Grizzly Bear Conservation in the Yellowstone to Yukon Region

Yellowstone to Yukon
CONSERVATION INITIATIVE

Technical Report # 6
August 2005

By Troy Merrill

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PREFACE

The Yellowstone to Yukon Conservation Initiative (Y2Y) works with non-governmental organizations, government agencies, communities and businesses to maintain and restore the natural heritage of the Yellowstone to Yukon region. A significant component of this heritage is the intact populations of native plants and animals. As one means of protecting and preserving this biodiversity, Y2Y conducts scientific research to identify priority areas within the region for large carnivores, birds and fish. The basis for focusing on large carnivores is the "umbrella" concept, which assumes that preserving habitat for wide-ranging species, such as large carnivores, will in turn protect species with smaller area requirements. However, because there are limitations to protecting species by applying the umbrella concept, Y2Y also incorporates the needs of other focal species into planning efforts. In particular, Y2Y has sponsored research to identify bird diversity hot spots-key bird habitats-to assess aquatic integrity.

This report summarizes the results for one component of Y2Y's large scale planning efforts: research on a large carnivore, the grizzly bear. Y2Y commissioned LTB Institute of Landscape Ecology to conduct the modeling work on grizzly bears presented in this report. This research focuses on developing models that define and characterize grizzly bear habitat by quantifying how many bears the Y2Y landscape can support at current levels of habitat productivity and human activity. Spatially explicit models, such as grizzly bear density and landscape lethality were developed to allow us to determine the extent and location of habitat required to meet specific demographic and evolutionary goals. Understanding the relationship between habitat productivity and grizzly bear density, and between human related mortality rates and proximity to humans, enables us to evaluate the effectiveness of various conservation approaches.

The results and conclusions presented in this report are derived from the work of the primary author, and also draws upon the work of other scientists listed in the acknowledgements and reference sections.

The audience for this report is the staff and members of the Yellowstone to Yukon Conservation Initiative, non-governmental organizations, agency personnel and other parties interested in large-scale planning and preservation of grizzly bears. Y2Y plans to use the information in this report to guide its conservation activities for grizzly bears in western North America.

ACKNOWLEDGMENTS

A vision of conservation of this scope and ambition is never the property of a single person. This document is the product of years of research and conversation. Information, data and suggestions came from many individuals, both scientists and advocates.

Marcy Mahr, in her role as Science Coordinator for Y2Y, masterly shepherded this project through all of its phases by providing support, encouragement and discipline as needed. Contributions from Harvey Locke provided context, wisdom and style. Thoughtful reviews by Michael Proctor, Wayne McCrory and Lance Craighead significantly improved and strengthened the document. Grizzly bears have no stauncher ally than Louisa Willcox. Without her support this project would not have happened.

This strategy is the application of the results of a long-term, ongoing collaboration between Troy Merrill and David Mattson. Their knowledge, insights and understanding of how grizzly bears live and die made this strategy possible. Gary Tabor has been instrumental in directing funds to the project. Funding was provided by Wilburforce Foundation, LaSalle Adams Fund, Summerlee Foundation, and Earth Friends Wildlife Foundation.

In addition, many thanks to John Marriott and Peter Dettling for the use of their photographs.

John E. Marriott Photography
<http://www.wildernessprints.com>

Peter Dettling Photography
<http://www. http://www.sedrungallaria.ch/PetNet/html/StartFr.html>

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Introduction

This report describes a conservation strategy for grizzly bears (*Ursus arctos horribilis*) in the Yellowstone to Yukon region. The conservation strategy addresses broad-scale issues, both geographically and temporally. This strategy is designed to maintain grizzly bear populations across the region and throughout the foreseeable future. It is hoped that this report will guide the Yellowstone to Yukon Conservation Initiative and its partner organizations in developing its strategies and realizing its goals.

This report identifies areas that are critical to the long-term maintenance of robust, well-distributed grizzly bear populations, as well as conditions that need to be preserved or changed in each of the areas identified. This species-specific conservation strategy derives from Y2Y's broader organizational goal:

> *Combining science and stewardship, we seek to ensure that the world- renowned wilderness, wildlife, native plants and natural processes of the Yellowstone to Yukon region continue to function as an interconnected web of life, capable of supporting all of the natural and human communities that reside within it, for now and for future generations (www.y2y.net).*

Grizzly bears need large wilderness areas. As per the umbrella concept (Frankel and Soule 1981, Meffe and Carroll 1997) these large areas are likely to contain intact populations of many other native species. They will benefit from management that favors grizzly bears because of shared sensitivities to human-related stressors (Mattson et al., in review). Conserving grizzly bears also ensures areas large enough to contain broad-scale ecological processes critical for maintaining healthy landscapes. Areas required for long-term conservation of grizzly bears will likely contain refuges and buffers needed by other biota.

In this report, grizzly bear conservation is implicitly framed within the context of current human practices and patterns of settlement. The analysis and recommended strategies flowing from it are encouraging. There is sufficient productive habitat remote from humans that can support large populations of grizzly bears, with the genetic and behavioral diversity needed to adapt to a warming climate and increasing human population.

We can have robust populations of grizzly bears now if we, as a society, choose to have them. We can have robust populations of grizzly bears in the future if we are willing to limit our impact on the large wild places they need.

It is important to acknowledge the challenges and problems we face; in some areas human population growth is beginning to limit grizzly bear access to important food sources. Mining, forestry, and recreational developments are degrading and fragmenting grizzly bear habitat, especially in the US-Canadian border region where some populations teeter on the brink of extirpation. Across the entire Y2Y region, oil and gas exploration and development is occurring within occupied grizzly bear habitat. Almost everywhere south of 60°, human impacts have reduced grizzly bear populations – reducing their likelihood of future existence.

The Cores and Corridors Concept and Issues of Scale

The spatial structure of this grizzly bear conservation strategy is similar to that of the core/corridor model described by Reed Noss and others (e.g., Noss and Copperrider 1994). In the classic core and corridor model large core protected areas are connected to each other by corridors that provide for safe passage of biota. This strategy provides for interchange of individual bears (and genes) among populations, increasing the probability of survival for the entire grizzly bear "metapopulation" – a population of populations (Hanski and Gilpin 1991).

The concept of a system of connected core areas is valid at any scale, but the design of such a system is scale dependent. Connectivity between blocks of habitat fragmented by a settlement such as Canmore, Alberta is very different than connectivity between the wilderness complex of Central Idaho and the Parks and Crown Lands of British Columbia. At the scale of an animal moving through a town such as Canmore, 'corridor' accurately describes what is needed: a well-defined linear path of habitat extending from point A to point B. At the scale of the region including Central Idaho and British Columbia, connectivity has a different meaning because no 'corridor', or pathway, explicitly links the upper Clearwater River drainage to the Purcell Mountains.

Habitat 'connectivity' may require habitat suitable for residence between core areas. The area between core habitats can be described as *transition* habitat, resulting from alterations caused by management and natural disturbance. As an animal moves further from core habitat, habitat quality declines until the landscape can no longer support the species. For example, female grizzly bears do not readily disperse over long distances.[1] For them, linkages between core areas occur where usable transition habitat surrounding one core meets usable transition habitat surrounding another core. Spatially, such linkages do not resemble corridors, nor are they used as such by the bears. Individuals frequently reside in transition habitat, sometimes permanently. Such places may be population sinks, where the death rate exceeds the birth rate, or just mediocre habitat (Proctor, pers. comm.).

Populations in transition habitat seldom thrive and generally depend upon migrants from source populations in habitat cores for their survival. Within transition habitat animals may use linear, corridor-like features to travel from one place to another, to bypass human developments, or to cross roads. However, at the scale of Y2Y, corridors are embedded within transition habitat and do not necessarily define linkages between core areas.

Core areas can be defined in several ways. According to the traditional cores/corridors model, core areas are 'protected' by law or policy as a park, wilderness area, or other specific management designation. In the model adopted for this conservation strategy, cores are areas where habitat conditions, including human influences, are sufficient to contain 'source' grizzly bear populations regardless of their

[1] Adult juvenile males sometimes move larger distances (Craighead and Vyse, 1996) through unoccupied habitat but frequently encounter trouble which leads to their death.

management designation. Core areas may or may not correspond with currently protected areas. I make no *a priori* judgment about whether a protected area is the best way to preserve core features. Rather, my analysis and interpretation allows for a context-sensitive approach that can provide guidance on where to focus, what to do there, and why. This approach to defining cores is based on a single species of interest, albeit a species likely to be an umbrella for other biota (Mattson et al., in review; see Carroll et al. 2001).

The location of humans and the location of bear foods determine the location of core areas for grizzly bears. Abundance of grizzly bear food functions as a surrogate for population productivity, or combined density and birth rate, whereas the level of human activity functions as a surrogate for grizzly bear death rates. The relation between death rate and human activity follows from the fact that humans are directly responsible for the deaths of almost all adult and subadult grizzly bears in the Y2Y region (see Essentials of Grizzly Bear Life and Death on page 6).

Photo: © John E. Marriott

Grizzly Bear Conservation Strategy

Developing a grizzly bear conservation strategy has been a long-term goal of Y2Y. Concurrent with this report, researchers supported by Y2Y and other organizations were developing habitat and linkage zone models for several carnivore species at multiple scales in the Y2Y region (Carroll et al. 2001, Walker and Craighead 1999, Apps 1997, Alexander et al. 2003). Complementing these efforts, the models referred to in this report allow:

1. Estimations of grizzly bear density over the Y2Y landscape (grizzlies per 100 km^2), and,

2. Calculations of the rate at which humans kill grizzly bears in relation to human settlements and roads, and,

3. The delineation of the areas required for the conservation of grizzly bears in the Y2Y region.

While models will undoubtedly continue to evolve, the current generation is sufficient for the identification of grizzly bear source areas capable of containing demographically robust populations (DRPs) of 500–700 individuals, and the most likely linkage areas between DRPs to form evolutionarily robust populations (ERPs) of 2000 or more individuals. A demographically robust population is expected to persist for several hundred years; an evolutionarily robust population is expected to persist for several millennia.

The numeric definition of a DRP is empirical; it is based on the observed fates of grizzly and brown bear populations. The numeric definition of an ERP is theoretical; it is based on results of modeling that considers the effects of genetic diversity (*more details on these definitions are provided in Population Basics, page 7*). This report describes our habitat modeling methods and presents maps displaying the results of their application. It concludes with recommendations for a general management regime required to achieve or maintain population goals for each DRP and ERP.

This grizzly bear conservation strategy stops at 60°N latitude. At this point, the primary data layers used in this set of habitat models run out. As the models developed in unanticipated directions, we focused on exploring model performance and the identification of source areas and linkages where data was available. Model development has now reached a plateau and we are shifting our emphasis to applying these models to the rest of Y2Y.

It was beyond the scope of our resources to acquire data for the Yukon and Northwest Territories at this time. While a northern extension will help identify areas of high potential grizzly bear density, it may not be as useful in identifying conservation priorities because the influences of human populations and roads are less pronounced, and thus less apparent.

Essentials of Grizzly Bear Life and Death

The key to successful management and recovery of endangered or otherwise vulnerable grizzly bear populations is managing habitat as well as human activity to maximize female survival and reproduction (Knight and Eberhardt 1985; Mattson et al. 1996; McLellan et al. 1999). Grizzly bears are intelligent, active creatures who constantly explore their environment. They know their range well enough to shift use and take advantage of local resources that are seasonally or annually available.

Female grizzly bears show comparatively strong fidelity to their home range (Blanchard and Knight 1991). When previously secure areas are opened to human access, bears are exposed to higher risks of being killed by humans, or risks associated with shifting activity to less well known areas (Mattson et al. 1996). While grizzly bears will avoid roads and other human facilities, they seldom entirely abandon an area. Avoiding roads and other human-related landscape features may mean individuals are forced to use poorer-quality habitats within or adjacent to their traditional home range. Alienation from prime habitat can reduce female reproduction because bears forced into unfamiliar territory must spend time and energy finding new food sources, and are more likely to come into potentially lethal contact with humans or other bears (Mattson 1990).

Humans cause most grizzly bear deaths (Mattson et al. 1996; McLellan et al. 1999; Mattson and Merrill 2002; Merrill and Mattson 2003; Benn 1998). Despite their reputation for strength and ferocity, grizzly bears are no match for humans with firearms. Humans kill bears in response to perceived attacks, in defense of livestock or other property, or, increasingly, during conflicts over the remains of animals killed by big game hunters.

In many areas of the Canadian portion of Y2Y, grizzly bears are legally hunted. Even in areas where hunting grizzly bears is illegal they are sometimes mistaken for legally hunted black bears and shot. Wildlife managers kill grizzly bears out of concern for human safety, usually after bears obtain human-related food or become habituated to humans.

Cause or opportunity to kill grizzly bears depends largely on overall levels of contact between humans and grizzly bears. These levels depend, in turn, on conditioning factors such as the density of humans and the density of road and trail access. Grizzly bears and humans are more likely to come into contact where there are greater numbers of people with greater road access to bear habitat. Whether contact results in dead bears depends on several other factors, including management jurisdiction and human attitudes. Grizzly bears are much less likely to die in parks where loaded firearms are prohibited and/or during encounters with humans who carry pepper spray rather than loaded firearms (McLellan et al. 1999, Mattson and Merrill 2002, Merrill and Mattson 2003).

Population Basics

Demographically Robust Populations

History has shown that grizzly bear populations of 400-450 are robust enough to deal with vagaries of food availability and human behavior (Mattson and Reid 1991, Mattson and Merrill 2002). Grizzly bear populations of less than 250 are prone to decline and can rapidly reach a critically low threshold of 40-125 individuals (Mattson and Reid 1991, Weilgus 2002). Without dramatic intervention, populations of 40-125 bears are vulnerable to extinction (Shaffer 1983, Samson et al. 1985, Wiegand et al. 1998). Because the proportion of a population that actually reproduces – referred to as the *effective population* – is approximately 1:4 for grizzly bears (Harris and Allendorf 1989), a total population of 450 corresponds to an effective population of 112. A relatively small number of individuals, therefore, determine the fates of even moderately large populations.

Conditions for grizzly bears vary season to season and year to year; during good years populations increase, in bad years they decline. The health and growth of a population reflects the number of good versus bad years. Healthy populations have more good than bad years. But this can, and does, change quickly. A string of years with scarce food and intolerant humans can throw the healthiest populations into dramatic decline (Mattson and Merrill 2002). Rates of increase, or decrease, for grizzly bear populations vary substantially from year to year. When food is abundant or humans are tolerant, a population can increase by as much as 5-7% per year. Conversely, in years when critical foods are scarce and human-caused mortalities are high, populations can decrease just as quickly (Pease and Mattson 1999, Mattson and Merrill 2002).

At what level should a population be managed? Too often the goal has been to maintain a minimum viable population. Managing a population at minimum levels of viability may not adequately address natural variation and history. The precautionary principal, often invoked as a guiding tenet for managing imperiled species, and common prudence aims for populations large enough to absorb normal natural variation as well as long-term changes in the availability and quality of habitat due to human activities.

Populations of keystone species managed at minimum numbers and density lose their ecological effectiveness. This may lead to the disruption of ecological processes, shifts in the relative abundance of other species, and alterations in local biodiversity (Soulé et al. 2003). Given these considerations, we define *Demographically Robust Populations* as 500–700 individuals. Populations of this size are likely to persist for several hundred years (Mattson and Reid 1991; Mattson et al. 1996; Wielgus 2002; Mattson and Merrill 2002) and would have an effective size of 125–175 individuals. This number would likely provide for enough genetic and behavioral diversity to withstand environmental variation over several hundred years, or longer, provided there was an exchange of individuals and genes with other populations (Miller and Waits 2003).

Evolutionarily Robust Populations

It is not possible to predict with any precision what the world will look like in several thousand years, but it is likely the climate will have significantly changed (Giorgi et al. 2001, Gordon et al. 2000, Bartlein et al. 1997). This will affect grizzly bear habitat. Climate-induced habitat changes will alter where bears can survive and their numbers. For example, in the Greater Yellowstone region, important grizzly bear foods such as ungulates, whitebark pine (*Pinus albicaulis*) seeds, and cutthroat trout (*Oncorhynchus clarki*) may be extirpated or rare (Reinhart et al. 2001). This will greatly reduce the region's carrying capacity (Mattson, pers. comm.). Across the Y2Y region, a warming climate means changes in fire regimes, precipitation, and hydrological cycles. All of these will impact grizzly bear populations.

Given our limited ability to see the future, it is unwise to think that we will be able to manage grizzly bear survival over thousands of years. Survival over such extended time depends upon grizzly bears being able to adapt to environmental change, an ability contained within their genetic and behavioral diversity. *Genetic diversity* determines the array of physical attributes available to grizzly bears for adaptation to future change. Similarly, *behavioral diversity* determines the array of learned behaviors available to aid in adaptation. The greater the diversity of genes and behaviors, the more likely it is grizzlies will have the physical and behavioral traits needed to survive and evolve in a continually changing world. Thus, while it is not possible to foresee the future, it is possible to manage for genetic and behavioral diversity that will help grizzly bears now and in the future. While it is not possible to confidently predict most aspects of the future, it is known that large contiguous populations of grizzly bears stand a better chance of surviving the next millennium than small isolated populations. That is the focus of this report.

Several thousand interacting individuals are required to maintain genetic diversity over thousands of years (Gilpin and Soulé 1986; Soulé 1987; Thomas 1990; Reed et al. 2003). We therefore seek to maintain *Evolutionarily Robust Populations* with greater than 2,000 individuals. This requires relatively frequent exchanges of individuals and genes among several DRPs. In terms of maintaining healthy grizzly bear populations in the Y2Y region over the long-term, persistence will depend on maintaining linkages among potential DRPs in the Greater Yellowstone (GY), Central Idaho, the Northern Continental Divide (NCD), Southern Canada and Northern BC, the Yukon and NWT.

Model Evolution and Development

At the start of developing a grizzly bear conservation strategy for the Yellowstone to Yukon region, our habitat model produced only **relative habitat values** (Merrill et al. 1999, Merrill and Mattson 2003). We could determine whether one area was 'more suitable' than another, but we could not predict bear densities or demographic rates. We judged sufficiency by basic guidelines regarding size and shape of putative core areas and nearness to other blocks of suitable habitat (Mattson and Merrill 2002). However, we were not able to estimate whether a particular block of suitable habitat could support demographically or evolutionarily robust grizzly bear populations.

This problem was partially solved with the development of a model that **estimated potential number of bears** per 100 km^2 – referred to as *density* (Mattson and Merrill, in review). This model is based on relations between estimated grizzly bear densities from field studies in twelve Rocky Mountain study areas (Table 1, Map 2), and several potentially predictive or explanatory variables that included tassled cap transformed MODIS satellite imagery, the extent of whitebark pine range, diet energy concentration, remoteness from humans, and study area size. We wanted to develop a model that could estimate potential grizzly bear population sizes in areas currently unoccupied by bears or supporting small and vulnerable populations. To test our models, we examined goodness of fit statistical analysis of predicted and observed densities in five additional study areas and determined whether predicted densities were spatially correlated with observations of grizzly bears in two regions. We also determined whether key predictive metrics correlated positively with a direct measure of habitat productivity in the Yellowstone region (Mattson and Merrill, in review; Figure 1). Our best model included a single variable – wetness from MODIS satellite imagery. This model optimized parsimony and fit, and produced density predictions that correlated well with distributions of grizzly bear observations.

Concurrent with developing habitat models for the Y2Y region we created more sophisticated models for the Greater Yellowstone area (GY), where relatively comprehensive and abundant data were available. We were able to specify relationships between where bears die and, a) landscape measures such as distance to roads and human population centers and, b) whether the bear was inside or outside of a national park or a grazing allotment. This model provided an annual human-related mortality rate, which allowed us to identify grizzly bear population sources and population sinks (Merrill and Mattson 2003). In order to apply this GY-specific model to the entire Y2Y region, we assumed that humans kill bears at the same per person rate throughout Y2Y as they do in the GY (i.e., humans are uniformly lethal) and dropped the grazing allotment term from the model. This yielded a spatially explicit estimate of human-caused death rate for grizzly bears for the entire Y2Y region. The assumption of uniform human lethality may not be correct; anecdotal evidence suggests that, on a per capita basis, humans are much more likely to kill bears in some areas than in others. For example, the disparity between the potential and estimated population in the Cabinet-Yaak region may be due to locally high

rates of human lethality. Even with anecdotal and localized evidence there was not sufficient information to support altering the human lethality rate regionally. The potential magnitude of the error, if any, is defined by altering assumptions regarding sustainable mortality rate – the proportion of the population that can be killed each year, on average, without causing population decline (Map 3). Decreasing the assumed sustainable mortality rate is, within the model, equivalent to increasing the rate of human lethality. In both cases the result is decreased size and number of potential population source areas.

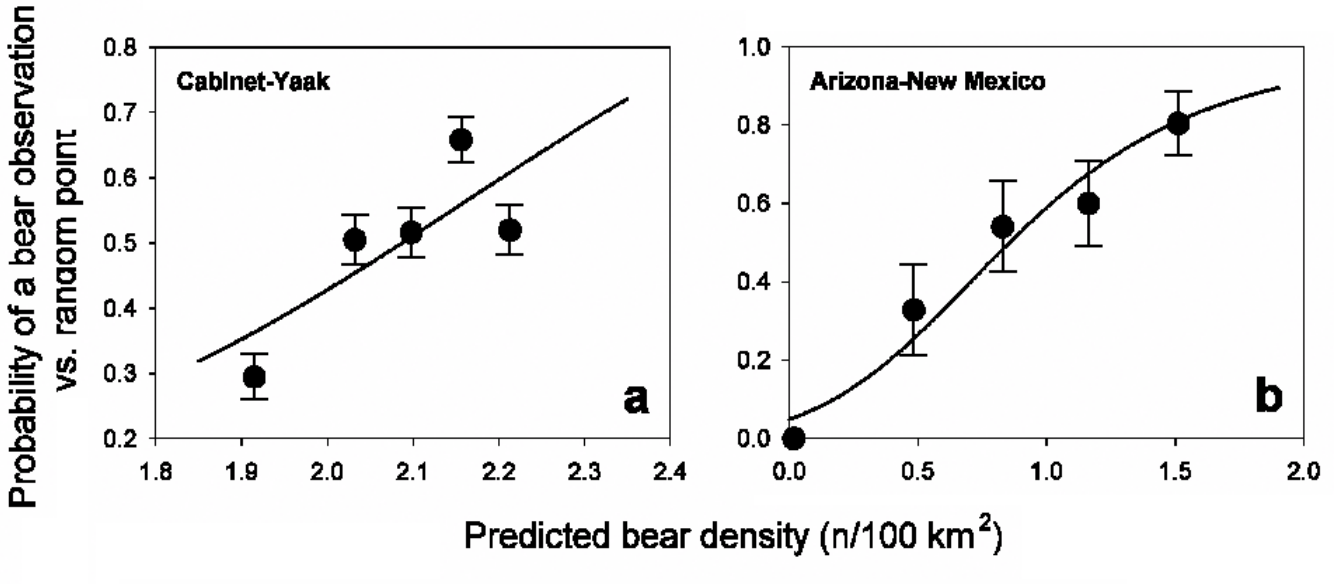
Another refinement to the model was also made. The **sustainable mortality rate for a population** of grizzly bears depends, partially, on habitat productivity expressed as grizzly bear density. Grizzly bear populations can sustain higher mortality rates where habitat is more productive because birth rates are also higher. This relationship was captured in a set of models that varied sustainable mortality rates as a positive function of potential grizzly bear densities. We used this set of models to identify grizzly bear source areas for the Y2Y region under different assumptions about human lethality. Population source areas are the building blocks of the broad scale grizzly bear conservation strategy for the Y2Y region.

Table 1. Grizzly Bear Density Estimates

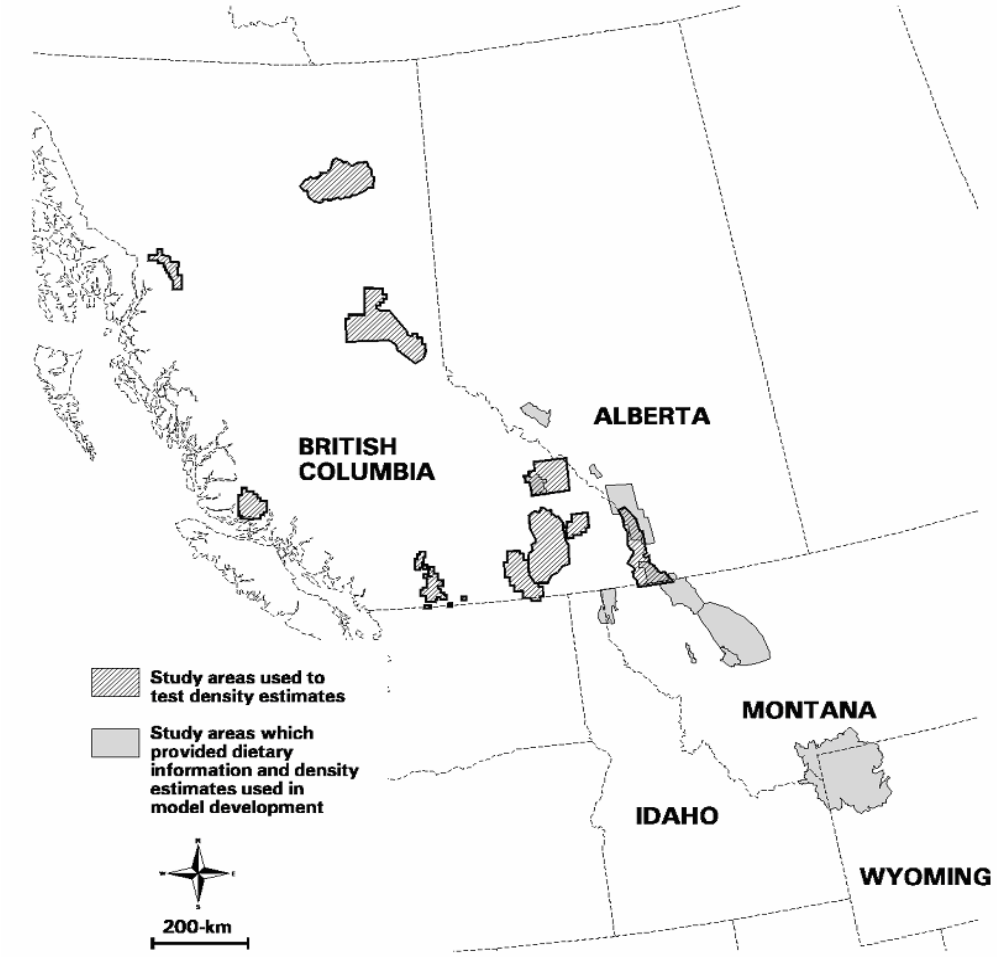
Empirical grizzly bear density estimates and density estimate derived from the Mattson & Merrill density model for study areas used in this analysis for model development.

Study Area	Density Estimate (n/100 km^2)	Density Estimate Method	Density Reference	Model Density Estimate (n/100 km^2)
Jasper	1.07	Enumeration	Russell et al. (1979)	1.55
Banff	0.83	Sighting rate	Vroom (1974)	1.6
Kananaskis	1.60	Mark-recapture	Mowat & Strobeck (2000)	1.77
Glacier, BC	2.60	Sighting rate	Mundy (1963)	2.37
N. Fk. Flathead	6.40	Modified enumeration	McLellan (1989)	1.92
Waterton	1.50	Mark-recapture	Mowat & Strobeck (2000)	1.83
Glacier, MT	2.00	Mark-recapture	Mowat & Strobeck (2000)	1.87
Selkirk/Cabinets	2.30	Enumeration	Wielgus et al. 1994, Servheen and Sandstrom 1993	2.16
Mission Mtns	2.04	Enumeration	Servheen and Sandstrom 1993	1.99
East Front	1.53	Enumeration	Aune & Kasworm (1989)	1.2
Scapegoat	1.53	Enumeration	Aune & Kasworm (1989)	1.70
Yellowstone	1.50	Mark-recapture	Eberhardt & Knight (1996)	1.67

Figure 1. Predicted Bear Density



Map 2. Study Area

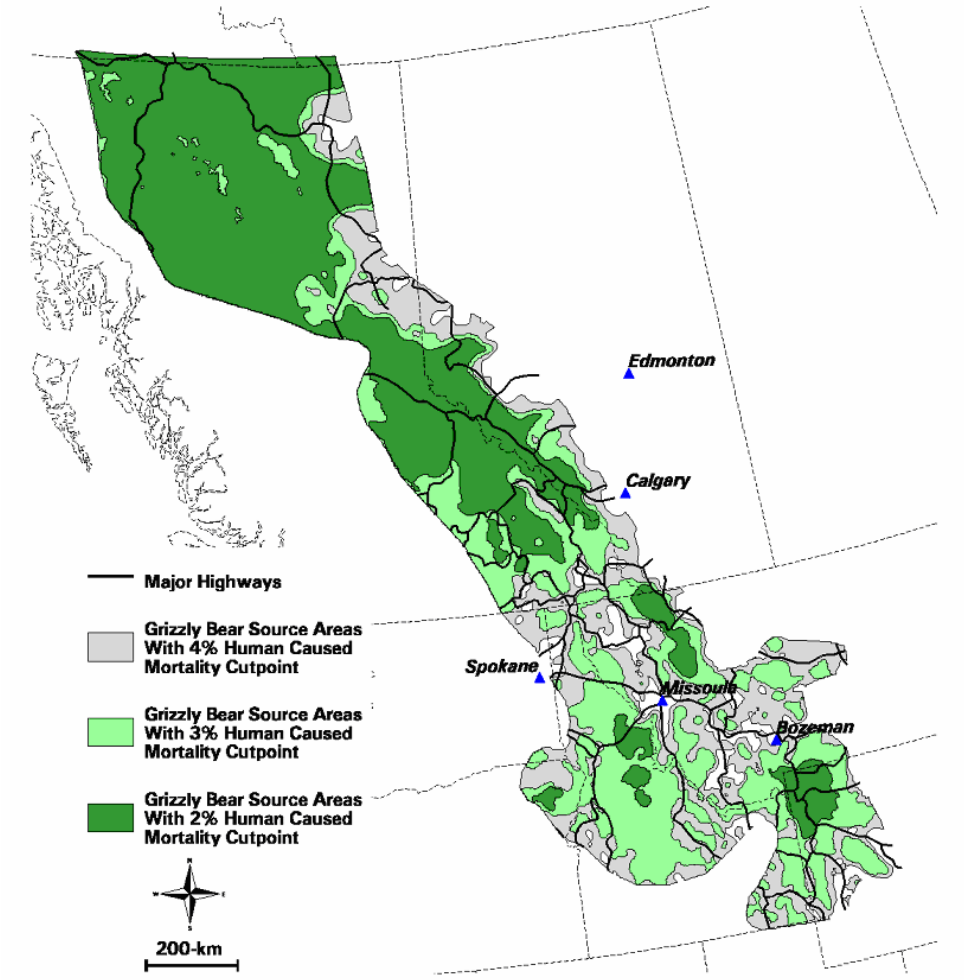


Distribution of Grizzly Bear Source Areas

Source areas are places where animals reproduce faster than they die – where the local population is more likely to grow than decline. Grizzly bear source areas are determined by potential grizzly bear density and the anticipated rate of human caused mortality. Areas with higher potential grizzly bear density can sustain higher mortality rates compared to areas of lower potential density. There is lack of agreement on how much mortality a population of grizzly bears can sustain; however, a rate of human-caused mortality between 2 to 4 percent, in addition to natural mortality, is likely to be sustainable (Merrill and Mattson 2003).

In acknowledgement of uncertainty over sustainable death rates and possible differences in rates of human lethality as described above, we define grizzly bear source areas using three assumptions of the sustainable rate of human-caused mortality. Areas where the human-caused mortality rate is less than the assumed sustainable rate are designated as population source areas — areas where grizzly bears reproduce faster than they are killed. The size and distribution of the source areas vary dramatically with the assumed rate of sustainable mortality (Map 3).

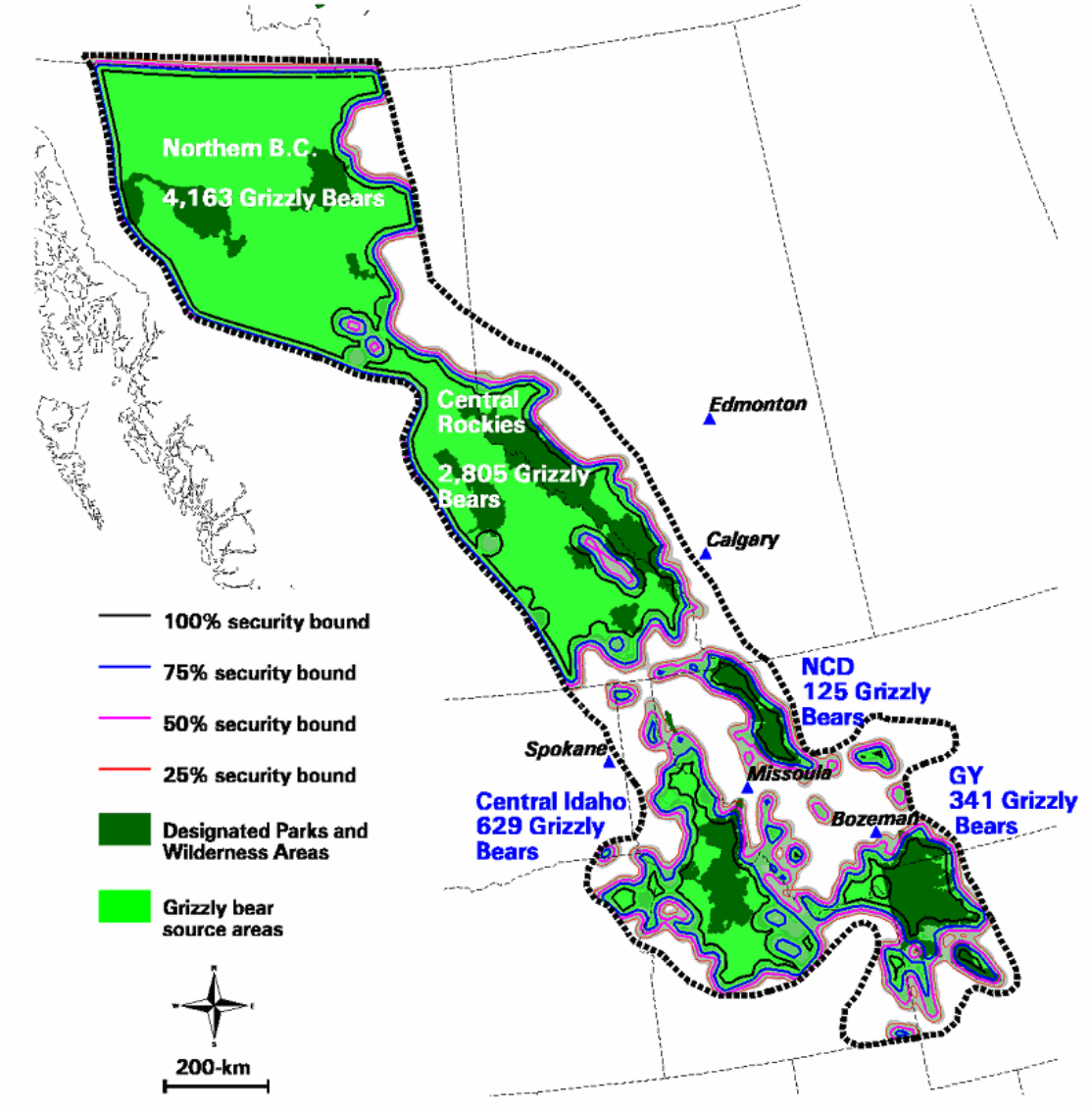
Map 3. Grizzly Bear Source Areas. Decreasing the assumed sustainable mortality rate is, within the model, equivalent to increasing the rate of human lethality.



Distribution of Demographically Robust Populations

Grizzly bear source areas were defined assuming an annual 3% human caused mortality rate is sustainable (Map 4). Demographically robust populations (DRPs) were delineated using a moving window 900 km^2 in size – the area of a female life range in GY – to define relative risk boundaries based on the percentage of a life range inside the source area. For example, if the center of a grizzly bear's home range is in the 50% gradient, that bear would spend half of its time inside a population source and half inside a population sink. Such a bear is more likely to be killed by a human than a bear who stays inside a source area. Only grizzly bears within secure

Map 4. Secure Source Areas



source areas (100% gradient; solid black line on map) are counted in determinations of demographically robust populations. Bears outside of the 100% gradient – bears that theoretically spend some time outside of a source area – were not counted toward the DRP target of 500. The purpose of this was to identify areas with the highest probability of containing bears that will produce a surplus of offspring likely to immigrate carrying genes and learned behaviors between populations.

Five separate existing or potential grizzly bear populations south of 60°N were defined by this approach (Map 4):

1. Northern British Columbia
2. Central Rockies
3. Central Idaho
4. Northern Continental Divide (NCD)
5. Greater Yellowstone

Our results suggest that only three of these populations have the potential to support more than 500 individuals in secure source areas, and thereby meet our criterion for DRPs. Northern British Columbia (Muskwa-Kechika and surrounding wilderness) and Central Rockies populations contain greater than 500 individuals. Central Idaho has the potential to meet our criteria of containing greater than 500 individuals, potentially ~ 620, but currently contains zero bears. Of the two areas that do not meet our criteria, the Greater Yellowstone population is no surprise. Current estimates of the population for the entire region range from 400 to more than 600 bears. Many of those bears live in sink habitat – areas where death rate exceeds birth rate that remain occupied only by immigration from source areas (Merrill and Mattson 2004), perhaps as many as one third of the population (Schwartz et al. 2002). The conservative definition of secure source habitat used in delineating secure source areas for DRPs identified habitat for approximately 341 bears which is consistent with both population estimates and demographic analysis. Many scientists believe that the Greater Yellowstone grizzly bear population's long-term persistence is dependent upon establishing linkages to other grizzly bear populations (USFW 1993). Our results support that opinion.

Failure of the Northern Continental Divide (NCD) to meet our criteria for DRPs runs counter to most other assessments. The NCD grizzly bear population is estimated to contain 500–700 grizzly bears (Proctor, pers. comm.). Our analysis does not dispute that estimate; to the contrary, this set of models estimates a similar number of bears. However, our analysis reveals that the shape of the NCD source area, relatively long and narrow (Map 4), exposes a larger than expected portion of the population to potential conflicts with humans.

Other researchers suggest this result is an artifact of the size and shape of the moving window used to identify secure habitat areas and that a smaller window size would be more appropriate for the NCD where female life ranges are smaller than female life ranges in the GY (Proctor, pers. comm.). This is a valid point. However, few studies report an average life range for female grizzlies in the NCD, and this means it is uncertain what size of moving window would be appropriate. There is also a good possibility that life range size would vary substantially from the west side with a moist coastal climate to the east side's dry continental climate. Despite uncertainties about the size of female life ranges in the NCD, this analysis reveals a real,

important and previously ignored vulnerability

This analysis was conducted at the spatial and temporal scale of a female life range and life span. It is possible the analysis may identify less secure habitat than currently exists. However, given present trends in regional human population growth, results that underestimate secure habitat today will likely be an accurate description of conditions in 20 years, the approximate life-span of a grizzly bear. Because of the importance of the NCD to regional grizzly bear conservation in the U.S., Southern Alberta and B.C., a high level of protection and careful management is warranted.

of the grizzly bear population in the NCD.

This analysis should not be interpreted as devaluing the importance of the NCD in maintaining viable grizzly bear populations in the Yellowstone to Yukon region. Questions about the appropriate size of the moving window should not obscure the fundamental point; the NCD must remain connected to other populations or it will eventually be extirpated.

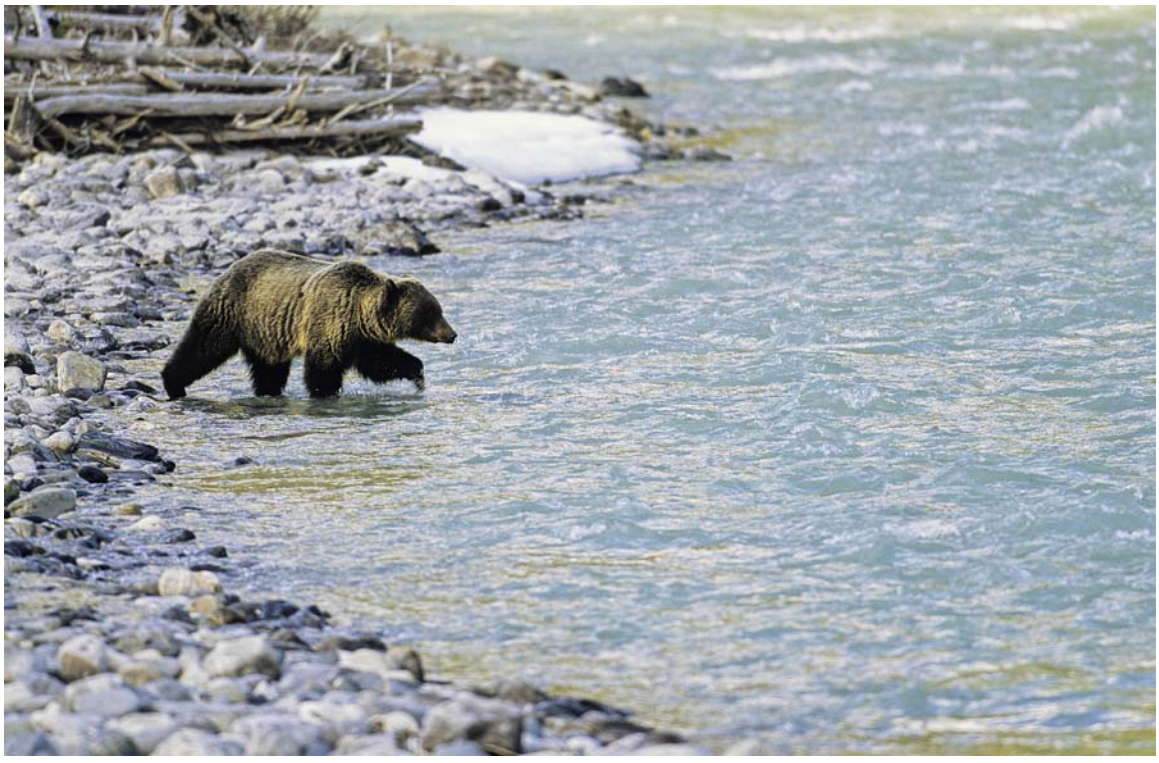
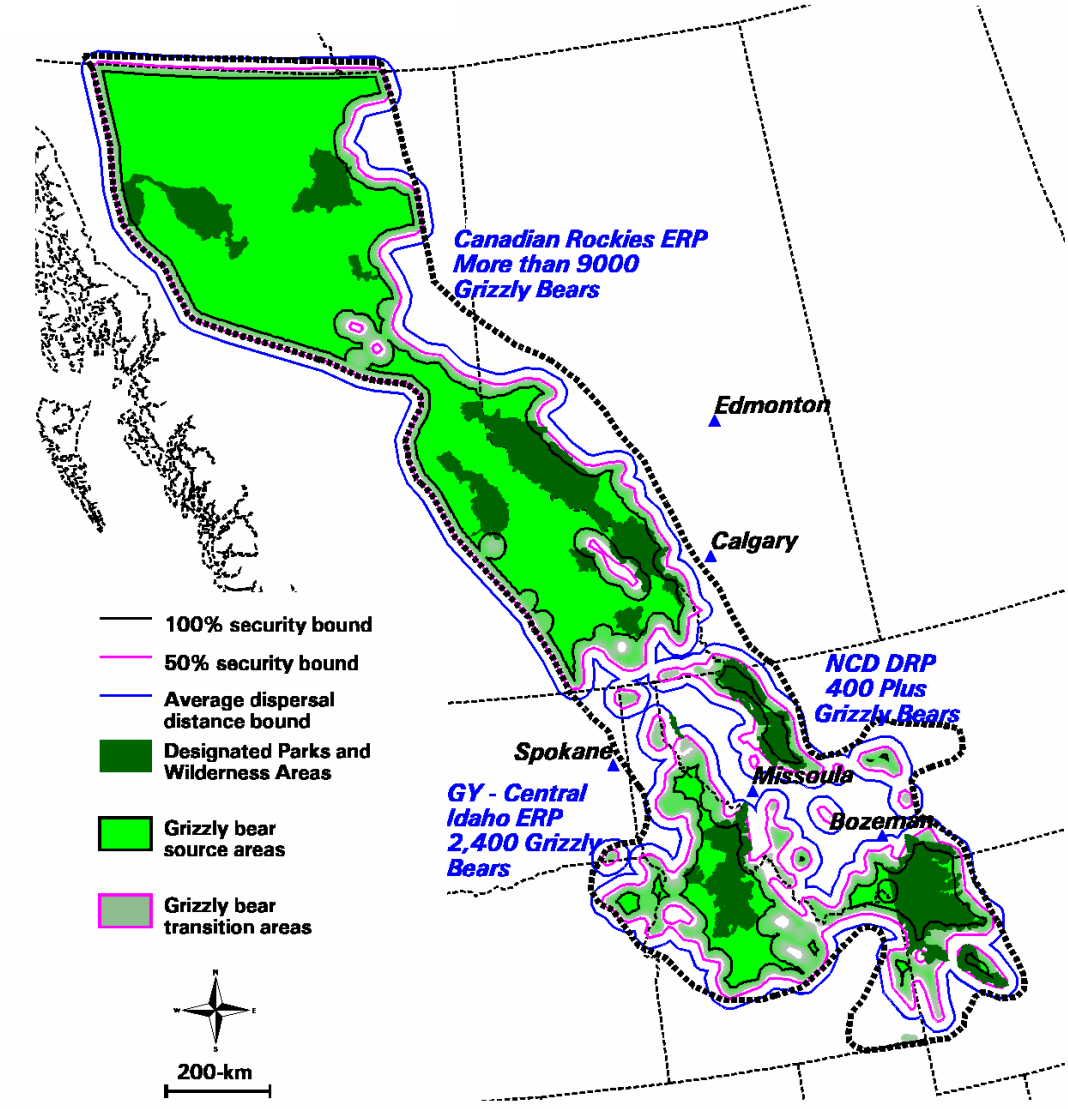


Photo: © John E. Marriott

Distribution of Evolutionarily Robust Populations

Only two of the three DRPs – Northern B.C. and Central Rockies – meet our criterion for *evolutionarily robust populations*. The remaining three populations – Central Idaho, NCD, and GY – can meet the criteria for evolutionarily robust populations (ERPs) *only* if individual bears can move among them, transferring genes and behaviors. Grizzly bears within transition habitat – defined by relative risk as described on page 3 – need not be self-sustaining and thus security of transitional habitat in linkages need not be as high as in the core. If we assume a relative risk level of 50% is secure enough to allow bears to move between sources areas, the five separate populations coalesce to form two ERPs (Map 5), as follows:

Map 5. Source Areas and Dispersal Distance



1) the Canadian Rockies ERP, which has the potential to support over 9,000 grizzly bears (although it is unlikely that many bears reside there now); and 2) the GY-Central Idaho ERP which, with current levels of habitat productivity and human activity, could support almost 2,400 grizzly bears in secure core habitat and surrounding transition habitat. The NCD, under these criteria, remains a separate population but would contain enough grizzly bears to be considered a DRP. All population units, if they were occupied, are within dispersal distance of an ERP (blue line, map 5). Maintaining that potential for inter-population dispersal is critical to stopping the northwestward contraction of grizzly bear range (Map 6a and 6b).

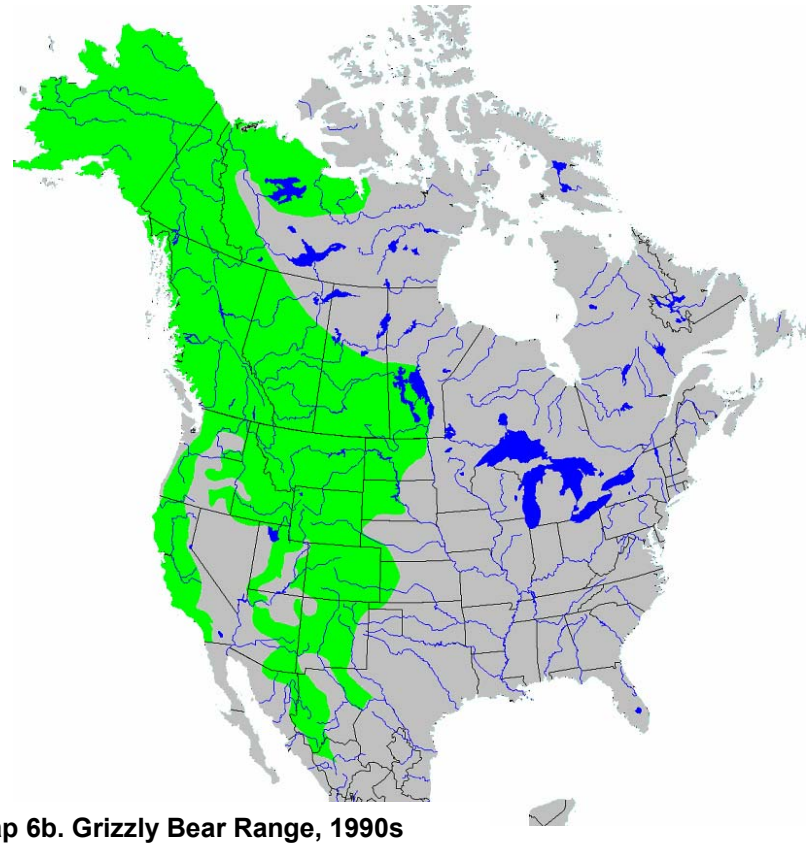
The two ERPs are the super-structure of the grizzly bear conservation strategy for the Y2Y. These two ERPs must remain connected. In theory an ERP can persist for the long-term on its own and there would be no need to maintain connectivity between the Canadian Rockies and GY – Central Idaho ERPs. However, for several reasons, allowing the loss of connectivity between population groups, no matter how large, is unwise. In the specific case of Y2Y, only one potential ERP is fully occupied. Currently, the GY population is isolated, and although the loss of genetic diversity is less than initially feared (Miller and Waits 2003), it is detectable. Central Idaho is currently unoccupied and, if linkages to the north are lost, the peninsular-shaped NCD would become an island. If the potential of a southern ERP is to be realized it is critical that GY – Central Idaho be linked to the Canadian Rockies gene pool. The Canadian Rockies ERP is the genetic and behavioral pool of the future.

The fracture zone between the Canadian Rockies and the potential U.S. Rockies ERPs coincides with the Canadian Highway 3 corridor. Connecting the U.S. Rockies ERP to the Canadian Rockies ERP, which includes the Columbia Mountains, is a critical challenge for grizzly bear survival in the Lower 48. Such a connection would enhance the genetic and behavioral diversity of the Canadian Rockies ERP, increasing its repertoire of potential responses to a warming climate. This is why thinking at the Y2Y scale is important.

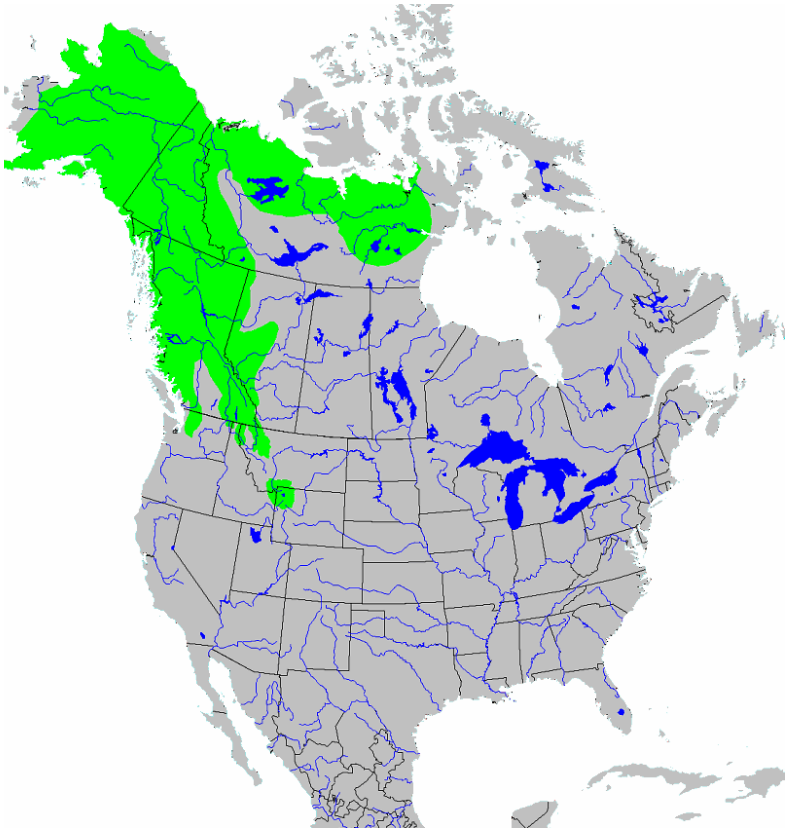
Many researchers have posited a number of potential linkages that would contribute to grizzly bear connectivity (Walker and Craighead 1999, Carroll et al. 2001). These potential linkages include a route north out of Yellowstone through Bozeman Pass, up the Bridger Range and the Big and Little Belt Mountains into the south end of the NCD, and a route that roughly follows the Continental Divide's course through Montana (Walker and Craighead 1999). Those linkages are not identified by our models as being secure enough to support resident female grizzly bears for their life-span at this time. Such linkages may be sufficient for young males that disperse over long distances (Craighead and Vyse 1996) and as such could establish gene flow between the NCD and GY (Craighead, pers. comm.) in the near-term.

If humans become more tolerant of bears in the future, these linkages will provide the most direct route for individuals and genes to move between the NCD and the GY region. With a more tolerant human population and land management policies consistent with that tolerance, the possibility of the NCD and GY populations sufficiently linked to be considered an ERP becomes real. Although these areas may not be currently used by grizzly bears they are

Map 6a. Grizzly Bear Range, 1850s



Map 6b. Grizzly Bear Range, 1990s



important for other large carnivores such as cougars and wolverines (Steve Gaemen, pers. com.) and ungulates, such as elk, have important current conservation value at a regional scale. Again the precautionary principal and common prudence dictate their conservation.

Linkages across the Clark Fork Corridor on either side of Missoula, Montana (at Fish Creek/Nine Mile on the west and Rock Creek on the east) have also been shown in other analyses. (Walker and Craighead 1999, Carroll et al. 2001). Recent use of both these areas by individual grizzly bears and wolves suggest that these areas are used by wildlife for dispersal. Our models indicate that human lethality is too high for them to be effective grizzly bear linkages currently. Factors related to high human lethality are not always apparent to animals at risk. Dispersing grizzly bears seem to be attracted to the area but any who have come to the attention of humans have eventually been killed. This is not to imply that conservation efforts directed to this linkage are unimportant. Human education, proactive management and habitat restoration may turn this into a viable linkage in the future. Achieving that, however, may be difficult given a growing human population that is also attracted to this area.

This analysis and interpretation suggests the Cabinet-Yaak is a significant linkage that operates at a scale commensurate to connecting two ERPs. The Cabinet-Yaak is composed of the Yaak river valley, southern Purcell Mountains, and Cabinet Mountains. The southern Purcells and Yaak drainage of Southeast B.C. and Northwest Montana are a functioning ecological unit from U.S. Highway 2 in the south to Canadian Highway 3 in the North. South of U.S. Highway 2 the rugged Cabinet Mountains provide good habitat to U.S. Highway 200 to the south. To the southeast the Cabinets abut the Clark Fork corridor, to the southwest across the Clark Fork River are the Coeur d'Alene Mountains. They represent the northern-most extension of the largest block of potential, though currently unoccupied, grizzly bear habitat in the U.S., which is Central Idaho.

A Cabinet-Yaak linkage has the potential to support more than 200 grizzly bears (Mattson and Merrill 2004) Less than 40 live there now (Kasworm et al. 2000). The Cabinet-Yaak has a moist, temperate climate and offers productive grizzly bear habitat. If current constraints on grizzly bear population growth are removed, the Cabinet-Yaak could be a source area providing immigrants to a re-established Central Idaho population in the south. Also, it could allow individual exchanges across Canadian Highway 3 with the Canadian Rockies ERP and to the east with the NCD.

Our analysis indicates that linkage between bear populations in Canada and the Cabinet-Yaak could occur in two ways. It could go directly north up the South Purcells across highway 3 in British Columbia. It could also go directly east along the international boundary to the NCD, then north across highway 3 and up the Canadian Rockies. Both linkages should be secured. Maintaining the Purcell and the Rockies linkages across Highway 3 are key conservation strategies at the Y2Y scale. Maintaining both those connections is vital to the long-term viability of the Cabinet-Yaak and thereby the long-term viability of Central Idaho and GY populations.

The Canadian Rockies linkage across Highway 3 has already emerged as vital to maintaining regional connectivity (Apps 1997; Apps et al, in prep) including linkages on the U.S. side identified by Walker and Craighead (1999), Carroll et al. (2001) and others. This analysis supports those findings and also stresses the importance of the Purcells, the boundary area and the Cabinet-Yaak.

The Highway 3 corridor across the mountains of southern Canada with its associated human development is a major concern for connectivity of grizzly bear populations between the two countries. Proctor's (Proctor et al. 2002) work shows there is population isolation in the Selkirk Range of the Columbia Mountains on either side of Highway 3, but that populations remain connected in the Purcell Range to the east of it. Moving east, the Rocky Mountain Trench is a north-south zone of fragmentation. Connectivity still exists in the Rockies on the east side of the Trench in both Alberta and B.C. (Proctor et al. 2002, Apps et al, in prep). Our model shows that these linkages are under significant pressure and could be a point of fragmentation. Maintaining and improving existing linkages and developing new ones wherever possible is essential for the continued survival of the border populations – the Selkirks, the Cabinet-Yaak-Purcell, and ultimately the NCD – on both sides of the 49th.

Preservation and Restoration Areas

In addition to the key linkages between the two ERPs, various parts of the Y2Y region are identified as restoration or preservation areas for grizzly bear conservation. Critical linkage areas are also identified. Restoration areas, as the name implies, require restoration. These areas are critical to meeting long-term, large-scale grizzly bear conservation goals in Y2Y but do not currently support source populations of grizzly bears or are barriers to movement of grizzly bears between source areas. Restoration, while site dependent, generally involves restoration of habitat – i.e. road removal, re-introduction or population augmentation or removing/mitigating barriers to movement. The main concern in preservation areas is maintaining conditions that are currently sufficient for meeting conservation goals such as roadlessness, special-management designations and low rates of human-caused mortality. Preservation does not mean attempting to impose static criteria on an ever-changing system, but includes the ecological dynamics that currently promote or are otherwise consistent with source grizzly bear population characteristics.

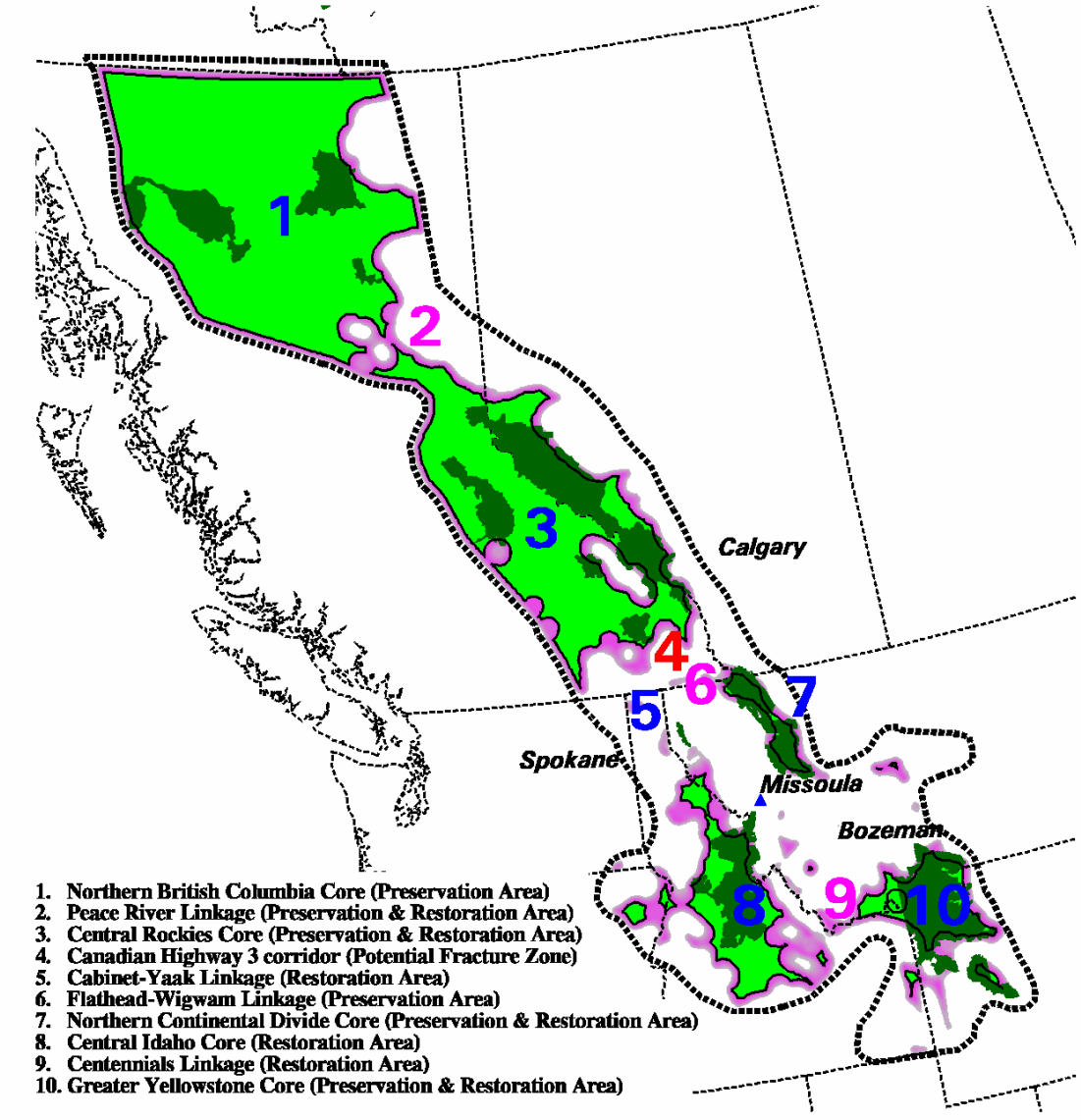
Nine areas in the Y2Y region (below 60°N) were identified as either cores or linkages and one area was identified as a potential fracture zone (Map 7). These areas are differentiated by whether the prescribed management emphasis is on preservation, restoration or both. From north to south, these areas are:

1. Northern British Columbia Core (*Preservation Area*)
2. Peace River Linkage (*Preservation and Restoration Area*)
3. Central Rockies Core (*Preservation and Restoration Area*)
4. Canadian Highway 3 corridor (*Potential Fracture Zone*)
5. Cabinet-Yaak Linkage (*Restoration Area*)
6. Flathead-Wigwam Linkage (*Preservation Area*)
7. Northern Continental Divide Core (*Preservation and Restoration Area*)

8. Central Idaho Core (*Restoration Area*)
9. Centennials Linkage (*Restoration Area*)
10. Greater Yellowstone Core (*Preservation and Restoration Area*)

In the following section an overview of conditions within each area and a brief description of conditions that need to be changed or actions that need to be taken to achieve Y2Y's grizzly bear conservation goals is provided.

Map 7. Grizzly Bear Conservation Areas



Management Recommendations South to North

Greater Yellowstone Core

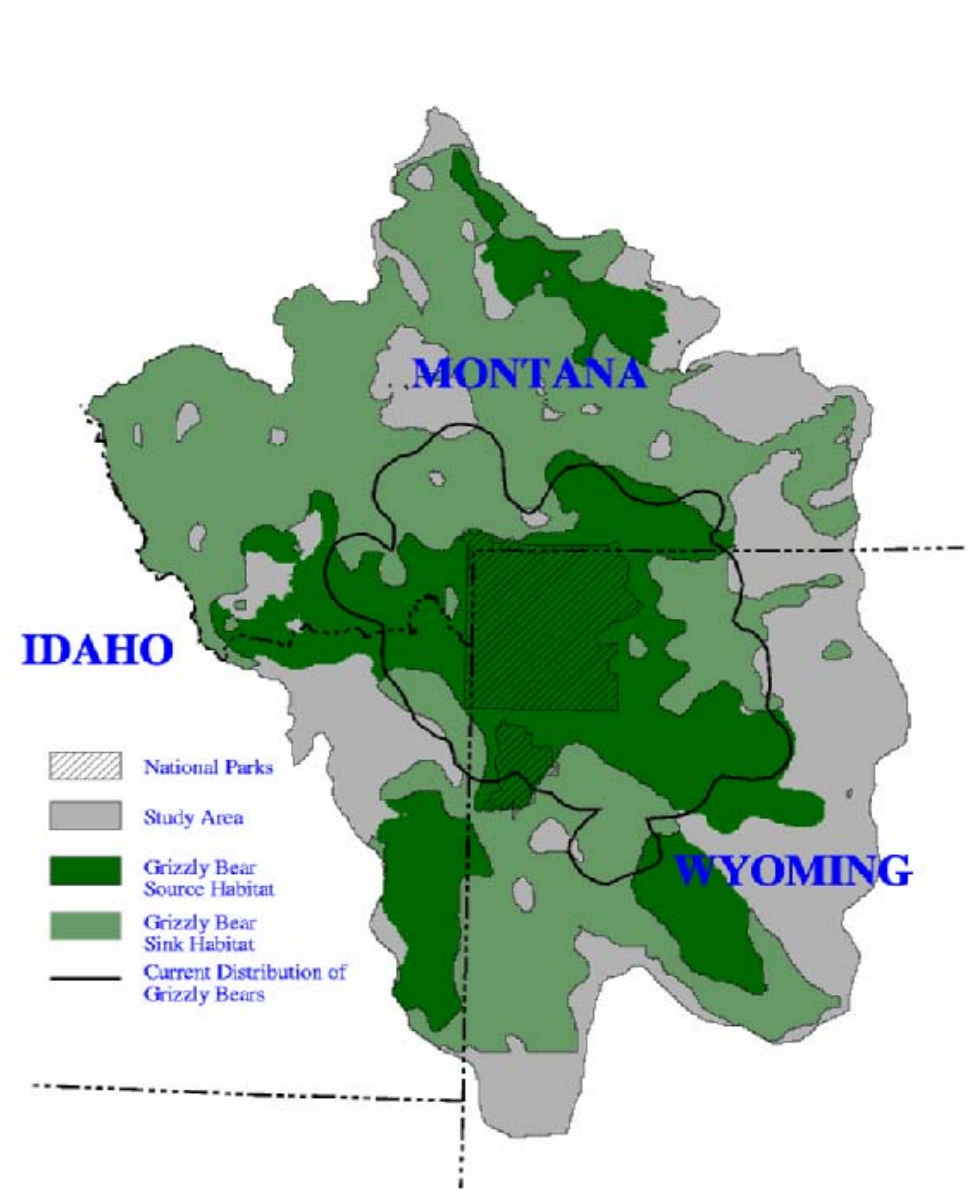
Grizzly bears in this ecosystem receive significant benefit from Yellowstone and Grand Teton National Parks. The park complex is large, productive and generally managed to maintain abundant populations of native species. This provides bears with a relatively dependable food supply. However, it is probably the protection from humans provided by the Park Service and the Endangered Species Act that is most beneficial to bears (Mattson and Merrill 2002). It appears the grizzly bear population in the GY is increasing in numbers and expanding its range (Schwartz et al. 2002). The human population in the GY is also increasing in numbers and range and is providing obstacles to the expansion of the grizzly bear population beyond currently occupied habitat (Merrill and Mattson 2003). But there are still opportunities to secure additional habitat. Merrill and Mattson (2003) identify currently unoccupied suitable habitat in the Wind River, Palisade and Centennial Mountains, which could support an additional 120–150 grizzly bears. Most importantly, habitat in the Centennials provides essential linkage to Central Idaho (Map 8).

Grizzly bears in the GY obtain over 80% of their dietary energy from four key foods: whitebark pine, cutthroat trout, large ungulates (bison [*Bos bison*] and elk [*Cervus elaphus*]) and army cutworm moths (*Euxoa auxiliaris*) (Mattson et al. 2004). All of these foods are expected to decline in the near future – whitebark pine due to the exotic disease blister rust (*Cronartium ribicola*); cutthroat trout due to predation by introduced lake trout (*Salvelinus namaycush*); elk and bison due to control of the bovine disease brucellosis (*Brucella abortus*); and cutworm moths due to climate change (Reinhart et al. 2001). All existing unoccupied habitat will be needed to support the current number of grizzly bears if their foods diminish.

Spokespeople for the U.S. Fish and Wildlife Service (USFWS) have stated that removal of Endangered Species Act (ESA) protection for grizzly bears in the GY population will likely occur within the next few years. Removal of ESA protection will result in reduced habitat protection, make removal and destruction of problem bears easier, and turn management of grizzly bears over to the state governments of Idaho, Montana and Wyoming. All three states plan on managing grizzlies as 'trophy wildlife' and may reinstate a hunting season (Willcox, Director of NRDC Wild Bears Project, pers. comm.). Under such conditions further expansion of the grizzly population is unlikely.

Given the uncertainty associated with future food supply and expected growth of the human population, when and where delisting occurs should be carefully considered. Historically, this species has been eliminated from 98% of their former contiguous U.S. range (Map 6a and 6b, Page 18) and reduced to less than 2% of their historical number. Given the biology of this species, negative impacts of human activities and the vagaries of natural disturbances and weather, delisting seems premature. Certainly, with delisting the odds of achieving an ERP would be reduced.

Map 8. Greater Yellowstone Core



Prior to delisting it should be verified that the following components are present and operational: sufficient numbers of bears to buffer populations against large-scale stochastic variation, connectivity between populations (for genetic exchange and/or re-colonization) and an adequate number of widely dispersed metapopulations in a wide range of habitat types.

The Centennials Linkage

The Centennial Mountains and associated highlands are currently the most likely linkage for grizzly bears between the GY and Central Idaho (Merrill and Mattson 2003, Walker and Craighead 1999, Servheen and Sandstrom 1993). The habitat is productive and currently remote from humans; human lethality is the limiting factor. The Centennials are one of the few areas left near the GY that support large numbers of domestic sheep. Sheep are notoriously easy to kill and are thus a highly preferred prey of grizzly bears (Mattson 1990). Sheep caretakers are often intolerant of grizzly bears and historically have been a major cause of death for bears in the GY (Jorgenson 1983, Knight and Judd 1983). Looking to the future, the Centennials are also threatened by the development of currently remote flanking private lands. If the grizzly bears of the GY are ever to be part of a functioning ERP, livestock-related mortality will have to be prevented, human lethality in general reduced and private lands protected by conservation easements or outright purchase by the government or conservation groups.

The other outstanding issue is Interstate Highway 15 (I-15), which transects the Centennial Mountains north to south. Managers and researchers are concerned about the extent to which heavily trafficked highways can physically bar movements of wildlife, including bears, to the extent that populations can become nearly severed (Gibeau et al. 2002, Proctor et al. 2002, Kaczensky et al. 2003). Structures that facilitate wildlife movement will likely be needed along I-15 if linkage between the GY and Central Idaho is to be achieved. Currently I-15 is the least used part of the U.S. interstate highway system. There are plans to upgrade it to accommodate increasing commercial traffic between Canada and Mexico (Craighead, pers. comm.*)*, which will require extensive mitigation structures such as those recommended by Clevenger and Waltho (2000).

Central Idaho Core

Central Idaho (CI), also known as the Salmon-Selway Ecosystem, is the largest block of suitable habitat for grizzly bears in the contiguous USA. It is big, remote, and has everything a grizzly bear needs to survive and reproduce. The only problem; it has no bears. It is uncertain why bears were extirpated from CI while they persisted in the GY and NCD. Likely contributing factors were: 1) the historic presence of salmon, which concentrated bears in predictable locations where they could be easily killed by humans; 2) large-scale sheep grazing early in the 20th century and associated persecution of grizzly bears; and 3) the lack of a large national park in which at least a few bears could find refuge (Merrill et al. 1999, Mattson and Merrill 2002).

Restoration of the grizzly bear population in CI is an essential element in securing grizzly bear populations in the conterminous U.S. The re-establishment of bears in this region has been

a contentious issue and is not yet resolved. While this issue is being addressed, it is essential that management efforts to preserve the quality and quantity of bear habitat of CI continue. A critical aspect of maintaining habitat will be to prevent additional road building, manage access on existing roads and decommission roads where possible. The protected roadless areas buffer the designated Wilderness Areas that are the heart of CI, and substantially increase the effective size of core habitat (Loucks et al. 2003).

Maintaining CI's wildness will be challenging as private lands along the boundary of prime grizzly bear habitat are converted from livestock and timber production to recreational use, tourist attractions and high-end housing. Increased density of human residences will generally result in more bear/human conflicts and more dead bears (Mattson and Merrill 2004). In sum, although most of CI's secure core is legislatively designated wilderness, increasing human population around the edges will make successful restoration of grizzly bear populations more difficult.

In addition to being a large block of diverse, high-quality habitat, CI is also valuable as a robust connection between the GY and the NCD. The primary challenge in restoring CI is not in the core wilderness area; it is the transition habitat between GY and CI, the Centennials discussed above and the transition habitat to the north. The northern connection would run from CI north to the Purcell Mountains and from the Purcells east just north of 49^{o}N latitude through Wigwam Creek into the Flathead Valley of the NCD (Merrill and Mattson 2003, Mattson and Merrill 2004).

Northern Continental Divide Core

Many biologists consider the NCD grizzly bear population to be the center of grizzly bear conservation in the Lower 48. They believe the NCD grizzly population is larger and more secure than the GY population and that NCD bears are demographically and genetically healthier because they continue to interact with larger populations of grizzly bears in Alberta and B.C. Certainly the size of the NCD population and its proximity to other populations make the area extremely important for grizzly bear conservation.

The results of this analysis differ from the results of other studies that have appraised grizzly bear habitat in the NCD. This analysis found that because of the relatively long and narrow shape of the core area, many bears are at risk of coming into conflict with humans – greatly increasing the probability they will be killed (Mattson and Merrill 2002). While the NCD ecosystem likely supports over 475 bears, only 129 of those bears live in secure core habitat due to its linear shape (assuming a conservative 3% sustainable human caused mortality). This status could radically shift if habitat conditions deteriorate (for any number of plausible reasons) or legal protections are relaxed, allowing more grizzly bears to be killed by humans. In either scenario the long, narrow shape of the NCD range makes this population more vulnerable than ranges such as the GY and CI, where there is a better ratio of interior to edge habitat.

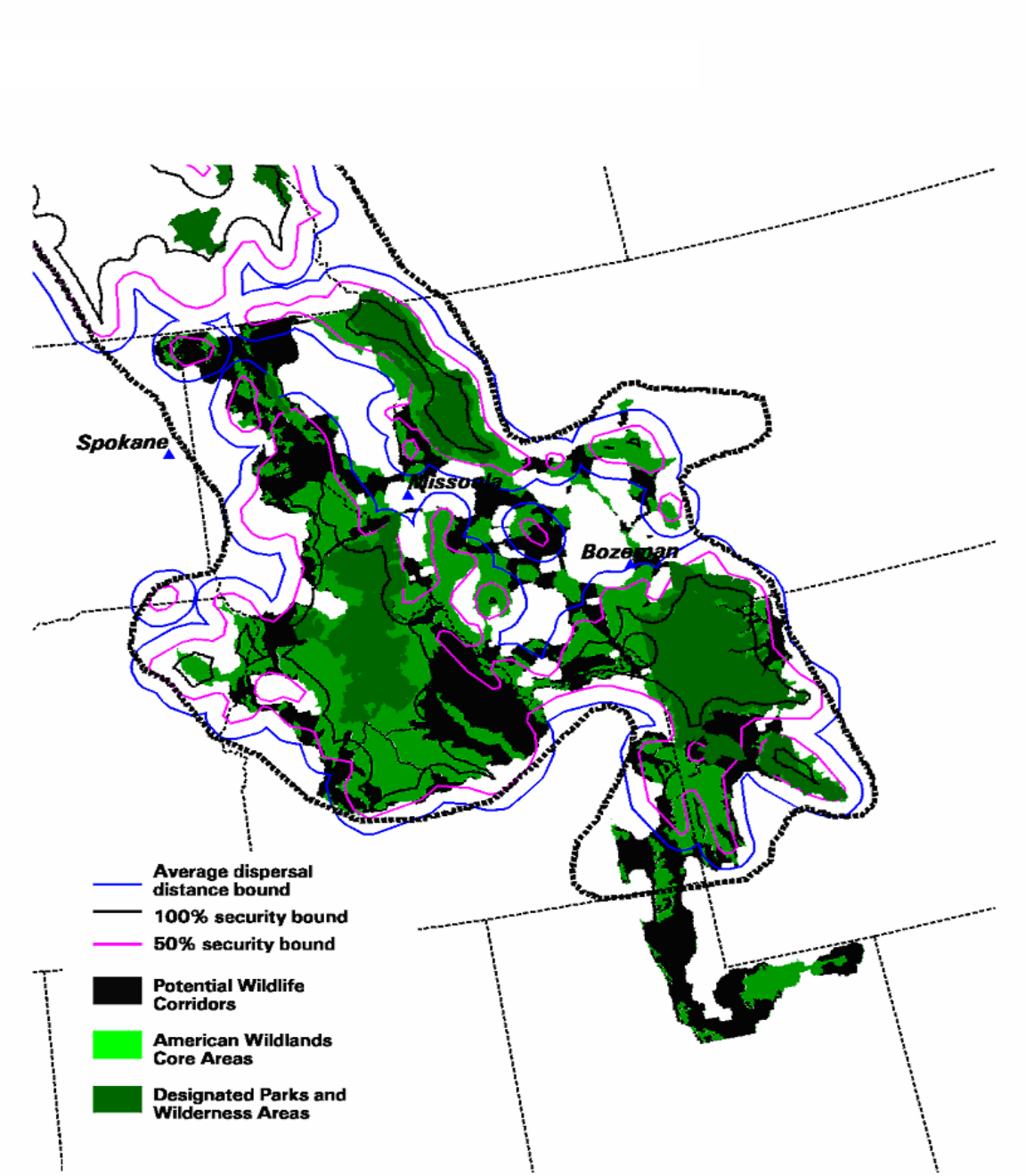
Maintaining linkages between the NCD and neighboring populations is also important for population persistence. If the NCD were to become an island, its shape – relatively long and narrow – would become a major factor in

determining the fate of its grizzly bear population. Currently there is no known movement of grizzly bears between the NCD and the GY. There are very few, if any, bears in CI. The likelihood of long-term survival for NCD grizzly bear populations could be increased by securing linkage to grizzly bear populations to the north. This linkage is already fracturing along Canada Highway 3 (Proctor et al. 2002, Apps 1997). If that fracture becomes complete, the NCD becomes an island population.

Ensuring the NCD does not become isolated is a key short-term strategy. In the long term, the NCD needs to be connected to more than the Central Rockies. Our results identified a potentially robust linkage between the GY and NCD through CI. This link runs east-west from the Flathead River valley, north of 49^{o}N latitude, to the Yaak River valley, south through the Cabinet, Coeur D'Alene, and St. Joe Mountains to the Upper Clearwater. However, this potential linkage is in danger of disappearing as conditions in the Yaak and Cabinet Mountains deteriorate. There are also potential linkages between the GY and NCD along the Bozeman pass and Continental Divide (Map 9). These linkages are threatened by private lands development and burgeoning off-road vehicle use (Gilbert 2004).

More immediately, grizzly bears in the NCD are threatened by high levels of existing or proposed road access and use associated with logging, as well as oil and gas production; by mortality associated with major transportation corridors; by black bear hunters who mistakenly kill grizzlies; and by conflict with livestock producers. The first issue relates to levels of exposure to humans whereas the last three relate to lethality of contact. Road access is especially problematic on the west side of the ecosystem, in places like the South Fork of the Flathead River drainage, and of increasing concern along the East Front of the Rockies if plans for oil and gas exploration proceed. Trains along the Highway 2/Burlington Northern railroad corridor, south of Glacier National Park, have killed numerous grizzlies attracted to edibles spilled along train tracks. Many bears have also died as a result of conflicts associated with bone yards, calving and lambing areas and beehives on private agricultural lands along the East Front and in the Blackfoot River drainage (Seth Wilson, Blackfoot Challenge, pers. comm.). Management of access and attractants needs to remain a priority concern for the NCD, especially along current margins of grizzly bear range that determine the extent and shape of source areas.

Map 9. Grizzly Bear Habitat: Montana and Surrounding Area



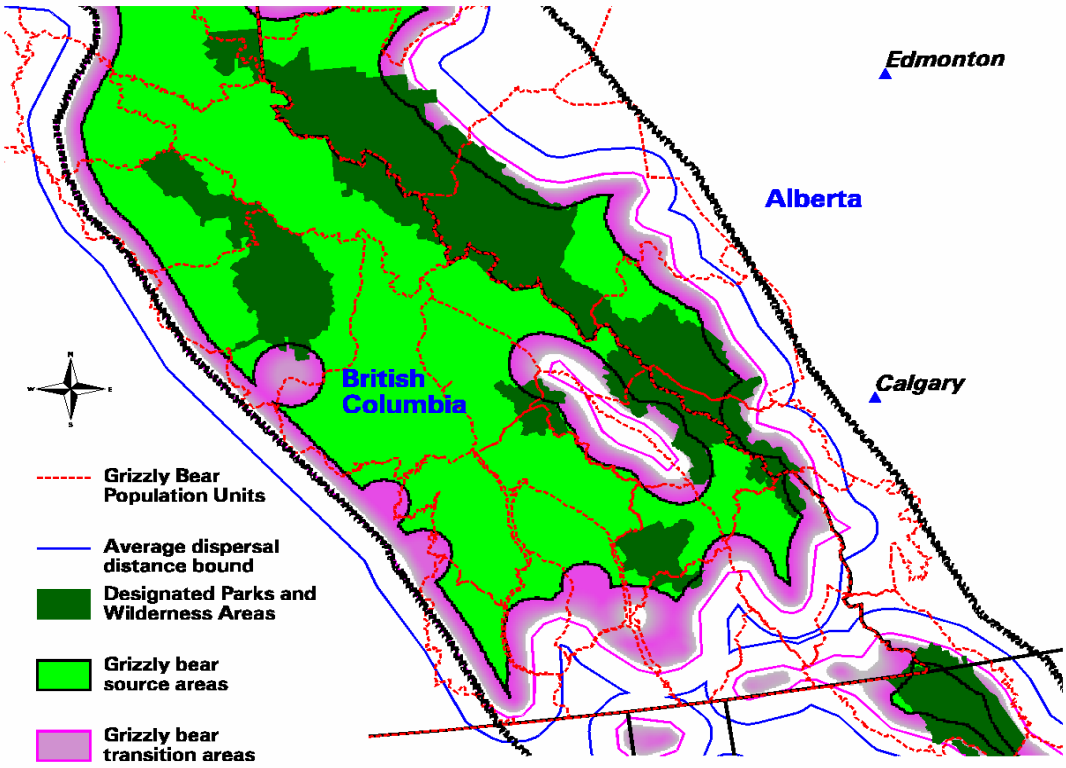
The Cabinet-Yaak Linkage

Grizzly bear populations in the Yaak Valley and Cabinet, Selkirk and Purcell Mountains are frequently overlooked in discussions of grizzly bear conservation. All of these populations are small, isolated and on the verge of extirpation (Mattson and Merrill 2004, Proctor et al. 2002, Wakkinen and Kasworm 2004). Our work suggests the survival of these populations is critical for several reasons. First, this area provides linkage habitat that is vital to maintaining the behavioral and genetic diversity essential for long-term survival. These populations inhabit the last remaining stepping stones in what once was a continuous distribution of grizzly bears. Restoring the habitat surrounding those stepping stones is essential in order to achieve the large linked populations necessary to achieve true grizzly bear recovery.

It is through the Cabinet, Selkirk and Purcell Mountains and the Yaak Valley that a fully recovered grizzly bear population in CI will be linked to populations in the North. It is through here that the most promising link between the NCD and CI will pass. If the linkage potential of the Cabinets, Yaak, Selkirks and Purcells is lost, achievement of long-term conservation goals for grizzly bears south of 49^{o}N latitude will be greatly complicated, if not impossible. Without north-south linkage west of the main range of the Rockies, severance of Canadian and U.S. grizzly bear populations becomes more likely.

Immediate threats to the border region include: 1) high road densities associated primarily with logging and the related human-caused mortality and alienation of bears from essential seasonal habitats; 2) proposed development of the Rock Creek Mine in the Cabinet Mountain Wilderness and associated increased human activity; 3) the absence of large blocks (1,000's of km^2) of secure grizzly bear habitat; and 4) recreational and residential development of private lands. Restoration of this currently impaired and highly threatened linkage zone will be difficult given the extent of the existing and proposed human infrastructure. However, any meaningful remediation must reduce levels of road access, increase the number and size of secure areas for grizzly bears, reduce human lethality, protect private lands and promote sanitation and other practices that increase the compatibility of humans and bears.

Map 10. Grizzly Bear Source Areas and Transition Zones in Alberta



Grizzly bear population units as defined by B.C. Ministry of Water, Land and Air Protection (dotted red line). Population units are primarily management designations and there is substantial interchange between units. They do, however, illustrate the uneven distribution of grizzly bears in BC.

Highway 3

Canadian Highway 3 divides the northern and southern ERPs (Map 4). The division is not complete; grizzly bears utilize habitat adjacent to both sides of the Highway 3 corridor (Apps et al., in prep). Male grizzly bears maintain ranges transected by the highway but female grizzly bears do not. Gene flow from north to south is impeded (Proctor et al. 2002). Mike Proctor, a well-known grizzly bear biologist, has determined there is contiguous gene flow for grizzly bears from the southern edge of the NCD in the Rockies, the southern edge of the Purcells in Montana (Hwy 2 through Libby and Troy) and the southern edge of the Central Selkirks at Highway 3A (Nelson to Balfour B.C.). However, there are differences between females and male grizzlies' willingness to cross Highway 3. Female migration over the highway is limited and male migration is reduced, and the gene flow is currently mediated by male migration (Proctor, 2002, pers. comm.). Should Highway 3 become a total barrier to gene flow, as has occurred with Highway 3A (thus isolating the small population in the Southern Selkirks south of Highway 3A), populations south of Highway 3 would be genetically isolated. If that should occur it may be only a matter of time before those isolated populations die, just as populations in New Mexico, Arizona and Colorado did before them (Mattson & Merrill, 2002).

Development pressures along Highway 3 are increasing as the economy shifts from resource extraction to tourism and service provision, which tend to concentrate development along major travel routes. Despite increased development pressure, it is not inevitable that Highway 3 will sever the linkages still existing between grizzly bears north and south of the highway. Along with the economic shift is increasing awareness of the value of maintaining wildlife populations and their habitat. Momentum and support for the expansion of Waterton Lakes National Park is growing. Dialogue about the need and methods to mitigate the effects of twinning Highway 3 has begun.

Maintaining linkage across Highway 3 requires two separate but related types of activities. The first are activities required to keep the highway corridor permeable to grizzly bears; activities such as preventing development within known wildlife crossings and assuring that highway improvements include adequate crossing structures. The second type of activities are those that assure there will be bears on both sides of the Highway; making sure there are bears available to cross the road. Maintaining the roadless and wilderness characteristics of key landscapes, including the upper Flathead, Wigwam Creek and the Yaak Valley watersheds, is critical.

Central Rockies Core

Our models suggest that grizzly bears in the Central Rockies form a single population; this view is not held by most grizzly bear researchers familiar with the region (McCrory, pers. com., Proctor et al. 2004, Hamilton and Austin 2003). It all depends on how one defines a population. In any case, grizzly bears are not uniformly distributed in the Central Rockies. Highways and zones of concentrated human settlement restrict grizzly bear movements (Gibeau et al. 2002; Proctor et al. 2002, Map 10) but these population segments are not completely isolated from each other, with the exception of the Southern Selkirks (Proctor et al. 2002).

While there is fragmentation of grizzly bear habitat in the Central Rockies, the degree to which one sub-population is isolated from another is less than the isolation of grizzly bears in the U.S. portion of the Y2Y region. Preventing further fragmentation and the amelioration of fragmentation that currently exists are key challenges for grizzly bear conservation in the Central Rockies. Large recreational developments, such as the proposed Jumbo Glacier resort, could fracture this population.

Grizzlies are struggling to hold on in the eastern slopes of the Canadian Rockies where human populations are increasing. Recreational development threatens bears in Kananaskis Country. Grizzly bears die on the Trans-Canada Highway and railroad tracks in Banff National Park. Conflicts between cattle and grizzly bears create a population sink in the Castle-Crown area outside of Waterton Lakes National Park. All along Alberta's Rocky Mountain east front, oil and gas development and its associated network of roads and pipelines impact the landscape and bear habitat (Mattson and Merrill 2002). Human populations are rapidly increasing. All of these factors result in increased human-grizzly bear conflict and human-caused mortality. Remediation is urgently needed along Alberta's eastern slopes. Measures such as co-existence training, bear-proof sanitation and non-lethal deterrence have reduced grizzly bear mortalities in the Y2Y region. Yet it is unlikely that these kinds of measures, by themselves, can reverse the downward trend of the grizzly bear population along the eastern slopes. There are too many people and too much road access. More and larger conservation areas are needed. East-west access to the foothills from the mountains must be maintained. Currently impaired north-south movement of grizzly bears across the Trans-Canada Highway and railroad must be restored.

The key challenge west of the Continental Divide in B.C. will be maintaining present population levels and distribution in order to maintain long-term grizzly bear survival (Peek et al. 2003, Gilbert et al. 2004). This means maintaining bears where they are now, preserving existing blocks of unfragmented habitat on public and private lands, and creating core refuges. This is not to suggest that challenges in this region are small. In fact, preservation of the status quo may be as difficult as restoration. There are two major threats to grizzly bears in British Columbia: 1) a government that is actively rolling back environmental protections; and 2) legal sport hunting of grizzly bears. By far the greater threat is the lack of support for environmental laws by the current provincial government of British Columbia. This is illustrated by the

recent rollback of the Southern Rockies Provincial conservation area which was designated in 2001. As more of the landscape is industrialized, grizzly bears will have fewer secure refuges. The relationship between human access and increased human-bear conflicts and human-caused deaths is clear (Mattson 1993, Mattson et al. 1996, McLellan et al. 1999, Merrill and Mattson 2003, Mattson and Merrill 2004). When legal harvest is coupled with other human-caused mortality arising from increased roading and human activity, grizzly bear population declines could be relatively rapid and undetected.

Some recommendations of the grizzly bear scientific panel that recently reviewed the issue of sport hunting in British Columbia have merit. Members of the review panel said sport hunting of grizzly bears was sustainable, and they recommended large security areas (e.g. source areas) be established. Resource extraction, human access and hunting would be restricted within these security areas. If such a system of grizzly bear security areas was established in good faith (see Gilbert 2004), it could provide a robust skeleton for a conservation area network for grizzly bears in B.C.

The Peace River Linkage

The Central Rockies and Northern British Columbia grizzly bear populations are separated by a swath of forestry development and human settlement that follows Highway 97 between Dawson Creek and Prince George B.C. Currently the Central Rockies and Northern British Columbia DRPs are sufficiently connected to qualify as a single ERP. This connectivity, however, is under threat from increased forestry activity, expanding road networks and human settlement.

It is often assumed that Canada gets wilder and the habitat more intact as one goes north and this is largely true. However, the Peace River region that forms a break in the mountains of northern British Columbia is an exception. Several things have the potential to fragment this area of British Columbia, including the highway from Prince George to Fort St. John, forestry, oil, gas, coal-bed methane development, a growing network of roads and a growing human population. These pressures are compounded by the large reservoir at Williston Lake and a smaller reservoir adjacent to it that floods a significant portion of the Peace River. Yet a third large dam is proposed on the Peace River at Site C near Fort St. John. The combined effects of all these activities call for further study and planning to ensure grizzly bears can continue to fully occupy this critical linkage.

If linkage across the Peace is lost, the Canadian Rockies population would be isolated from the populations in the large wild areas of the Muskwa-Kechika and further north. This would sever the continuous distribution of grizzly bears that currently stretches from the far north to Highway 3 just north of the U.S./Canadian border. In the adjacent Mackenzie Mountains of the Yukon and Northwest Territories, the most genetically diverse grizzly bears ever studied in North America are located (Weaver, pers. comm.). The long-term survival of the species can only be enhanced by maintaining connections to this genetic diversity. The potential for losing this connection is illustrated by the historical contraction of grizzly bear range (Mattson and Merrill 2002) (Map 6a and 6b, page 18).

The Peace River linkage must be protected before it is further degraded. Maintaining continuous north/south linkages should be considered in the siting of future industrial projects. However, in addition to habitat degradation from increased industrial activity and human settlement, grizzly bears in this region are killed by sport hunters under a limited entry system or as the result of conflicts with humans over big-game carcasses, garbage or chance encounters. The pressure on the grizzly bear population from industrial development and human population in addition to the mortality from sport hunting may not be sustainable.

Northern British Columbia

The Muskwa-Kechika and adjacent wilderness areas of Jennings, Horse Ranch, and Liard are located in Northern B.C. As in the Central Rockies, grizzly bears in Northern British Columbia are not evenly distributed across the landscape. Grizzly bears naturally occur at low densities, especially in northern and central parts of this region, and are vulnerable to habitat fragmentation and human-caused mortality. It is difficult to imagine grizzly bears in Northern B.C. being threatened. In 1850, in the conterminous U.S., it was unthinkable that grizzly bears could be pushed to the brink of extinction in little more than a century (Mattson and Merrill 2002). Grizzly bear population declines are difficult to detect and reversing a decline is even harder. Because of this, human activities in grizzly bear habitat must be precautionary.

Although grizzly bears in Northern B.C. are not immediately imperiled, there are threats such as natural gas development that can harm grizzly bears through displacement and conflict-related mortalities. Increased access needed for exploration and service of wells and pipelines combined with sport hunting and increasing human recreation do impact grizzlies in Northern B.C. Despite the current scarcity of humans, grizzly bear populations should be closely monitored. Mitigation of impacts from human activities should be aggressively pursued. Although detailed analyses are being conducted in some areas, such as those being done by Round River Conservation Studies in the Muskwa-Kechika, it is unlikely that natural gas exploration and development will be limited while monitoring regimes are developed and put in place. Development should be done with minimal construction of permanent access and maximum possible reliance on temporary routes. As recreational use increases, the number of bear/human conflicts is also likely to increase. Educational programs designed to reduce the likelihood of bear/human conflicts and the lethality of conflicts if they occur should be designed and implemented.

Most importantly, we as a society should recognize this is our last chance to avoid the wildlife losses historically incurred in the South (Laliberte and Ripple 2004) where the legacy of human exploitation is already written in lost, diminished, and isolated grizzly bear populations. It should not be written yet again in the North.

Conclusion

The implications of this analysis include good and bad news for grizzly bears. The bad news is that the majority of the middle and southern portions of the Y2Y region is facing many threats. If unchecked, these will perpetuate the historical, at times catastrophic, decline of grizzly bears in North America. The drive to exploit oil and gas reserves, regardless of their location, seems to be accelerating and this brings human industry into grizzly bear habitat. Humans continue to crowd grizzly bears, building houses, expanding resorts, claiming territory previously available for grizzly bears.

The good news is we still have the potential for healthy, widely distributed populations of grizzly bears in the Y2Y region. There is room for several DRPs with existing or potential linkages between them to form ERPs. Humans and grizzly bears arrived on the North American continent at about the same time and have shared the continent for thousands of years. For most of that time, the relationship between the two species has been one of tolerance and respect. These values can be regained. We can choose to continue to share the region with grizzly bears for thousands of years into the future.

Conservation strategies are framed by the goals of individuals or groups. We desire to conserve something because it is important to us. This importance may be rooted in a concern for nature, a desire to maintain wilderness recreation, hunting opportunities or any number of other reasons. The areas identified as being important for conservation depend upon what is to be conserved. For example, areas providing valued recreational opportunities may not be the best areas for conserving rare birds. Similarly, areas prioritized by hunters may differ from areas prioritized by others for spiritual reasons. In short, conservation strategies are frameworks that maximize the odds of achieving specific conservation goals by focusing attention on critical areas. Although conservation targets may be other species, human perspectives and behavior have the central role in conservation. Places on the ground that are critical to achieving Y2Y's grizzly bear conservation goals have been identified in this report. However, that achievement ultimately depends on our ability to influence and positively change the behavior of other humans.

14 Things We Can Do

1. Prevent or mitigate the loss of key grizzly bear foods in the Greater Yellowstone to avoid significant reductions in numbers of bears at the southern terminus of Y2Y.
2. Allow grizzly bears to occupy suitable but unoccupied habitat in the Wind River, Palisades and Centennial Mountain Ranges of the Greater Yellowstone.
3. Facilitate repopulating Central Idaho with grizzly bears and maintain grizzly bear habitat quality.
4. Reduce human access to grizzly bear range, especially in the U.S.-Canadian transboundary region.
5. Prevent further habitat degradation and reduce human-caused mortality especially around the boundaries of the Northern Continental Divide Core to prevent isolation of this population.

6. Ensure connectivity across heavily used transportation corridors, including U.S. Interstate Highways 15 and 90, U.S. Highways 200 and 2, Canada Highways 3, 97, 16 and the Trans-Canada Highway, and the Burlington Northern, Canadian Pacific, Canadian Northern, and Canadian National Railways.
7. Persuade the Alberta government to develop and implement policies and programs to restore grizzly bear numbers and geographic range.
8. Persuade the British Columbia government to follow the recommendations of the independent science panel and designate a system of secure Grizzly Bear Management Areas.
9. Support the Muskwa-Kechika management area and other wilderness areas in the region.
10. Promote use of the precautionary principle in conservation designs for grizzly bears in Northern British Columbia.
11. Insist that energy developments use industry 'best practices' that reduce impacts on grizzly bears and their habitat.
12. Implement improved sanitation practices, such as bear proof garbage containers, to reduce human/bear conflict in all communities along the edges of core areas and in linkages where grizzly bears are present.
13. Maintain and expand the roadless nature of potential grizzly bear habitat, as described in the Clinton Roadless Area Conservation Rule.
14. Avoid large recreational and extractive industry developments, such as the Jumbo Glacier Resort in the Purcell Mountains and the Rock Creek mine in the Cabinet Mountains, which increase human access and habitat degradation in the heart of grizzly bear cores and corridors.

We must protect and restore critical grizzly bear habitat and populations before opportunities to do so are forever lost. The Y2Y region has the potential to sustain thriving grizzly bear populations for millennia to come, but only if people act now to make this potential a foreseeable reality.

Modeling Highlights and Improvements

During the modeling process presented in this report, several new contributions to grizzly bear modeling were developed including:

Habitat effectiveness

A new metric was developed by Troy Merrill (as per Merrill et al. 1999) to predict grizzly bear mortality risk caused by humans. Merrill calculated road density (a commonly used measure of human impact) and combined it with local human population density. He then interpolated human population density that approximates the effect of population centers over distance. Merrill's metric quantifiably interprets human impact as more complex than just the number of roads/mi^2 — for the risk to a bear is not a road itself but the likelihood that humans using the road will run into conflict with a grizzly bear. Calculating remoteness in terms of road density in relation to the estimated distance from a human population center provides key information on the potential for human-grizzly conflict.

Grizzly bear density

Troy Merrill refined measuring landscape productivity in terms of the probable presence of key grizzly bear foods to calculate the number of bears in terms of net digested energy available/unit area. Broad-scale productivity is typically derived from remotely-sensed data. Merrill's model further refines productivity in terms of the needs of grizzly bears that influence bear fecundity and survivability on the landscape.

Spatially explicit mortality

A component of the modeling work uses the relationship between the proximity of bears to humans and the rate at which bears are killed to predict the spatial distribution of human related mortality. Merrill's lethality thresholds identify potential grizzly bear population source areas according to a range of risk that would assist wildlife managers in appraising the effect of different management actions on bear populations as well as habitat security.

Lethality

The lethality metric was developed and tested in the Greater Yellowstone Ecosystem and then applied Y2Y-wide. As more information becomes available it would be useful to refine the lethality component of the model to reflect differences in how lethality varies within the Y2Y region.

Home range size parameter

The home range size used for modeling in this report was based on 900km^2. However, in other portions of the region, home ranges sizes ranging from 50-100km^2 (personal communication Mike Proctor), and 46-272 km^2 (mean = 125km^2) (personal communication Brian Peck) have been noted. It would be informative to test the sensitivity of the modeling to differences in home range and evaluate if and/or how results for areas where bears have smaller home ranges might vary. In particular, it would be useful to evaluate predictions related to NCD grizzly bear population vulnerability using smaller home range sizes.

Extend north of 60 degrees:

Data were not available for the Y2Y region north of 60^{o} latitude at the time of this modeling effort. At the time this data becomes available it will be useful to apply the modeling methods described in this document to this northern region.

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