090	B	?	?	9/18/2000	None
00-091	G	?	?	10/28/2000	None
Non-DLP Bears					
00-092	G	?	?	10/?/01	None
Unverified					
00-007	G	?	?	6/10/2000	None

Table 2.6. Reported bear kills in the Kennicott valley, 2001.

Conflict #	Species	Sex	Bear's Age	Date killed	Hair Sample
DLP Bears					
01-002	B	M	3	6/13/2001	MI010101
01-005	B	M	3	6/17/2001	MI010102, MI010103
01-008	B	F	23	6/21/2001	MI0102
01-036	B	M	4	7/26/2001	MI0111, MI0112
01-041	B	M	6	7/28/2001	MI0118
01-042	B	M	9	7/28/2001	MI0116
01-044	B	M	?	7/30/2001	None
01-063	B	M	2	8/18/2001	MI0121, MI0122
Non-DLP Bears					
01-065	G	F	?	9/6/2001	MI0120
Unverified					
01-004	B	?	?	6/14/2001	None
01-066	G	?	?	7/?/2001	None
01-056	B	?	?	8/10/2001	None
01-067	6 Black	?	?	Sept/Oct 2001	None

When the number of bears genetically identified in the study area (Chapter 1) is compared to the number of reported conflicts attributed to brown bears, my data suggests that brown bears are disproportionately involved in conflicts with humans compared to black bears (Figure 2.4). While brown bears accounted for only 8 of 92 (8.7%) of the individual bears identified, they were involved in 49 of 132 (37.1%) of the reported bear-human conflicts attributable to a specific species. Genetic analysis of conflict samples supports the data in Figure 2.4. Brown bears were identified in 33.3% (8 of 24) conflict samples for which species could be determined (Chapter 1).

Figure 2.4. Reported bear-human conflicts by species and number of individuals genetically identified per species, 2000-2001.



Bear Sightings

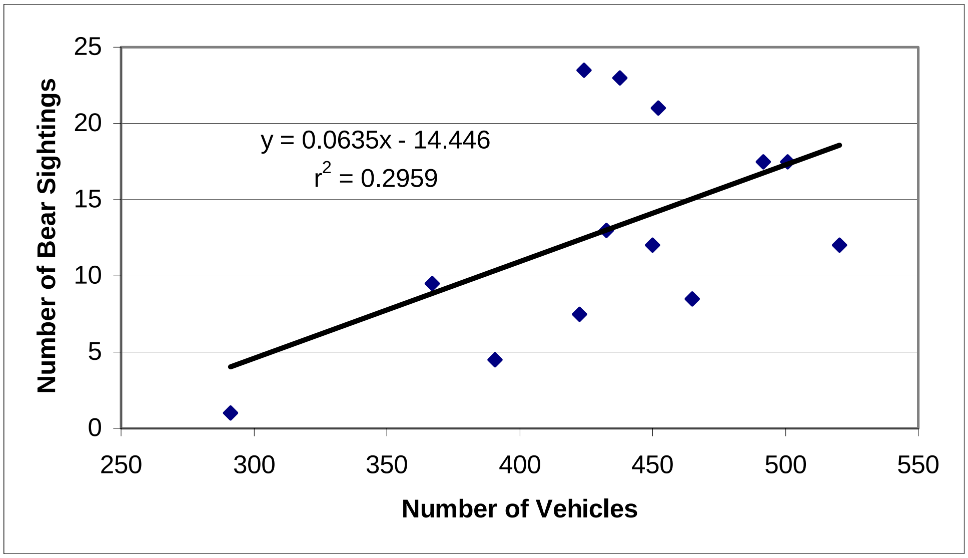
Based on data from returned bear observation forms, there was a decrease in cub sightings in 2001 (Table 2.7). Visitation accounts for only 30% of the variation in the number of bears observed (Figure 2.5).

Table 2.7. Bear sightings by month, 2000 and 2001.

Month	Black	Grizzly	Unknown	Cubs
2000				
April	0	0	0	0
May	0	2	0	0
June	21	12	0	7
July	85	14	5	25
August	59	7	2	12
September	9	2	1	0
Total	174	37	8[1]	44
2001				
April	0	1	0	1
May	3	2	0	0
June	19	6	3	1
July	66	8	2	5
August	40	13	2	4
September	6	2	0	1
Total	134	32	7	12

[1] One Unknown observation had no date reported with it

Figure 2.5. Average number of vehicles versus average number of bear sightings, by one week period, 2000-2001.

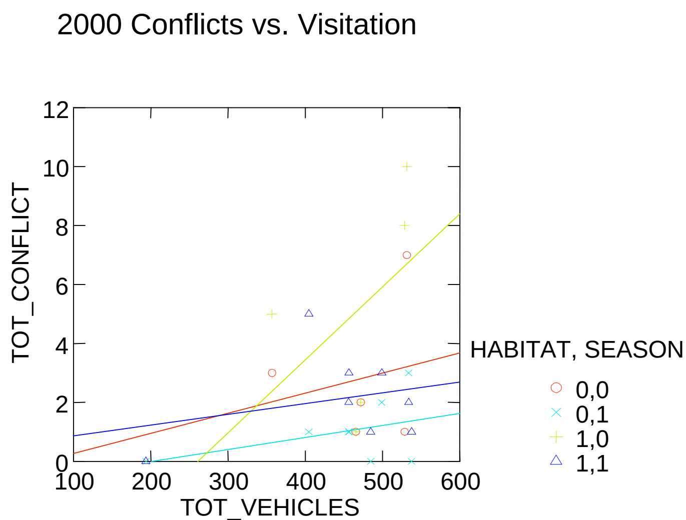


Data Analysis

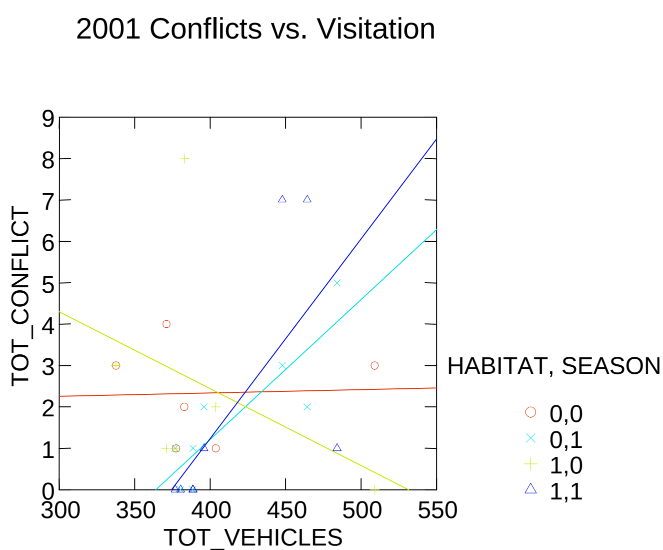
Soapberry

To investigate the relationship between visitation, soapberry, and bear-human conflicts, I plotted the number of vehicles entering the valley by the number of conflicts by one week period. Conflicts were separated into categories according to whether the conflict occurred in soapberry habitat (1=soapberry habitat, 0=non-soapberry habitat) and whether the berries were ripe (1=ripe, 0=not ripe) (Figure 2.6). It was not possible to establish complete independence of conflicts (i.e. an individual bear could be responsible for more than one conflict). To address this, I removed conflicts for which I could individually identify the bear responsible (through genetic analysis of hair left at the conflict site or through human participant descriptions and spatial/temporal

Figure 2.6. Comparison of visitation by conflicts for habitat type (1=soapberry, 0=non-soapberry) and season (1=ripe, 0=not ripe), 2000-2001. Data points represent one week periods.



r **= 0.194**
r **= 0.423**
r **= 0.457**
r **= 0.261**



r **= 0.039**
r **= 0.861**
r **= -0.380**
r **= 0.658**

associations). A total of 14 conflicts were removed from the 2000 data set and 6 from the 2001 data set (n=124) which were attributable to individual bears. This did not, however, ensure independent evidence for association; consequently, this analysis is exploratory rather than explanatory.

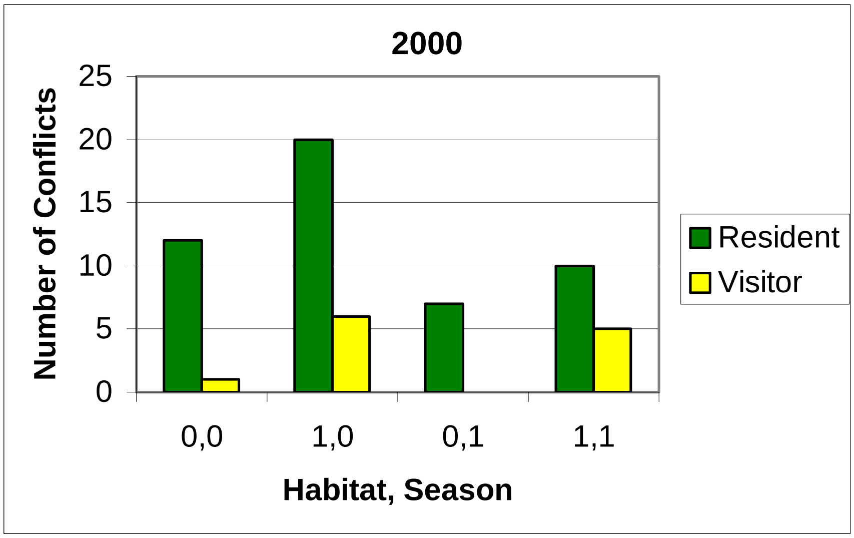
The strongest correlation between habitat/season and number of conflicts appears to be non-soapberry/berries ripe (0,1) (Table 2.8). However, no consistent pattern of correlation was revealed between years for the four combinations of habitat and season, so this line of inquiry was discontinued.

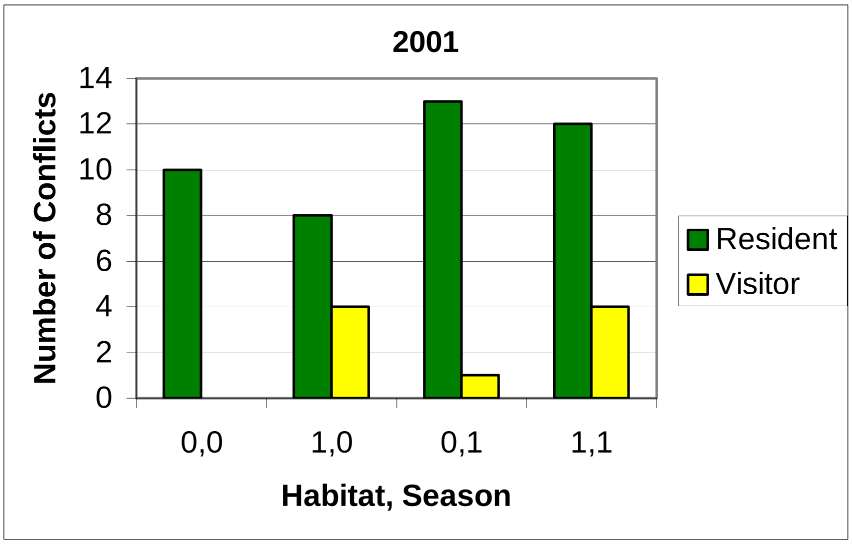
Table 2.8. Pearson correlations of conflicts versus vehicles by habitat (1=soapberry, 0=non- soapberry) and season (1=ripe, 0=not ripe) combinations (from Figure 2.6).

	Habitat, Season			
	0,0	0,1	1,0	1,1
2000	0.194	0.423	0.457	0.261
2001	0.039	0.861	-0.38	0.658

I also summarized conflict occurrence by habitat, season, and residency of the human involved for the period June 19 to September 17 (Figure 2.7). Again, I removed conflicts (20 in all) which were attributable to individually identified bears to better meet assumptions of independence of observations. Conflicts for which the residency of the human involved was unknown were also removed (n=113).

Figure 2.7. Conflicts by habitat (1=soapberry, 0=non-soapberry), season (1=ripe, 0=not ripe), and party involved.

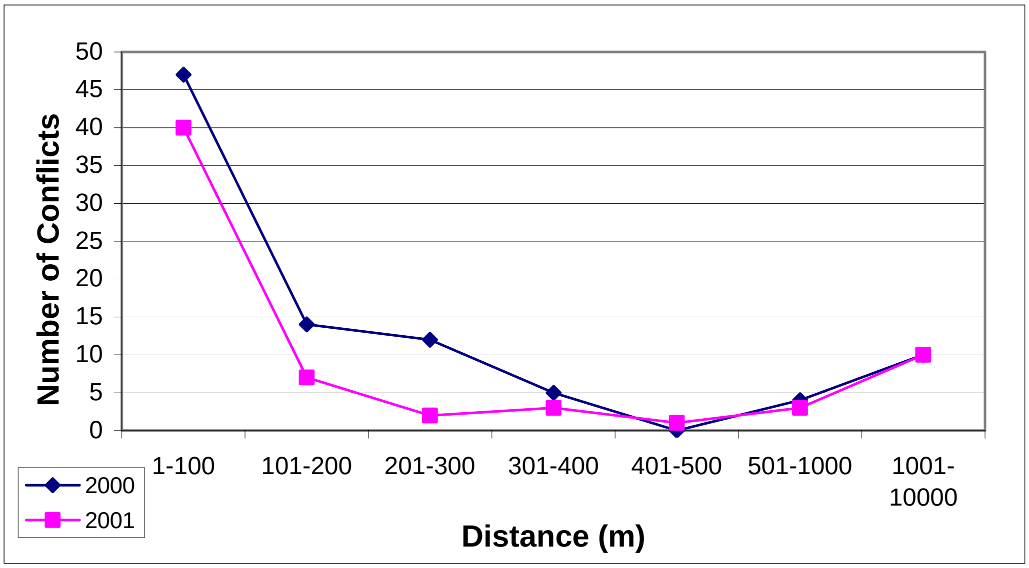




Residency of Person Involved in the Conflict

Because residents are involved in the vast majority of conflicts with bears (Table 2.1), I investigated the distance between a conflict location and the nearest private development (Figure 2.8). Public developments, such as the NPS campground, were not included in this analysis. These calculations were performed in Arcview.

Figure 2.8. Number of conflicts by distance to private development, 2000-2001.



This analysis suggests that distance to private development may be a better predictor of bear-human conflicts than visitation. A total of 55% (87 of 157) of reported conflicts were within 100 meters and 69% (108 of 157) were within 200 meters of a private development. Spearman rank correlation coefficients calculated for 2000 and 2001 between number of conflicts and 7 distance categories showed bear conflicts increased in proximity to private developments (r_s=-0.75 [P=0.052] and r_s=-0.25 [P=0.585], respectively). The Kruskal-Wallis test for difference in conflicts between years indicates that there was no significant difference (p=0.306). Therefore, I combined years for Spearman rank correlations. This yields a r_s=-0.61 (P=0.148)

Discussion

Visitation

My method of tracking visitation did not include those visitors who arrived by air, whether by the twice weekly mail plane or by private charter. Although the number of visitors who arrived by these means was no doubt fewer than those arriving by the road system, individually they were likely no less significant. My system of tracking visitation to the area did provide a measure of the relative amount of visitation over the summer. I have also provided baseline data for future reference on the impact that future road improvements will have on visitor numbers.

In the Kennicott valley, the majority of conflicts occurred in July (Figure 2.3), and are largely independent of visitation (Figure 2.1). This is to be expected, as visitors were involved in only 20% of reported conflicts (Table 2.1). However, visitation contributes to bear habituation, which helps to explain the modest correlation seen in Figure 2.1. Although visitation apparently explains 39% of the variation in the number of conflicts which occurred in the study area (Figure 2.1), the relationship may be a spurious correlation as regressions are susceptible to patterns and both visitation and bear activity increase independently during the summer. Although bear sightings were somewhat influenced by the number of people in the valley, visitation explains only 30% of the variation in the number of bear sightings reported (Figure 2.5).

Bear-human conflicts

At least 26 bears, and perhaps as many as 36, were killed in and around the Kennicott valley from 1999-2001 (Table 2.4, Table 2.5, Table 2.6). Confirmed deaths include at least 10 grizzly bears, of which at least two were females and 4 were cubs; and

16 black bears, at least 3 of which were female (Table 2.4). It is likely that other bear killings went unreported during this time (Smith et al. 1989); therefore the actual number of bears killed may be much higher. This rate of mortality is probably unsustainable, particularly for grizzly bears, and lends further support to the idea that the Kennicott valley functions as a population sink for grizzly bears.

The obvious question which arises is why are so many bears being killed in the Kennicott valley? The first major points to consider are that residents were responsible for 80% of reported conflicts and that bears received a food reward in 37% of reported conflicts (Table 2.1). Occasional confrontations with bears are routine for people living in the valley (Smith et al. 1989), and most homesteads have a history of nuisance bear problems, many of which go unreported. Therefore, the high number of reported conflicts in this study is probably an under-representation of the actual number of conflicts which occurred.

Residents were involved in the great majority of reported conflicts in which bears received a food reward (88%), destroyed property (82%), or in which bears were killed (93%) (Table 2.2). Seventeen individual bears (13 black and 4 brown) were identified from conflict samples (Chapter 1), suggesting that a relatively large number of bears are coming into conflict with humans in the valley, rather than just a few “problem” bears. All of these facts are a direct result of the widespread availability of human attractants in the Kennicott valley, and are indicative of the many opportunities bears have to become habituated and food conditioned. This situation exists because local residents live in fixed locations with inadequate trash disposal, raise gardens, use compost, dispose of garbage on site, and often store their possessions in less than desirable circumstances for excluding bears.

Many studies have documented a relationship between the availability of human foods and garbage and the occurrence of bear-human conflicts (Mattson 1990), and there are many attractants associated with human areas in the Kennicott valley (Table 2.3). Garbage is a major attractant for bears in the valley (Rogers et al. 1976, Stringham 1986, Blanchard 1987, Rogers 1987a), and bears received a food reward in 61% of reported conflicts which involved garbage (Table 2.1). Although I found little evidence to suggest that garbage comprises a major portion of bears' diets in the Kennicott valley, it is implicated in many conflicts (Table 2.1) and contributes to the food-conditioning of bears, which is directly implicated in human-caused bear mortality. Mattson et al. (1992) found that habituated and food-conditioned bears were 3-4 times more likely to be killed by humans than were non-habituated bears.

Although there are currently no garbage dumps in the McCarthy area, they may have produced many food-conditioned bears in the recent past. McCarthy had a town dump at the junction of Clear Creek and McCarthy Creek until around 1975 (Jim Edwards, pers. comm.). There was also an open garbage dump in Kennecott from at least 1987 until around 1995**.** This dump was implicated in the death of many bears over the years (WRST case incident records #8700107, 880107, 920123). Because bears are long-lived, intelligent animals with the ability to navigate to food sources, previous dumps may still be a factor in bears returning to the area, even after long periods of no use.

Although no bear-caused human injuries have occurred in the Kennicott valley to date, both visitors and residents have experienced "physical contact" with bears (Table

2.2), particularly brown bears. In 1999 and 2000, there were several instances of brown bears acting very aggressively towards humans. In 1999, a female brown bear with 2-year old cubs chased, treed, and cornered people and destroyed property on numerous occasions (WRST records). These bears were extremely aggressive and were successful in obtaining food and garbage numerous times.

The above facts indicate that a very dangerous situation currently exists in the Kennicott valley. Human-habituated, food-conditioned bears are responsible for the vast majority of injuries inflicted on people in national parks (Herrero 1985). Such bears learn to forage in campgrounds and other areas of human development, and can become quite aggressive in their search for garbage and unsecured foods. This situation is exacerbated when developments are located near regularly used bear habitat, where non-habituated bears may become so (Herrero 1985).

<u>Soapberry</u>

The onset of hyperphagia in the fall drives bears to seek out the most productive and nutritious food sources available to them (Nelson et al. 1983). The most important factors influencing bears' selection of food items are apparent digestible energy (ADE) and the availability and handling time of each food type (C. Robbins pers. commun, Robbins 1993). Soapberry offers several foraging advantages for bears. It occurs on relatively recent glacial moraines in very extensive stands of up to several km^2 in size, and individual fruiting branches may contain from 20-100 clustered berries (Roseanne Densmore, pers. comm.). Its fruits are relatively high in protein (Figure 2.9) and energy (Figure 2.10), and are easily digestible (> 70%) (Prichard and Robbins 1990, McLellan and Hovey 1995, Welch et al. 1997). In the Flathead valley of British Columbia, *Vaccinium sp.* and *Shepherdia canadensis* contained the highest ADE of the plants collected in any season (Figure 2.10) and when fruits of these species ripened, bears abruptly switched to them (McLellan and Hovey 1995). The ripening of soapberry probably draws bears into the Kennicott valley in a similar manner.

LeFranc et al. (1987) note that, where present, *Vaccinium* spp. and *Shepherdia* spp. are the primary sources of energy and fat deposition for grizzly bears. Pearson (1975) estimated that grizzlies could eat up to 200,000 soapberries a day during peak feeding periods. He reported that one immature grizzly gained an average of 1.4 pounds a day over a sixteen day period while feeding exclusively on soapberries. However, grizzlies' utilization of less productive berry patches is constrained by their need to sustain their larger body size. The heavier masses required for successful reproduction in grizzlies may not be obtainable by bears relying on fruit alone for the acquisition of body fat; they may require a richer food resource, such as meat or salmon (Rogers 1987a, Farley and Robbins 1995, Hilderbrand et al. 1999b). Because black bears are smaller, they are better able to utilize soapberries (Welch et al. 1997, Rode and Robbins 2000).

Figure 2.9. Comparison of percent apparent digestible protein (ADP) of major bear foods in the Flathead drainage, B. C. (Modified from McLellan and Hovey 1995).

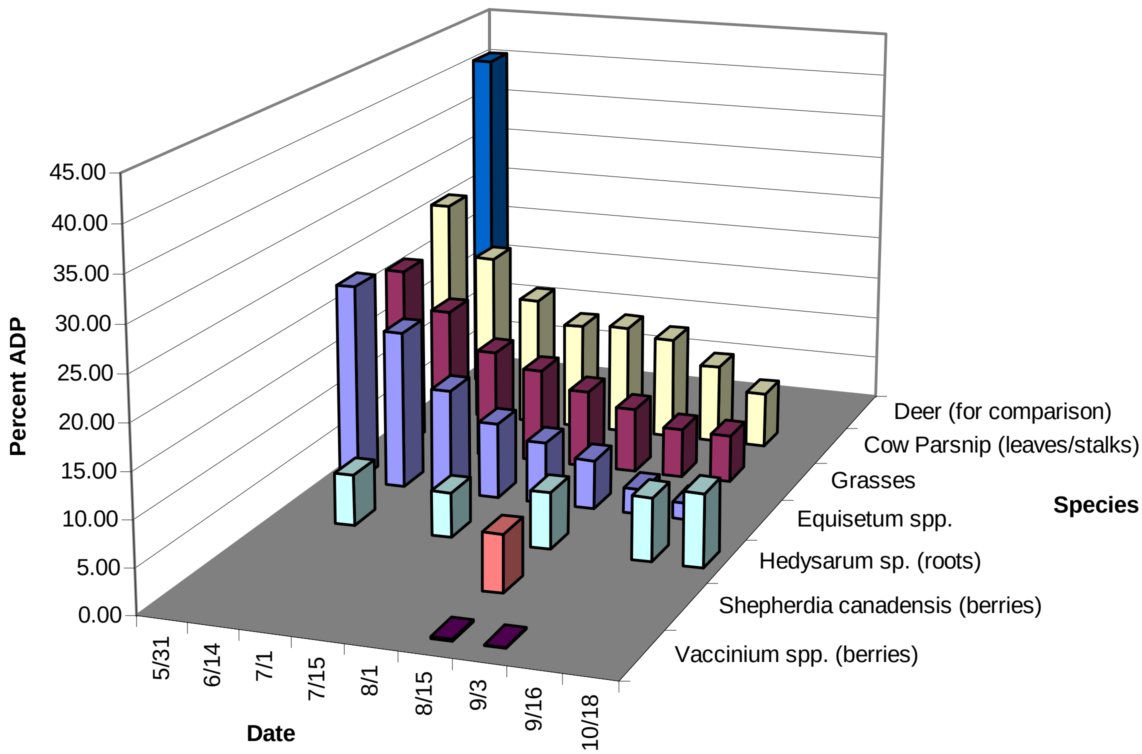
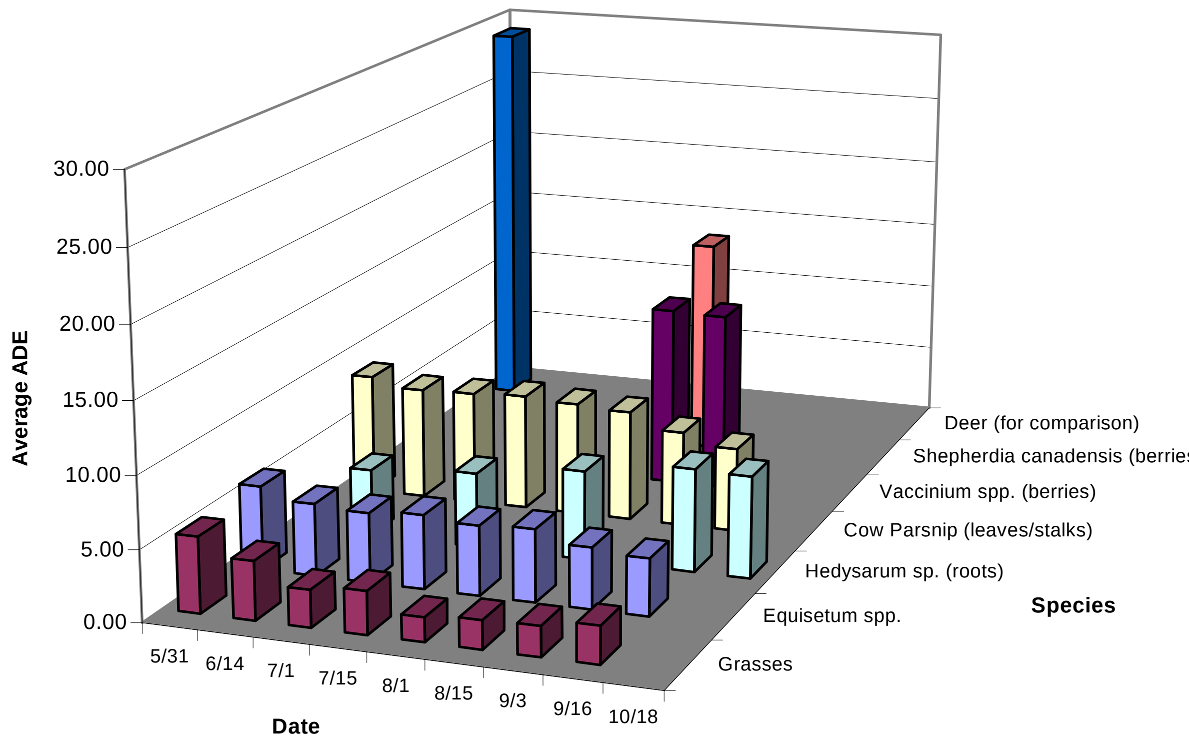


Figure 2.10. Comparison of average apparent digestible energy (ADE; kJ/g dry matter) of major bear foods in the Flathead drainage, B. C. (modified from McLellan and Hovey 1995).



Conflicts probably peak in July (Figure 2.3) due to a combination of increasing bear use of the valley, habituation, and food conditioning. Prior to soapberry ripening, bears generally feed in lush alpine meadows. Humans generally concentrate around the glacier edge during the summer and don't regularly encounter bears until they switch to feeding on berries. Family breakup occurs during June-July, so many sub-adult bears are newly independent at this time (MacHutchon and Smith 1990), and prone to come into conflicts with humans (Jonkel and Cowan 1971, Ruff 1982, Klenner 1987, Rogers 1987a, Garshelis 1989, Mattson 1990, Schwartz and Franzmann 1992).

Genetic data suggests that a large number of bears enter the valley after soapberry ripens (Chapter 1). The peak of bear sightings in July and August of both years (Table 2.7), which is largely independent of the number of humans in the valley (Figure 2.5), also supports the idea that bears enter the valley as soapberry ripens. While they await berry ripening, they inevitably encounter humans and conflicts ensue. Conversely, once bears begin feeding on berries, they are less inclined to range widely and seek out human foods, thus reducing the incidence of conflicts in August and September (Figure 2.3). In the McCarthy area, I found that bears seemed less inclined to react to humans as the season progressed, particularly when feeding on soapberries. Nadeau (1987) also observed that bears in Glacier National Park may have reduced perceptions of humans as a threat as the season progresses.

The failure of the berry crop could presage an increase in bear-human conflicts (Young and Ruff 1982, Knight et al. 1988, Mattson et al. 1991, Kontio et al. 1998). For example, 2000 appeared to be a poorer berry year than 2001, and the number of reported conflicts was 38% higher in 2000 (Table 2.1). Although black bears may be more likely to cause property damage in their search for food during years of berry crop failure, there is little evidence that grizzly bear attacks on humans increase during these same years (Herrero 1985). During poor food years, nearly 6 times the number of bears were "management-trapped" and nearly twice as many bears were killed in Yellowstone (Mattson et al. 1992). Fatalities were highest among adult females and sub-adult males, which tended to range closer to humans during low-production years.

Therefore, conflict occurrence is not necessarily dependent on soapberry habitat per se. It is more likely related to habitat phenology and availability rather than strictly to habitat type. Although I hypothesized that conflicts would be highest in soapberry habitat prior to soapberry ripening due to many hungry bears entering the valley to seek out productive berry patches, my data did not support this prediction (Figure 2.6, Table 2.8). My data provided no strong evidence that conflict occurrence is more prevalent in soapberry habitat. There is some explanatory power, but r^2 values are modest (Table 2.8, Figure 2.6).

When looking at conflicts by habitat, season, and residency, no clear pattern of conflict occurrence was revealed (Figure 2.7). The only pattern revealed was that visitors are more likely to experience conflicts in soapberry habitat, which is to be expected, as they spend the majority of their time along the glacier edge, which is prime soapberry habitat. Resident conflicts are much more common, regardless of habitat type.

Private Developments

Figure 2.8 suggests that distance to private developments is more important than habitat type and time of year (Figure 2.6, Figure 2.7) with regard to conflict occurrence. Coefficients of determination for this relationship are stronger but different than those associated with soapberry habitat and ripening in that they do not incorporate temporal aspects of conflict occurrence.

Mattson et al. (1992) indicated that the preponderance of bears using habitat around human facilities in Yellowstone did not tolerate humans as a means of acquiring human-related foods. Rather, bears frequent these areas during the course of using native foods near them, and because they have fewer options in more remote areas. While using natural foods in human-occupied areas, the temptation of unsecured attractants at human developments is overwhelming, and conflicts ensue. Bears used areas near human facilities significantly more during years of little or no natural food production (Mattson et al. 1992).

Bears are strongly attracted to human areas in the Kennicott valley due to the potential food rewards associated with them (Table 2.3). Resident homesites and developments which aren't "bear-proofed" act as point sources of attractants for bears. Bears that receive food rewards at human developments learn to associate humans with food and can become particularly aggressive in their pursuit of these attractants (Herrero 1985).

There is a clear pattern when conflict sites are mapped spatially (Figure 2.2); 69% of reported conflicts were within a 4 km radius of the proposed campground. The concentration of conflicts at the "end of the road" is probably a function of three things: it is a natural travel corridor, there is a concentration of human attractants there, and it is good berry habitat. Genetic data (Chapter 1) indicates that a large number of bears use this same area, 72% of which are male, many of which are probably sub-adults (Rogers et al. 1976, Mattson et al. 1987). Subadult male bears, and to a lesser extent adult females, are involved in the majority of bear-human conflicts and are more likely to tolerate humans (Kolenosky and Strathearn 1987, MacHutchon and Smith 1990, Mattson et al. 1987, McLellan and Shackleton 1988, Mattson 1990, Albert and Bowyer 1991, Mattson et al. 1992). These facts indicate that a very dangerous situation exists near the proposed campground, and largely explain the high number of bear-human conflicts in this area. The lesser area of conflict concentration near Kennecott is primarily due to one homestead that has poor garbage security, chickens, guineas, and pigs.

Population Sink

The fact that the Kennicott valley may function as a dispersal sink for surrounding bear populations (Chapter 1) has profound implications for bear-human conflicts in the valley. For example, social interactions often prevent subdominant animals from entering high-quality habitat. Dominant male bears generally occupy areas away from human disturbances, while sub-adults seem to prefer areas of high visitor use (Nadeau 1987). As a result, sub-adult males and adult females often forage closer to humans because more secure and productive sites are often preempted by adult males (Jonkel and Cowan 1971, Pearson 1975, Garshelis and Pelton 1981, Pelchat and Ruff 1986, Mattson et al. 1987, Rogers 1987a, McLellan and Shackleton 1988, Mattson 1990), which leads to increased conflicts with people, as noted earlier. Thus, the high number of reported conflicts in the study area (Table 2.1) is likely due to the presence of a high number of sub-adult male bears (Chapter 1).

Sinks may actually contain high quality habitat, but be located in a human dominated matrix (Van Horne 1983). Although adult females and sub-adult males may experience short-term advantages in human-occupied areas, the longer-term consequences probably result in lower survivorship for both classes (Mattson 1990).

Killing bears does not prevent the future occurrence of bear-human conflicts; indeed it likely only perpetuates them (Gunson 1975, Mattson 1990). The proportion of adult and sub-adult males in a population probably has the greatest ramifications regarding bear-human interactions (Young and Ruff 1982, Mattson et al. 1987, Mattson 1990). Killing bears, particularly males, may simply create opportunities for dispersing individuals to establish home ranges in the valley (LeCount 1993, McLellan 1993). The combination of increased numbers of sub-dominant bears and their tendency to forage on human foods and garbage leads to increased bear-human conflicts in areas where adult males are absent (Mattson 1990). These are most likely naive bears with little or no experience with humans.

The death of older males represents an unusual form of mortality and greatly reduces the effectiveness of intrinsic population control (Bunnell and Tait 1981). According to LeCount (1993), killing adult males may greatly reduce the effectiveness of intrinsic population control and may increase total mortality in the population. It also prevents human "savvy" bears from establishing home ranges in the area. For example, the 23 year old female black bear killed in 2001 had probably lived in the valley her whole life, knew how to live peacefully around humans, and likely passed these survival skills on to many generations of her offspring.

Demography of Conflict Bears

I considered sub-adults to be between 1 and 4 years of age (Schwartz and Franzmann 1992, Taylor 1994, Garshelis 1994). Five of eight bears for which I determined age were sub-adult males (4 black, 1 brown); two were adult male black bears; and one was an adult female black bear (Table 2.5, Table 2.6). My limited sample of DLP bears seems to support the theory that young male bears are more likely to be involved in bear-human conflicts (Kolenosky and Strathearn 1987, MacHutchon and Smith 1990, Mattson et al. 1987, McLellan and Shackleton 1988, Mattson 1990, Albert and Bowyer 1991, Mattson et al. 1992).

Contrary to initial predictions, there is little evidence to suggest that females with cubs are more prone to come into conflict with humans in the Kennicott valley. In fact, during 2000-2001, females with cubs were involved in only 4% (7 of 157) of reported incidents. However, there seems to be few cubs in the valley (Table 2.7), which may indicate poor reproductive success and/or that sub-adult males are killing cubs in the valley, as postulated by LeCount (1993). Based on their spatial/temporal distribution, many reported cub observations were probably repeat sightings of the same family groups.

In the Kennicott valley, brown bears are disproportionately involved in conflicts with humans compared to black bears (Figure 2.4). This is probably a consequence of resident humans' greater intolerance of grizzly bears and the bears' aggressive pursuit of feeding opportunities (Jonkel 1970, Herrero 1972, Herrero 1978, Mattson 1990).

Management Implications

The Kennicott valley will continue to be developed as the centerpiece of visitation within WRST for years to come. Human occupation and development of private lands within the valley will also continue apace. The fact that local residents are involved in a disproportionate share of the reported bear-human conflicts suggests that increasing development and human occupation of the valley may presage a dramatic increase in the occurrence of bear-human conflicts in the future. Unless WRST makes bear management a high-priority natural resource concern and devotes adequate personnel and resources to implement pro-active management strategies, bear populations in the park will continue to suffer and human safety will be compromised.

A dangerous situation now exists in the Kennicott valley, due to the high number of food-conditioned bears and a lack of basic services for local residents. The priority management task should be to implement an effective local system of waste-disposal which is easily accessible and convenient to use. WRST should continue to provide bear-proof storage containers and electric fencing to local residents through agreements in place with local non-profit environmental organizations. This service is cost-effective, encourages local residents to take responsibility for bear-proofing their homesteads, and suits the independent self-sufficiency of those who choose to live in the valley. Obviously, the use of these items is most important during the month of July (Figure 2.3). The use of electric fencing is only effective if the user is dedicated to its proper installation and maintenance.

Based on information provided by local residents, the increased focus on bear education of visitors by the NPS in the Kennicott valley, in conjunction with the use of food storage boxes in the NPS campground and along the Root Glacier trail, have helped reduce the current number of food conditioned bears in the area. Education of visitors obviously works; now efforts should be increased to educate local residents, particularly concerning securing human food and garbage.

In 2001, WRST instituted a park-wide voluntary program whereby park visitors could borrow bear resistant food containers (BRFC's) to secure their food and garbage while camping. The fact that residents are 18 times more likely to be involved in conflicts due to improper storage of garbage and were twice as likely to be involved in conflicts because of human food and pet food than were visitors seems to indicate that the voluntary use of BRFC's by visitors and providing bear education to them is working. However, while the number of incidents has diminished, visitors must continue to be educated by the NPS regarding the consequences of leaving pet and human food accessible to bears.

WRST should continue to develop park-specific bear education programs, brochures, articles, and displays. Bear education programs will be particularly important and effective in the rural schools in and around the park. Information should be provided on basic bear ecology and natural history, how to live responsibly in bear country, and the significance of WRST to grizzly bear conservation in North America and as part of an international World Heritage complex. At the same time, common myths and misinformation concerning bears should be debunked. This information should be presented in as many media formats as possible to also reach the large transient population which works in and around the park each year.

The NPS should encourage aversive conditioning of bears by local residents as an alternative to indiscriminate killing. It is important that residents begin "educating" bears early in the season. Once a bear becomes food-conditioned, aversive conditioning will likely not deter it from actively seeking human foods and garbage (Herrero 1985). If bears are taught early and often to avoid areas of human occupation, conflicts should be minimized. Dogs are by far the most effective deterrent used by local residents to dissuade problem bears. Proper food and garbage storage, airhorns, rubber shot, and electric fences are also very effective. WRST could provide information to residents on proper aversive conditioning techniques. Wounding bears should be strongly discouraged. WRST should cooperate with local residents on DLP bears, including filling out the necessary paperwork, transporting the hide and skull to ADF&G, and providing specific recommendations on how to avoid bear problems in the future.

In order to better elucidate the "soapberry effect," a more fine-grained time scale would be needed, which better isolated the period when bears are actively searching for productive berry patches (July). Larger sample sizes would greatly enhance the rigor of future investigations into this matter. In order to effectively model the occurrence of bear-human conflicts, I would need to have a measure of when conflicts *did not* occur, and would need to equalize reporting rates by visitors and residents. A data set that reports non-conflicts as well as conflict occurrence would be ideal for model creation as the probability/risk of a conflict could be determined.

Some variables which should be included in future modeling efforts of bear-human conflicts include: bear species, time period (prior to soapberry ripening, period of soapberry ripening [month of July], post soapberry ripening), soapberry productivity, visitation, habitat type, distance to nearest human development or local residence, and whether the person(s) involved were residents or non-residents. The dependent variables of interest are the location of incidents and the number of incidents which occur in a given year.

High-priority future research needs include an investigation into the home range sizes and configurations of the bears which use the Kennicott valley and whether the high densities of bears observed in the valley (Chapter 1) are partially a result of the breakdown in social hierarchies among bears feeding on soapberry, as documented for other seasonal concentration feeding sites such as salmon spawning streams. Resident bears' spatial use of the landscape, particularly by different sex/age classes of bears, should also be investigated to determine how "problem" bears and "people-savvy" bears move across the landscape and use habitats in human-dominated areas.

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