Evaluating the success of grizzly bear rehabilitation in British Columbia, Canada

A thesis submitted
to the School of Forest Science and Resource Management
Sustainable Resource Management Program
in partial fulfilment of the requirements for the degree of
Master of Science

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May 2009
Technische Universität München

Dedication

To Sam - You are already such an amazing person. I hope you'll always keep your interest in wildlife, I hope you'll be surrounded by it throughout your life.

Acknowledgements

A lot of people helped me turn this Thesis into something that would eventually be worth a read. I want to thank all of them, but some in particular.

Most important of all: I want to thank my wife Angela, the perfect addition to my life. Without you I couldn't have done any of this; without you I wouldn't have wanted to do it. You mean the world to me!

I thank my Thesis advisor Dr. König for taking on this Thesis; a project 7,783.94 kilometers away from his office with a sample size of two bears. I thank Angelika Langen from the Northern Lights Wildlife Society for sharing her home with me and for inviting me to be a part of this project. I thank the German Academic Exchange Service (DAAD) for granting me a stipend; my part in this project would not have been possible without it. I thank the people that contributed their wealth of knowledge for this Thesis: Dr. Helen Schwantje, Tony Hamilton, Dr. John Beecham, Dr. Lana Ciarniello and Leonardo Bereczky. I thank Kim Elmslie and Anand Ramanathan from the *International Fund for Animal Welfare* for supporting our field work and especially for dressing me warm while being in the field. I thank Ruth Fitzell for her support with the field work. I thank Morgan Hite for turning regular maps into art and Volker Schunicht for sharing his ArcGIS skills. I thank *GPS central* for their generous donation of TOPO Canada and *ESRI Germany* for supplying me with ArcGIS. I thank chief pilot Eric Stier from Guardian Aerospace for trying his best to find the bears as well as trying to keep me in Prince George.

And last but definitely not least: I want to thank my parents for their constant support throughout my life.

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Abstract (English)

The grizzly bear (*Ursus arctos*) is a well studied species, but little is known about the possibility and feasibility of orphaned grizzly bear cub rehabilitation and release as a practical, humane management technique. The goal of this Thesis is to gather information on grizzly bear rehabilitation in North America and brown bear rehabilitation globally. In addition, as a demonstration, it follows two orphaned grizzly bear cubs (1 male, 1 female) before and after their release back into the wild. The cubs were hand reared at a wildlife rehabilitation facility and released in July of 2008 in the Hart Ranges of the Canadian Rocky Mountains in central British Columbia. The bears (1 ½ years at release) were released before the natural age of dispersal of grizzly bears (2-3 years in study area). Post release monitoring was conducted to establish survival and gather behavioral information on the bears. The GPS/Argos collars used had a collar fix rate of 19.44% (♂) and 21.57% (♀); they transmitted 56 (♂) and 88 (♀) GPS locations before failing to transmit after 27 (♂) and 39 (♀) days in the field. The bears' initial center of activity (95% Fixed kernel home range: 102.38 km^2 (♂) 41.51km^2 (♀)), was close to the release site (11.35 km (♂), 4.81 km (♀)). After their last known GPS location (August 9th (♂), August 20th (♀)) and their first known VHF location obtained by plane (September 29th), the bears dispersed in a direction opposite to the original direction from the release site (51.87 km (♂), 26.69 km (♀)). The results indicate that the bears survived for at least 79 (♀) and 96 (♂) days in their new environment without displaying aggressive behavior towards humans. Their body condition and health status is not known. It appears that the bears were able to find natural sources of food. Results of this research further indicate that grizzly bear rehabilitation has been conducted in North America before, but with a lower success rate than brown bear rehabilitation in Europe and Russia.

Abstract (German)

Es gibt viele Studien über Grizzlybären (*Ursus arctos*), dennoch ist bis heute wenig darüber bekannt, ob man verwaiste Grizzly-Jungbären per Hand aufziehen kann, um sie dann später wieder in die Wildnis zu entlassen. Das Ziel dieser Arbeit ist es, Informationen zu bisherigen Rehabilitationen von Grizzlybären in Nordamerika und Braunbären weltweit zu sammeln. Ausserdem werden im Rahmen dieser Arbeit zwei verwaiste Grizzly-Jungbären (1 männlich, 1 weiblich) vor und nach Ihrer Rückkehr in die Wildnis begleitet. Die beiden Bären wurden in einer Wildtierauffangstation großgezogen und im Juli 2008 in Britisch-Kolumbien in den kanadischen Rocky Mountains ausgewildert. Die Bären waren bei ihrer Freilassung $1^1/_2$ Jahre alt. Normalerweise trennen sich Jungbären erst in einem Alter von 2-3 Jahren von ihrer Mutter. Die Bären wurden nach ihrer Freilassung beobachtet, um ihr Überleben zu dokumentieren und Daten über ihr Verhalten zu sammeln. Die benutzten GPS/Argos Halsbänder übertrugen nur 19.44% (♂) und 21.57% (♀) der geplanten GPS-Positionen (56 (♂) und 88 (♀)), bevor sie nach 27 (♂) und 39 (♀) Tagen komplett ausfielen. Das Aktivitätszentrum der Bären (95% Fixed kernel home range: 102.38 km^2 (♂) 41.51km^2 (♀)) lag für diesen Zeitraum nahe der Stelle, an der die Bären freigelassen wurden (11.35 km (♂), 4.81 km (♀)). In der Zeit zwischen der letzten GPS- (9. August (♂), 20. August (♀)) und der ersten VHF-Ortung von einem Flugzeug aus (29. September) wanderten die Bären in die entgegengesetzte Richtung ihrer ursprünglichen Bewegungsrichtung (51.87 km (♂), 26.69 km (♀)). Als ein Ergebniss dieser Arbeit kann belegt werden, dass die Bären für einen Zeitraum von mindestens 79 (♀) und 96 (♂) Tagen in ihrer neuen Umgebung überlebten, ohne sich dabei Menschen gegenüber aggressiv verhalten zu haben. Über den gesundheitlichen Zustand der Bären zu diesem Zeitpunkt wurde nichts bekannt. Es ist sehr wahrscheinlich, dass die Bären in der Lage waren, natürliches Fressen zu finden. Des Weiteren zeigen die Ergebnisse dieser Arbeit, dass Grizzlybären in Nordamerika bereits rehabilitiert wurden, jedoch mit einer geringeren Erfolgsquote als Braunbären in Europa und Russland.

Introduction

The grizzly bear (*Ursus arctos*) represents the rugged wilderness to many people more than any other North American mammal. Due to its size, speed, agility and its ability to inflict not only serious harm but even death to humans, it is respected, often feared and the topic of many myths and campfire stories.

Grizzly bears in Canada are very sensitive to human activities; grizzly bear mortality has been directly linked to human access to bear habitat (Nielsen, et al., 2004). Human encounters and legal and illegal hunting are the main causes of death for grizzly bears (McLellan, Hovey, & Woods, 2000). The British Columbia Ministry of Environment lists the grizzly bear as S3, Blue Listed, which means that it is of special concern, vulnerable to extirpation or extinction (B.C. Ministry of Environment, 2008a). Out of the 57 grizzly bear population units in British Columbia, 9 have been designated as “Threatened” under the grizzly bear Conservation Strategy (Hamilton, Heard, & Austin, 2004). The *Committee on the Status of Endangered Wildlife in Canada* ranks the grizzly bear as being of "special concern". This status is due to habitat changes and fragmentation as a result of expanding industrial, residential and recreational developments (COSEWIC, 2002).

Human-induced grizzly bear mortality is one of the main reasons leading to orphaned grizzly bear cubs. Conservation officers dealing with these cubs have four options; they can leave them in the wild, put them in a zoo/research facility, destroy them or put them temporarily into a rehabilitation facility (B.C. Ministry of Environment, 1993). Bear rehabilitation is an option if the cub is of adequate size with no serious injuries or obvious illnesses and not habituated to humans or conditioned to human food sources (B.C. Ministry of Environment, 2001). To enter a rehabilitation facility a grizzly bear cub must be a cub of the year (< 1 year of age). Successful rehabilitation requires the release of animals that function like, and are indistinguishable from, other wild animals in their native environment (Pokras, 1997).

While the success of black bear rehabilitation has been documented for other jurisdictions (Kilham, 2002) (Wasserman, Clumpner, & Mack, 1995) (Rogers, 1986),

there is little data for BC. There is almost no published data on the rehabilitation of grizzly bears. To close the existing gap of information, this Thesis will answer the question if grizzly bear rehabilitation has been attempted before and collect rehabilitation data currently available globally on grizzly bears and brown bears through literature research as well as email and telephone surveys with wildlife biologists and bear rehabilitators.

Before the rehabilitation of grizzly bears can be accepted and used as a valid wildlife management tool, its feasibility and limitations must be researched (Kolter & van Dijk, 2005) (van Dijk, 2005). Post release monitoring of rehabilitated grizzly bears is critical. This Thesis is based on the currently ongoing grizzly bear rehabilitation efforts in British Columbia, Canada and addresses whether the study bears survived and if they adapted to the wild. GPS and VHF data from the collared bears as well as reports from hunters, hikers and biologists were used.

One of the most important aspects of grizzly bear rehabilitation is the care the bears receive in the rehabilitation facility. This Thesis observes the treatment of two bears in a rehabilitation facility in British Columbia and evaluates their behaviour to demonstrate aspects of the captive care that appear important.

The two studied bears survived for at least 79(♀) and 96(♂) days after their release; after this time no signals were picked up from their collars. We can assume therefore that they were able to find sources of food and avoid fatal encounters with both animals and humans for this time; no human attractants were available at or near the release site, very few attractants were available in the broader landscape. As such, the released bears had few opportunities to obtain human foods or garbage. The bears did not display any aggressive behaviour towards humans during their time of known survival.

Six orphaned grizzly bears are reported to have been rehabilitated in British Columbia before, but no post release monitoring was conducted to determine their fate. Grizzly bears in the United States have been rehabilitated with limited success. In Europe the rehabilitation of brown bears has proven to be successful.

Chapter 1 - Data on brown bear rehabilitation

Introduction

This chapter addresses the following question: Has rehabilitation of the North American grizzly bear been attempted before?

Material and Methods

The currently accepted classification of brown bears in North America is based on research dating back more than 45 years (Rausch, 1963). It identifies two subspecies. Bears from the mainland are classified as grizzly bears *(Ursus arctos horribilis),* while bears from the Kodiak Archipelago in Alaska are classified as kodiak bears (*Ursus arctos middendorffi*).
Studies show that there is no genetic (mitochondrial DNA) support for the validity of either of these subspecies (Waits, Talbot, Ward, & Shields, 1998). Instead five lineage groups were defined as clades; clade IV containing brown bears of southern Canada and the lower 48 states (Schwartz, Miller, & Haroldson, 2003).

As rehabilitation efforts of grizzly bears in North America are very limited, attempts to rehabilitate brown bears in Europe and Russia (clade III) were investigated as well. Using the Internet and personal communications with wildlife management and bear rehabilitation personnel, including attendees of the *International Workshop on the Rehabilitation, Release and Monitoring of Orphan Bear Cubs (2007*), information on rehabilitation was gathered.

The following information was asked of people directly involved in past or present bear rehabilitation activities:

- The date of the capture and the release of the bears
- The location of the capture and the release of the bears
- The number of bear cubs that were reared in captivity and released back into the wild
- The age of cubs at release
- The release results

- The method used for marking the bears
- Post release monitoring details (if applicable)
- Details on the captive care

Information about grizzly bear rehabilitation that was vague or came from unknown sources was either further investigated or discarded. The information listed here is what the author of this Thesis was able to find in published papers or through firsthand communication with people involved in rehabilitation efforts. The communication with involved people broke off in some cases and could not be reestablished. This led to a lack of consistency in the presented data. An overview of the results is given in Table 1 on page 7, followed by detailed information of each case.

This history of brown bear rehabilitation claims in no way to be a complete overview of the activities that have been conducted. It is therefore called a “short history”.

Results

A short history of brown bear rehabilitation

	Date	Location	Number of cubs	Age of cubs at release	Release results	Marking	Post release monitoring
NORTH AMERICA	2007	BC/Canada	4	~ 17 months	•Food conditioning (2) → destroyed (2) •Unknown (2)	Ear tags	No
	2004	Montana/USA	2	~ 12 months	•Food conditioning (2) → Zoo (2)	Ear Tags	No
	2003	Montana/USA	2	~ 15 months	•Food conditioning (2) → Zoo (1) → Death after surgery (1)	Ear tags	No
	1999	BC/Canada	2	~ 17 months	Repeated sightings (2)	Ear tags	No
	1995	Montana/USA	1	~ 12 months	•Killed by larger bear (1)	unknown	No
	1994	Montana/USA	3	~ 12 months	•Food conditioning (3) → Zoo (2) →Killed by large bear (1)	Ear tags	No
	Late 70s	Montana/USA	2	~12 months	•Survival & Reproduction (1) •Unknown (1)	Ear tags	No
	1977 - 1978	Montana/USA	5	7 - 11 months	•Repeated sightings (3) •Food conditioning (2) → Zoo (2)	Ear tags	No
	1975	Montana/USA	1	~ 10 months	•Repeated sightings (1)	Ear tags Radio collar	Failed (Dropped collar)
EURASIA	Ongoing	Romania	25	18 months – 24 months	•Killed by large bear (7) •Survival for > 1 year (18)	Radio collars	Yes
	1990 - 2002	Russia	70 – 100	7-8 months / 16 months	•74% adjusted to the wild •16% died of natural causes •5% died of injuries/disease	Ear tags Some transmitters	Yes
	1989	Croatia	5	~ 8 ½ months	•Food conditioning (3) → Zoo (3) •Killed by car (1) •Unknown (1)	Radio collar	Yes

Table 1: Overview of grizzly bear/brown bear rehabilitation in North America and Eurasia

Between **1999 and 2007** a total of six orphaned grizzly bear cubs were hand raised and released in British Columbia. This was done by a wildlife rehabilitation facility near Dawson Creek, British Columbia:

In the spring of 2006 three grizzly cubs of the year were retrieved from Km 14 of the Red Willow Forest Service Road near Dawson Creek and transported to the rehabilitation facility. The bears were assumed to be siblings. A fourth orphaned grizzly cub of the year was captured on Flatbed Creek along Hwy 52 and also transported to the rehabilitation facility. The four bears (two male, two female) were held in the same enclosure with an orphaned black bear throughout the winter.

In May 2007 all four grizzly yearlings were chemically immobilized and transported by helicopter to the same remote release site. Two 16 kg bags of dry dog food were left at the release site. The cubs were ear tagged before their release; no post release monitoring was conducted. Of the four bears released, two were killed in September 2007 at a recreational campsite in self defense as a result of becoming food conditioned. A few months prior the same two had been re-captured when they attended an industrial camp and persisted around it (personal communication, Brad Lacey, conservation officer, December 1st, 2008.) The fate of the other two bears is unknown.

The two bears released in 1999 have been seen repeatedly and appear to be in very good physical condition (personal communication, Leona Green, Hillspring Wildlife Rehabilitation Facility, November 1st, 2008).

In the winter of **2003/2004** two orphaned grizzly cubs of the year were released in Montana. The release itself was a success. Later in the year the two bears got into uncontained grain and birdseed. The resident did not call Montana Fish, Wildlife and Parks for several weeks and the two cubs became food conditioned. The bears were captured and are now living in the San Francisco Zoo (personal communication, Jamie Jonkel, Montana FWP, December 9th, 2008)

In **2003** a male grizzly bear cub of the year and a female grizzly bear cub of the year were released to the wild. Their mother, an adult female was shot in self defense at a chicken coop near Fortine, Montana. The cubs were captured in October and sent to

the Montana Fish, Wildlife and Parks wildlife center in Helena. They were fed and in March 2004 released into an artificial den in the North Fork of the Flathead drainage. In July 2004 they were both recaptured after persistently approaching residences. They were again released along Hungry Horse Reservoir on Forest Service lands. Eventually, they ended up in campgrounds. They were recaptured in August 2004 and sent back to the wildlife center in Helena. The female bear died while coming out of anesthesia after an ovariohysterectomy. The male was eventually sent to a zoo (personal communication, Tim Manley, Montana FWP, December 8th, 2008).

In **1995** one injured female grizzly cub of the year was treated on private land near Yellowstone National Park, Montana. The cub had been orphaned all summer and showed no problems until its injury. After its initial stay in a large culvert trap, a pen and den was constructed during early November. The cub was reported to be shy. It was fed with deer and elk meat. The cub would hide in the den while food was placed in the pen. After about a month the then healthy cub escaped and naturally denned about 3 kilometers from the artificial den. In the spring some deer carcasses were dropped in the area and the bear fed upon them and moved further into Yellowstone National Park. In early July of 1996, the bear was found dead. The yearling had been killed and consumed by a larger bear (personal communication, Kevin Frey, Montana FWP, December 9th, 2008).

In **1994** three orphaned male grizzly bear cubs of the year were returned to the wild. All three bears originated from the Confederated Salish and Kootenai Reservation in Montana. All of them were very food conditioned when captured. They were held in captivity at a wildlife rehabilitation contractor's facility from September 1994 to February 1995. They were denned at the facility in late December. All three were then placed in a den in natural habitat along the Rocky Mountain Front. In spring of 1995 the bears were seen repeatedly at a guest ranch and eventually two were recaptured and sent to the Bronx Zoo in New York. The third one was killed by a larger bear (personal communication, Tim Manley, Montana FWP, December 8th, 2008).

In the **late 70s**, two orphaned cubs of the year were ear-tagged and transported by helicopter to a remote winter den in Thorofare River Country, Wyoming. The bears had

spent a couple of weeks in captivity before their winter denning. They were left with 4 – 5 elk carcasses. One of the bears was recaptured in the late 80's with cubs of her own and the ear tag still attached (personal communication, Jamie Jonkel, Montana FWP, December 9th, 2008).

In **1977 and 1978** a total of 5 grizzly cubs were released back into the wild as part of the Montana Border Grizzly Project. All of these bears were tattooed and ear tagged:

In 1977 one cub of the year was released in late November and was spotted the following year in July.

In 1978 two cubs of the year were denned in a remote area in an artificial winter den. The bears stayed together for over a year and were seen repeatedly in the years after their release.

In 1978 two cubs of the year were released in summer. They appeared to be food conditioned shortly after their release. They were recaptured and sent to a zoo (personal communication, Dr. Charles Jonkel, April 6th, 2009).

In **1975** one orphaned female grizzly cub of the year was returned to the wild as part of the Montana Border Grizzly Project. The cub was placed in an artificial den on November 11th after being fed for maximum weight gain at facilities of the University of Montana. The cub was approximately 10 months old at the time of release. A box of fruit was stashed near the den two days after the release. Investigations of the den site two days later showed that some of the fruit had been eaten. The cub was ear-tagged and radio collared. Monitoring attempts failed; the cub lost the radio collar two days after its release. The cub was spotted the next spring on more than 10 occasions 8 kilometers from the artificial den site and appeared to be in good condition. The background, the captive care, the den site and the release have been described in detail and published (Jonkel, Husby, Russel, & Beecham, 1980).

In addition to these North American grizzly bear rehabilitation efforts, the following are brown bear rehabilitation projects conducted in Eurasia:

Romania: In Harghita (North Eastern Romania) a bear rehabilitation center was established to prepare orphaned brown bear cubs for their return into the wild. The cubs go to the center at a maximum age of 6 months (in rare cases > 6 months). During their time at the rehabilitation centre contact to humans is kept to a bare minimum. One full time staff member is the only human allowed to be close to the bears. The space offered to the animals shows a dynamic enlargement. The bears' release does not follow a certain time pattern; it is instead based on the individual's behavior and body shape and on average happens when the bear is $1^1/_2$ to 2 years old. After their release the bears are monitored using GPS/GSM collars for at least one year. Twenty-five bears have been hand reared and released. Seven of them were killed by large bears in the beginning of summer, the mating season for bears. None of the bears have been involved in any conflict or nuisance activity after their release (personal communication, Leonardo Bereczky, Harghita Bear rehabilitation cente, December 7th, 2008).

Russia: At the Toropetsky Biological Station in the Central Forest Natural Reserve in Pozhnia, Russia, orphaned brown bear cubs have been rehabilitated since 1990. The number of bears rehabilitated differs depending on the literature reviewed. Approximately 70 to 100 bears had been released by the year 2002, 10 of these cubs originating from zoos. Bears are released at the ages 7-to-8 months and 16 months from July to October.

74% of the released bars adjusted to the wild, 16% died of natural causes (killed by male bears, stray dogs, wolves or poisonous plants) and 5% died of injuries or diseases (Pazhetnov & Pazhetnov, 2003). Two papers about the rehabilitation efforts exist. The papers not only give this overview but also describe the fate of all bear cubs accepted into the program between 1990 and 2001 (Pazhetnov & Pazhetnov, 2005) and describe in detail the release of 17 brown bears in 2002 (Pazhetnov & Pazhetnov, 2003). Out of those 17 bears, 12 bears adjusted to the wild. Five bears returned to towns or villages within 10 to 42 days after their release; these bears were taken back into the station for denning through the winter. After the denning period the bears reportedly become wild and adjust easily to nature.

Croatia: In **1988** and **1989** five orphaned brown bear cubs were returned to the wild after losing their mother. All were between the ages of 1 to 3 months when found. They were kept in a human residence till they were about 5 ½ months old and were bottle fed during that time. Afterwards they were kept in an enclosure (30 x 30 meters) in a natural environment for another 3 months. During this period they were fed with artificial as well as natural bear food. They were then released into remote areas and monitored using radio collars. All five bears were released together. The day after the release one of the bears had dispersed, while the other 4 were waiting at the release site. After being scared away from that site by car/horn, the bears went into the forest where they approached at least two backpacking parties and accepted food from them eagerly. Seventeen days after the release two of the bears were captured in a village 4 km away from the release site. The bears had at that point been fed by humans in the village and the decision was made to move them to the Zagreb Zoo. Thirty days later one more of the bears appeared in the same village and was also moved to the zoo. One of the two remaining bears was killed by a car 69 days after its release. The last bear was never seen again after its release into the wild, it was the only one to not receive a collar. The information on these 5 bears has been published (Huber, Dabanovic, Kusak, & Frkovic, 1994). The author of the paper believes that "keeping the bears in a house certainly contributed to their habituation" (personal communication, Prof. Dr. Djuro Huber, December 23rd, 2008)

Estonia: At the Nigula Wildlife Rehabilitation Centre in Pärnu County, more than 30 orphaned brown bear cubs have been tended to since 1999. Of these cubs, 25 have been released successfully back into the wild (personal communication, Murel Merivee, Nigula Wildlife Rehabilitation Centre, January 14th, 2009). How the center defines a successful release, at what age the bears enter the facility and what age they leave the facility and if the bears were collared or ear tagged before their release is unknown. Additionally 9 cubs were raised and released between 1998 and 1999. If these cubs were raised in the mentioned facility, if they were marked or collared and if the release was successful is not mentioned (Valdmann, Saarma, & Karis, 2001).

Discussion

When searching for information, it becomes apparent that the term rehabilitation is occasionally used with different meanings. “Wildlife rehabilitation is the treatment and temporary care of injured, diseased and displaced indigenous wildlife and the subsequent return of healthy animals to appropriate habitats in the wild” (National Wildlife Rehabilitators Association, 2009). This means, that the care of injured wildlife followed by captivity for the rest of the animals life (e.g. zoo placement) is not considered wildlife rehabilitation by the NWRA.

Another problem is the variation in definitions of success. For most wildlife rehabilitation facilities the main measure for success is the release rate (Dubois, 2003). Release rates alone may not be a true estimate of rehabilitation success. While the animal survived in captivity, it might not survive after its release. Ear tagging released animals and quantifying success by the amount of returned ear tags is also not a sufficient measure of success, as the tags of dead animals might never be found. Rehabilitation success has been defined as the release of animals that function like and are indistinguishable from other wild animals in their native environment (Pokras, 1997).

Tony Hamilton, Large Carnivore Specialist with the BC Ministry of the Environment, suggests that the ultimate measure of success of a grizzly bear orphan cub of the year rehabilitation and release program would be that the cubs, released as yearlings, will:

- survive to breeding age and become members of the local breeding population
- not conflict with humans at a frequency higher than their wild counterparts
- not introduce atypical genes into the recipient population (that is, cubs should normally be released at or near their maternal home ranges)
- not introduce atypical behavioural patterns that could lower individual or population fitness
- naturally adapt to the habitats, food sources, denning opportunities, and human influences at or near their release sites.

Hamilton also suggests that there is normally little conservation benefit to rehabilitation and release, even if successful, given the good health of most of British Columbia’s

grizzly bear populations. However, he does acknowledge that if orphan cubs could be used to successfully augment threatened populations, the rehabilitation of orphaned grizzly bear cubs could have a significant conservation outcome. In such situations, Hamilton has suggested that his aforementioned qualifiers of success all hold true except the concern about gene contamination. He informed me that if cubs were to be used to augment a threatened unit, the concern about undesirable genetic exchange would be dropped to help achieve the broader conservation objective of population recovery in the threatened unit (personal communication, Tony Hamilton, March 28th, 2009). Establishing the success or failure of rehabilitation measures would therefore include long term monitoring of the released animals which is technically challenging and expensive.

The rehabilitation of grizzly bears and brown bears has been attempted before in North America and Eurasia. The information regarding these attempts however is rather limited, detailed information can, in most, cases only be obtained through personal communication with the people involved. The reasons for this lack of documentation are manifold: the scientific community often tends to be reluctant to accept the rehabilitation of animals as a tool for conservational purposes. It is often instead solely seen as an animal welfare or social issue. Additionally, working with rehabilitated animals usually means small sample sizes. Small sample sizes don't allow statistical comparisons or scientific analysis. Small sample sizes also mean little scientific value in the short run, little public interest, and little chance of meaningful publications. The rehabilitation of animals is therefore a field that is often left to dedicated operators of wildlife shelters as well as dedicated (temporary) volunteers that rarely have the time and/or scientific background to design programs, collect data and document or write up manuals or publications on the work they have performed.

A weakness of the data presented in this chapter is, that it is most likely incomplete. Grizzly bear and brown bear rehabilitation may have occurred elsewhere without being recorded. It might have happened without the sanctioning of the government and has therefore never been reported. Another possibility is that it failed, and few people like to

go into detail about failures. In the case of Europe and Russia it might have been documented, but not translated into the English language.

It is important to change anecdotal information about rehabilitation success or failure into scientific facts that can be used for the justification and improvement of rehabilitation policy with guidelines and captive care manuals for grizzly bears. Documentation should be made accessible to the interested public and used as a basis for discussion on the use and feasibility of wildlife rehabilitation for large carnivores.

It appears that the rehabilitation of grizzly bears in North America is rare and has had little success so far. Out of 22 bears, 11 became food conditioned and ended up in zoos or killed/euthanized. For 3 of the bears the fate is unknown, only 8 of the releases can be considered a success, if success is determined to be short term survival and a lack of conflict with humans. Only one of the bears was observed to become part of the breeding population.

The main concern was not the survival of the bears but their behavior after release back into the wild. Bears in general are opportunistic and such behavior seems to get them into trouble only too often in their search for food.

To minimize the chances for the display of problematic post release behavior, it is important to keep the bears' habituation to humans during their captivity to a minimum and avoid the bears becoming conditioned to manmade food. How this may be achieved will be discussed in detail in Chapter 2 of this Thesis.

Chapter 2 - Grizzly bears in the rehabilitation facility

Introduction

British Columbia has about 40 wildlife rehabilitation facilities (Dubois, 2003). These facilities provide care to sick, injured and orphaned wildlife with the goal of ultimately returning them to their natural habitat (National Wildlife Rehabilitators Association, 2009). Improving the welfare of individuals is expensive; the relevance of rehabilitating single wild animals for the conservation of populations is highly debated amongst wildlife interest groups (Dubois, 2003). The rehabilitation of wildlife can lead to public education on wildlife and conservation issues as well as the collection of biological data on species and their behavior. Rehabilitated bears may be suitable for the augmentation of threatened populations and reintroduction into their historical range.

Five wildlife rehabilitation facilities in British Columbia have permits that allow them to rehabilitate black bears (Parker C. , 2008). There is currently only one facility that is licensed to rehabilitate and release grizzly bears. Permits for the rehabilitation of wildlife are issued by the B.C. Ministry of Environment under the provisions of the Wildlife Act. Most wildlife rehabilitation facilities are privately funded and run by volunteers.

Rehabilitation facilities provide humane care, suitable and nutritious food, a safe enclosure in which the animals live and shelter within the enclosure. Additionally the staff of rehabilitation facilities either provides or has veterinarians provide any veterinary care needed. The type and intensity of the care of the bears in the rehabilitation facility may have a strong influence on the bears' level of habituation to humans and if the bears become conditioned to human foods or not (Beecham, 2006) (Valdmann, Saarma, & Karis, 2001) (personal communication, Leonardo Bereczky, Harghita Bear rehabilitation center, November 28th, 2008) (personal communication, Prof. Dr. Djuro Huber, December 23rd, 2008). The care in the rehabilitation facility is therefore a crucial part for the success or failure of the rehabilitation process.

This chapter looks at the care that the two grizzly bears of British Columbia's grizzly bear rehabilitation project underwent in the project's first year.

It answers the following two questions: How were the bears treated during their time in captivity? How did the bears behave during captivity?
It also details how their treatment could influence their behavior and survival after their release.

Material and methods

In the first year of the grizzly bear rehabilitation project, one male and one female grizzly bear entered the program and were studied. The bears were not related to one another and entered the project at different times.

Bear 1, female

The female bear was reported by a wildlife photographer to the Dawson Creek Conservation Officer Office. It had been seen for a week without its mother. The bear was captured on June 25th 2007 by a conservation officer in Monkman Provincial Park in British Columbia, Canada. The officer used a fish landing net after the cub came down a pine tree; no drugs were involved in the capture. The reason for the sow's mortality is unknown, no sow grizzly bear carcass was ever found; no harvested grizzly bears (compulsory inspected) were identified as being a possible sow of this cub (personal communication, Brad Lacey, conservation officer, October 22nd, 2008). After its capture at approximately N 54◦47'00" W 121◦12' 00", the bear was transported to the Northern Lights Wildlife Shelter in Smithers, BC where it arrived on June 26th 2007. The bear was placed in a 2.40m x 2.40m quarantine enclosure for 14 days before it joined a male 5 month old black bear in a 42m^2 enclosure.

Before the release the female grizzly bear was measured and received a yellow ear tag with the number 6343 in its left ear. Additionally the bear received a tattoo on the inner lip with the inscription 02/07. Measurements were taken on July 11th, the day before the release and are recorded in Table 2 on page 18.

Bear 2, male

The male bear originated from Purden Lake Provincial Park in British Columbia, Canada. The bear was tranquilized with a mixture of tiletamine hydrochloride and zolazepam hydrochloride (Telazol, Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) on November 12th 2007 by a conservation officer from Prince George after being seen feeding alone alongside the highway close to a sow carcass (personal communication, Michal Bartos, conservation officer, March 6th, 2009).
After its capture at approximately N 53°54'32.74" W 121°53'49.01", it was transported to a veterinarian for an examination and the removal of the tranquilizer dart. Afterwards it was transported to the Northern Lights Wildlife Shelter. The bear was placed in a 2.40m x 2.40m quarantine enclosure for 14 days. Afterwards it joined the female grizzly bear cub in its 42 m^2 enclosure; the black bear was at that point moved into a neighboring enclosure together with other black bears.
Before the release the male grizzly bear was measured and received a yellow ear tag with the number 6342 in its right ear and a tattoo on the inner lip with the inscription 07/01. Measurements were taken on July 11th, the day before the release and are recorded below in Table 2.

		Female Bear	Male Bear
Head girth		620 mm	not taken
Head length		330 mm	340 mm
Body length		1500 mm	1570 mm
Chest girth		1000 mm	990 mm
Neck girth		Not taken	645 mm
Left front foot -	Length	120 mm	135 mm
	Width	60 mm	65 mm
Left hind foot -	Length	160 mm	175 mm
	Width	110 mm	120 mm

Table 2: Measurements for male and female grizzly bear from June 11th, 2007

The rehabilitation facility

The Northern Lights Wildlife Society started off as the Northern Lights Wildlife Shelter in 1989. Two animal keepers that immigrated from Germany started caring for injured and orphaned wildlife around the town of Smithers in British Columbia. To secure more resources to provide adequate housing and care for the animals, the Northern Lights Wildlife Society was formed in 2001 and became a registered charity shortly thereafter in 2002. To date the rehabilitation facility accepts all birds and mammals. While birds usually get transferred to specialized bird shelters, the Northern Lights Wildlife Society focuses mainly on moose and deer and has become a specialist in the care for bears (Langen, 2008). 152 black bears have been sent to the facility since it first started operating. Nineteen bears died, the rest were released by the shelter (personal communication, Angelika Langen, Northern Lights Wildlife Society, December 8th, 2008). The Northern Lights Wildlife Society is currently the only rehabilitation facility in British Columbia with a permit to hold and release grizzly bears.

The enclosure of the grizzly bears

Both grizzly bears were held together in a 42m^2 enclosure. On May 19th the enclosure was opened to incorporate the 20m^2 neighboring enclosure. The original enclosure was made of chain link fence, which was also buried into the dirt floor. The enclosure had no roof. Two tree trunks as well as two wooden houses were added as enrichment and shelter. The neighboring enclosure had a small pool (~2m^2) that was filled with water as needed, 6 wooden shelves and a tree to climb on. The enclosure was fully covered; the floor was made of concrete. One of the walls was made of brick; the other 3 were chain link fence.

The enclosure was 500 meters uphill from the closest human activity. Access to it was restricted to rehabilitation facility staff. The enclosure was situated in a clearing of a small forest. The trees surrounding the shelter were trembling aspen (*Populus tremuloides*), black cottonwood (*Populus balsamifera*), paper birch (*Betula papyrifera*), willow (*Salix spp.*) and spruce (*Picea spp.*).

Directly connected to the enclosure, with no visual barrier, was an enclosure for black bears. An enclosure for a lynx was 20 meters west of the grizzly bears' enclosure. Free ranging moose and deer were in the area and walked past the bears' enclosure.

24 hour observation

The grizzly bears shared the same enclosure during their time in captivity at the Northern Lights Wildlife Society. To get a better idea of the bears' behavior, a non-stop 24 hour observation was conducted. This observation occurred from June 25th to June 26th 2008 with a 2 person team and was conducted from a blind made out of plywood and tarp. The blind was positioned in a small forest about 20 meters north of the enclosure that held the 2 grizzly bears.

It was about 14° Celsius on the day of observation, overcast with minimal rain in the evening. It was a typical day at the shelter with normal feeding and cleaning times.

The Ethogram used was constructed after several hours of initial observations at different times on different days prior to June 25th. The behavior scan led to the following 13 categories:
Walking, Sitting, Standing, Lying on belly, Lying on back, Climbing, Bathing/Drinking, Eating, Playing, Clawing/Biting fence, Pacing, Chewing (bones, branches), Digging.

These categories were coded for the ease of documentation.
The time in which a bear would lie either on its belly or on its back without playing or consuming food was considered resting/sleeping time. The distance to the bears as well as the darkness at night made it impossible to establish if the bears were actually sleeping.

The activity of each bear was documented for every single minute over a 24 hour period. The resulting time budgets for the parts of the day in which the bears were awake are shown in Figure 1 and Figure 2 on page 23. The bears' resting times are shown in Figure 3 on page 27.

Results

Care in the shelter

The bears were fed twice a day at irregular intervals to avoid food anticipating behavior. The morning feeding took place between 8am and 12pm; the late feeding between 4pm and 8pm. The food consisted mainly of ripe/overripe fruit such as apples as well as raw vegetables such as carrots and lettuce donated and collected daily from local grocery stores (Table 3). Bananas were avoided, as the shelter noted bananas to cause diarrhea in bears. In the evening dry dog food was added.

Fruits	**Vegetables**	**Meat**	**Natural vegetation**	**Other**
apples	carrots	salmon	trembling aspen (*Populus tremuloides*)	ants (*Formicidae*)
grapes	lettuce heads	trout	black cottonwood (P*opulus balsamifera*)	dry dog food
pineapples	cucumbers	sole	willow (*Salix spp.*)	water/snow
honeydew melons	celery stalks	red snapper	spruce (*Picea spp.*)	
watermelons	corn cobs	horse	cow parsnip (*Heracleum lanatum)*	
oranges	horse radishes	domestic cow	sedges (*Carex spp.)*	
strawberries	broccoli	cow hooves	small-flowered woodrush (*Luzula parviflora*)	
mandarins	cauliflower	wild game	grasses	
papayas	peppers			
kiwis				
blackberries				
raspberries				

Table 3: Grizzly bear diet during captive care at the Northern Lights Wildlife Society 2007 - 2008

Additionally donations from the local bakery were added, mainly white and whole wheat bread and buns, about two loafs per bear per feeding. Each bear received an average of 9.2 kg of food per feeding.

Meat was also fed, mainly salmon, occasionally horse, beef and wild game (Table 3, page 21). In the fall the bears received meat almost daily, during the rest of the year only at irregular intervals. The bears received items such as cow hooves to chew on about once a week. If dandelion were in season they were collected and added to their diet. Other natural feeds included ants, grasses and cow parsnip. In the winter the bears consumed snow, in the summer water was offered in water troughs.

Observations

The main differences between the 2 bears based on the Ethogram and the observations made are the following:

- The female bear spent 199 minutes of the day lying on its back, while this behavior was never observed in the male bear. The female bear even consumed food lying on its back.
- The male bear spent 51 minutes climbing on the provided tree trunks and structures in the enclosure. He did so when humans were close by (feeding or cleaning) but appeared to do this also as play, "for fun" during the day. The female bear was never observed climbing during the 24 hour observation or any other time.
- The male bear spent 65 minutes digging, the female bear only 28 minutes. The male bear dug along the fence and also dug himself daybeds to rest in.
- The female bear spent more time in the water than the male bear (69 minutes versus 16 minutes). The female bear was not only observed bathing in the water, but also consuming food after “washing” it.

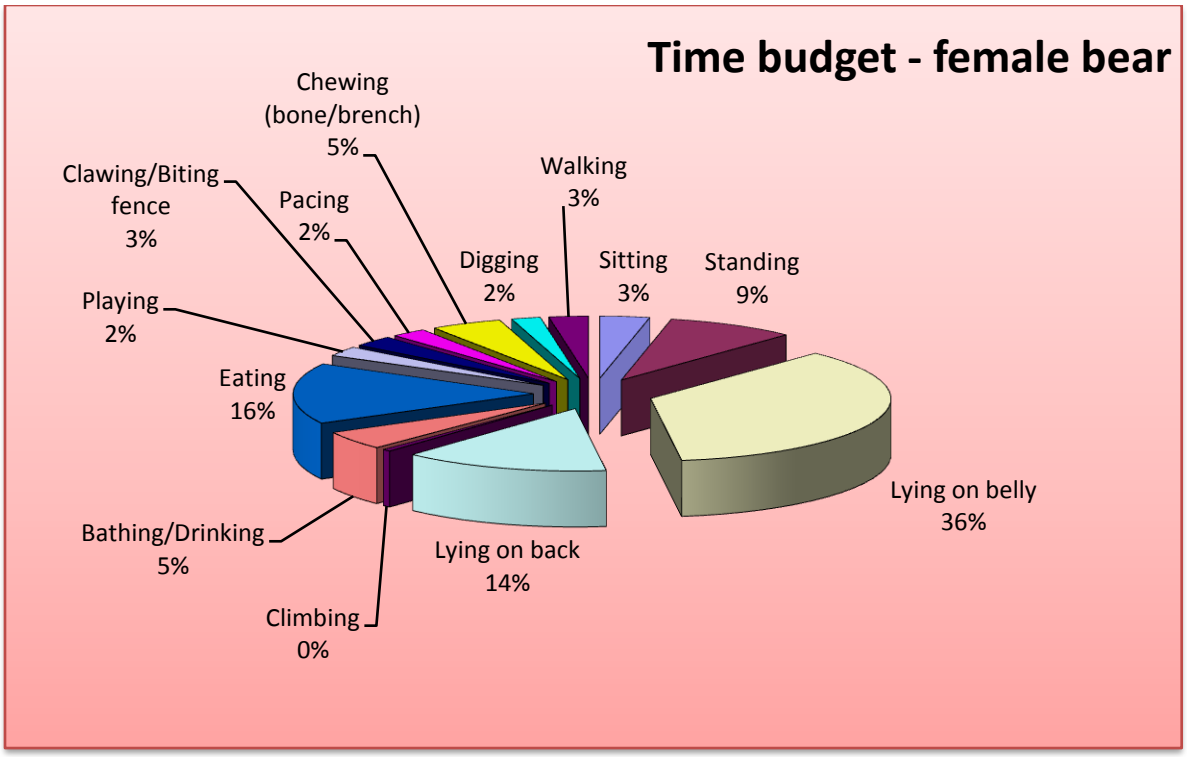

Figure 1: Time budget for female grizzly bear in captivity at Northern Lights Wildlife Society - based on 24 hour observation June 25th - June 26th 2008

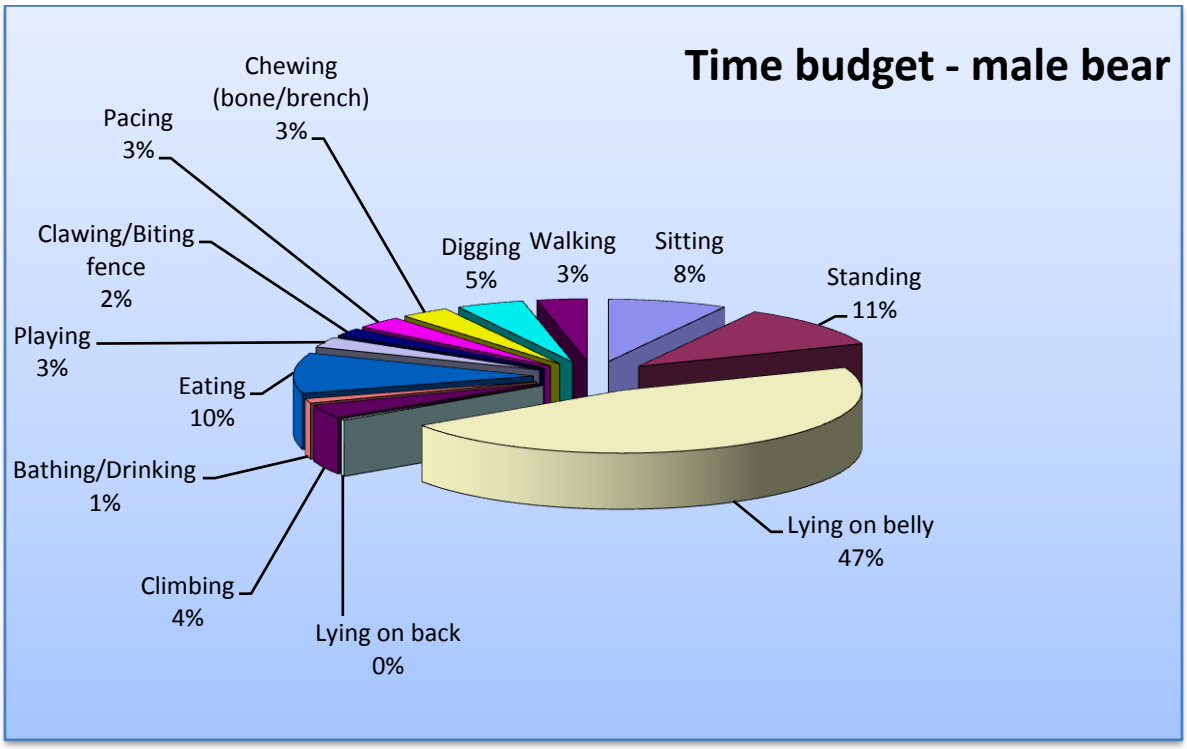

Figure 2: Time budget for male grizzly bear in captivity at Northern Lights Wildlife Society - based on 24 hour observation June 25th - June 26th 2008

Feeding behavior during intensive observation period

1st feeding

The food of the first feeding consisted of 2 cow hoofs, 2 buckets of mixed fruits and vegetables (9kg/bucket), 3 loafs of white bread as well as some grass. It was scattered throughout the enclosure at 1056 hr. The bears were able to see the feeder.

The process mentioned as eating included the time the bears spent chewing on a hoof.

The female bear ate right away and continuously for 22 minutes. After a 3 minute drinking/bathing pause, the bear continued to eat for another 24 minutes. The following hour the bear ate with a few breaks (<=6 minutes) to drink, play or pause (stand). After the feeding the female bear spent 9 minutes digging and then rested for 3 hours and 16 minutes.
Overall the female bear spent 81 minutes eating during the first feeding.

The male bear started to eat later, as he waited to descend from his tree until the human was gone. The bear started eating at 1101 hr for 38 minutes, taking 2 short breaks for drinking/bathing and fence biting in between. He then drank again for 7 minutes and continued to eat for another 14 minutes interrupted by short breaks (<= 4 minutes) for drinking and playing.
The male bear then spent the next 49 minutes restlessly in a mixture of sitting, walking and fence biting/clawing, before joining the already resting female bear.

Overall the male bear spent 52 minutes eating during the first feeding of the day.

When the bears rested, most of the food had been consumed. The only items left were grasses and 2 cow hooves.

2nd feeding

The food of the second feeding consisted of 2 buckets of mixed fruits and vegetables and dog food (8.6 kg/bucket) and 1 loaf of white bread and 1 loaf of whole wheat bread. The food for the second feeding was again scattered throughout the enclosure at 1953 hr. The female bear ate for 77 minutes, took one short break (1 minute) to drink and continued to eat for another 31 minutes with short breaks (<= 3 minutes) for drinking

and walking. Afterwards the female bear played with the male bear for a long period of time before going to sleep.

The male bear spent 72 minutes eating, taking only 2 short breaks (<= 2 minutes) to drink. After that he only spent 6 more minutes eating during the rest of the evening.

Overall the female bear spent 98 minutes eating during the second feeding.

Overall the male bear spent 74 minutes eating during the second feeding.

Over the course of the day, the female bear spent 296 minutes eating.
The male bear spent only 197 minutes eating.

The interesting difference between the two bears is that the male bear consumed almost all of his food right after the feedings (126 out of 197 minutes). The female bear consumed the majority of its food right after the feeding (179 out of 296 minutes), but kept eating leftovers/greens throughout the day.

While the male bear stood or sat next to his food while eating, the female bear laid itself right on top of it, consuming most of it lying on the belly or even the back.

Both bears showed food anticipating behavior, they were restless before the food was delivered, which might have also been triggered by hunger. Their food was delivered by a four wheeler. The bears were not able to see the feeder approach, but when the bears started to hear the engine, their behavior changed. The female stayed relatively calm, while the male bear started to pace, bite the fence, growl, dig and direct aggression towards the furniture of the enclosure. The male bear also moved into the corner of the enclosure from which it could see the approaching care giver best. Using a different 4 wheeler for the delivery of food led to different results, the bears got scared instead of excited. It was therefore decided to use the same 4 wheeler at all feedings to avoid habituation of the bears to engine noises in general.

Other observations

The bears showed no aggressive behavior towards one another during the intense observation period. They occasionally bit each other's rear ends, but never hard enough

to provoke a reaction. They would chew on the same bone at the same time without any signs of aggression. At night they slept curled up together. The male bear had its head on the female bear's back for the entire night. The bears were not disturbed by noise made by the neighboring black bears and the lynx.

Discussion

Ethogram

The Ethogram provides an overview of the daily time budget of the two grizzly bears in captivity. The 24 hour observation was only conducted once.

The observation was conducted from a blind. The bears seemed to pick up the scent of the observer a few times, but never showed much interest. An improvement would be to conduct several 24 hour observations with the incorporation of a professional wildlife blind, constructed downwind and at a greater distance from the enclosure. This way the bears wouldn't be able to pick up the scent of the observer. Repeated 24 hour observations could investigate the connection between feeding and resting times. They could also investigate the possible food anticipating behavior and its trigger.

The bears in captivity were sleeping or resting from 2330 hr (♀) / 2344 hr (♂) until 0807 hr. Wild bears in the area the bears were eventually released into were reported to be most active from 0600 hr to 1000 hr (Heard, Ciarniello, & Seip, 2008). Bears in the wild start foraging after sunrise. The bears in captivity didn’t need to forage as they were fed twice a day in a relatively small space.

The wild bears in the release area were least active from 1000 hr to 1600 hr (Heard, Ciarniello, & Seip, 2008). The bears in captivity were active longer, as they were fed at 1056 hr. They rested from 1257 hr (♀) / 1310 hr (♂) till 1613 hr (♀) / 1553 hr (♂). The female bear spent this entire time on its back on the day of intense observation.

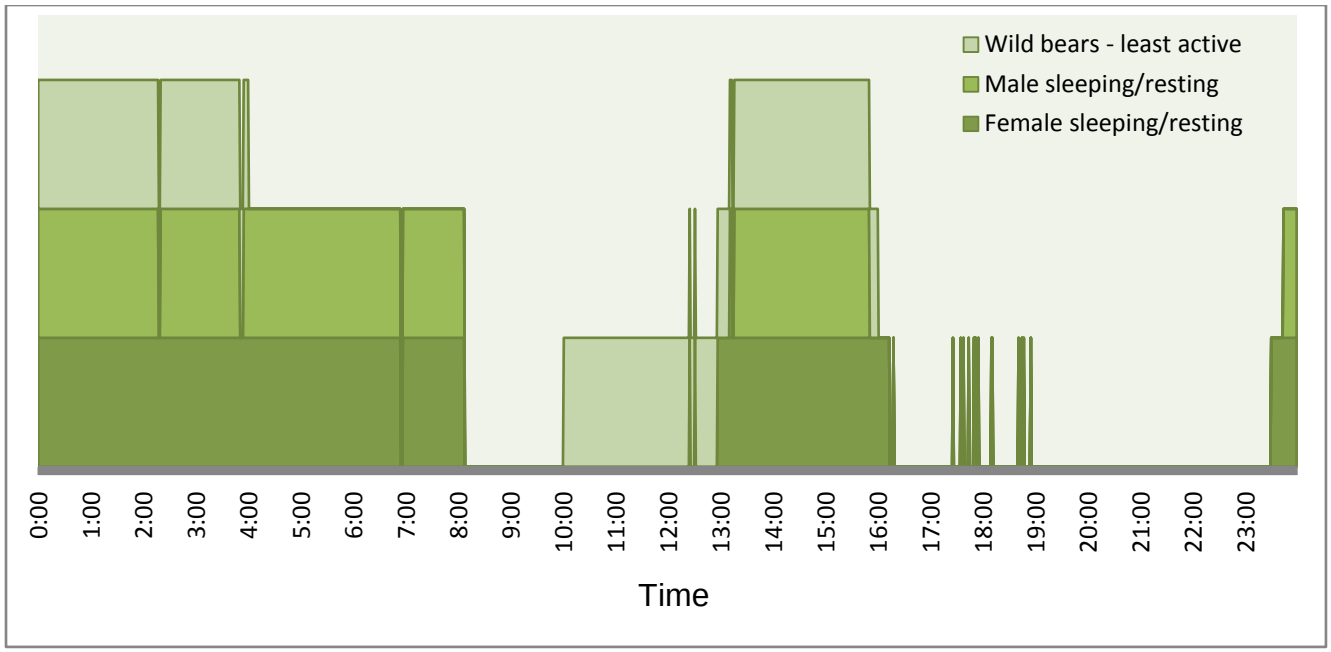

Figure 3: Sleeping/resting times of grizzly bears in captivity in comparison with wild grizzly bears in the release area

One of the most obvious differences between the captive grizzly bears and wild grizzly bears is that the captive bears spent little time moving. Most of their time was spent sitting, lying or standing.

Studies have shown that grizzly bears in the wild are much more active. Independent from the season of the year and their main source of food, bears were reported to be active about 66% of the day (MacHutchon, 2001). Bears in captivity may need to be stimulated to be more active in captivity for a more natural transition back into the wild.

The 24 hour observation period in this study showed some stereotypic behavior (pacing and clawing/biting of the fence) for each of the observed bears. One likely reason for this behavior is that the bears in the rehabilitation process are fed large amounts of (partially) concentrated food in captivity that is consumed rapidly and not throughout the day. The bears have therefore an excess of time.

The ability to find adequate amounts of suitable food at the right time of year is crucial to the survival of the bears after their release. Foraging behavior can be stimulated through foraging devices as well as the spatial and temporal scattering of food within an enclosure (Young, 2003). One foraging device used for captive grizzly bears is a

"boomer ball" that is filled with food/treats. The delivery and textures of food can reduce boredom and prolong the time eating/foraging and therefore prolong the time spent active. The food can be fed alternating chopped or whole. It can be fed frozen as a "popsicle" or turned into a paste that gets spread over furniture in the enclosure. Increasing the number of daily feedings would also stimulate the foraging behavior (Grandia, van Dijk, & Koene, 2001).

In the time grizzly bears are held in a rehabilitation facility they should get thoroughly prepared for their release back into the wild. This includes minimizing the habituation to humans, which can most likely be achieved by minimizing the number of care takers and their interaction with the bears (Beecham, 2006). The bears must be adaptive and flexible in their behavior to adjust successfully to the wild after their release; enrichment in the enclosure may help in achieving this goal. Enrichment has been shown to have a positive influence on the behavior of captive bears (Beecham, 2006)(Forthman, Elder, Bakeman, Kurkowski, Noble, & Winslow, 1992) (Carlstead, Seidensticker, & Baldwin, 1991).

A recent black bear rehabilitation study suggests, that the handling of bears in captivity seems to have little to no influence on the bears behavior and survival after their release (Binks, 2008). It is not known if this applies to grizzly bears. Due to the very small sample size of orphaned grizzly bear cubs, certain studies are simply not feasible or possible at this time.

If the grizzly bear program continues, the implementation of enrichment will be possible, as the wildlife rehabilitation facility just built a 788 m^2 enclosure for the grizzly bears.

General observations

Even though brown bear rehabilitation has been conducted before, little has been reported or published, leading to a lack of knowledge on many issues. Certain principles and standards have been established and are generally agreed on; some are supported only because they have proven to work with other species of bears. The standards are documented in a manual on how to release orphaned bear cubs (Beecham, 2006). The manual suggests certain connections such as “minimizing the number of caretakers

appears to be very important in creating and maintaining the bears' avoidance behavior toward people".

It is recommended that grizzly bear rehabilitation be as conservative as possible with regards to such guidelines.

Principles for rehabilitation of grizzly bears may include:

- A large enclosure made of sturdy construction material (Beecham, 2006). The minimum enclosure size for an adult black bear is 6 m x 11 m x 5 m (Miller, 2000), minimum standards for grizzly bears in captivity could not be found. The construction material can be heavy-gauge chain link or net wire, brick, concrete or other solid, durable materials, including heavy-gauge metal tubing and metal sheeting (Beecham, 2006).
- Natural vegetation within the enclosure (Beecham, 2006). Small bushes and vegetation will most likely be destroyed by the bears through biting and climbing. Larger trees have proven to work. Climbing deterrents can be attached to tree trunks if needed.
- Furniture for the enrichment of bears simulating the bear's natural habitat (Beecham, 2006) (Young, 2003).
- Denning and shade structures within the enclosure (Beecham, 2006). The denning structure should be made of solid wood, concrete blocks or bricks and measure 2.5m x 2.5m x 1.8 m (Miller, 2000)
- Water within the enclosure. Measurements for pools are not given in the minimum standards for wildlife rehabilitation. Omaha's "Henry Doorly Zoo" suggests pool areas for brown bears should have a mean horizontal diameter of at least 2.4 m and a surface area of at least 8.9 sq m for two adult bears. The pool should be at least 1 m deep. For each additional bear, the surface area should be increased by 3.7 sq m, all of which should be at least 1 m deep (Johnson L. A.).
- Temporal and spatial scattering of foods (Young, 2003)
- Provision of food in different ways: Cut, whole, frozen or as a paste (Young, 2003)
- Up to 6 daily feedings (Grandia, van Dijk, & Koene, 2001)

The provision of such standards requires a significant financial investment. The material for the construction of the enclosure is expensive. The upkeep of enclosures of large animals is expensive. Minimal contact with a limited amount of caregivers with staff intensive activities such as enrichment requires (based on the numbers of grizzly bears in care) a full time care giver.

Additionally, grizzly bears consume large amounts of food. While some of the food gets donated to wildlife rehabilitation facilities, care has to be taken in what can be fed to the bears. Meat must be from healthy sources. Processed food must be avoided to avoid food conditioning of the bears. At certain times, this limits the use of donations and food has to be purchased.

Overall the rehabilitation of grizzly bears is labor intensive and expensive. Wildlife Rehabilitation facilities in British Columbia are not financially supported by the government and must pay for the captive care of the animals themselves. Most facilities have regular donators and use the media for fundraising events. More money would most likely be needed if grizzly bear rehabilitation becomes a standard practice in the Province of British Columbia. Collaborations with Animal Welfare organizations would be a possibility for increased funds. Financial support through the government might be another option.

The field of Wildlife Rehabilitation seems to struggle with financial constraints and acceptance. Wildlife rehabilitation can serve the wildlife community and educate the public on wildlife and environmental issues, play a role in habitat, species and population conservation and preservation and contribute to the knowledge about species (Dubois, 2003). Better acceptance of the use of wildlife rehabilitation, especially in the scientific and wildlife management community could result from the documentation and use of acquired knowledge and data from rehabilitation facilities. Connecting rehabilitation with science and management is crucial. It is important that partnerships are developed with professionals and academics. Scientific research on animal behavior, animal welfare, captive care as well as animal care and post release performance of animals are all possibilities.

Shared information and scientific publications from a rehabilitation facility will increase the effect of the shelters work dramatically, as other rehabilitation facilities worldwide would be able to learn from it. It will most likely also lead to an increased acceptance of the facility and its work. It could also lead to an increased amount of donations; people will most likely be more willing to donate money to a cause that is scientifically backed up and documented to work.

Chapter 3 - Post release Monitoring

Introduction

Post release monitoring of the bears was conducted to see if the bears survived and if they came into conflict with humans. This chapter will describe the movement of the bears after their release and discusses possible reasons for their post release behavior. The following questions will be answered: Did the bears get into conflict with humans after their release? Did the bears disperse from their release site? How big was the area they initially used? How far away from roads were the bears located?

Material and methods

The collars

The animals were both fitted with a PTT monitor (TenXsys, Eagle, Idaho, USA). The PTT monitor is a VHF and GPS/Argos collar. A 2 Gigabyte flash card onboard each collar was expected to ensure the safe storage of over 2 Million GPS locations. Each unit was equipped with a separate lithium battery to power the VHF signal and the GPS independently. A release mechanism was integrated and set for September 30th, 2009. In addition, a spacer of canvas fire hose was installed in accordance with provincial policy. In case of a release mechanism failure, the fire hose would either rot off or be ripped off by the animal (Hellgren, Carney, Garner, & Vaughan, 1988).

The VHF was programmed on both collars to transmit at 40 beats per minute (bpm) while the animal was alive and 75 bpm in case of mortality. The female bear's VHF frequency was set for 150.063 MHz; the male bear's VHF frequency was set for 150.042 MHz. By the end of September 2008 a fixed-wing aircraft (Cessna 172) was used for tracking. The VHF was neither programmed to shut off while the GPS tried uploading to Argos nor was it supposed to power down during hibernation.

Argos technology

The Argos technology (CLS America Inc., Largo, Maryland, USA) in this project was incorporated to ensure that the GPS locations from the collars would not only be stored onboard the collar, but additionally transmitted in regular intervals to the people involved in this project through ArgosDirect email (Bretillot, 2005). The collars were set up to transmit GPS locations to Polar Orbiting Environmental Satellites of the National Oceanic and Atmospheric Administration and MetOp, of the European Organization for the Exploitation of Meteorological Satellites used by Argos. These satellites are on a polar orbit at an altitude of 850 km and can receive data from the collars when the transmitters in the collar are within the visibility of the satellite. This is an average of 10 minutes per satellite pass.

The configuration of the collars was set for a 16 channel GPS fix every 85 minutes through November 15th at which point the fix rate was reduced to one GPS fix per day to save battery power and because the bears were likely to be less active or in hibernation. The transmission of the GPS locations to the satellites was scheduled for 3 times a week, on Monday, Wednesday and Friday. After November 15th the collar would then only transmit once a week on Wednesdays. The data received by satellites would be sent on as an email and contain the battery voltage of the collar battery, a high resolution GPS fix with altitude and time of the location from which the bear transmits as well as the most recent 24 GPS fixes together with the times that they were obtained.

Field monitoring

Intense post release monitoring with a two person team constantly in the field was conducted from the release of the bears on July 12th 2008 until August 17th 2008. Two additional site investigations were conducted afterwards, one from September 16th - 18th 2008 and one from October 2nd - October 4th 2008.

The original set up of the monitoring was to obtain the GPS data of the bears by email through ArgosDirect. After plotting the locations on maps and the handheld GPS unit, the monitoring team planned to move into GPS location clusters of high activity (n >= 5)

to conduct site investigations including vegetation analysis and documentation of bear activity. By the time the data was transmitted and the team was back in the field, locations would be at least 3 days old. VHF was used during the field work to ensure a safe distance from the bears at all times. VHF was also to be used to plot additional locations and establish an activity pattern for the bears. The team was to stay in the field for several days at a time.

For the purpose of finding the GPS locations transmitted by Argos, the locations were plotted using ArcGIS 9.2 (Environmental Systems Resource Institute, Redlands, California, USA) together with DNR Garmin 5.4.0 (Minnesota Department of Natural Resources, St. Paul, Minneapolis, USA) and Mapsource Version 6.13.7 (Garmin International, Inc., Olathe, Kansas, USA) together with Garmin's Topo Canada. The locations were then transferred to a Garmin GPSMAP 76CSx handheld receiver.
For the purpose of finding the bears in the field, a TR2 receiver and a TS1 scanner (Telonics, Mesa, Arizona, USA) as well as an R1000 receiver (Communication Specialists Inc., Orange, California, USA) were used together with omnidirectional, H and rubber ducky antennas.

Additional information from the field

In addition to the data received from the collars and gathered by the field monitoring team, relationships with local conservation officers, the local outfitter as well as the active hunting and recreation community were established. Sightings of the bears by any of these groups were passed on to the field monitoring team. The collars on the animals were very visible (Figure 4). Each collar measured 110 mm x 72 mm x 63 mm and weighed approximately 700 grams. As the two orphaned grizzly bear cubs were the

Figure 4: Male grizzly bear at release, TenXsys GPS/Argos collar very visible

only collared bears in the entire area, accounts of sightings were presumed to be one of the two study bears.

Release technique

The bears were immobilized at the Northern Lights Wildlife Shelter in Smithers, BC on July 11th 2008 for measuring and the fitting and installation of the collars.
They were immobilized with Telazol at an estimated combined dose rate of 8 mg/kg. They were then both placed into the same culvert trap for recovery. The culvert trap was lined with grass as well as dirt from their enclosure.
Once recovery was observed, they were transported 360 kilometers on paved roads from Smithers to Prince George, where they spent the night in the trap on the grounds of a local wildlife shelter. The next morning they were driven another 135 kilometers to their final release site.

Once at the release site, the culvert trap was positioned with the opening pointing towards a secondary forestry road with a vegetated slope behind it, leading to a newly reforested lot. Four accompanying vehicles were parked parallel behind the close end of the culvert trap towards a natural embankment. One vehicle was parked parallel and in front of the culvert trap in about 60 meters distance to film the release. People at the release site were either in or on top of the vehicles during the release. The bears were released together at 1345 hr on July 12th 2008.

Data analysis

Using the ArcView Animal Movement extension (Hooge, Eichenlaub, & Solomon, 1999), the fixed kernel home range utilization distribution was calculated as grid coverage with the ad hoc calculation of a smoothing parameter and a 300 x 300 meter cell size. Separate fixed kernel home ranges with probabilities from 70% through 95% were calculated.

The 100% Minimum Convex Polygon (MCP) is the area of a polygon which includes all the locations the study animal is known to have been and consists of transmitted GPS locations as well as the VHF data obtained on the aerial flights.

The maps used for the calculation of the distance to roads are from the province-wide series of 1:20,000 digital raster maps derived from TRIM topographic data. The roads were hand painted in black into the map over the originally orange roads for better visibility.

The maps used to display home range sizes were created for better elevation and water body visibility. They were constructed using a Digital Elevation Model for the 1:50,000 National Topographic System (NTS) map sheet for the release area, draping it with an image of the NTS 1:50,000 topographic map, a semi-transparent layer of color bands corresponding to different elevations and a layer for water bodies from the matching vector dataset. The maps used are all available online (Natural Resources Canada, 2008).

The study area

Figure 5: Study area for grizzly bear rehabilitation project in British Columbia (100% MCP of both released animals) - 1:10,000,000

The general release area (Figure 5) was chosen by the BC Ministry of Environment's Large Carnivore Specialist. The decision was based on the original locations of the project's two grizzly bears.

The release area was close to the capture site of the male and that of the female grizzly bear and within the same Grizzly Bear Population Unit (GBPU). The 57 GBPUs in British Columbia are meant to identify similar behavioral ecotypes and sub-populations of bears (Hamilton, Heard, & Austin, 2004). They are based on ecological characteristics of the landscape and further defined by natural or human-caused barriers such as mountain ranges, water bodies, highways, and areas of intensive human development (West, 2003).
Releasing the rehabilitated bears in the area of their origin is aimed at releasing them into the population they originated from. This is done to keep the gene pool in any one GBPU as natural as possible and to ensure that the local behavioural patterns and adaptations to the environment are not negatively modified.

The final release site within the given area was chosen by local conservation officers and the Northern Lights Wildlife Shelter operators on the day of the release. This decision was based on distance to primary forestry roads, the possibility for a safe release of the bears with lots of clear area for the bears to move to as well as the suitability of the area as grizzly bear habitat.

The bears were released at 1345 hr on July 12th, 2008 at 54°35'46.38"N 121°53'30.10"W at an elevation of 820 meters. This site was 50 km linear distance (ld) west of the female bear's capture location and 76 km ld north of the male bear's original capture location. The site was 96 km ld north east of Prince George (80,000 citizens) and 50 km ld east of the nearest human settlement, Bear Lake (170 citizens).

The release site was in the Southern Hart Ranges of the Canadian Rocky Mountains. The primary forest type is Engelmann spruce – subalpine fir (Cariboo wet cool Engelmann spruce–subalpine fir (ESSFwk1)), valley bottoms are mainly sub-boreal spruce, dominated by hybrid white spruce (Picea glauca × engelmannii) and subalpine fir (Abies lasiocarpa) on zonal sites (DeLong, 2003). The elevation of the immediate surrounding mountains ranged from 1000 meters up to 1800 meters. The mean annual temperature in the area is 0.3°C with 154 cm rainfall and 700 cm snowfall (Ciarniello L. M., 2006). The rivers close to the release site drain north towards the Arctic; the bears

therefore had no access to salmon. The site was crown land and not protected, no special protection was given to the bears by choice of release site.

A population census conducted 8 years prior to the release states a high grizzly bear density of 49 bears per 1,000 km^2 for the release area (Ciarniello, Seip, & Heard, 2002).

The site was open for a Limited Entry Hunt. Hunting of females with cubs and yearlings as well as grizzly bears under the age of 2 is not allowed in British Columbia and shooting of collared, implanted or ear tagged wildlife is discouraged (B.C Ministry of Environment, 2008b). Chances of the released bears being legally shot in their first year was therefore low. Bears with radio collars often have hair worn off their necks, so poachers on the lookout for trophies would most likely also avoid these bears.

Results

Movement of the bears

The bears left the culvert trap reluctantly. After a quick initial inspection of the site the bears ate some of the grass growing at the site, bluff charged one another and went down the slope into the newly planted plot where they began to separate from one another.

Initially the female paid no attention to the people watching the release. The male bear showed some interest 5 minutes after the release and approached slowly, but was at that point chased away by the operator of the rehabilitation facility. After about 25 minutes the female bear looped back up the slope towards the people but was chased away.

The male bear had its activity center for the next 27 days on a mountain 11 km southeast of the release site. The female bear had its activity centre for the next 39 days on a different mountain 5 km west of the release site.

The GPS collars failed to transmit GPS locations after 27 days (♂) and 39 days (♀).

The data is limited. Only a small amount of reliable GPS locations (56 ♂ and 88 ♀), were received. The GPS collar fix rates were 19.44% (♂) and 21.57% (♀) (received GPS locations/active days x scheduled GPS transfers). After the loss of GPS data a fixed-wing aircraft (Cessna 172) was incorporated for the search of the bears using VHF. The flights produced two locations for the male bear and one location for the female bear.

The first flight on September 29th with a Cessna 172 flying at 9500' altitude came up with a potential mortality (120 bpm) for the male bear at 54°55'35.67"N 122°03'45.34"W. The female bear was located at 54°35'40.80"N 121°29'41.78"W at 37 bpm with signal resting or power down mode.

The second flight on October 15th produced a VHF signal of the male bear at 54°54'12.06"N 122°27'14.32"W. There was no signal from the female bear.
All flights after October 15th were unsuccessful in locating the bears. The bears were either denning and the VHF transmission was too weak to be picked up, they moved out of the search area of the pilot or both collars failed completely.

All VHF and GPS locations are shown in Figure 8 on page 44.

Fixed kernel home range sizes

	70%	75%	80%	85%	90%	95%
Female	18,24	20,65	23,32	26,67	31,60	41,51
Male	44,07	49,25	55,18	62,80	78,30	102,38

Table 4: Fixed kernel home range sizes of released grizzly bears in km^2 - based on GPS locations for 27 (♂) and 39 (♀) days after the bears' release

The fixed kernel home range sizes for both bears are shown above in Table 4 and are displayed in Figure 6 on page 41. The home ranges are predominantly on mountain peaks and ridges as most successful GPS transmissions were sent from these locations. The female bear's fixed kernel home range size in this study is less than half the size of the male bear's fixed kernel home range.

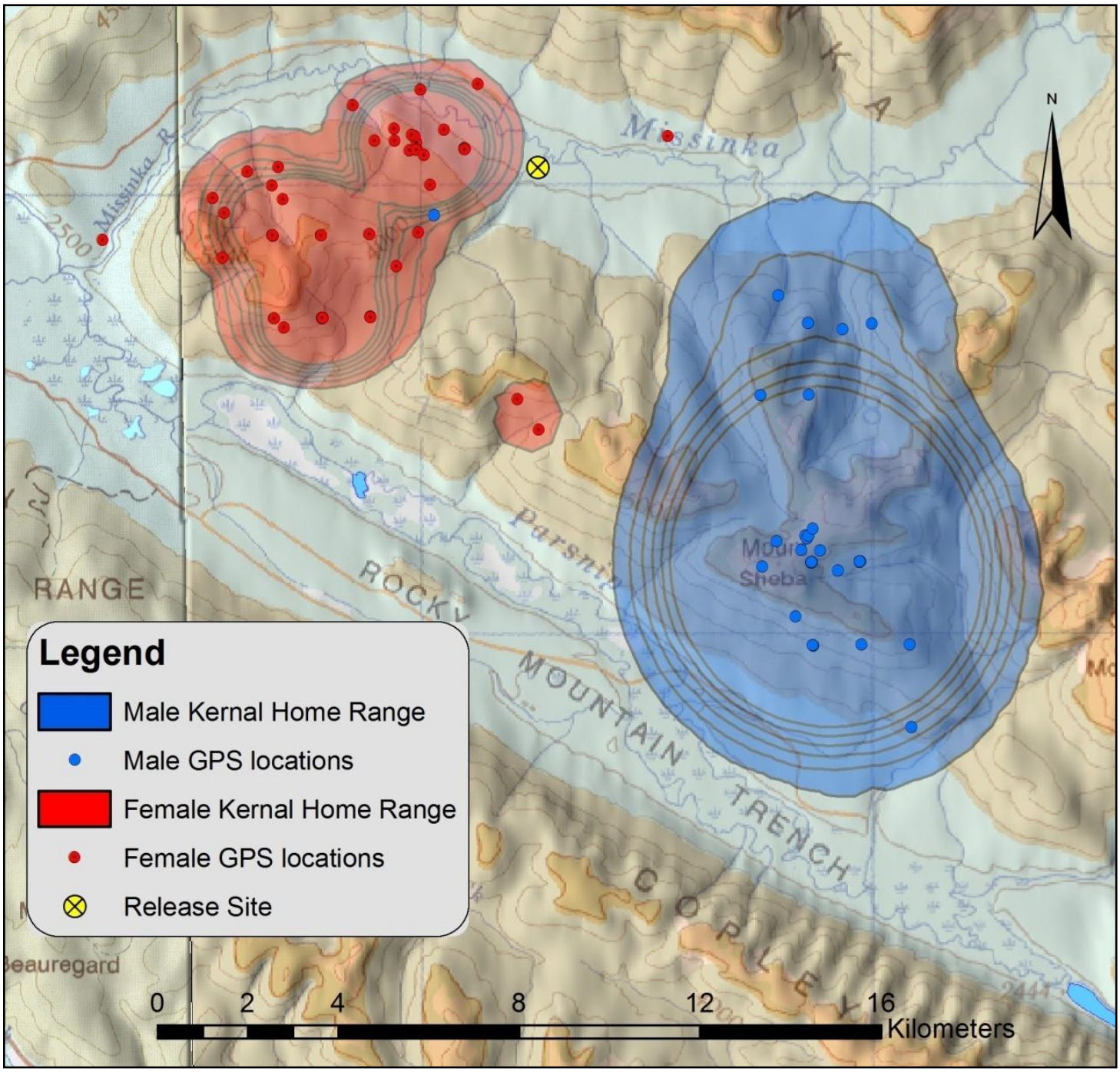

Figure 6: Fixed kernel home ranges (70%/75%/80%/85%/90%/95%) for male and female grizzly bear based on GPS locations for 27 (♂) and 39 (♀) days after the bear's release - 1:150,000

Bear Dispersal

The closest GPS location for the female bear to the release site was 1.75 km (27 days after release). The furthest GPS location was 10.23 km (9 days after release).
The average distance from the release site for the female bear during the first 39 days was 4.81 km.
For the male bear the closest GPS location to the release site was 2.67 km (6 days after release). The furthest GPS location was 15.53 km (12 days after release). The average distance from the release site for the male bear during the first 27 days was 11.35 km.

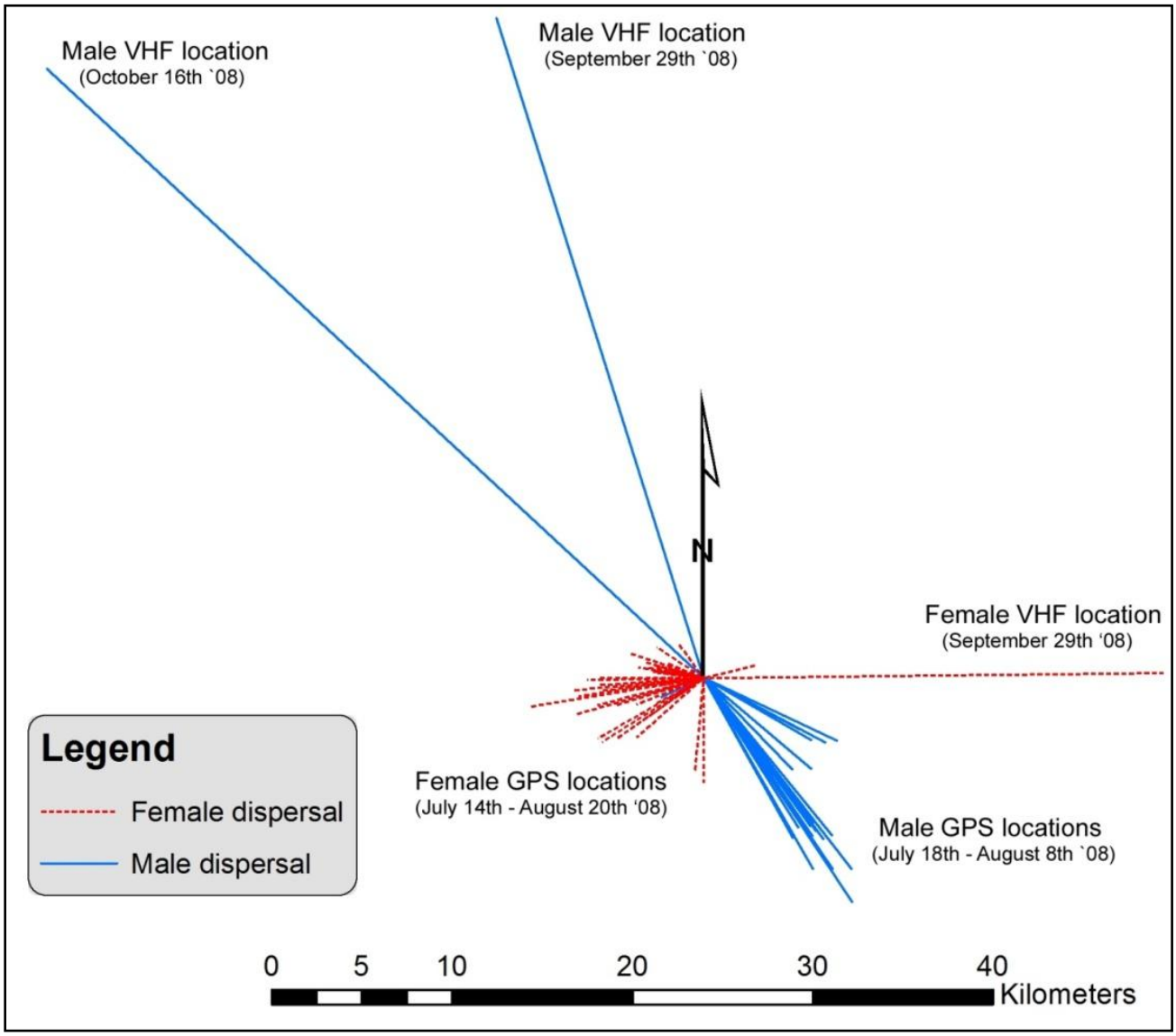

Figure 7: Female and male grizzly bear dispersal after release on July 12th, 2008 - 1:400,000

Sometime between August 20th and September 29th the female bear travelled 26.69 km away from the release site. Between August 9th and September 29th the male bear travelled 39.96 km/51.87 km away from the release site (Figure 7, page 42).

The bears moved in a direction opposite to their original movements from the release site. While the female bear's main bearing after the release was westward, it finally moved away eastwards. The same is true for the male bear. While initially moving southeast, it finally moved northwest.

The surrounding landscape did not appear to restrict the bears' movement. The only natural movement barriers in the area are 2100 meters southeast of the last know VHF location of the female bear; the Vreeland Glacier, the Parsnip Glacier and the Monkman Glacier.

100% Minimum Convex Polygon

The VHF locations obtained by air are far away from the center of the initial fixed kernel home ranges (48 km/57 km (♂) and 30 km (♀)) and substantially increase the home range of the bears. The female bear has a MCP of 153 km^2 and the male bear has a MCP of 780 km^2 (Figure 8, page 44).

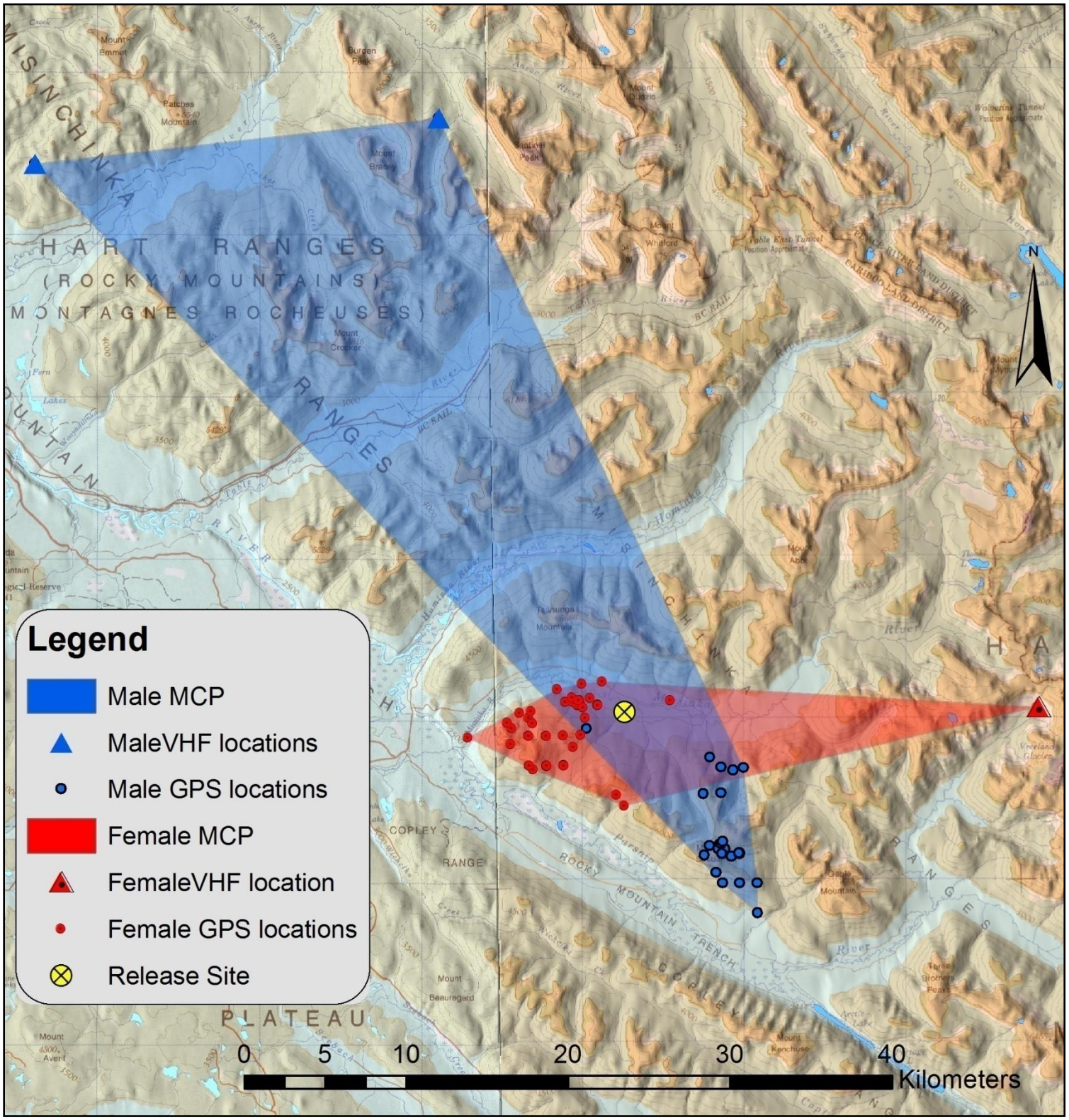

Figure 8: 100% Minimum Convex Polygons of male and female grizzly bears after their release, based on female GPS (July 14th-August 20th) and VHF (September 29th) locations as well as male GPS (July 18th-August 8th) and VHF (September 29th, October 16th) locations

Distance to roads

The release site was accessible by vehicle. Former logging activities in the area provided a rich network of primary and secondary forestry roads.

Figure 9 on page 46 shows the GPS locations of the female grizzly bear in relation to the forestry road network (black).

It can be seen that some of the female bear's GPS locations were right on roads. The distance of GPS locations to primary or secondary forestry roads ranged from a minimum of 0 meters to a maximum of 3.26 km. Based on the TRIM maps, the location that the female bear finally dispersed to has neither primary nor secondary forestry roads nearby. Satellite image analysis suggests the nearest road to be 14.72 km away.

The GPS locations of the male grizzly bear (Figure 10, page 47) were from a minimum of 328 meters to a maximum of 4.92 km from roads, similar to the female. On average, the locations of the male bear were slightly further from roads then the locations of the female bear.

The road distance to the male bear's VHF locations is 4.38 km and 5.27 km. On the way to these locations the bear must have crossed territory without road access.

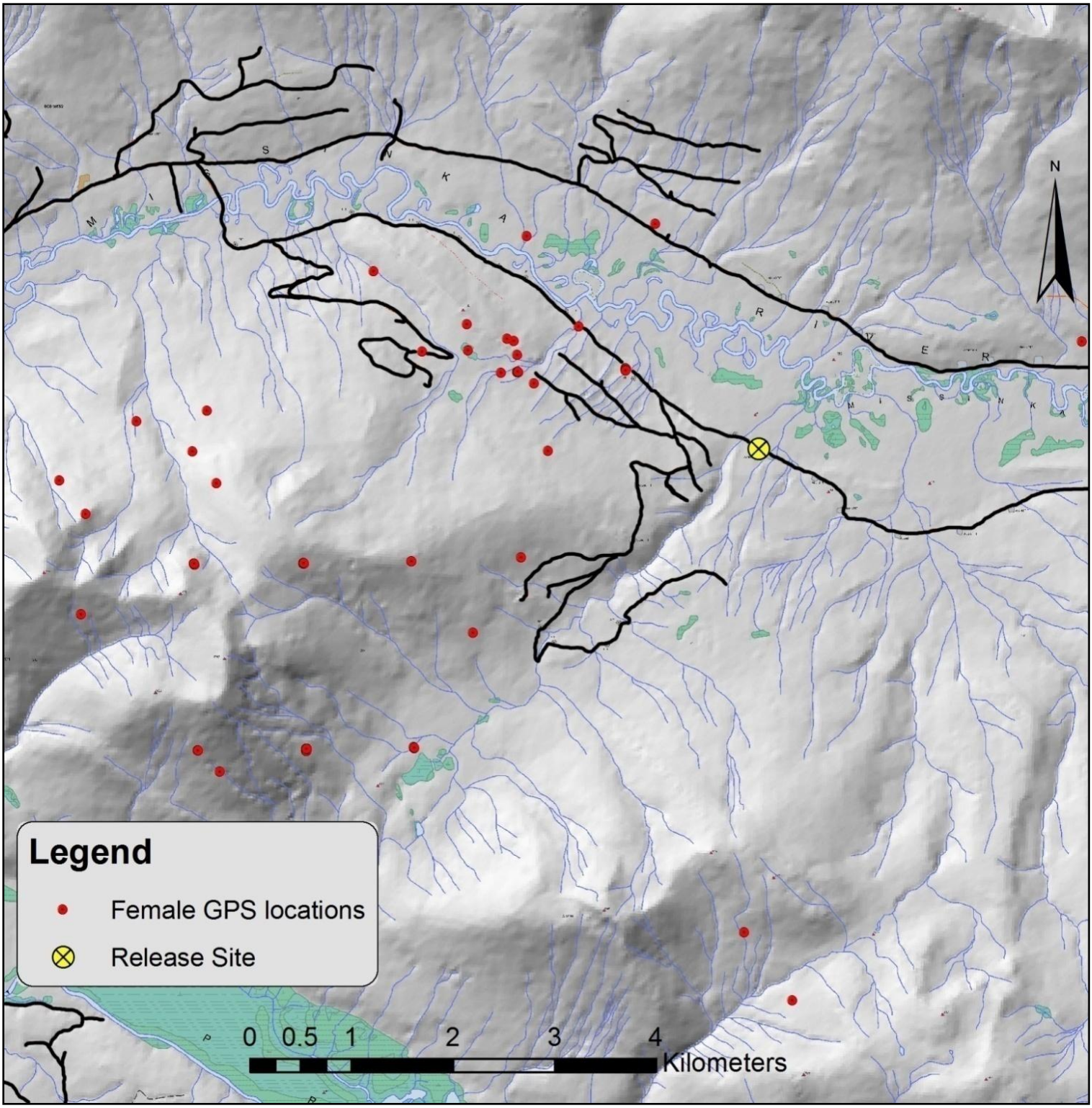

Figure 9: Distance from forestry roads to female grizzly bear GPS locations 1:65,000

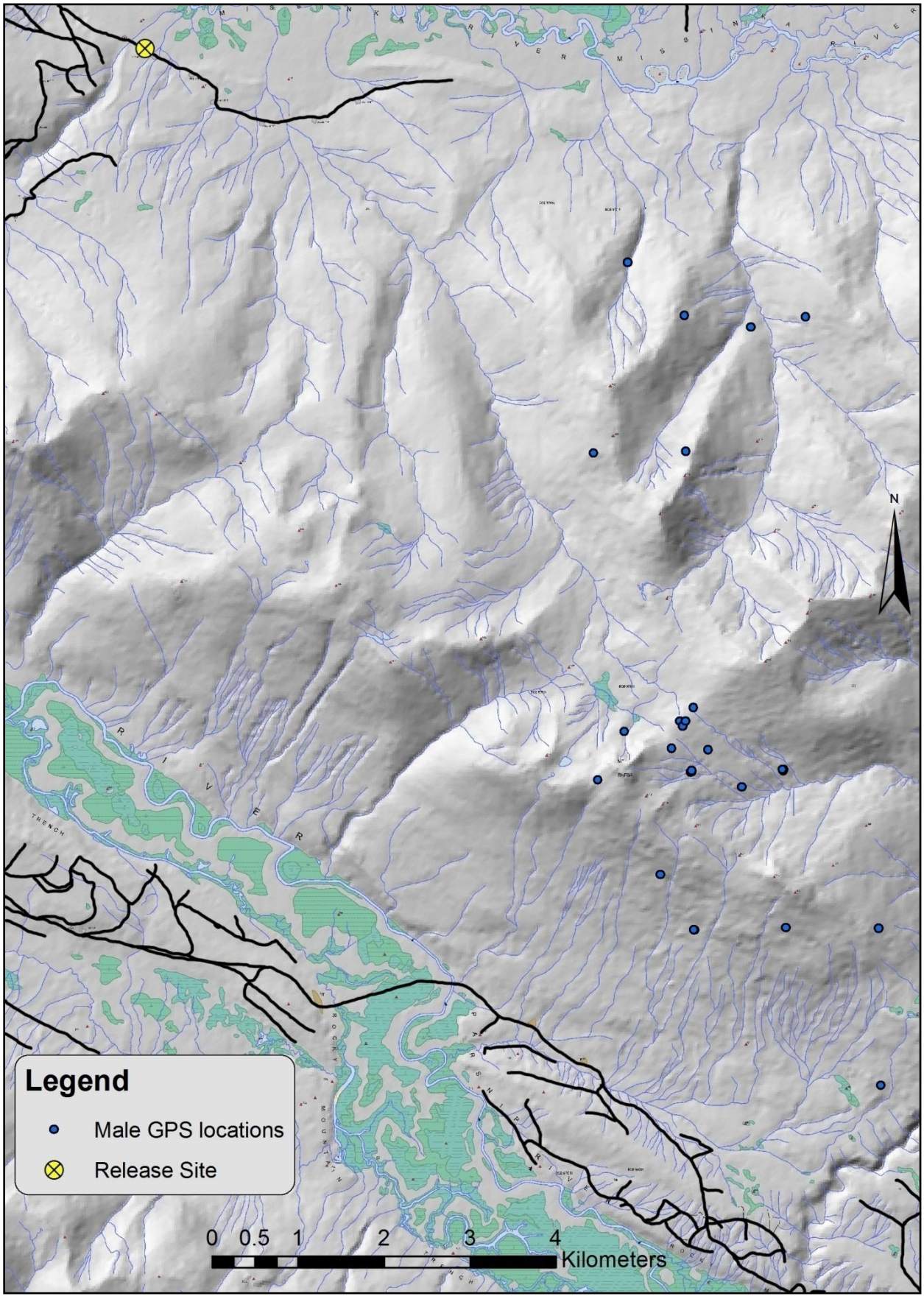

Figure 10: Distance from forestry roads to male grizzly bear GPS locations - 1:65,000

Sightings of the study animals

Most of the transmitted GPS locations were either close to or on mountain tops or ridges (♀n=47, 53.4%, ♂n=49, 87.5%) or clearings (♀n=35, 39.7%, ♂n=0, 00%).

An overall small amount of transferred locations (♀n=88, ♂n=56) led to very few clusters of GPS locations. Accessing these clusters by car and by foot was attempted several times. None of the clusters in the vicinity of the mountain tops (♀n=3, ♂n= 2) could be reached in adequate time with adequate gear to perform a site investigation. Of the clusters outside of mountain tops (♀n=2, ♂n= 0), one was reached for a site investigation. It was a cluster of locations that had been visited 5 times by the female bear. The bear used the site three times 27 days after its release, one time 36 days and one time 37 days after its release.

The site was visited at the end of August during berry season. It was on the edge of a regenerating cut block. Several signs of fresh grizzly bear activity were observed on site. Torn apart logs and fecal matter laced with berries were present. Black huckleberry (*Vaccinium membranaceum*) shrubs were on site.

The communication with local hunters, outfitters, biologists and conservation officers was very good. News of bear sightings was passed on quickly. No conflict activity of either bear was reported.
In addition to the small community of Bear Lake, 50 km west of the release site, there were 3 cabins within a 30 km radius of the release site. Communication with the owners of two of the cabins showed that the bears did not approach these cabins to the best of their knowledge. The third cabin did not appear to be in use during the time of post release monitoring.

Visual sightings in the release area were made on a couple of occasions:

On September 13th, one of the bears was sighted by a recreationist on a secondary forestry road ~54°38'2.66"N 121°40'8.08"W, feeding on a lynx carcass. The carcass was reported to have been in the area for several days, it was most likely not killed by the bear. When approached by humans the bear fled and attempted to hide behind a

nearby tree. The bear was described as being in good health. It is not clear which of the bears was spotted.

In the week of October 27th the male bear was spotted by a local outfitter along a primary forestry road at ~54°34'23.11"N 122°5'43.98"W. When spoken to and whistled at, the bear approached inquisitively. This led the outfitter to chase the bear away by means of using his car horn. The experienced outfitter said that the behavior appeared normal to him; he had observed this kind of behavior before with young and inexperienced wild grizzly bear cubs. He described the bear as healthy.

This concludes the information that was collected on the bears between their release on July 12th 2008 and the loss of contact with the female bear on September 29th, 2008 and the male bear on October 15th, 2008.

Discussion

Movement of the bears

It is important to keep in mind that the home range calculations will differ from typical home range estimations and cannot be considered accurate for several reasons:

- The situation is manmade. The bears didn't establish their home range as they normally would, had they dispersed from their mother's home range. The age grizzly bears naturally disperse from their mothers within the study area is 2-3 years (Ciarniello, Seip, & Heard, 2002); the bears in this study area were only 1 ½ years old. The release occurred before the normal age for dispersal and home range establishment.
- The GPS locations only cover the months of July and August. Grizzly bears in the release area emerge from their dens around May 11th and enter their dens around October 24th (Ciarniello, Boyce, Heard, & Seip, 2005). Wild grizzly bears in this area are therefore active for more than 5 months. The GPS data covers less than half of that period.
- The GPS locations were biased and underrepresent high canopy cover sites. Due to the nature of GPS collars, fix attempts were more successful in some areas than

other, depending on the forest canopy and the terrain (DeCesare, Squires, & Kolbe, 2005) (Cain III, Krausman, Jansen, & Morgart, 2005) (D'Eon, Serrouya, Smith, & Kochanny, 2002) (Rodgers, 2001) (Rempel, Rodgers, & Abraham, 1995). GPS collar locations underrepresent high canopy cover sites even more when the bears are resting there (Heard, Ciarniello, & Seip, 2008)

Nonetheless, the data provides a good idea of the initial movements and behavior of the bears immediately following their release.

Home ranges of wild grizzly bears can vary within and among populations, based on key food items, breeding, reproductive and individual status, security and human disturbance (Feldhamer, Thompson, & Chapman, 2003). Home ranges for Grizzly bears in Interior BC have been reported from 57km^2 for female bears to 446km^2 for male bears (Ciarniello L. M., 2006) (Feldhamer, Thompson, & Chapman, 2003).

Larger home range sizes for adult male brown bears as a promiscuous, nonterritorial and polygynous species have been observed in many brown bear studies. Two factors are usually considered to be the reason for this; breeding activity (Blanchard & Knight, 1991) and higher nutrition demand due to body mass and size (Kelt & Van Vuren, 2001). The breeding activity as a reason can be ruled out as both study animals were subadults and not sexually mature. Sexual maturity in female and male grizzly bears is usually reached between the ages of 5-7 years (Hovey & McLellan, 1996) (White, Berardinelli, & Aune, 1995) but the bears in this study were not even 2 years old. The habitat quality was almost the same for the male and for the female grizzly bear as their areas were only about 12 kilometers apart with almost the exact climate, elevation and vegetation.

The male bear was slightly larger at release. It can only be assumed that the higher nutrition demand due to its larger body size is the sole reason for the larger home range.

A prior grizzly bear study in the release area reports female MCPs to be 57 km^2 and male MCPs to be 423 km^2 (Ciarniello L. M., 2006). The female bear in this study has a MCP of 153 km^2 and the male bear of 780 km^2. This considerably larger MCP results

most likely from the bears not using the area shown as MCP as their actual home range, but rather dispersing from their original center of activity towards their last known VHF locations. This would mean that they did not establish a home range. Dispersing animals have, by definition, no home range.

Dispersal

Natal dispersal is the movement of animals from their natal home range to their adult breeding area. It is believed that this movement minimizes inbreeding and competition between related individuals for nutritional resources as well as sexual partners.

The natural dispersal of grizzly offspring usually happens at age of 2, it has been observed as early as age 1 (McLellan & Hovey, 2001). In this specific location it has been documented to be between the ages of 2-3 years (Ciarniello, Seip, & Heard, 2002).

A study of grizzly bear dispersal (McLellan & Hovey, 2001) showed the following dispersal for males and females in Southern BC in their first year of dispersal (2 year old offspring): Males dispersed 5.7 km ± 2.0 km (mean ± SE) and females dispersed 3.1 km ± 1.2 km.
The dispersal distance of male grizzly bears was reported to increase constantly during the first 4 years (23.5 km ± 1.7 km after 4 years), while the dispersal distance of female grizzly bears (2-, 3-, and 4-year olds) stayed the same.

The average distance from the release site during the first 39 days for the female study bear (4.81 km) is very similar to McLellan and Hovey's findings for the female bears in their first year of dispersal (3.1 km ± 1.2 km).

The average distance from the release site during the first 27 days for the male bear (11.35 km) is comparable to a 3 year old male (12.8 km ± 3.4 km) in McLellan and Hovey's study.

The male bear initially dispersed further from the release site than the female bear. Its long distance dispersal later in the study was also greater than that of the female bear.

A greater dispersal of male brown bears has been observed in North America (McLellan & Hovey, 2001) and also in Scandinavia (Zedrosser, Stoen, Saebo, & Swenson, 2007).

The female bear's movement to disperse further occurred between August 20th and September 29th and led the bear to travel 26.69 km away from the release site. This is a far greater dispersal than described in the literature for BC's interior grizzly bears.

The male bear's movement occurred between August 9th and September 29th and led the bear to travel 39.96 km /51.87 km away from the release site. This is also a much greater dispersal than described elsewhere. The reasons for this dispersal can only be speculated.

As the time for dispersal of the bears is roughly the same, even though the locations of the bears were not exactly the same, a possible theory for their dispersal is that the bears were disturbed by something that affected the entire area. One possibility is the start of the hunting season in the area.
Hunting season in the area (Region 7A, Omineca, Management Unit 7-23) started on the following days (B.C Ministry of Environment, 2008b) (for grizzly bear: personal communication, Dirk Schuirmann, local outfitter, February 6th, 2009).

- Grizzly bear: August 15th - October 25th
- Black bear: August 15th - November 15th
- Mule deer (Black-tailed) - bucks: September 10th - November 20th
- White-tailed deer (Black-tailed) - bucks: September 10th - November 20th
- Moose - Spike-fork Bulls: September 10th - November 5th
- Elk - 6 Point Bulls: September 10th - October 9th
- Blue Grouse: .September 1st - November 15th
- Spruce (Franklin) and Ruffed Grouse: September 1st - November 15th
- Coots, Common Snipe: September 1st - November 30th
- Ducks: September 1st - November 30th
- Geese: September 1st - November 30th

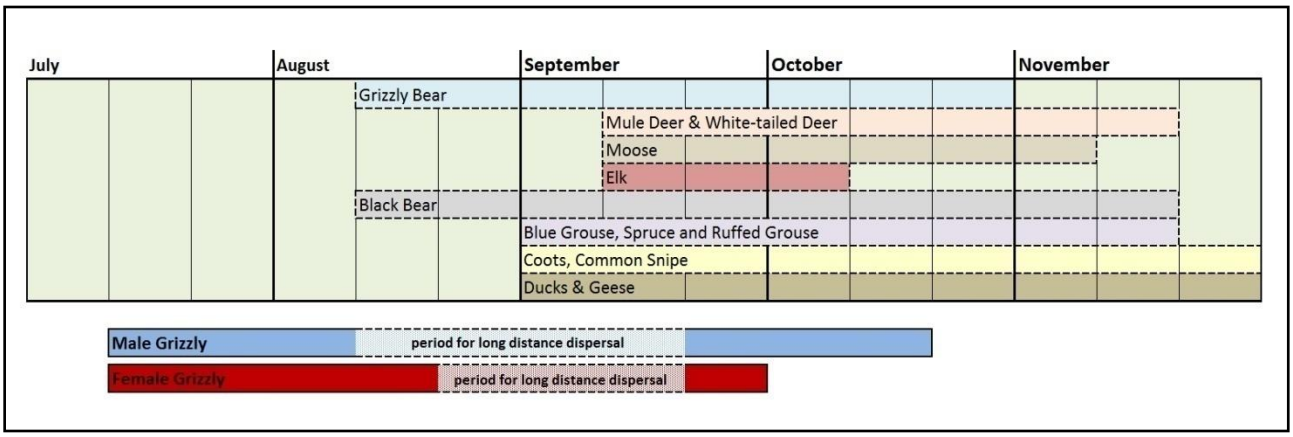

Figure 11: Hunting seasons in release area in relation to the monitoring period and the long distance dispersal of the grizzly bears

Figure 11 shows that the possible time period of the long distance dispersal coincided with the beginning of the hunting season.
Hunter kill statistics for this area at the time of the release are not available at this point (personal communication, Doug Heard, regional Wildlife Biologist, February 6th, 2009). Personal observations in the field however showed increased activity in the area with the establishment of temporary hunting camps (mainly trailers), increased traffic (vehicles for access to the site, then mainly motorcycles and ATVs) and the presence of hunters. It is possible that increased disturbance in the general area initiated the long distance movement of the study bears.

This however can only be seen as one of many possibilities for the long distance dispersal, as the increased traffic was concentrated on forestry roads and the bears stayed within a certain distance to these roads most of the time (Figure 9 and 10, page 46 and 47). The network of forestry roads was too scarce to provide a likely bear-hunter encounter.

Distance to roads

The distance of bear locations from roads has a big influence on a bear. Not only do roads offer different sources of food for bears (Roever, Boyce, & Stenhouse, 2008), they also allow motorized access to the backcountry for recreationists and hunters.

Increased access to bear habitat is therefore associated with high human-caused bear mortality (Nielsen, et al., 2004) and has been confirmed for the study area of this project (Ciarniello L. M., 2006).

The forestry road network in relation to the majority of the bears' GPS locations suggests that the bears did not rely on the roads as a primary travel corridor. The bears were spotted close to or on a road on two occasions and four of the female bear's GPS locations are close to or on a road. Other than that the bears appeared to stay away from them. One possible reason the bears may have avoided roads could be that they were trying to avoid other bears. The bears' motivation is not known for this study.

The maps used for the calculation of the distance to roads provide great detail, but they are not completely accurate; during field work many of the roads were being deactivated and only accessible by ATVs or on foot. A local study (6 years of VHF data from 17 female and 6 male bears) calculated the average distance to roads for male and female adult grizzly bears in the study area to be 5.10 km (personal communication, Dr. Lana Ciarniello, December 10th, 2008). The smaller amount of distance to roads in this study is most likely due to the bears' release in an area that had to be easily accessible by car and the bears' limited initial dispersal afterwards. The large distance to any roads in the new location for the female bear supports the theory that the bear dispersed from high traffic back country to a quiet and fairly inaccessible backcountry habitat.

Answering the post release monitoring questions

Technical difficulties with the VHF arose on the first day after the release and lasted throughout the monitoring period. Those technical difficulties mainly consisted of complete shut offs of the VHF function for up to several days, shifts in the VHF bpm as well as frequency drift. While most of these problems were initially attributed to the mountainous terrain of the release site, the later incorporation of a plane supported the theory of malfunctioning collars. The early exchange of VHF receivers and antennas on the ground brought no solution to the problem. Even though VHF receivers were constantly used while in the field, they led to no reliable triangulations of the bears at any point of time. They also did not allow the establishment of activity patterns for the

bears. Despite several attempts, the VHF was not picked up by ground or air since September 29th 2008 (♀) and October 15th 2009 (♂). The GPS delivered locations for the first 27 (♂) and 39 (♀) days after the bears' release.

Post release monitoring questions that can be answered for the time of their definite survival from July 12th 2008 to September 29th 2008 (♀) and October 15th 2009 (♂) are the following:

Were the bears seeking out humans?

Habituation to humans and/or conditioning to non natural food sources during the time in captivity are risks associated with bear rehabilitation programs (van Dijk, 2005) (Kolter & van Dijk, 2005) (Huber, Dabanovic, Kusak, & Frkovic, 1994). When habituation and food conditioning are combined, conflict with humans and dangerous situations can arise. If the bears approached humans or human settlements in search of food it would suggest food conditioning.

Neither of the two studied bears appeared to seek out human contact. Even though the bears were spotted on at least two occasions, they never approached these individuals beforehand nor did they stalk them. They were always spotted by people that had approached them in vehicles. The bears were seen on both occasions close to roads. The preference of road-like habitat, especially for subadult grizzly bears has been shown in several studies (Roever, Boyce, & Stenhouse, 2008). This behavior is likely food motivated as roads offer a bigger variety of herbaceous plants due to disturbance and the edge effect.

Were the bears finding appropriate food sources?

Technical and logistical challenges prevented site investigations that could show in depth what the bears consumed. The one site investigation that was conducted showed one bear feeding on Black Huckleberry (*Vaccinium membranaceum*) as well as insects in logs.

However, in an area as remote as the release site it is impossible to assess whether or not the bears would use inappropriate food sources. With no garbage dumps, no farm fields and no human settlements around, few inappropriate food sources were available.

The bears did not appear to have approached any of the hunting cabins or hunters in the area. The bears survived at least 79 days (♀) and 96 days (♂). Their survival for this time indicates that they were able to feed themselves, likely consuming “appropriate” food sources. This theory is supported by the bears’ healthy appearance at both observations (September 13th 2008 and October 27th, 2008). Observations in captivity show that bears learn what to eat by trial and error and that cubs do not necessarily need their mother for this task (Pazhetnov & Pazhetnov, 2005)(personal communication, Leonardo Bereczky, Harghita Bear rehabilitation center) (personal communication, Jubilee Cacaci, Kicking Horse Grizzly Bear Refuge Manager).

How did the bears react to other bears or animals?

Close up observations of the bears were discouraged from the very beginning of the project. The goal was to have the bears "go wild" without further influence of humans. The bears were not supposed to see, smell or sense the presence of the field team in their new territory. The reaction of the two bears to other bears or animals in the area could therefore not be documented.

In a grizzly bear study in the same area (Ciarniello L. M., 2006) 2 out of 8 grizzly yearlings accompanied by their mother died (25%).

Mortality reasons for subadult bears can be manifold, infanticide by male and female bears, starvation and accidental death can be causes. Compared to these high numbers of mortality, the survival of both of the studied bears in this project without any kind of maternal protection for at least 79 (♀) and 96 (♂) days can already be considered a small success. A small success at most, as the period of survival is rather short and no observation of the bears’ general health status were made. Malnutrition and injuries are possibilities that would diminish even this small success.

Denning:

Contrary to public opinion, denning behavior in grizzly bears is genetically passed on to the offspring and does not need to be learned directly from the mother. Hibernation by orphaned brown bears without learning it from their mother has been observed on several occasions (Beecham, 2006) (Pazhetnov & Pazhetnov, 2005) (personal communication, Jubilee Cacaci, Kicking Horse Grizzly Bear Refuge Manager) (personal communication, Leonardo Bereczky, Harghita Bear rehabilitation center).

The lack of denning knowledge (neither of the study bears denned during their winter in captivity) is therefore not a limiting factor. A possible limiting factor is the preparation of the bears for denning. Gaining enough weight for a long denning period is essential for survival.

Bears in the release area enter their dens on average around October 23rd after spending about 10 days in the vicinity of the den site. Bears emerge from their dens around May 11th (Ciarniello, Boyce, Heard, & Seip, 2005). At the time this Thesis is being written, if still alive the bears are most likely denning. If a VHF signal is picked up by a plane after the bears emerge, many questions about the denning behavior of the two orphaned grizzly bears can most likely be answered.

Recommendations for future monitoring

This project is not the first release of orphaned grizzly bear cubs into the wild in North America. It is however the first attempt to scientifically accompany the release over a long period of time to gather data on the behavior and survival of the bears and use this information for the development of standards and protocols for further grizzly bear rehabilitation.

The ultimate goal is that the information will not only help the grizzly bears in British Columbia and across borders, but also improve or help establish brown bear rehabilitation projects worldwide.

Technology used

The collars used for this project had a very low collar fix rate of 19.44% (♂) and 21.57% (♀) and provided only few GPS locations (56 (♂) and 88 (♀)) before they failed to transmit GPS locations completely after 27 (♂) and 39 days (♀).

Out of 8 interviewed users of GPS collars on grizzly bears and brown bears, no one was completely satisfied with the performance of their collars. Collars often have slight failures or even completely fail to transmit (Gau, et al., 2004).
The most satisfactorily operating GPS collars on brown bears are Vectronic collars (Vectronic Aerospace, Berlin, Germany) in Scandinavia. The latest collars (manufactured 2007 and later) are reported to get >95 % position success when scheduled to take positions every 10 minutes or less frequently (personal communication, Ingela Jansson, Scandinavian brown bear Research Project, January 12th, 2009). The newest collars of Vectronic Aerospace incorporate Iridium technology for one or two way communication as an improvement to Argos or Globalstar for data transfer with the additional bonus of cheaper location transmissions.

No collars can be guaranteed to work 100% of the time. In a large study with many animals some collar failure might be acceptable; in a study like this with a very small sample size, collar failure is catastrophic. To minimize the chance of a potential collar failure, collars should be ordered in advance, activated before the actual release and tested at the future release site. In case of pre-deployment failure steps must be taken to replace the faulty collar.

In addition to testing the collar in field conditions, a backup should be implemented for failing collars. If possible, an extra VHF beacon transmitter should be implemented into the collar. Vectronic Aerospace currently offers this for 100 Euros/collar (personal communication, Robert Schulte, CEO Vectronic Aerospace, January 13th, 2009).

If the collar manufacturer does not offer this service, ear tag transmitters may be used as a backup. They can be attached to the bear's ear/ears or directly to the collar (personal communication, Dave Hobson, Alberta Fish and Wildlife Division, January 19th, 2009) (personal communication, Terry Mack, Alberta Fish and Wildlife Division,

January 19th, 2009) (personal communication, Karen Graham, Grizzly Bear Project Foothills Model Forest, January 16th, 2009).

Ear tag transmitters are comparably cheap ($179.00 for M3620 eartag, Advanced Telemetry Systems, Isanti, Minneapolis, USA) and ensure that the bears can be located through VHF even after collar failure.

The battery of an ear tag transmitter can last up to 869 days and have warranty for 435 days (personal communication, David Bryson, Advanced Telemetry Systems, January 13th, 2009). In the field, ear tag transmitters live an average of 400 days (personal communication, Karen Graham, Grizzly Bear Project Foothills Model Forest, January 16th, 2009) (personal communication, Wayne Kasworm, US Fish and Wildlife Service, February 13th, 2009).

The use of ear tag transmitters on grizzly bears has already been proven to be successful on several occasions (Ciarniello L. M., 2006) (Garshelis, Gibeau, & Herrero, 2005) (Wood & Hengeveld, 2001).

They were also proven to work on small grizzly bears and yearlings (Wakkinen & Kasworm, 2004) (Waller & Servheen, 2005) (personal communication, Terry Mack, Alberta Fish and Wildlife Division, January 19th, 2009).

Ear injuries or irritation due to the transmitter attachment (Wood & Hengeveld, 2001) can be avoided or at least minimized by shaving the hair around the hole location, then using a 4mm - 6mm dermal biopsy punch to form the hole while avoiding blood vessels and using an antiseptic cream on the post of the ear tag when attaching it (personal communication, Karen Graham, Grizzly Bear Project Foothills Model Forest, January 16th, 2009) (personal communication, Terry Mack, Alberta Fish and Wildlife Division, January 19th, 2009) (personal communication, Dave Hobson, Alberta Fish and Wildlife Division, January 19th, 2009).

There are many advantages of using ear tag transmitters as a backup: If the collar fails, the bear can still be located, the collar can be retrieved and possibly replaced. If the collar is in mortality mode, listening to the ear tag transmitter can determine if the collar is still on the bear. Listening to the ear tag transmitter also gives clarification if the bear really is dead (mortality mode on the ear tag transmitter) or if the collar is sending a false mortality signal.

A way to simplify field identification of the released bears and to potentially ensure poachers do not target collared bears would be to choose a brightly coloured collar, ensuring maximum collar visibility.

Research questions

It is important to focus on the two main questions of interest throughout the entire program: The survival of the bears and aggressive behavior towards humans after the release.

A lot of additional information such as home range sizes, distance to roads and dispersal distance from the release location can be retrieved from analyzing the GPS/VHF data from the bears' collars. Descriptions of the habitat type of the release site can most often be found in literature and maps (B.C. Ministry of Forests and Range, 2008), in depth habitat descriptions can often be acquired from other studies from the same area.

Some information however requires a field monitoring team. Information that is necessary to establish a possible real long-term grizzly bear rehabilitation success and requires field work is the following:

- Occasional assessments of bear's health status (injuries etc.) through visuals
- Occasional assessments of bear's nutritional status (especially right before and after hibernation) through visuals

The use of a field monitoring team has other possibilities: The team can conduct microsite habitat investigations from GPS location clusters or reliable VHF locations to establish what the bear consumed or what the bear did at the specific site (day bed, mark tree, digging etc.), scat and hair can be collected for analysis (DNA, food intake etc.), tracks can be documented.

Additionally the field monitoring team can and should establish relationships with local project stakeholders such as nearby communities and industries as well as backcountry users such as recreationists and hunters. This way the team can provide information on

the project, receive feedback and act as a point of contact for the entire project. The human dimensions in a project like this are of utmost importance (Decker & Chase, 1997). The involvement of the stakeholders is crucial for the success or failure and acceptance of the grizzly bear rehabilitation project.

A long term goal should be to find out if released orphaned grizzly bear cubs eventually contribute to the wild breeding population. A focus on female bears should be made as females are especially vital for population survival.
The contribution to the breeding population can only be established if the bears are monitored from their release (currently ~ 1 $^{1}/_{2}$ years) until they reach sexual maturity between the ages of 5-7 (Hovey & McLellan, 1996) (White, Berardinelli, & Aune, 1995). This requires a monitoring period of 4 to 6 years which is expensive and technically challenging. Collars will possibly need to get refitted during the collar's battery life and exchanged shortly before the end of the battery life (battery life depends mainly on collar brand, data transfer schedule, amount of location fixes and temperature. It ranges on average from 1 to 4 years).

Depending on the future release sites of bears, field work can be extremely pricy. Helicopters (Bell 206B) at the initial release site currently run $1100/hour for wildlife work (personal communication with Pete McGill, Aberdeen Helicopters Ltd., January 9th, 2009), flights for VHF monitoring with a Cessna 172 cost $370/hour (personal communication, Eric Stier, Guardian Aerospace, September 29th, 2008).

Ways to minimize the project costs, while still getting scientifically sound information on the feasibility and/or limitations of grizzly bear rehabilitation should be used, as funding is limited. The project is currently solely funded by the International Fund for Animal Welfare and the Northern Lights Wildlife Society.

Discussion

The rearing of orphaned grizzly bear cubs by hand and releasing them back into the wild has the potential to be a humane response to orphaned bear cubs and to be a practical wildlife management technique. What currently hinders the incorporation of such a technique is the lack of knowledge in regards to rehabilitation outcomes.

This study, though well documented, appears to lack functioning collars for any further documentation of long term rehabilitation results.

Former attempts of grizzly bear rehabilitation in North America have often been ad-hoc and seldom led to long term success, no protocols for the release or manuals for the captive care of grizzly bears have been established. Experience from Eurasia shows possibilities for the successful rehabilitation of brown bears. How comparable European brown bears are with North American grizzly bears in regards to their rehabilitation and post release behavior is at this time unclear.

The grizzly bear is a large and potentially dangerous carnivore; its rehabilitation must be approached with extreme caution and care. Failed rehabilitation attempts can have devastating results for further rehabilitation approaches. Manuals on the care of grizzly bears in captivity should be established. Data on rehabilitation and release techniques and success or failure must be shared worldwide between rehabilitation facilities involved in grizzly bear/brown bear rehabilitation.

Black bears have been successfully reared by hand and released; the experience from this however should not blindly be transferred to hand rearing and releasing grizzly bears. The major difference here is that black bears are released from the rehabilitation facility at their natural age of dispersal. Grizzly bears are currently released about a year before their natural age of dispersal. Keeping them longer at the facility would make the rehabilitation more expensive and the habituation of the bears to humans more likely.

It is too early to call the rehabilitation of grizzly bears a success or a failure. Many questions remain unanswered at this point in regards to the post release behavior and movement of rehabilitated grizzly bears. An important aspect in this regard is the

connection between possible food conditioning and the remoteness of the release site. Does a remote release location with little to no human food sources possibly lead to the bears "going wild" after their rehabilitation and "forgetting" their time in human care?

Everything that can be done should be done to minimize the number of orphaned grizzly bear cubs. However, due to both human related mortality as well as natural reasons, it will never be possible to completely eliminate the issue of orphaned grizzly bear cubs. Research in orphaned grizzly bear cub rehabilitation should therefore be continued.

Long term monitoring and research is needed to establish the feasibility and limitations of grizzly bear rehabilitation. This research is not only technically challenging, but also very expensive. Wildlife shelters most likely do not have the capability of financing the captive care and the post release monitoring of grizzly bears out of their own funds. The BC Ministry of Environment considers most of British Columbia's grizzly bear populations healthy and sees currently little conservation benefit in the rehabilitation of individual grizzly bears, therefore giving rehabilitation attempts a low priority at the moment. This means while it supports rehabilitation attempts in the ongoing pilot project with staff time and expertise, it doesn't financially contribute to them.

Funding for the rehabilitation attempts is urgently needed.

Another important aspect of the rehabilitation process is to avoid the habituation of bears to humans. One possible approach that might help and should be researched would be to minimize the time the bears spend in captive care. The two bears were released at an age of about 19 months. This was done in an attempt to release at a larger size than cubs of the year. A second goal was to release them at a season in which natural food was plentiful.

Even though the natural dispersal of brown bear cubs from their mother happens around the age of 2-3 years and the mortality rate of cubs of the year in comparison to yearlings was shown to be higher in the bears' release area (Ciarniello L. M., 2006), studies indicate that brown bears can in some cases be self sufficient from their first year on:

In Sweden, orphaned brown bear cubs that were left in the wild to fend for themselves were observed to survive for at least 4 years without showing a negative effect on subsequent growth or survival (Swenson, Franzen, Segerstrom, & Sandegren, 1998).

Alaskan brown bears have been observed to be self sufficient from the age of 7 months on (Johnson & LeRoux, 1973).

The long term survival of a cub of the year in North America that was fattened up in captivity and then placed into an artificial winter den has been documented (Jonkel, Husby, Russel, & Beecham, 1980).

In Montana two orphaned cubs of the year were left in the wild with supplemental road kill (deer and elk) in September 2007. One year later the cubs were recaptured; they were healthy and made it through the winter without any conflict (personal communication, Kevin Frey, Montana FWP, December 9th, 2008).

In British Columbia an orphaned grizzly bear cub of the year was fed scraps from May till the end of June 1992 by an outfitter. The bear denned and survived until next spring at which time it got shot by a resident hunter during a legal limited entry hunt (personal communication, Brian Schuck, Gemstar Outfitting, December 13th, 2008).

Additionally there are documented cases where cubs of the year survived, but developed conflict behavior using human food sources. Examples for this include bears in Montana and Russia (see Chapter 1) as well as in Austria (Zedrosser, Gerstl, & Rauer, 1999).

Healthy cubs orphaned in August and later could be fitted with a monitoring device and left in the wild. Depending on where they were found they might be moved to a more remote location. Cubs orphaned before August will be fattened up for hibernation at a rehabilitation facility and placed in a remote artificial winter den with supplemental food. Growing/break away collars should be used for the monitoring (Strathearn, Lotimer, Kolenosky, & Lintack, 1984). This is an approach that should be researched for healthy orphaned grizzly bear cubs.

Minimizing the possibility of bears being drawn to unnatural food sources after their winter den release would include the artificial den to be located in a remote area as well

as supplemental feeding (e.g. carcasses). Whether the supplemental food would attract other predators that pose a serious threat to the bear would have to be researched.

The advantage of this approach in the long run might be the minimization of captive care cost as well as the minimization of the bear's chance of habituation during captive care.

Grizzly bears are currently not endangered in British Columbia, but they are vulnerable to extirpation or extinction (B.C. Ministry of Environment, 2008a) making it imperative that we find a viable method for dealing with orphaned grizzly cubs. With increased use of backcountry areas and the shrinking number of remote release locations, we must find out if rehabilitation is a realistic option. If it is, we need to identify best practices, as has already been accomplished for black bears.

Works cited

B.C. Ministry of Environment. (2008a). *B.C. Conservation Data Centre*. Retrieved January 25th, 2009, from BC Species and Ecosystems Explorer: http://a100.gov.bc.ca/pub/eswp/

B.C Ministry of Environment. (2008b). *Hunting & Trapping Regulations Synopsis 2008 - 2009.* Victoria: B.C Ministry of Environment.

B.C. Ministry of Environment. (2001). Preventing and Responding to Conflicts with Large Carnivores. *Vol. 4, Sec. 7, Subsec. 04.01.1* . Victoria: B.C. Ministry of Environment.

B.C. Ministry of Environment. (1993). Possession of Live Wildlife. *Vol. 5. Sec. 4-05.01.* Victoria: B.C. Ministry of Environment.

B.C. Ministry of Forests and Range. (2008). *Biogeoclimatic Ecosystem Classification*. Retrieved May 12th, 2008, from http://www.for.gov.bc.ca/hre/becweb/index.html

Beecham, J. (2006). *Orphan Bear Cubs: Rehabilitation and Release Guidelines.* The World Society for the Protection of Animals.

Binks, M. J. (2008). Post-release behaviour and survival of shelter reared, juvenile black bears in central Ontario. *Master's Thesis* . Sudbury, Ontario: School of Graduate Studies, Laurentian University.

Blanchard, B., & Knight, R. (1991). Movements of Yellowstone grizzly bears. *Biological Conservation 58* , 41-67.

Bretillot, J. (2005). *Argos flash #7*. Retrieved January 3rd, 2009, from Argos: http://www.argos-system.org/documents/publications/flash/argos_flash_07.pdf

Cain III, J. W., Krausman, P. R., Jansen, B. D., & Morgart, J. R. (2005). Influence of topography and GPS fix interval on GPS collar performance. *Wildlife Society Bulletin 33* , 926–934.

Carlstead, K., Seidensticker, J., & Baldwin, R. (1991). Environmental enrichment for zoo bears. *Zoo Biology 10* , 3-16.

Ciarniello, L. M. (2006). Demography and Habitat selection by Grizzly bears (Ursus arctos L.) in central British Columbia. *Ph.D. dissertation* . Edmonton, Alberta.

Ciarniello, L. M., Boyce, M. S., Heard, D. C., & Seip, D. R. (2005). Denning behavior and den site selection of grizzly bears along the Parsnip River, British Columbia, Canada. *Ursus 16* , 47-58.

Ciarniello, L. M., Seip, D., & Heard, D. (2002). *Parsnip Grizzly Bear Population and Habitat Project - Summary Data Sets, 1998 to 2002, including habitat use and availability.* Retrieved November 13th, 2008, from Parsnip Grizzly Bear Population and Habitat Inventory Project: http://web.unbc.ca/parsnip-grizzly/new_site/progress/Final-98-02.pdf

COSEWIC. (2002). *COSEWIC assessment and update status report on the Grizzly Bear Ursus arctos in Canada.* Ottawa: Committee on the Status of Endangered Wildlife in Canada.

Criswell, A., & Galbreath, G. J. (2005). Behavioral persistence in captive bears: a critique. *Ursus 16* , 268-273.

DeCesare, N. J., Squires, J. R., & Kolbe, J. A. (2005). Effect of forest canopy on GPS-based movement data. *Wildlife Society Bulletin 33* , 935–941.

Decker, D. J., & Chase, L. C. (1997). Human dimensions of living with wildlife: A management challenge for the 21st century. *Wildlife Society Bulletin 25* , 788-795.

DeLong, C. (2003). *A Field Guide to Site Identification and Interpretation for the Southeast Portion of the Prince George Forest Region.* BC Ministry of Forests - Forest Science Program.

D'Eon, R., Serrouya, R., Smith, G., & Kochanny, C. (2002). GPS radiotelemetry error and bias in mountainous terrain. *Wildlife Society Bulletin 30* , 430-439.

Dubois, S. (2003). A survey of wildlife rehabilitation goals, impediements, issues and success in British Columbia, Canada. *Master's Thesis* . Vancouver, British Columbia: The University of British Columbia.

Feldhamer, G. A., Thompson, B. C., & Chapman, J. A. (2003). *Wild Mammals of North America, 2nd edition.* The Johns Hopkins University Press.

Forthman, D. L., Elder, S. D., Bakeman, R., Kurkowski, T. W., Noble, C. C., & Winslow, S. W. (1992). Effects of feeding enrichment on behavior of three species of captive bears. *Zoo Biology 11* , 187 - 195.

Garshelis, D., Gibeau, M., & Herrero, S. (2005). Grizzly bear demographics in and around Banff National Park and Kananaskis Country, Alberta. *Journal of Wildlife Management 69* , 277-297.

Gau, R., Mulders, R., Ciarniello, L., Heard, D., Chetkiewicz, C., Boyce, M., et al. (2004). Uncontrolled field performance of Televilt GPS-Simplex collars on grizzly bears in western and northern Canada. *Wildlife Society Bulletin 32* , 693-701.

Grandia, P. A., van Dijk, J. J., & Koene, P. (2001). Stimulating Natural Behavior in Captive Bears. *Ursus 12* , 199-202.

Hamilton, A., Heard, D., & Austin, M. (2004). British Columbia Grizzly Bear (Ursus arctos) Population Estimate 2004. Victoria: B.C. Ministry of Water, Land and Air Protection.

Heard, D. C., Ciarniello, L. M., & Seip, D. R. (2008). Grizzly Bear Behavior and Global Positioning System Collar Fix Rates. *Journal of Wildlife Management 72* , 596-602.

Hellgren, E. C., Carney, D. W., Garner, N. P., & Vaughan, M. R. (1988). Use of breakaway cotton spacers on radio collars. *Wildlife Society Bulletin 16* , 216-218.

Hooge, P. N., Eichenlaub, B., & Solomon, E. (1999). The animal movement program. USGS, Alaska Biological Science Center .

Hovey, F., & McLellan, B. (1996). Estimating population growth of grizzly bears from the Flathead River drainage using computer simulations of reproduction and survival rates. *Canadian Journal of Zoology 74* , 1409-1416.

Huber, D. (2005). Why not to Re-introduce "Rehabilitated" Brown Bears to the wild? *Rehabilitation and release of bears* (pp. 28-34). Cologne: Zoologischer Garten Köln.

Huber, D., Dabanovic, V., Kusak, J., & Frkovic, A. (1994). Reintroduction of hand-reared brown bears into the wild: experiences, problems, chances. *International Conference on Aspects of Bear Conservation*, (pp. 179-186). Bursa, Turkey.

Johnson, L. A. *Bears.* Omaha's Henry Doorly Zoo.

Johnson, L. J., & LeRoux, P. (1973). Age of Self-Sufficiency in Brown/Grizzly Bear in Alaska. *The Journal of Wildlife Management 37* , 122-123.

Jonkel, C., Husby, P., Russel, R., & Beecham, J. (1980). The reintroduction of orphaned grizzly bear cubs into the wild. *International Conference on Bear Research and Management 4*, (pp. 369-372).

Kelt, D. A., & Van Vuren, D. H. (2001). The Ecology and Macroecology of Mammalian Home Range Area. *The American Naturalist 157* , 637-645.

Kilham, B. a. (2002). *Among the bears: raising orphan bear cubs in the wild.* New York: Henry Holt and Co., LLC.

Kolter, L., & van Dijk, J. (2005). *Rehabilitation and release of bears.* Cologne: Zoologischer Garten Köln.

Langen, A. (2008). *Who we are*. Retrieved December 17th, 2008, from Northern Lights Wildlife Society: www.wildlifeshelter.com/about.htm

MacHutchon, A. (2001). Grizzly bear activity budget and pattern in the Firth River Valley, Yukon. *Ursus 12* , 189-198.

McLellan, B. N., & Hovey, F. W. (2001). Natal dispersal of grizzly bears. *Canadian Journal of Zoologie 79* , 838-844.

McLellan, B. N., Hovey, F. W., & Woods, J. G. (2000). Rates and Causes of Grizzly Bear Mortality in the Interior Mountains of Western North America. *Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Volume Two* (pp. 673-678). Kamloops: B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops.

Miller, E. (2000). *Minimum standards for wildlife rehabilitation, 3rd edition.* St. Cloud, MN.: National Wildlife Rehabilitators Association.

National Wildlife Rehabilitators Association. (2009). *National Wildlife Rehabilitators Association*. Retrieved January 15th, 2009, from NWRA: http://www.nwrawildlife.org/

Natural Resources Canada. (2008). Retrieved October 9th, 2008, from Natural Resources Canada: http://www.nrcan-rncan.gc.ca

Nielsen, S. E., Herrero, S., Boyce, M. S., Mace, R. D., Benn, B., Gibeau, M. L., et al. (2004). Modelling the spatial distribution of human-caused grizzly bear mortalities in the Central Rockies ecosystem of Canada. *Biological Conservation 120* , 101-113.

Parker, C. (2008). *Recommendations for Black Bear–Human Conflict Management and Black Bear Rehabilitation in British Columbia.*

Pazhetnov, V. S., & Pazhetnov, S. V. (2003). Brown Bear Rehabilitation at Toropetsky Biological Station. *International Bear News 12* .

Pazhetnov, V. S., & Pazhetnov, S. V. (2005). Re-introduction of Orphan Brown Bear Cubs. *Rehabilitation and release of bears* (pp. 53-69). Cologne: Zoologischer Garten Köln.

Pokras, M. (1997). Introduction to wildlife rehabilitation purpose and philosophy. In A. T. Moore, & S. Joosten, *Principles of Wildlife Rehabilitation* (pp. 7-20). St. Cloud: National Wildlife Rehabilitators Association.

Rausch, R. (1963). Geographic variation in size of North American brown bears, Ursus arctos L, as indicated by condylobasal length . *Canadian Journal of Zoology 41* , 33-45.

Rempel, R. S., Rodgers, A. R., & Abraham, K. F. (1995). Performance of a GPS animal location system under boreal forest canopy. *Journal of Wildlife Management 59* , 543-551.

Rodgers, A. R. (2001). Tracking Animals with GPS: The first 10 years. *Tracking animals with GPS*, (pp. 1-10). Aberdeen.

Roever, C., Boyce, M., & Stenhouse, G. (2008). Grizzly bears and forestry II: Grizzly bear habitat selection and conflicts with road placement. *Forest Ecology and Management 256* , 1262–1269.

Rogers, L. L. (1986). Long-term survival of adopted black bear cubs in suboptimal habitat. *Wildlife Society Bulletin 14* , 81-83.

Schwartz, C., Miller, S., & Haroldson, M. (2003). Grizzly Bear. In G. Feldhamer, B. Thompson, & J. Chapman, *Wild mammals of North America: Biology, Management, and Conservation - second edition* (pp. 556-586). Baltimore, Maryland, USA: Johns Hopkins University Press.

Strathearn, S. M., Lotimer, J. S., Kolenosky, G. B., & Lintack, W. M. (1984). An expanding break-away radio collar for black bear. *Journal of Wildlife Management 48* , 939–942.

Swenson, J., Franzen, R., Segerstrom, P., & Sandegren, F. (1998). On the age of self-sufficiency in Scandinavian brown bears. *Acta Theriologica 43* , 213-218.

Valdmann, H., Saarma, U., & Karis, A. (2001). The brown bear population in Estonia: current status and requirements for management. *Ursus 12* , 31-36.

van Dijk, J. (2005). Considerations for the Rehabilitation and Release of Bears into the Wild. *Rehabilitation and release of bears* (pp. 7-16). Cologne: Zoologischer Garten Köln.

Waits, L. P., Talbot, S. L., Ward, R. H., & Shields, G. F. (1998). Mitochondrial DNA phylogeography of the North American brown bear and implications for conservation. *Conservation Biology 12* , 408-417.

Wakkinen, W. L., & Kasworm, W. F. (2004). Demographics and population trends of grizzly bears in the Cabinet–Yaak and Selkirk Ecosystems of British Columbia, Idaho, Montana, and Washington. *Ursus 15* , 65-75.

Waller, J., & Servheen, C. (2005). Effects of transportation infrastructure on grizzly bears in northwestern Montana. *Journal of Wildlife Management 69* , 985-1000.

Wasserman, J., Clumpner, C., & Mack, K. (1995). Post-release survival and movements of captive-reared Black Bear cubs (Ursus Americanus) in wildlife rehabilitation. *Symposium of the National Wildlife Rehabilitators Association.* Minneapolis, MN.

West, A. (2003). *Environmental Indicator: Wildlife Populations in British Columbia*. Retrieved 11 23, 2008, from Ministry of Water, Land and Air Protection: http://www.env.gov.bc.ca/soe/et02/16_wildlife/technical_report/Wildlife_2002.pdf

White, J., Berardinelli, J., & Aune, K. (1995). Reproductive Characteristics Of The Male Grizzly Bear In The Continental United States. *Ursus 10* , 497-501.

Wood, M. D., & Hengeveld, P. E. (2001). *Behaviour of Grizzly Bears (Ursus Arctos) in Relation to Closure of the McLeod Lake Landfill, North-central BC.* Peace/Williston Fish and Wildlife Compensation Program.

Young, R. J. (2003). *Environmental enrichment for captive animals.* Blackwell publishing Universities Federation for Animal Welfare (UFAW).

Zedrosser, A., Gerstl, N., & Rauer, G. (1999). *Brown Bears in Austria - 10 Years of Conservation and Actions for the Future.* Vienna: Federal Environment Agency Austria.

Zedrosser, A., Stoen, O., Saebo, S., & Swenson, J. (2007). Should I stay or should I go? Natal dispersal in the brown bear. *Animal Behaviour 74* , 369-376.

Declaration

Declaration of Originality

I declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published, or substantially overlapping with material submitted for the award of any other degree at any institution, except where due acknowledgment is made in the text.

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Joachim Treptow

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