The Grizzly Bear

of the Central Rockies Ecosystem

Population and Habitat
Viability Assessment
28 - 31 January 1999
Seebe, Alberta, Canada

EASTERN SLOPES GRIZZLY BEAR PROJECT

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYST
(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

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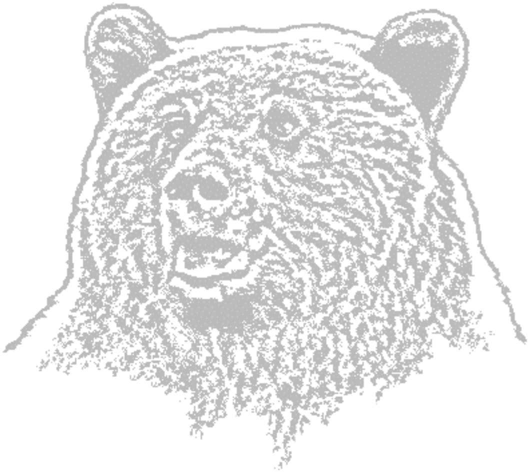

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EASTERN
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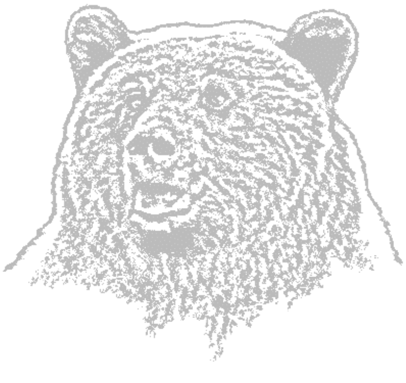
A Special Word of Thanks…

To the 87 PHVA Workshop participants who so generously donated their time and talent toward trying to understand and create a future for grizzly bears in the Central Rockies Ecosystem.

This Workshop would not have been possible without the vision and financial support of World Wildlife Fund, Canada (WWF) and the Canadian Association of Petroleum Producers (CAPP).



THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

Seebe, Alberta, Canada
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TABLE OF CONTENTS

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

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28 – 31 January, 1999

Section

1

Executive Summary

The Grizzly Bear of the Central Rockies Ecosystem (*Ursus arctos*) Population and Habitat Viability Assessment (PHVA) Workshop Executive Summary

Abstract

- *A collection of experts (ecological and social) and interest groups spent four days reviewing data on the grizzly bear in the Central Rockies Ecosystem, and the most recent research and future modeling efforts for grizzly bears throughout North America.*
- *The local human population is expected to increase in the Central Rockies Ecosystem region at an annual rate of 4%, potentially resulting in severe stress to grizzly bears with major impacts on grizzly bear habitat and a reduction of the population from current numbers. Extensive and successful management will be necessary to maintain local populations and to reverse current negative trends.*
- *A recovery plan is necessary to restore the function of enough compromised habitat to counter the effects of continuing development and expanding human activities elsewhere.*
- *Joint action between Alberta, British Columbia and Parks Canada is required.*

Introduction

Stephen Herrero, ESGBP

Rapid and continuing human population growth and infrastructure development has occurred in the last 30 years in Calgary, Canmore, Banff, and surround. This has resulted in grizzly bears being challenged to live in one of the most developed landscapes in North America where they still survive.

The Eastern Slopes Grizzly Bear Project (ESGBP) began in 1994 in response to an urgent need for scientific understanding of the grizzly bear population and habitat, and relationships with people. Several major new pieces of environmental legislation, such as the Canadian Environmental Assessment Act (CEAA) of 1992, and the Alberta Environmental Protection and Enhancement Act (EPEA) of 1993, made cumulative effects assessment of major projects mandatory. Grizzly bears, because of their potential rapid decline with certain human influences, became a focal species for cumulative effects assessments where this species occurred (Herrero et al. 1998).

ESGBP research is based out of the University of Calgary and is conducted in cooperation with many agencies and stakeholders. Research is carried out by graduate students, professors and associates and is vetted through the thesis review and defense process, and peer-reviewed and other publications (Herrero et al. 1998). Strategic directions for research and funding are overseen by the ESGBP Steering Committee. The Project has no formal links to policy or management decisions although it has had significant influence in this regard (Herrero et al. In press).

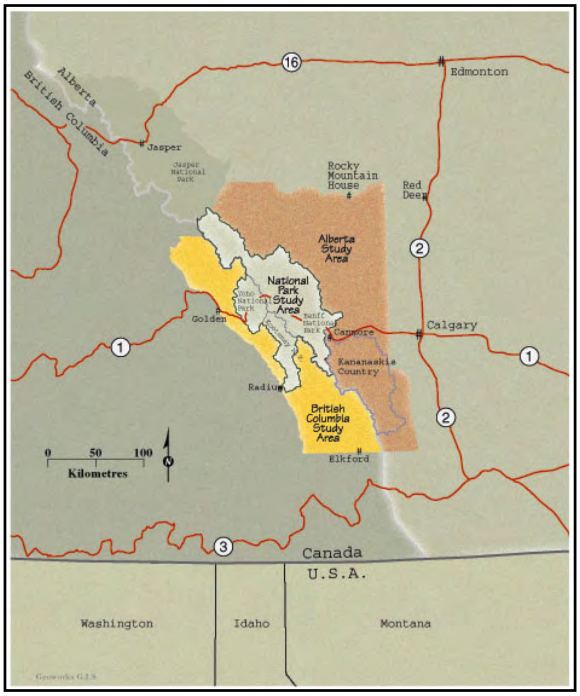

Figure I-1. Map showing the Central Rockies Ecosystem study area of the Eastern Slopes Grizzly Bear Project.
Map courtesy of Scott Jevons, Geoworks GIS.

To meet their needs, grizzly bears, especially males, move long distances, often using lands managed by several jurisdictions. Responding to the extensive use of land by the mobile grizzly bear, the ESGBP focuses research on a large landscape. This approximately 42,000 sq. km. area has been called the Central Rockies Ecosystem (CRE) (Komex International 1995) and includes lands in Alberta and British Columbia (Figure I-1). As an ecological unit it has significant but not complete closure. Indeed, one of the ESGBP objectives is to contribute to maintaining connectivity for grizzly bears between the CRE and other regions.

Coordinated land and wildlife management throughout the CRE is a daunting task because it requires interagency communication, coordination and cooperation, even though agencies may have very different management objectives regarding grizzly bears. For example grizzly bears are hunted in portions of the CRE in Alberta and British Columbia, while they are not on Parks Canada lands, or in certain provincial areas. Blending different management processes around a potentially common goal of grizzly bear population persistence has been recognized as important (Dueck 1990, Herrero 1994, Herrero et al. 1998, In Press). But, only recently, with the formation of the Rocky Mountain Grizzly Bear Planning Committee, has there been a structure to try to coordinate activities of different jurisdictions.

Such a simple sounding task as preparing a grizzly bear habitat quality map that spans jurisdictions has been mired in the different and incompatible map products used by each of the jurisdictions. Attempts are now being made to develop a Landsat based map that will cover the entire CRE (and other regions as well), but this task has not been completed, let alone validated with data from actual grizzly bear habitat use. The PHVA workshop was constrained by lack of a scientifically vetted grizzly bear habitat map for the CRE.

Three regional scale projects of the ESGBP have contributed to the goal of understanding the cumulative effects of human activities throughout the CRE. Grizzly bear mortality from 1971 through 1996 has been summarized and analyzed (Benn 1998). We also have five years of data collected from 52 radio-marked grizzly bears regarding relationships with development and demographic parameters (Gibeau and Herrero 1999b). Finally, we have completed a “security area” assessment for the CRE (Gibeau and Herrero, in press). This GIS-based analysis identified landscape units 9 sq. km or larger that were without major human activities, and that contained potential grizzly bear habitat. These are the size of units thought to be important to meet the daily foraging needs for adult female grizzly bears (Mattson 1993). This analysis contributed an important understanding of our CRE landscape---the usable habitat is naturally fragmented by the snow and rock of the Rocky Mountains. Human developments and activities further fragment grizzly bear habitat into smaller units. This raises concerns for the long-term persistence of reproductively successful adult female grizzly bears.

The PHVA workshop is the ESGBPs first attempt to integrate available population, habitat and human impacts data regarding grizzly bears, and to develop population and habitat modeling to forecast future trends based on what we now know and assume. We attempted to do this by combining outside expertise with our own. We invited the CBSG of IUCN/SSC, chaired by Ulysses Seal, to structure the workshop and to share their accumulated experience gained in managing similar workshops for other potentially threatened species. To try to insure that we had some of the best population modeling expertise in North America regarding grizzly bears we also invited four internationally recognized experts: Mark Boyce, Rick Mace, Dave Mattson, and John Weaver. Perhaps most importantly we asked about 50 regional stakeholders, whose activities in the CRE influence the fate of grizzly bears, to donate four days to the workshop process. We express our sincere thanks to all participants.

The specific scientific framework for the workshop was a Population and Habitat Viability Assessment (PHVA). The variables affecting the grizzly bear habitat or population are well known human activities such as transportation, residential development, resource extraction, intensive recreation, and hunting. Through the workshop process, and based on ESGBP data, we tried to understand and quantitatively predict the cumulative effects of development and human activities on the grizzly bear population and habitat.

To the extent possible model variables were derived from ESGBP project data. However, and inevitably, assumptions had to be made for some variables. We caution interested readers to carefully examine the strengths and limitations of our data. We strongly believe in the modeling process because it forces quantitative values to be entered for all relevant variables. Once done, others can dispute or change the variables based on more complete data or understanding. At least the process is explicit and subsequent iterations can be run as data change or improve.

The PHVA workshop process

Ulysses Seal, CBSG

This report is from a Population and Habitat Viability Assessment Workshop (PHVA) conducted 28-31 January 1999 at Camp Chief Hector, near Seebe, Alberta. The Workshop was organized by the Eastern Slopes Grizzly Bear Project (ESGBP) Steering Committee in collaboration with Conservation Breeding Specialist Group (CBSG/SSC/IUCN). CBSG has 800 volunteer member experts around world and 15 years of experience with workshop processes. Workshops are always conducted at the invitation of local wildlife agencies. The process and report are advisory not prescriptive and derive their strength because they are locally engendered with local ownership. CBSG has done more than 150 workshops in 50 countries with more than 4,500 experts and other local stakeholders participating.

The CBSG team for this workshop included 8 people who provided a wide range of expertise as a resource and assisted in facilitating the individual working groups. Steve Herrero and the ESGB steering committee assembled 87 people, a remarkable accomplishment attesting to the work done on this project and its implications for management of the entire ecosystem. This provided a high concentration of expertise on the ecosystem, bear habitat, bear biology and human impact activities in this system. Included were 4 top grizzly bear experts from the USA with extensive knowledge of the Yellowstone system and other bear populations, managers and field biologists from the range of agencies with responsibilities in this ecosystem, representation from commercial and industrial interests, and university based researchers.

The workshop process extended over 3 ½ days building on materials provided in fieldwork and studies done to date. The 60-70 participants, after initial plenary presentations of background material and guidelines for the process, were divided into working groups that then remained together over the duration of the workshop. This provided for a rapid building of mutual common ground to allow a focus on the tasks of the group. Working groups included a big picture group based on an ecosystem and landscape mapping approach, a habitat and bear distribution group, a population modeling group, a secure areas group, a human access impact group, and a physical impact group for six working groups. All individuals conducted a structured analysis of the goals and problems in small working groups to ensure intensive participation. The intense commitment of time and energy by all in this beautiful site was creative and productive.

A draft report was prepared by each working group with plenary reporting each day to ensure effective flow of information between groups. This was augmented by exchange of individuals between groups as needed to transmit or obtain information or guidance on particular questions. Strategies and specific actions with measurable outcomes were then developed in each group to respond to the carefully identified and defined problems. These actions constituted the recommendations of the workshop. The final report was prepared from a compilation of the working group reports and thus is a direct product of the participants in the workshop.

The first day's agenda began with an opening presentation by CBSG (Seal) on the workshop process, the use of thinking tools, the use of small working groups to do the analyses and prepare the report, and basic facilitation guidelines for conduct of the group sessions. This was followed by technical presentations summarizing grizzly bear status in Eastern Slopes.

The first plenary session was opened with each person introducing himself or herself and stating their primary goal for the PHVA workshop. This process and the expressed goals provided a unifying experience of shared values and interests in the outcome for the workshop and their shared vision to:

'**Maintain the presence of grizzly bears in the regional landscape**'.

Theme topics for the working groups were formulated based upon the objectives of the workshop, the range of stakeholders and experts in attendance, and the wish to divide people approximately equally between the groups to maintain a size of 8-12 participants in each group. The proposed groups were discussed in plenary with suggestions on the definitions of the themes for clarification. The working groups were Landscape, Mortality, and Risk Modeling; Habitat and Distribution; Population Modeling; Human Physical Impacts on Habitat; Human Access Impacts on Habitat; and Secure Areas**.** The results of their analyses and deliberations form the body of this report and their summaries follow.

A common characteristic of management decision-making processes throughout the world is to argue for delay of management decisions to wait for additional or definitive (often unattainable) information. This poses a real threat to effective management before a population reaches a severe decline or terminal crisis stage. Also it undervalues the accumulated wisdom of the managers and local field biologists and their knowledge for making management decisions. There is a substantial body of knowledge to inform management decisions for the grizzly bear in the CRE here and now. The results of application of these management decisions will need to be part of an adaptive management program and there is a strong need for continuing the long term studies through a longer fraction of the life cycle of the species since there clearly are ecosystem specific characteristics of its demography.

Working Group Summaries

Landscape, Mortality, and Risk Modeling

This working group focused on issues related to modeling the viability of grizzly bear populations and implementing the *VORTEX* population viability model using grizzly bear data from the ESGBP study area. It was recognized that a strong link to habitat conditions was necessary if viability projections were to have any meaning. It was also recognized that conditions were not uniform throughout the ESGBP study area and that the prospects of local grizzly bear populations varied accordingly. The boundaries of the ESGBP study area were furthermore recognized to be open to movement of bears into and out of the study population. These conclusions lead the group to adopt *VORTEX* models that were open to emigration and immigration at the margin of the modeled population and structured to allow for internal differences in birth and death rates. Kananaskis Country and Banff National Park were chosen to be the focus of finer-scale simulations. These conclusions also lead to the development of two related approaches to modeling the effects of habitat on death rates of grizzly bears. The output of these proposed habitat-based models would be used by *VORTEX* to project population viability in a way that was sensitive to temporal and spatial differences in habitat conditions.

The modeling working group provided estimates of demographic rates that were used in *VORTEX* model simulations presented at the workshop. Credible estimates of grizzly bear birth and death rates were available for the ESGBP study area. Comparable estimates of immigration and emigration rates were lacking and so a plausible range of exchange rates was used in model simulations. The working group recognized the importance of uncertainty in vital rates (e.g., birth and dearth rates) and the related importance of sensitivity of viability projections to variation in each of the rates. This lead to a description of uncertainty as well as an analysis of sensitivities for each rate.

The habitat-based models of grizzly bear death rate were based on the premises (1) that most adult grizzly bears die because humans kill them and (2) human-caused deaths will occur at a rate governed by the frequency of encounter between humans and bears and the likelihood that a human will kill a bear during a given encounter (i.e., lethality of contact). Frequency of contact between humans and bears is affected by, among other things, the numbers of humans in grizzly bear habitat, the amount and dispersion of road and trail access, and the quality of grizzly bear habitat near human facilities. Areas secure for grizzly bears (i.e., security areas) are those areas sufficiently productive to attract bears and sufficiently remote from humans to ensure survival of the bear while it is there. Lethality of contact will be affected by administrative jurisdiction and whether a legal hunt occurs. These concepts were the basis for the habitat-based models which correspondingly used maps of jurisdictional boundaries, human facilities, roads and trails, human populations, and grizzly bear habitat productivity to describe and predict variation in grizzly bear death rates.

Habitat and Distribution

The Habitat and Distribution Working Group served as a resource providing data regarding habitat quality, effectiveness, supply, and distribution from existing research results and habitat evaluation for input into the habitat-based population viability model. This group: 1) defined terms and scale of assessment; 2) analyzed existing information on the spatial distributions of animals over the landscape and broke it down into measures of population density, home range size and minimum daily movements relative to habitat, at the appropriate working scale; and 3) developed a rational basis for linking existing mortality data to habitat-based landscape evaluations.

The overall recommendation from this working group is to establish and fund a technical group to validate, and incorporate into a revised PHVA model the following parameters:

- habitat quality polygons (ground-truth LANDSAT greenness polygons)
- linkage zones
- population density, home range size and other values by habitat class

These tools should then be used to determine where conservation efforts should be focused when implementing the following specific strategies (listed in priority order based on the results of paired ranking analysis):

1. Implement seasonal recreation and/or road closures in areas that have high habitat quality
2. Maintain an open population/landscape, including high quality dispersal linkages, to minimize extinction risk.
3. Locate/relocate roads and trails in lower quality habitat
4. Optimize/restore amount of secure habitat. Implement management actions to increase habitat effectiveness, especially in higher quality habitats; at a minimum, maintain habitat effectiveness region-wide.
5. Based on current knowledge implement management actions to achieve a minimum of 60% habitat security in areas where we want to maintain females within their home ranges.
6. Prioritize conservation efforts (eg: restoration of security) on high quality habitats

7. Secure existing areas that currently have high habitat effectiveness by eliminating future development of roads or modification of habitat (=protected areas)
8. Document a minimum of five crossings of the fenced portion of the Trans-Canada Highway (TCH) within the next two years. Failing this, implement active measures to increase secure crossing areas and enhance habitat quality.
9. Create administrative flexibility to meet habitat goals by renegotiating existing leases and tenures.
10. Each jurisdiction should identify explicit measurable goals for habitat effectiveness and habitat quality in resource and land use plans.

Population Modeling

The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving the grizzly bear in Alberta and eastern British Columbia. *VORTEX*, a simulation software package written for population viability analysis, was used as a tool to study the interaction of a number of life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of a suite of possible management scenarios.

Working group participants used the best available information on life history and demography of the Eastern Slopes grizzly bear to develop a series of stochastic simulation models of grizzly population viability. Initially, demographic sensitivity analysis was employed in order to assess which population demographic parameters (such as birth rate, age-sex specific mortality, etc.) influence population growth rate most strongly. The group found that their risk assessment projections depend most heavily on two demographic parameters: the percentage of adult females breeding and the level of adult female mortality. Interestingly, female breeding success was one of the most important parameters we need to *improve* our understanding of, even though it is also one of the better-estimated parameters. This is most likely because small differences in breeding rate (3 to 5 years) can almost double the net lifetime reproduction for bears. If mortality is (or becomes) as high as in some other populations, bears could be in trouble. (Low fecundity in the area places extra emphasis on keeping mortality low.)

Workshop participants noted that the primary goal of grizzly bear management in Alberta and British Columbia is to prohibit population decline or to promote a modest increase in the provincial bear population. Consequently, the group defined “extinction” as the probability of population decline below current levels (this is technically referred to as a “quasi-extinction” probability). Under this definition, modeling efforts indicate that the population is not secure: the provincial goal of maintaining or increasing the population above today’s numbers is not likely to be met under current conditions.

The modeling group was also able to use estimates of growth in the human population in and around the Central Rockies Ecosystem (CRE) to derive models assessing its impact on the local grizzly bear populations. These models show unequivocally that the impact of the expanding human population could be severe. The CRE grizzly population probably cannot sustain increases in adult female mortality (or decreases in fecundity), so it will be imperative that the impacts of humans be reduced even while the numbers of humans in the region increase.

Human Impacts – Physical Components

Physical developments on the landscape have the potential to significantly affect grizzly bear habitat. Historically, human activities such as fire management, oil and gas development, and logging have been the economic drivers of land uses that can strongly influence grizzly bear habitat. Using information on current and possible future land use activities, estimates were made of direct effects of human activities on grizzly bear habitat over the next 100 years assuming best management practices.

In general, only low to moderate changes were forecasted in most land uses for most areas. This prediction occurs because existing land use is already relatively intense throughout much of the CRE. However, there is potential for high increases in some areas when existing land use is compared to that approved in land-use plans.

This analysis of current and future land use conditions for CRE suggests that core protected areas alone will not sustain viable grizzly bear populations in the CRE. State-of-the-art management of development activities on intense recreation and multiple-use lands will be required. Five activities will most directly affect grizzly bear habitat: timber harvesting, fire management, oil and gas development, recreational developments, and residential developments. Recommendations for specific land-use strategies and management actions for all areas designated as occupied grizzly bear habitat were developed for each of these primary human impacts and these can be found in the working group report. In addition, the following overall land-use strategy was proposed:

- All land use will take place within the context of cumulative effects models that utilize grizzly bears as key indicators.

Three actions steps were identified to implement this strategy: 1) Prepare a grizzly bear habitat map for all lands within the CRE; 2) Prepare a map of existing land uses and 3) Develop a CEM to evaluate the effects of current and proposed land uses.

Human Access Impacts on Habitat

Data suggest that 80-90% of adult grizzly bear mortalities in the CRE result from human/grizzly encounters and that grizzly/human encounters result from human access to grizzly territory. In terms of access, the rule of thumb is that mortality correlates to:

1. The number of roads and trails in a given region;
2. The number of people using those roads and trails;
3. The activities pursued by the people using those roads and trails and, specifically;
4. The use of firearms by the people pursuing those activities.

The working group identified types of access and their attributes, identified and rated the impacts associated with each type of access in terms of: a. Mortality; b. Displacement (of bears from habitat, especially security areas); c. Reduced reproduction (through stress to the population); and d. Habitat reduction and degradation. The group then worked to create scenarios that capture the current state of affairs, a probable future, and a possible future, allowing for spatial and temporal variation (i.e., within different jurisdictions in the CRE over time) of impacts.

The group of experts concluded that the increase in access has a direct correlation with human/grizzly encounters in leading to both displacement and mortality. The projected increase is 4% annually. Through an aggressive management program that involves education, management of human food, aversive conditions, law enforcement, and cooperative strategies, this increase could be mitigated by only 50% at best. This leaves a residual impact of 2% annually. Even with our best efforts the model clearly demonstrates that a 2% decline would result in a population collapse within a few decades, especially for the east slopes subpopulation.

Restoration scenarios must be developed within a decade and should be implemented for at least a decade to reverse this trend. The level of restoration must approach 2% annually. Principally, restoration will involve closing and restoring access to particular areas, and relocating recreation activity to areas with low grizzly bear density. The following recommendations were made to realize a more intensive "restoration scenario" focusing on adult female home ranges:

1. Select restoration pilot project (s) for high profile communications vehicle (one which create success story for grizzly population recovery). Possible areas could include the Smith-Dorrien Road, the Elk Lake Grizzly Bear Conservation Area, and the Fairholme Benchlands.
2. Reexamine existing overflight and jetboat regulations and consider extending legislated restrictions.
3. Establish tighter quotas and controls on high-use areas (consider Lake O'Hara management schemes for such areas).
4. Open new camping/recreational areas in low-density grizzly areas in exchange for existing closing/restricting camping/recreational areas in high-density grizzly areas.
5. Select an area for "holistic" restoration – a multi-stakeholder approach with a social and economic component as well as ecological.
6. Hold a follow-up workshop based on the findings of this workshop, but dedicated to developing vision, strategies and actions for the long-term.

Human Impact – Secure Areas

The Secure Areas Group utilized a five-step process to structure their discussion. The first step described the current situation to establish a common understanding of the issues and to record the information as base line data. This scenario was projected to a probable future if trends continued and then a possible future created from which a vision statement was generated: *To establish and maintain a viable population of grizzlies by accommodating individual security needs in high quality habitat with emphasis on the survivorship of adult females.* A gap analysis between the probable and possible futures established the categories for future planning with feedback loops to the base line data.

A security area was defined to be 9 km^2 of habitat used by a female grizzly bear every day. (ESGBP research has demonstrated this to be the average size of an area used by an adult female.) This 9-km^2 area moves with the bear within her home range (Gibeau and Herrero in press). A home range that contains connected security areas can enhance female survivorship. Disturbances higher than 20 human parties per week were considered to cause significant and adverse behavioral changes in grizzly bears.

The group recognized that there needs to be a joint management response from the governments of Alberta, British Columbia and Canada to manage the grizzly bear as a unit. Without input from BC within the group, however, it was recommended that similar work be done in that portion of the Central Rockies Ecosystem. Socio-economic pressures require a focused management response to protect security areas for female grizzly bears and sufficient information currently exists to act. Due to scientific uncertainty, however, the precautionary principle needs to be applied and the burden of proof should shift to the developers. Some general and specific recommendations were made to maintain and increase the number of security areas in legally protected areas as well as in landscapes not protected. Using the security area concept combined with existing knowledge, specific and detailed recommendations were made within the public context in relation to science, management strategies, and legislation.

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM
(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

2

Landscape, Mortality, And Risk Modeling

Landscape, Mortality, and Risk Modeling

Working Group Participants:
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Introduction

At the outset of this workshop, a group of participants gathered together to discuss the many issues relevant to the overall grizzly bear viability modeling process. A number of topics emerged from this discussion, including the following:

- Exactly what do we want to model: habitat and/or life history?
- How are risk assessment models structured, and how are they interpreted?
- Is the group concerned only with existing models or can it contemplate new models?
- Can/should existing habitat models interface with population models?
- The topic of scale came up repeatedly. At which scale should modeling and the inputs to modeling occur? There was consensus to start at a regional scale (i.e., Central Rockies Ecosystem) and move to finer scales if possible.
- What data does the *VORTEX* model need to run? Is it the appropriate tool for Grizzly Bears in this context?
- It is important to integrate models with other information, both quantitative and qualitative.
- What role does / should modeling play in the decision-making process?

From these issues, the group developed the following goal statements:

- Understand the factors governing birth/death statistics in Eastern Slopes grizzly bears
- Identify thresholds for levels of acceptable development and human activities like recreation and hunting
- Identify parameters of population risk
- Develop criteria/measurement of risk to population, connectivity, habitat, behavior, habituation, etc.
- Articulate strengths and weaknesses of models
- Define the term "cumulative effects"
- To determine if modeling can be used to better understand cumulative effects and their impact on risk
- Identify /develop a dynamic landscape model that can interface with population models and is able to temporally model successional, stand level, and forage quality characteristics.

Because of the diversity of themes emerging from these discussions, the group suggested that it break up into three sub-groups:

- Habitat modeling
- *Vortex* (grizzly bear population) modeling
- “Big picture” – the model focuses on the measurement of risk as extinction probability, but there are other risk measurements such as behavioral modification, range contraction etc.

Some thought that another group already was dealing with habitat and it should be left to them. It was agreed to eliminate habitat from the working group’s discussions.

Some problems with models were put forward. For example, in 1989 hearings associated with the Northern Spotted Owl looked at a PVA model, with over two weeks of testimony, but the judge concluded she would not consider any of that evidence because she didn’t understand it. The same thing is happening in other jurisdictions and will happen/is happening in Alberta, e.g., with the Cheviot mine proposal, and proposed development of major resort at Spray Lakes in Kananaskis Country. Therefore, the complexity of the models is both their strength, and their weakness, as managers and decision-makers are unable to understand them and therefore don’t trust or rely on them. This raises again the issue of the need to articulate modeling technology in language that decision-makers can understand - scientists are not particularly good at this.

Building the model, not just interpreting the model, also needs to occur in context. There are critical questions of scale, e.g., entire populations of grizzly bears versus the scale of a specific development or road; regional populations versus local populations, and the interactions between them.

A habitat sub-group again was proposed. What is meant by habitat? It was suggested to mean everything that influences how bears use the landscape. There is a strong need for this modeling working group to interface with the habitat working group, which is attempting to quantify habitat factors. Scale issues again were discussed: integration across a chunk of the landscape that addresses population characteristics.

A critical question was whether population viability could be modeled in a population that is not closed? Would it be better to identify factors influencing the population trajectory rather than viability? *Vortex* can model open populations and look at whether the characteristics of the population are as a mortality sink, a source population, or neither. It was pointed out that there are source/sink dynamics on a meso-scale within populations. *Vortex* could model sub-components of a population to account for these, and then look at the overall dynamics of the bigger population. But if there is a lot of flow of animals across the sub-populations, it will be just as effective to model across the entire population. Whether or not this will be valid will depend upon the flow rate. At the micro scale, the rate of flow is so high as to not be useful. At a meso-scale there may be an influence caused by flow that is not reflected at the large population scale. It is necessary to play with the model at a variety of different scales. However, the Eastern Slopes Grizzly Bear Study team strongly wants the models to run at the regional scale of the entire project (Central Rockies Ecosystem). It was urged to run at least one model at the project scale because all of the data is available at that scale. Then run at least one at the meso-scale.

Birth and death rates are well known for the population, but immigration and emigration are far less confident. This will lead to greater uncertainty in the model. Different rates of immigration and emigration can be modeled.

The group needs to get confidence limits for the data we have; what do we really want to know to improve the accuracy of the model? If we could model anything in the world on *VORTEX*, what would we ask it to do? The issue is whether or not these issues of scale of habitat need to be determined first. The habitat working group is having exactly the same conversation.

The meso-scale could be either Kananaskis Country or Banff National Park; the regional scale would be the Central Rockies Ecosystem. There are issues of mapping systems across jurisdictional boundaries. The only way to compare them is from LANDSAT imagery, which is very coarse.

Two subgroups were proposed: one would focus on the *VORTEX* model and its parameters; the other would focus on the system (rather than the model). For maximum effectiveness, the *VORTEX* population modeling group needs to have some interface with the habitat working group.

The "big picture" sub-group is focussing on mortality and its association with interactions with humans, i.e., human-caused mortality. The task for the *VORTEX* group is to go through the parameters that input into *VORTEX* and examine what we know about each of them, and where the confidence limits are. Some questioned whether *VORTEX* is the right model because it models probability of extinction, which isn't the question that needs to be answered for the Central Rockies population. On the other hand, it also models trends and can be used to project the implications for populations of various scenarios.

Spatially explicit models of proxies for grizzly bear death rate in the Eastern Slopes study area

Background

- Growth of grizzly bear populations is universally most sensitive to death rates of adult females; i.e., mortality in the adult female group has a much greater population effect than does adult male mortality.
- 80-90% of adult grizzly bear mortality in the East Slope study area is human-caused. There is no foreseen change in this pattern.
- Human-caused mortality is thus likely to govern the future prospects of the grizzly bear population in the East Slopes region.
- Number of human-caused deaths is, tautologically, a function of the frequency of contact between humans and grizzly bears and the probability, given contact, that the bear will be killed (lethality).
- The features of grizzly bear habitat likely to govern grizzly bear death rates now and in the future are logically those that have a substantial effect on either frequency or lethality of contact between humans and grizzly bears.

Based on prior knowledge of human-bear interactions, possible factors for such an effect include (Fig. II-1):

- Frequency of encounter
  - Human-related factors
    1. Number of humans residing in the region
    2. Number of humans visiting the region (together determining to the number of people likely to be in grizzly bear habitat, contingent on the availability of access)
    3. Density of roads & trails (access)
    4. Characteristic activities of humans (affecting proclivities to use backcountry areas or be away from roads or trails)
    5. Juxtaposition of human facilities with habitat attractive to bears
    6. Presence of attractants near humans or human facilities
  - Bear-related factors
    7. Numbers of bears
    8. Proportions of bears of different sex, age, and reproductive classes
    9. Behavioral status of bears

- Lethality of encounter
  - Human-related factors
    1. Possession of an assembled firearm
    2. Engagement in a legal bear hunt
    3. Commodity value of bears or bear parts
    4. Levels of antagonism due to perceived opportunities or income lost to management promoting grizzly bear conservation
    5. Perceived value of live bears
    6. Knowledge of bear ecology and behavior
  - Bear-related factors
    7. Aggressiveness of the bear
    8. History of the individual bear

- Factors potentially interact, especially among those related to frequency and lethality of contact. For example, closure of roads to reduce frequency of contact may induce increased antagonism amongst certain humans and thus result in increased lethality. Increased frequency of contact between bears and humans due to increased bear populations may also result in an increased frequency of humans carrying firearms and resulting increased lethality of contact.
- These factors typically exhibit spatial structure and spatial interactions. For example, regions such as southeastern British Columbia may have high access densities but low levels of contact between bears and humans because of little human activity on those roads as a consequence of small local populations. A predominance of hunting-caused mortality also allows for regulation of lethality and the potential for relatively dense bear populations despite high levels of access.
- Specification of critical factors, interactions among factors, and their spatial structure could provide important information to decision processes. This specification can be partly conceptual and partly based on empirical models.

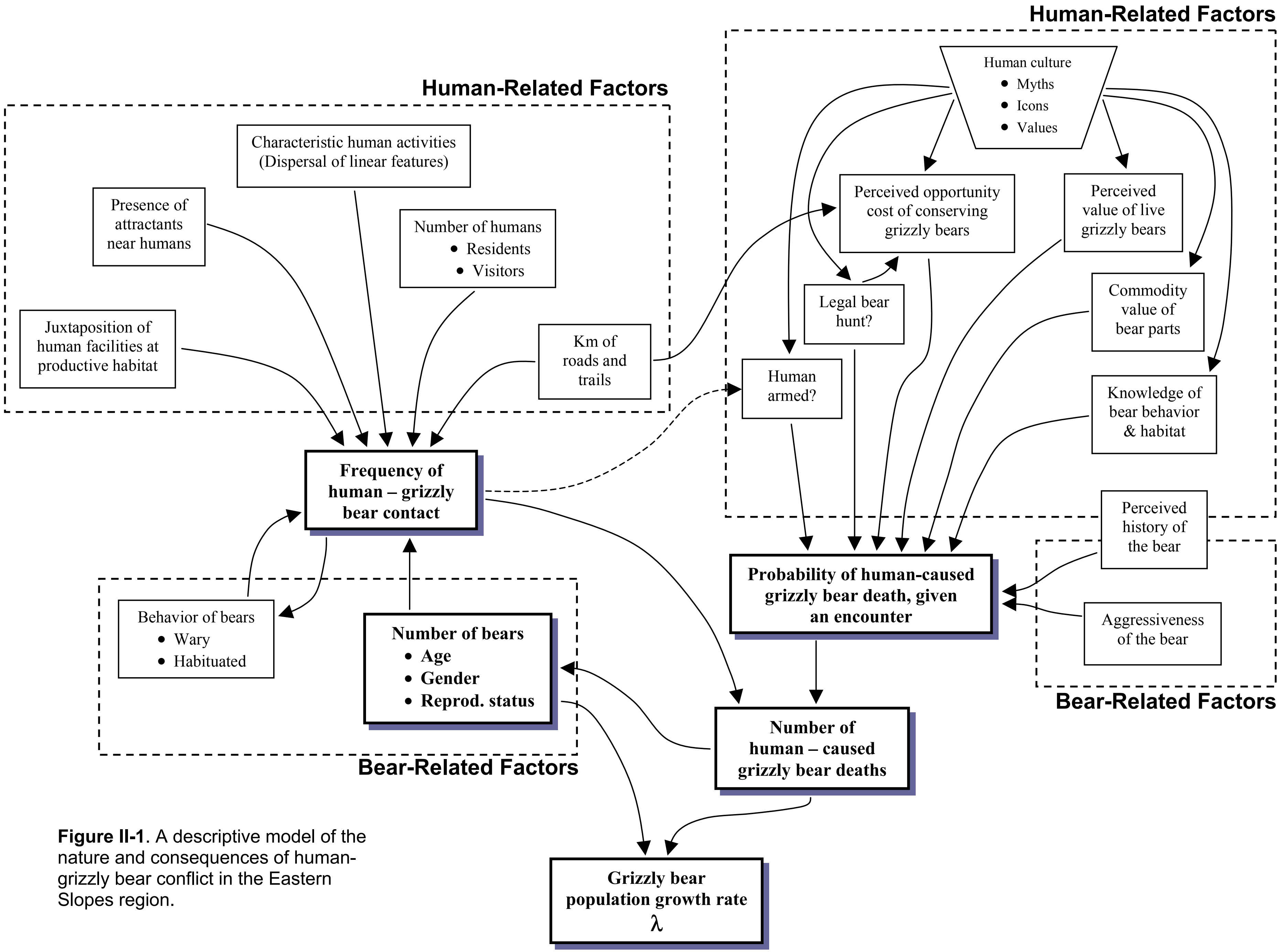

Figure II-1. A descriptive model of the nature and consequences of human-grizzly bear conflict in the Eastern Slopes region.

A modeling approach

General strategy

1. The model is fitted to existing patterns and the final form chosen on the basis of goodness-of-fit and information criteria (AIC_c).
2. Parameters will be adjusted to predict and explore the effects of future changes in grizzly bear range. For example, if the human population in the Bow River Valley grows substantially, does it matter whether this growth occurs in Canmore or Calgary?
3. Use maps of alternative "futures" to simulate changes in bear mortality over time with different development scenarios. This mortality function would be input into *VORTEX*

Response variables

1. Number of days bear is alive based on telemetry locations of radio-marked bears (modeled as probability) (T_a), stratified by gender and age class *a.*
2. Relative survival rate [$(T_a - D_a) / T_a$], where D_a is number of deaths stratified by gender and age class *a*.

Explanatory variables/data layers

1. Inverse distance-weighted number of humans potentially active in a grid cell (representative of the effect of human population size).
2. Density of access, distinguishing roads from trails.
3. Tassel-capped greenness (a surrogate for habitat productivity).
4. Jurisdiction (protected areas vs. not; areas with active hunting vs. not) (indicative of lethality).
5. Time period (by jurisdiction; associated with major changes in management such as closure of dumps, closure of bear hunting season or substantial reduction in hunting licenses) (indicative of lethality).
6. Year (as a surrogate for changes in road density and/or human population size over the 25 yr period of mortality data).
7. Elevation.

Generalizing the explanatory variables

- Using a moving or jumping window, average the value of each variable over a window-sized area for each pixel. The window size ideally is defined in terms relevant to the biology of the bear and related sampling processes. One possible window size would correspond to the average distance between aerial telemetry locations, stratified by season and sex and age class. This distance defines, in a probabilistic sense, the extent of the area "available" to the bear in the relocation interval. Window size would logically vary with variation in movements associated with bear densities, season, and habitat productivity. Thus window size might decrease in size from the drier east side of the system to the wetter west side.
- Average values for grid cells of the same size as the moving window, verified by recalculating values for grid shifted at standard intervals.

Calibration

Death rate can be calculated directly from the few deaths of radio-marked bears. Because of the small sample of deaths, this calculation may entail a model with only few explanatory variables. The results of the above-described model can be calibrated to the results of this analysis.

Biases and caveats

- Detectability of deaths may have varied by cause, jurisdiction, and time period.
- Number of deaths per telemetry location may not be closely related to death rate.
- Accuracy of digital data for human features varies within the study area.
- Road mileage and human population size changed over the period of time that mortality data were collected.
- Radio-telemetry data were not collected entirely contemporaneous with the mortality data.
- Habitat changes not accounted for by independent variables may have affected death rate.
- Telemetry data may not have been gathered from a representative sample of bears.

Input to *VORTEX*

- Time-specific death rate based on simulated landscapes

Security-Based Estimates of Population Risk

Background

- Security areas are a basic building block of grizzly bear habitat management.
- Security areas are defined as areas with the potential for producing food (i.e., excluding rock and ice) that are outside of zones of human influence.
- Theoretically, as the size of a security area declines relative to the area or space characteristically used by a bear to meet its life needs, risk of death caused by humans increases.
- Movements and associated use of space by bears vary with gender, reproductive status, productivity of habitat, and span of time (i.e., daily, seasonal, annual).
- Risk of death is thus predicted to vary, given the same suite of security areas, with the type of bear, the productivity of habitat, and the time frame considered.
- Given the same network of security areas, risk of death will also depend on the lethality of humans, which is predicted to vary with jurisdiction, human tolerance, and time-specific management regime.

A modeling approach

Response variables

Time- and unit area-specific number of deaths per identified inclusion of "secure" habitat i (d_{aij}), potentially stratified by type of death j.

Explanatory variables/data layers

1. Average movements of animal type *a* for specific time periods (day, season, yr.), distinguishing movements of animals in high productivity habitat from those in low productivity habitat.
2. Ratio (R_i) of the area of secure habitat in patch *i* (AP_i) to the area defined by a circle (AB_{at}) with diameter equal to the average linear distance moved by a bear of the associated class *a* during time period *t*. (an indicator of risk implicit to the size of secure area in a patch relative to the needs of a given type of animal over a specified period of time).
3. Management jurisdiction – protected area vs. not; hunted vs. not (a surrogate of lethality related to presence of firearms and characteristic activities of humans).
4. Management regime denoted by an indicator variable (0,1) corresponding to substantive changes in management over time within specific jurisdictions. (a surrogate for temporal change in lethality of contact as a function of changes in management).

Operational definition

Mortalities are ascribed to a given patch of secure habitat depending on whether a death occurred within the bounds of the associated area used by a bear. This hypothetical area would be ascribed to a patch by buffering the patch perimeter up or down to the area positively used by a bear, depending whether the bear area was greater than or less than the patch area. Number of mortalities would thus be tallied for each identified patch of secure habitat.

Stratification

1. By gender and age class *a*.
2. By periods of time (i.e., day, season, yr.) of length *t*.
3. By type of death *j*.

Model framework

- The primary relationship is between rate of death (d_{ai}) and the ratio of secure habitat to habitat "need" (R_i), with individual patches as the unit of observation. An analysis of covariance framework would allow for consideration of models that included the effects of jurisdiction, time period, and type of death.
- Goodness-of-fit could be used to judge the temporal and associated spatial scale (*t*) that explained best the rate at which bears were killed by humans.

Biases and caveats

- Detectability of deaths may have varied by cause, jurisdiction, and time period.
- Accuracy of digital data for human features varies within the study area.
- Road mileage and human population size changed over mortality data collection period.
- Habitat changes not accounted for by independent variables may have affected death rate.
- Rate of death as denoted for this analysis may not be highly related death rate directly calculated from fates of radio-marked bears.

Input to *VORTEX*

- Time-specific death rate based on simulated landscapes

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Section

3

Habitat and Distribution

Habitat and Distribution

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Kevin Van Tighem, Crown of the Continent Data Atlas
Onnie Byers, CBSG (Facilitator)

The objective of the Habitat and Distribution Working Group is to determine how to best incorporate habitat quality, effectiveness, supply, and distribution into a habitat-based population viability model. Essentially, we were tasked with deriving numbers for input to the *VORTEX* model from existing research results and habitat evaluation.

To that end, we:

- Defined terms and scale of assessment
- Analyzed existing information on the spatial distributions of animals over the landscape and broke it down into measures of population density, home range size and minimum daily movements relative to habitat, at the appropriate working scale.
- Developed a rational basis for linking existing mortality data to habitat based landscape evaluations.

Appropriate scale

Distribution of an individual's locations or movements – landscape scale (e.g.: Cascade River valley)
Distribution of individuals – Regional scale (e.g.: Central Rockies ecosystem)
Distribution of populations or subpopulations – Provincial scale

Some analysis requires and assumes a hierarchical link among scales.

Definitions

Patch – An unfragmented single occurrence of one habitat unit within a classification in any scale, thus the size and nature of a patch will change with scale.

Population – A number of individuals in the landscape without significant barriers to movement or interaction among them.

Habitat Quality – the potential of any given unit of landscape to produce grizzly bears. Female home ranges and population density are considered proxies of habitat quality at a regional scale. Average daily foraging distances are considered proxies of habitat quality at a landscape scale. Energetics are based on the broad diversity of alternatives (both food and habitat) – the more diversity the greater the productivity of an area and its resiliency to impacts.

Carrying Capacity – We assume that the current population represents the long-term carrying capacity of the existing habitat mosaic with the existing set of human influences. The *VORTEX* model works around a slightly higher carrying capacity since the model treats carrying capacity as the "ceiling" to which the population may climb during good years.

Suitability – Under optimal suitability, the population is assumed to climb to a level that reflects current carrying capacity plus an increment that reflects removal of all negative human impact (includes the combined effect of displacement and mortality risk). By removal of negative human impacts our group considered road closures and other realistic measures, not unrealistic measures such as dam removal or elimination of existing developments and dispositions.

Steps that increase Habitat Suitability by enhancing habitat effectiveness:

- Roads: Seasonal restrictions and limits on volume, frequency and speed limits, and distributing timing of motorized traffic
- Roads: obliteration of roads to road density thresholds (somewhere less than .4 and .6 km per km2 depending on habitat quality, quantity and distribution) – with extremely careful decisions about how to calculate road density.
- Seasonal closures of trails and/or limits on human user days (volumes, frequency and timing of trail traffic to avoid times or seasons when grizzlies normally forage in locally available habitats)
- Seasonal or complete closures of sub-drainages to provide core female security areas
- Limit new human settlement to poorer quality habitats, or direct it to areas outside occupied bear habitat.

Capability – Under optimal capability, the population is assumed to climb to a level that reflects current carrying capacity plus removal of all negative human impact, plus active management of the landscape to optimize its value to grizzly bears.

Steps that enhance Habitat Capability by enhancing habitat quality:

- Prescribed and natural (let-burn) fires in high-potential sites
- Target habitat enhancement on capable sites – smaller prescribed fire
- Trigger avalanche tracks
- Carcass redistribution – moving road-kills into grizzly foraging areas away from livestock herds and recreational developments
- Food planting on reclamation sites (use seeds of grizzly food plants like cow parsnip, hedysarum)
- Kokanee enhancement to replace lost salmon food sources
- Road or landing obliteration (or human settlements)
- Silviculture treatments that promote berry production (spacing, pruning)
- Designing harvesting systems to enhance security and provide foraging habitat

- Changes to livestock management (turn out times to avoid seasonal grizzly foraging, reallocating animal unit months to reduce forage competition, targeting low quality grizzly habitat for livestock production.)

Assumptions and qualifiers

We are basing the model on empirical data from disturbed systems where past human activities have had significant influence on bear numbers and the movements of individual bears?

We can derive measures of habitat quality, quantity and distribution from LANDSAT, vegetation inventories and other sources. Our challenge it to translate into effects on populations.

We assume that lakes, rock and other unusable habitats are discounted in calculations of habitat coverage, home range size and other values.

Elements we can derive from recent research and existing data: <u>carrying capacity, mortality, reproduction, habitat fragmentation</u>

Although it is relatively easy to get a measure of quality or quantity within a season but difficult to break it out into seasonal differences. E.g. Compare and contrast habitat values among seasons

Study area

For the purposes of our evaluation we considered the entire Central Rockies Ecosystem, including occupied grizzly habitat in the Bow and North Saskatchewan watersheds of Alberta and in B. C. from Clemenceau Icefield/Mica Reservoir south to Canal Flats, east of the Columbia River.

This area does not contain a closed population, so part of our task is to come up with a measure of connectivity to adjacent populations. Furthermore, this area is not consistent in terms of habitat quality. There is pronounced difference in quality (as indicated by grizzly population density) from the east to west of the Continental Divide and, within Alberta, between the Rocky Mountains and higher foothills regions and the lower foothills habitats further east:

West Side, north of Highway 1: 35 bears per 1000km2
West Side, south of Highway 1: 20 bears per 1000km2
(by comparison, the Flathead has 100 bears per 1000km2, adult female mortality rate = .04)

East Side: about 10 to 14 bears per 1000km2
much lower (not measured; estimated 2 per 1000 km2 north of the Bow River and east of the Forestry Trunk Road)

Influences of habitat quality on population parameters

From studies in the Flathead: the fruit component of bear habitat appears to drive productivity (breeding rate, success) when compared against spring foods. Spring foods appear to be superabundant and are more consistent from one year to the next than the berry component.

<u>Poor Habitat</u>: as berry crops diminish or as berry stands become sparser or more dispersed on the landscape, population effects include:

- Fewer cubs per litter
- Longer litter intervals
- Cubs staying longer with females
- Cub mortality higher because of:
  - ✓ higher encounter rate with other bears due to larger female home ranges
  - ✓ lower cub threshold weights
- Increased female mortality when food variety low because this drives females into habitats with higher probability of human encounter and, consequently, higher mortality risk

Carrying Capacity

Study site	**Current Density***	**Maximum carrying capacity****	**Suitability *****	**Capability ******
Glacier	30		40	60
Blue Water	45		50	60
Yoho/ Kootenay	10		12	20
Elk River	40		50	70
Flat head	80		80	90
East slopes	10-14		15-18	20-22
Northern EKT	10		10	10
Southern EKT	1		1	1
SW Alberta	15		20	40
East of continental divide	10 (268 bears)	375 bears	402	536
West of continental divide	20 (276 bears)	310 bears	322	497

* Current density (per 1000 km^2) based on study site information – includes cubs

** Carrying capacity (maximum possible in any given year, but not necessarily sustainable over several years, under current habitat and human influence conditions) is 1.4 X current estimate or 375 bears for east side). For the west, the carrying capacity 1.15 X 276 = 300). These values need to be validated through more analysis.

*** Suitability = current density minus all human impact (includes a combined effect of displacement and mortality risk)

**** Capability = current density minus all human impact plus effect of positive management actions

Mitigation
Locate trails, cottage developments, whatever, to avoid preferred habitat
(began separate list because above two were to recover lost values, this one is to make new developments as impact neutral as possible)

Habitat Effects on Mortality
At the small scale, (regional, subregional), no data – only at that the finer habitat resolution

Natural Fluctuations
Catastrophic effects – food crop failures, 2 results: mortality increase because of greater human contact during failure as bears search for alternative food sources, cub survivorship decrease because of poorer nutrition, and lack of implants leading to breeding synchronicity

Human Caused
Vulnerability caused by creation of open habitats (e.g. Clearcuts) – solution, visual screening (vegetative planting, no herbicide activity adjacent to roads, no silviculture

Must also introduce the attractiveness vs. repulsion concept (within home ranges) – solution: locate roads away from good habitat (because moralities higher in higher quality habitats)

Habitat Enhancement list – see above, management to improve distribution of habitat, improve quality could reduce mortality – bears may be attracted AWAY from mortality sources

Habitat Effectiveness recovery list – anything that reduces human access (roads or recreation or settlement) that reduces both the rate of human/bear encounters or reduce the lethality of that contact

The most quantitative datasets relating mortality and access are based on road densities. These data are slow to collect and may not be easily extrapolated.

In areas where females relegated to poorer quality habitats because of habitat segregation, roads through poorer quality habitats MAY be just as significant as roads through high quality habitat

Survivorship
Baseline Pooled Value (from B. McLellan's mortality paper, and B. Benn's 1998 thesis)

	East	West
Adult female	0.9	0.95
Adult male	0.89	0.84*
Subadult female	0.95	0.93
Subadult male	0.74	0.91
Cubs of the year	0.72	≥0.72?

* Related to hunting

Editor's note regarding survivorship: The two sets of data presented above were updated subsequent to this PHVA Workshop Benn (pers. comm.) analyzed ESGBP data from 1993 – 1998, and McLellan et al. (1999) analyzed data from all studies conducted between 1975 and 1977 in and around the Rocky Mountain National Parks of Banff, Jasper, Kootenay, Waterton and Yoho. These updated survival rates are presented below.

	Benn	McLellan et al.
Adult female	0.99	0.90
Adult male	0.87	0.89
Subadult female	0.89	0.95
Subadult male	0.68	0.74
Cubs of the year	0.72	—

Summary of Eastern Slopes mortality factors

Grizzly bears on the eastern slopes were believed to be more exposed to possible mortality risk because of greater habitat fragmentation, higher road densities (resulting in higher encounter rates), higher lethal encounter rates *and* lower-quality habitats resulting in larger home ranges, thereby exposing bears to more frequent opportunities for contact with humans.

Scenarios

A - Road through the Kananaskis Park
B – Resort Development

Goal of this exercise – to use the thinking on carrying capacity estimates we came up with earlier and apply them to a realistic development scenario.

DAY THREE

Start today with a discussion of the linkage between habitat mapping classes and population density. The mapping available for this exercise is a five-class greenness map derived from satellite imagery. Preliminary relationships between radio-telemetry locations and greenness classes are shown to be positive. Using these methods the carrying capacities can be made more specific. We have identified 2 major habitat barriers: the continental divide and the Trans-Canada highway. The north and south borders of the study area are defined as: Saskatchewan River (Alberta) and the height of land north of Bush Arm (BC) to Old Man River (Alberta) and Columbia Trench (BC) respectively.

Then determined permeability classes, and rates of immigration and emigration across the internal and peripheral boundaries of each of the 4 areas (NW, NE, SW, SE). Classes of permeability to grizzlies identified as: 1=high, 2=medium, 3=low, 4=nil. These classes of permeability were illustrated on a map. In cases where permeability is classified as High, it is recognized that the filter is across the valley bottoms not heights of land. No distinction was made between human caused and natural barriers or filters.

In this generalized class I, if resolve permeability at a finer map scale, you get areas of increased and decreased permeability but this is not appropriate scale for the model.

If any permeability is possible, this permeability is density dependent. Permeability and density are positively correlated.

Then an attempt was made to determine bear densities as a function of habitat quality and security.

Population density (numbers of individuals/1000 km^2) and home range characteristics as a reflection of habitat quality (as scaled by greenness maps).

Habitat quality Class	Greenness	Bear density/ 1000 km^2 (Suitability density)	Pre berry adult female home range* size (km^2)	During / post berry adult female home range size (km^2)	Pre berry adult female average daily movement ** (km^2)	During /post berry adult female average Daily movement ** (km^2)
1	.76-1.00	30-40	10	20	0.1	0.2
2	.51-.75	20-30	50	100	0.75	1.0
3	.375-.50	15-20	90	180	1.5	2.0
4	.26-.375	10-15	130	260	2.0	2.5
5	.13-.25	5-10	170	340	2.7	3.3
6	.025-.125	1-5	210	420	3.3	4
7	.001-.025	0-1	250	500	4.0	4.7
8	0	0	-	-	-	-

* Home ranges are multi-year ranges during worst berry years; pre-berry range = ¼ total annual home range and during/post berry range is ½ total annual range. Total ranges has 1/3 overlap between pre berry and during/post berry seasonal ranges. Home range figures based on actual Eastern Slopes Grizzly Bear Project home ranges which range from 35sq km in the best habitat (just west of the Continental Divide) to 1000 km sq. in the worst habitat (in the eastern portion of Kananaskis Country).

** Daily movement distances are derived from data from individual bears tracked by the ESGBP. Mean movement areas for each bear were linked to the habitat quality class with which that bear was most strongly associated. These formed reference points within the table, and distances in habitat quality classes for which reference bears did not exist were derived by averaging between data-based values. Pre-berry and during/post-berry movement data were not broken out in Gibeau's summary, so they were derived by adjusting season-long means as with home ranges.

The sequences of classes are not distinct. For any one BMU, the density would be the sum of densities assigned to the various classes.

Estimated population characteristics of 4 quadrants in the CRE (north and south of Hwy 1 and east and west of the continental divide).

	NE	NW	SE	SW
Area km2	21,000	4100	6600	9500
Current density /1000 km2	5.24	20	10	20
Total population	110	83	65	193
Carrying capacity	154	97	91	232

Strategies

We've been a resource group (focused on evaluating the current landscape) more than a management-focused group (dealing with impacts of human activities) and our recommendations reflect this. Our group identified and prioritized the following recommendations using paired ranking based on these following criteria:

- Most likely to reduce mortality risk
- Most likely to improve grizzly bear habitat
- Most likely to keep the CRE grizzly bear population open (i.e. connected internally and externally)

(Other criteria considered but not included in the pair ranking exercise were: doability-technically feasible, cost, likelihood of public support/consent, temporal need – first things first, and earliest payback).

Overall Recommendation

We have developed tools to identify where high quality or potential quality habitat overlaps with secure or insecure areas. There is now an immediate need to validate and refine the VORTEX model input values based on existing and new data. This is a foundational need that must be implemented before proceeding with the following recommendations. Specifically, this requires that we establish and fund a technical group to validate, and incorporate into a revised PHVA model:

- Habitat quality polygons (ground-truth LANDSAT greenness polygons)
- Linkage zones
- Population density, home range size and other values by habitat class

These tools should then be used to determine where conservation efforts should be focused when implementing the following specific strategies (listed in priority order):

1. Implement seasonal recreation and/or road closures in areas that have high habitat quality (e.g.: avalanche complexes in pre-berry season; high-berry production habitats in berry and post-berry season).
2. Maintain an open population/landscape to minimize extinction risk – linkages are vital. Dispersal linkages must be of quality so that animals will use them. Areas of suitable habitat should be provided to allow dispersal. Management efforts should address maintenance or restoration of high quality linkages so that grizzlies will occupy these areas by choice. We predict that this would increase likelihood of crossing. Grizzlies cross the TCH in Glacier NP where avalanche slopes extend to the valley floor, but in the lodgepole pine forested Banff Bow Valley they do not cross the TCH – likely a factor not only of traffic volumes but also of habitat quality.

Actions:

1.1. Monitor use of man-made linkages across the Trans Canada Highway. If a minimum of five female grizzlies do not cross the highway during the next two years, then:

- provide additional large underpasses
- expand size of overpasses
- implement active management to enhance habitat quality (foraging habitat) and security on each side of the TCH

Responsible parties:

- Tony Clevenger - Banff National Park – monitor ESGPB, Parks Canada, WWF, lobby for changes
- Funding from Parks Canada and Transportation Canada for continuation of monitoring funding.

1.2 Identify where priority linkages are needed in the Central Rockies Ecosystem

Responsible parties:

- ESGBP

1.3 Manage existing and new linkages to enhance both habitat quality (foraging habitat) and habitat security.

Responsible parties:

- Individual land management agencies associated with each priority area

2. Locate/relocate roads and trails in lower quality habitat

3. Optimize/restore amount of secure habitat. Implement management actions to increase habitat effectiveness, especially in higher quality habitats; at a minimum, maintain habitat effectiveness region-wide.

4. Based on current knowledge implement management actions to achieve a minimum of 60% habitat security in areas where we want to maintain females within their home ranges.

5. Prioritize conservation efforts (e.g.: restoration of security) on high quality habitats

6. Secure existing areas that currently have high habitat effectiveness by eliminating future development of roads or modification of habitat (=protected areas)

7 Document a minimum of five crossings of the fenced portion of the TCH within the next two years. Failing this, implement active measures to increase secure crossing areas and enhance habitat quality.

8. Create administrative flexibility to meet habitat goals by renegotiating existing leases and tenures.

9. Each jurisdiction should identify explicit measurable goals for habitat effectiveness and habitat quality in resource and land use plans.

Actions steps, timelines, resources needed, and responsible parties where specified for the three top priority strategies.

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

4

Population Modeling

Population Modeling

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Introduction

The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving the grizzly bear in south central Alberta and eastern British Columbia (known collectively as The Central Rockies Ecosystem, or CRE). *VORTEX*, a simulation software package written for population viability analysis, was used as a tool to study the interaction of a number of life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of a suite of possible management scenarios.

The *VORTEX* package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by stepping through the series of events that describe the typical life cycles of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters used as input to the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the winged mapleleaf mussel, the environmental conditions affecting the species, and possible future changes in these conditions.

For more information on the capabilities and use of *VORTEX*, see Miller and Lacy (1999).

Input parameters for simulations

Time Scale: A simulation duration of 100 years was agreed to be appropriate for this species. Less than 100 years has been demonstrated to give inadequate long-term population trends, while simulating a population for more than 100 years incorporates higher levels of uncertainty into the assumptions. (Even 100 years may have a significant amount of associated uncertainty.) One hundred years is the most common time frame used by many people when they develop population models. *VORTEX* also provides intermediates reports at e.g., 3, 5, 10 etc. year intervals. Ten years is the interval being used for this exercise.

Metapopulation Structure: The group reached a consensus that the scale of analysis should focus on the Central Rockies Ecosystem, or CRE. This region encompasses Kananaskis Country, Banff / Yoho / Kootenay National Parks, and some surrounding provincial Forest lands in both Alberta and British Columbia. The region is roughly dissected east-west by the Continental Divide, and north-south by the Trans-Canada Highway. Consequently, a grizzly bear metapopulation is envisioned that is composed of four populations or "patches" that exchange individuals through dispersal with variable frequency.

For the purposes of this simulation exercise, we focused our attention on subadult individuals (ages 4 through 6) as the primary dispersers, with no additional dispersal mortality imposed. Information on initial population size, local carrying capacity and between-population annual dispersal rates were assembled to build the metapopulation. In addition, we recognized that the external boundaries of the CRE were not absolute with respect to the movement of bears across them. We therefore developed estimates of in- and out-migration of individuals for each of the four populations in order to simulate the movement of individuals into and out of the region. This was best simulated in *Vortex* as "harvest" and "supplementation" of bears from each population. Demographic parameters are equivalent across populations unless stipulated below. Figure IV-1 below shows a simple representation of our metapopulation.

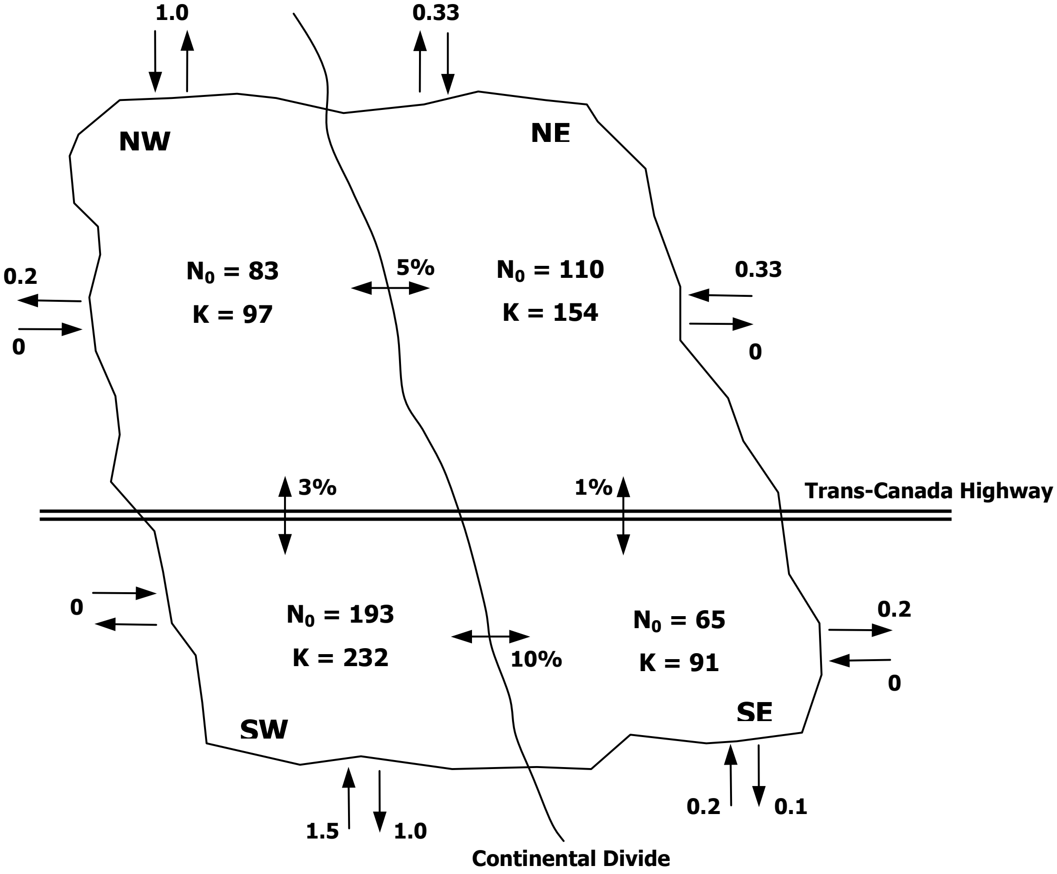


Figure IV-1. Graphical representation of the Central Rockies Ecosystem (CRE) grizzly bear metapopulation. Double-headed arrows indicate annual rates of dispersal between populations, while single-headed arrows give annual estimates of in-flow and out-flow of individuals across the artificial boundaries of the CRE. Initial population sizes (N_0) and carrying capacities (K) are also provided for each population.

Definition of Extinction: Traditionally, *VORTEX* defines extinction as the time at which the population consists of only one sex. However, some population biologists argue it should be considered to occur when the population drops below a number of animals from which the population cannot recover (this is sometimes referred to as *quasi-extinction*). Is it 10 bears? 25 bears? 50 bears? The group agreed to set a quasi-extinction level at ten animals for each subpopulation designated in Figure IV-1, while the overall CRE "extinction" risk was defined as any risk of a decline in population size below the current number of animals. This was chosen because current management policies throughout the CRE specify maintaining current grizzly bear population numbers.

Inbreeding Depression: Do we want to assume a detrimental impact on fitness resulting from inbreeding? The more conservative approach would be to assume that inbreeding does in fact impact demographic rates. Inbreeding depression has been observed in a large number of captive mammal populations (Ralls et al. 1988) and has specifically been shown to impact brown bears in Scandinavia (Laikre et al. 1996). The model by default assumes that inbreeding depression does not act to reduce fitness. However, in the CRE population, we know that there is a high degree of relatedness among individuals (same mitochondrial DNA tracing back to a single female.) This parameter may not lead to a large impact on the simulation results because if a population is highly inbred it is usually already in trouble due to other demographic factors. The median number of lethal equivalents among 40 captive mammal populations in the study of Ralls et al. (1988) is 3.14. This value was used in our baseline models. To assess the sensitivity of our simulated population to the severity of inbreeding depression, we developed an alternative set of models in which the number of lethal equivalents was set at either 1.0 or 6.0. This range was expected to encompass our best guess of the severity of inbreeding depression among Eastern Slopes grizzly bear populations.

Variation in Mortality Uncoupled from Variability in Survival/Fecundity: Are mortality and survival coupled? Both are dependent on berry crop production. One approach would be to look at data on observed mortality and fecundity compared to berry production. In the year following a strong berry crop, there will be a "good crop" of bears that year. If the subsequent year sees a berry failure, the problems associated with it will be magnified because of the higher number of bears on the landscape. It is likely that they are decoupled, but again this is not a major parameter in the model.

Catastrophic Events: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. For some species, hurricanes, floods, volcanoes, etc. could wipe out a large part of a population in one year. These events are modeled in *VORTEX* by assigning a probability of occurrence and a severity factor ranging from 0.0 (maximum or absolute effect) to 1.0 (no effect). It is likely that this kind of process is not common for grizzly bears in the Central Rockies Ecosystem. It is mostly human caused factors that lead to mortality, rather than environmental catastrophes.

Mike Gibeau estimates there is one major berry crop failure per decade. During (or immediately after) such an event, we assume (based on field observations) that there will be a complete failure among adult females to produce cubs. For the purposes of demographic sensitivity analysis, we ran alternative models in which the frequency of this event was changed to never or once every four years.

In addition, there may also be a wider dispersal of bears, more frequent contact with humans, and greater problem bear mortalities or removals when a berry crop fails. While this is very hard to quantify, we assume for the purposes of sensitivity modeling that this type of an event occurs much less frequently, i.e., on the order of once every 100 years. During this type of berry crop failure, we assume that 50% of the population does not survive; in other words, the survivorship of each age-sex class is reduce by 50% in a catastrophe year. For the purposes of demographic sensitivity analysis, we ran additional alternative models in which the frequency of this event was changed to never or once every fifty years.

Breeding System: Polygynous.

Age of First Reproduction: *VORTEX* precisely defines breeding as the age at which offspring are born, not simply the age of sexual maturity. In addition, the program uses the mean (or median) age rather than the earliest recorded age of offspring production. Female breeding age seems to be fairly well established at 6 years for the system. However, there is less certainty about the age of first breeding among males. Lance Craighead's data show that some females can carry litters with different cubs sired by different males. It was "guesstimated" that the age of first breeding in males is 8 years. A sensitively analysis could be undertaken to evaluate uncertainty in this parameter.

Age of Reproductive Senescence: *VORTEX* assumes that animals can breed (at the normal rate) throughout their adult life. The age of reproductive senescence for grizzly bears in the Central Rockies Ecosystem is conservatively estimated to be 20 years.

Sex Ratio at Birth: There are no data to suggest anything other than an equal sex ratio among newborn cubs.

Maximum Number of Offspring: Bears with 4 cubs have been recorded in the Rockies. However, this is extremely unlikely, and 3 cubs is a more realistic maximum value.

Density-Dependent Reproduction: This is unknown for bears. In some species reproduction shuts down at low populations numbers, while in others there is a compensatory increase in productivity. Moreover, as we are focusing our attention on the dynamics of small populations, we are less concerned about the intricacies of density-dependence that commonly act as a population approaches carrying capacity. While there is some data on density dependence for black bears, we did not incorporate this process into our risk assessment models.

Offspring Production: Field data from five years of observations on radio-collared bears provided by Mike Gibeau indicated that, on average, 27% of adult females will breed in a given year. The total variance (standard deviation) calculated from these five years of data was 17.9%. However, some proportion of this variance was likely due to sampling error as only five years of data were available to estimate long-term demographic rates. Using standard statistical methods, we calculated that the standard deviation that could be attributable to environmental variability (of most direct interest from the standpoint of stochastic modeling) was 13.6%.

Cub production in grizzly bears pulses because of variability in food crops, which affects implantation or reabsorption of fetuses. The range of annual reproductive rate (# female cubs born annually) is .42 to .23 based on four Grizzly Bear studies. The confidence limits for percent females breeding each year was calculated to be 22% to 32%. This range was used in the demographic sensitivity analysis that can be found later in this report.

Gibeau has calculated the following distribution of grizzly bear cub litter size from his field data:

# Cubs	Frequency
1	26.3 %
2	52.6
3	21.1

Once again, this distribution is based on a small sample; a total of N=19 females having 37 cubs form the basis of the estimated distribution. The mean litter size calculated from this distribution is 1.9 cubs. These results are similar to a Berland River study in the foothills of Alberta and Dick Russell's work in Jasper (also a small sample size (N=18) with only three years of data).

<u>Mortality</u>: The following mortality schedule is based on published scientific literature. In addition, it is important to note that the group assumed the overall mortality rates on the western side of the Continental Divide to be just 50% of those on the eastern side of the Divide. This is the lowest possible mortality rate estimate (based on the highest population estimate) one might assume for the West Slope. If the mortality rate were higher, population decline would occur sooner and proceed at a more rapid pace. We tabulated mortality for both subsets of the population in the table below. The overall mortality rate for adult females over the five years of the study was 12%, or 2.4% per year.

	Mortality (%) Eastern (Western)	
Age Class	Males	Females
0-1	24.0 (12.0)	24.0 (12.0)
1-2	20.0 (10.0)	20.0 (10.0)
2-3	5.0 (2.5)	5.0 (2.5)
3-4	32.6 (16.3)	11.4 (5.7)
4-5	32.6 (16.3)	11.4 (5.7)
5-6	32.6 (16.3)	11.4 (5.7)
6-7	32.6 (16.3)	2.4 (1.2)
7-8	32.6 (16.3)	2.4 (1.2)
8-	13.2 (6.6)	2.4 (1.2)

To investigate the impact of different rates of adult female mortality on grizzly bear population dynamics, we ran a series of models in which this variable was set at 4.0%, 6.0%, or 10.1% in addition to the baseline value of 2.4%. Additional preliminary models were also run with this mortality set at the minimum level of 0.1% based on expectations from field data. The maximum value is derived from field studies on other populations in the Rocky Mountains. For example, McLellan et al. (1999) analyzed radiotelemetry data collected during the period 1975-1997 from all grizzly bear studies conducted in and around the Rocky Mountain National Parks of Banff, Jasper, Kootenay, Waterton and Yoho. They reported an annual adult female mortality rate of 10%, while adult male annual mortality rates were estimated to be 11%.

Effects of Human Population Growth on Adult Female Grizzly Bear Mortality: In addition to the standard mortality scenarios, the group developed a set of models in which the mortality of adult females was influenced by the rate of human population growth in the CRE. Recent estimates project a 4% annual rate of human population growth in and around the Banff NP / Kananaskis Country area over approximately the next ten years. It is thought that this increase in population density will have an adverse impact on grizzly bear populations if mitigation measures are not taken. Workshop participants devised three alternative scenarios to investigate this phenomenon:

A) A direct relationship between the rate of increase in the local human population and the rate of increase in grizzly bear mortality. Under this scenario, adult female grizzly bear mortality will also increase at a rate of 4% per year for years 1-10 of the simulation.
B) Moderate mitigation efforts lead to a reduced impact on adult female mortality. Under this scenario, adult female grizzly bear mortality will also increase at a rate of 2% per year for years 1-10 of the simulation.
C) Aggressive mitigation efforts actually lead to a *decrease* in adult female grizzly bear mortality despite the increased human population. Under this scenario, adult female grizzly bear mortality will *increase* at a rate of 2% per year for years 1-10 of the simulation.

The amount of annual variation (as measured by the standard deviation in the mean rates tabulated above) in mortality due to environmental variability is dependent on food availability, berry crop failures, etc. The best expert "guesstimate" was that in each age class the SD is one-half the mortality rate, e.g., 12% in year one, 10% in year two, 2.5% in year 3, etc. For the purposes of demographic sensitivity analysis, we ran additional models in which the standard deviation in mortality rates attributable to environmental variability was set at either 25% or 75% of the mean rates.

Adult Male Breeding Pool: Gibeau expects that only a small percentage of adult males are breeding in any given year. We therefore set this parameter at 25% (both available to breed and actually breeding) for all simulations.

Initial Population Size: See Figure IV-1 for detailed information on current population sizes for each population making up the CRE metapopulation. This information was compiled and presented by the working group on grizzly bear habitat and distribution; see their working group report for additional information.

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed across all age classes in order to return the population to the value set for K.

For the purposes of demographic sensitivity analysis, we developed a set of models in which the carrying capacity was somewhat arbitrarily set at 250, 375, or 500. See Figure 1 for detailed information on estimated carrying capacities for each population making up the CRE metapopulation in our risk assessment models. This information was compiled and presented by the working group on grizzly bear habitat and distribution; see their working group report for additional information.

Number of Iterations: All scenarios have been simulated 500 times. All models were developed using *Vortex* version 8.11 (December 1998).

Results from simulation modeling

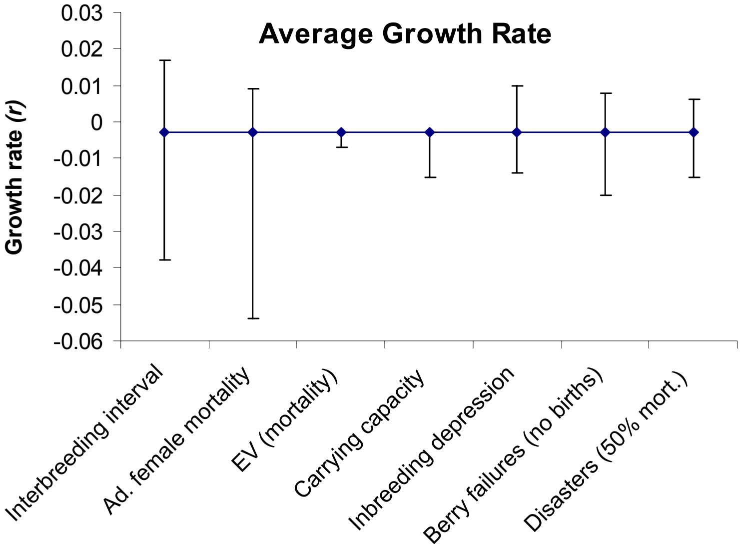
Demographic Sensitivity Analysis

Several participants at this workshop expressed concern at the number of "guessed" parameters used as input to *Vortex*, and/or a desire to explore the importance of "uncertainty" in our knowledge of grizzly bear biology on the Eastern Slopes, and in the Central Rockies Ecosystem. To deal with this issue (at least partially), we set up a table with upper and lower bounds for each parameter input into *Vortex*, based on formal confidence limits for parameter estimates when possible, and otherwise on Mike Gibeau's expertise regarding the range of values that could potentially be plausible for the Eastern Slope of the Rocky Mountains (see table below).

Model Parameter	Minimum	Best Estimate	Maximum
% Females breeding (interbreeding interval)	22.0	27.0	32.0
Adult female mortality (%)	0.1	2.4	10.1
% EV (Adult female mortality)*	25.0	50.0	75.0
Carrying capacity	250	375	500
# Lethal equivalents	1.0	3.14	6.0
Catastrophe frequency (no cubs)	0.0	0.10	0.25
Catastrophes frequency (50% mortality)	0.0	0.01	0.02

*EV expressed as coefficient of variation, i.e., (standard deviation) / (mean).

To explore the potential significance of this uncertainty, we ran a set of simulations in *Vortex*. For these simulations, we chose seven of the most uncertain *Vortex* parameters. Two of these parameters (percentage of adult females breeding and adult female mortality) are controversial because they appear to be very different in the Eastern Slopes region than in other areas in the Central Rockies Ecosystem; here, bears survive longer but breed less frequently than in other areas. Three additional parameters requiring educated guesses for the system: annual stochastic variance in mortality, the severity of inbreeding depression, and the maximum number of bears that could potentially be supported by an ecosystem at equilibrium (i.e., carrying capacity, *K*). Finally, we spent a considerable amount of time debating whether there might be a substantial effect of including occasional catastrophic events, particularly the effects of berry crop failure (which M. Gibeau thought might substantially decrease fecundity), and very infrequent severe increases in mortality (such as 50% mortality of bears feeding at garbage dumps in Yellowstone, in the year after dumps were closed).



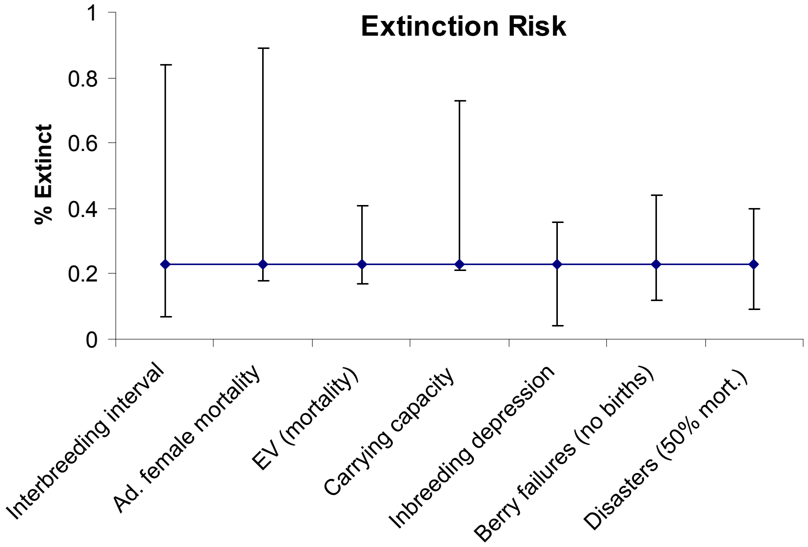


Figure IV-2. Demographic sensitivity analysis for simulated Eastern Slopes grizzly bear populations. Stochastic population growth rate (top) and extinction risk (bottom) under alternative demographic parameters. See text for additional information on parameter values.

For each of these parameters, we ran two simulations in *Vortex*, with a given parameter set at the prescribed minimum and maximum values, with all other parameters remaining at their best estimates. We then compared how our uncertainty in each parameter translated into uncertainty in the probability of extinction of an isolated population of 200 bears, and the average growth rate of these populations. This “thought exercise’ tells us both how confident we can be in our point estimates of Vortex output parameters, and which parameters are most important to study more to increase the precision of our population projections.

We found that our predictions depend most heavily on two demographic parameters: the percentage of adult females breeding and the level of adult female mortality (Figure IV-2). Interestingly, female breeding success was one of the most important parameters we need to *improve* our understanding of, even though it is also one of the better-estimated parameters. This is most likely because small differences in breeding rate (3 to 5 years) can almost double the net lifetime reproduction for bears. There were also some differences between the importance of each parameter, depending on whether average population growth rates or extinction probability were used as surrogates of risk. This is because increases in variance among replicate simulations increase extinction probability but not necessarily average trend.

After these simulations were run, participants at the workshop agreed that the best index of risk for this species was probability of decline from the starting density of grizzly bears in the region. Because this is also a probabilistic risk (which would increase with increasing variance), the extinction probability analysis is more relevant to our interests.

This type of sensitivity analysis has several limitations. The primary one is that much of the interpretation depends on the assumptions implicit in our stochastic simulation model. Second, our confidence limits were based primarily on the expert opinions of workshop participants; we may have under- or over-estimated our certainty about particular population parameters.

CRE Metapopulation Risk Assessment

Based in large part on the information obtained from the demographic sensitivity analysis presented above, the group decided to focus on assessing the effects of measurement uncertainty in the following demographic parameters during our metapopulation risk analysis:

Female breeding success (% Breeding) – the mean percent of adult females producing cubs each year.

Adult female mortality (%AF Mortality) – the mean annual percent mortality of adult females. See text for values used for mortality of other age and sex class. (Note: %eAF mortality is the mortality in the eastern side of the CRE. In these scenarios, the mortality on the western side was modeled at half the rate of the eastern side.)

Severity of inbreeding depression (Lethal equivalents) -- a measure of the effects of inbreeding on first year survival of inbred cubs. The number of lethal equivalents is the number of recessive lethal alleles per individual which would cause the observed effects of inbreeding. The median value for lethal equivalents observed in a survey of 40 captive mammalian populations was 3.14 (Ralls et al. 1988).

Human-induced mortality changes (% change in mortality) – an annual increase or decrease in bear mortality, projected over the first 10 years of a given simulation, resulting from changes in human population growth and interactions with bears.

The tables that follow present the numerical results from the risk assessment models developed during this workshop. The results are described in terms of the following:

Pop. Growth r	Deterministic population growth rate r_d, calculated from mean birth and death rates, without consideration of the effects of stochastic (random) fluctuations and other effects of small population size. The exponential growth rate, r, is approximately the mean annual proportional change in population size. E.g., r = 0.03 indicates average population growth of about 3% per year.
Stoch r	Mean stochastic population growth r_s in the stochastic simulations, calculated prior to any carrying capacity truncation, and averaged across years. The population growth rate in the simulations will be depressed relative to the calculated deterministic projection because of a variety of stochastic processes, such as random fluctuations in breeding, survival, and sex ratio, and possibly inbreeding depression.

SD(stoch r)	Standard deviation in the stochastic growth rate across simulated populations and across years. Larger SD(stoch r) indicates a less stable population, with more variation in size from year to year. In about 68% of the years, the value of r will fall within 1 SD of the mean.
N_{100}	Mean size of the simulated populations at year 100.
SD(N)	Standard deviation in the population size at year 100 across simulated populations. SD(N) is a measure of the predictability of the final population size. Larger SD(N) relative to N indicates that the final population size of any given simulated (or real) population may deviate considerably from the mean simulation result.
P[decl]	The probability of the CRE population declining (i.e., below initial size at year 100). The management goal for Grizzly Bears in the national parks, British Columbia and Alberta is to maintain or grow the population. Thus, P[decl] indicates the probability that a scenario will meet this goal.
P[below 10]	The probability of each of the four subpopulations being below 10 bears at 100 years. Below N = 10, a population might be considered locally extirpated or functionally extinct from that portion of the ecosystem.

Table IV-1. Deterministic population growth rate (r_d) for grizzly bears on the eastern and western sides of the Central Rockies Ecosystem, calculated from mean demographic rates for varying rates of fecundity and mortality.

% Breeding	%AF Mortality		Population growth (*r*)	
	Eastern	Western	Eastern	Western
32	2.4	1.2	0.038	0.044
	4.0	2.0	0.030	0.040
	6.0	3.0	0.020	0.035
	10.1	5.05	-0.001	0.025
27	2.4	1.2	0.024	0.030
	4.0	2.0	0.016	0.026
	6.0	3.0	0.005	0.021
	10.1	5.05	-0.016	0.011
22	2.4	1.2	0.007	0.014
	4.0	2.0	-0.001	0.009
	6.0	3.0	-0.012	0.004
	10.1	5.05	-0.034	-0.007

Baseline CRE metapopulation model: The baseline CRE grizzly bear metapopulation model, incorporating the group's best estimates for each of the demographic input parameters, shows the capacity for long-term population growth at an annual rate of about 2.4% (3.0% on the western side of the metapopulation) in the absence of random variation in birth and death rates (Table IV-1, middle). However, calculation of population growth rates from average birth and death rates in a life table will overestimate long-term population growth if there are fluctuations in demographic parameters, even if they arise solely from random sampling variation. Inclusion of these random forces in the modeling process results in stochastic growth rates that are nearly always lower than the deterministic growth rates. This is evident in Table IV-2, where the baseline model has a stochastic growth rate of 1.6%. The stochastic fluctuations included in our simulation model yield a reduction in the stochastic growth rate of 33% from the more simple deterministic calculation.

Table IV-2. Projections for the Central Rockies Ecosystem grizzly bear metapopulation under varying possible rates of fecundity and mortality. Severity of inbreeding depression set at 3.14 lethal equivalents.

Input parameters			**Simulation results**								
%	%eAF							P[below 10]			
Breeding	Mortality		stoch r	SD(r)	N_{100}	SD(N)	P[decl]	NE	SE	NW	SW
32	2.4		0.030	0.079	436	58	58	0	0	0	0
	4.0		0.024	0.080	405	61	77	0	0	0	0
	6.0		0.017	0.082	355	74	91	0	0	0	0
	10.1		0.001	0.088	222	82	100	3	8	0	0
27	2.4		0.017	0.079	361	65	93	0	0	0	0
	4.0		0.009	0.082	305	76	98	0	2	0	0
	6.0		0.001	0.085	229	81	100	1	6	0	0
	10.1		-0.012	0.094	111	45	100	16	37	0	4
22	2.4		-0.001	0.083	218	77	100	1	4	0	0
	4.0		-0.006	0.087	160	63	100	4	15	0	1
	6.0		-0.012	0.091	109	44	100	10	34	0	3
	10.1		-0.018	0.101	66	19	100	39	70	2	11

Effects of female fecundity and adult female mortality: As may be expected from the earlier demographic sensitivity analysis results, a reduction in female fecundity (percentage of successfully breeding adult females per year) leads to reduced deterministic and stochastic population growth rates (Tables IV-1 and IV-2). As the rate of stochastic population growth decreases, the final population size after 100 years of the simulation also decreases which naturally also translates into an increased probability of population decline below the current size. An even more pronounced effect on population dynamics is seen when the annual adult female mortality rate is increased from the baseline level of 2.4% to 10.1%. Only under the most optimistic estimate of female fecundity do stochastic population growth rates remain positive under all possible mortality estimates. When fecundity is 27% or 22%, higher adult female mortality rates lead to a switch in population growth rates from positive to negative, significant reductions in final mean population sizes after 100 years, and a 100% chance of population decline below current numbers. Moreover, at these same fecundity levels, the eastern populations show a considerably greater risk of dropping below 10 individuals by the end of the simulation period (Table IV-2, rightmost columns). This is determined largely by the higher mortality levels thought to be occurring on this side of the Continental Divide. These models demonstrate that the estimated rates of both dispersal between and movement into these populations is insufficient to maintain demographic stability.

These results are summarized graphically in Figures IV-3 and IV-4.

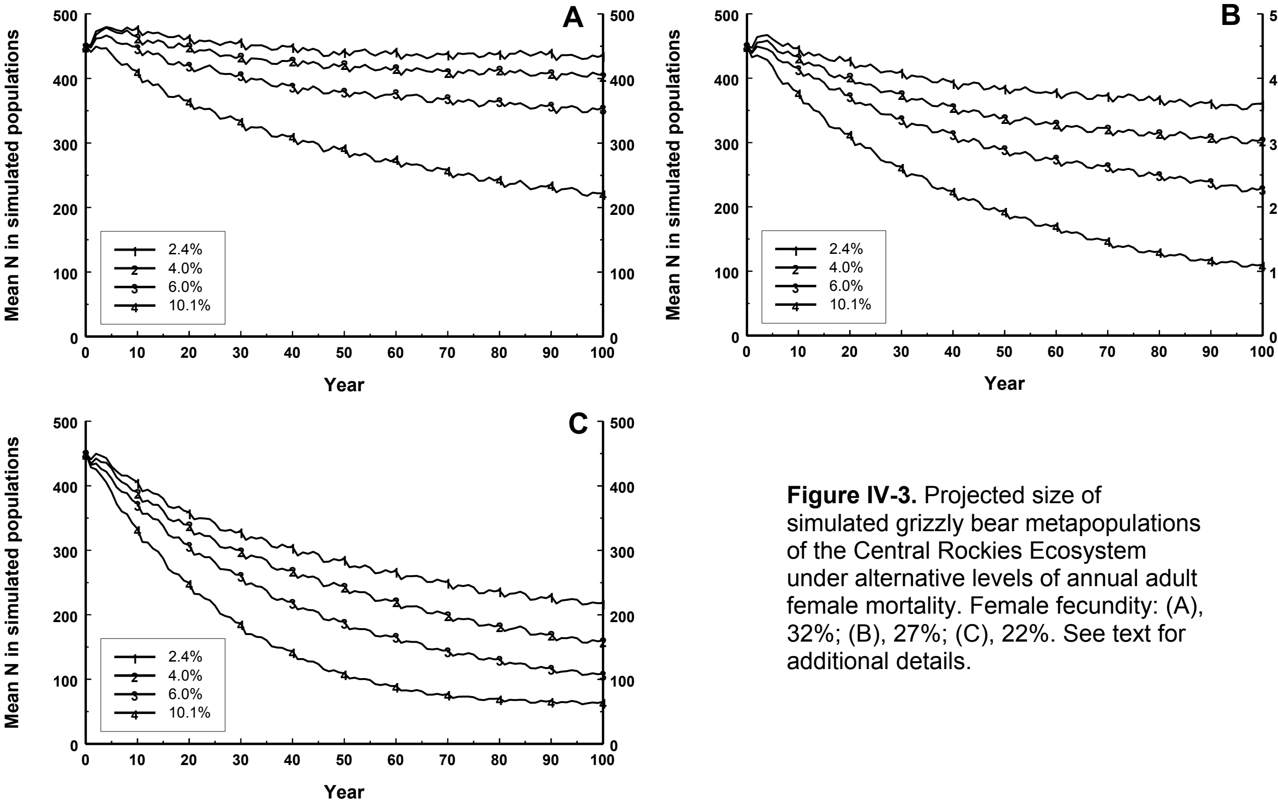


Figure IV-3. Projected size of simulated grizzly bear metapopulations of the Central Rockies Ecosystem under alternative levels of annual adult female mortality. Female fecundity: (A), 32%; (B), 27%; (C), 22%. See text for additional details.

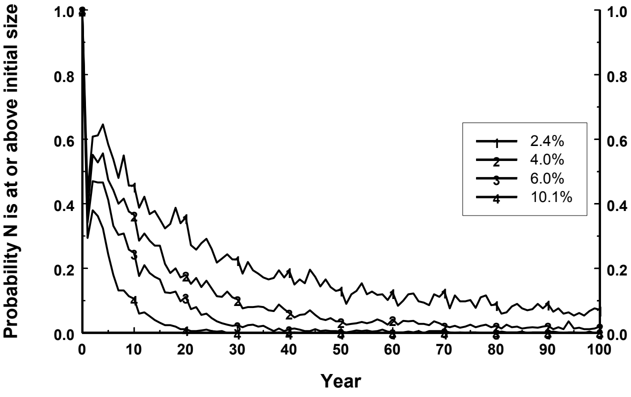


Figure IV-4. Probability of population stability (growth rate $r_s = 0.0$) or growth ($r_s > 0.0$) in simulated grizzly bear metapopulations of the Central Rockies Ecosystem under alternative levels of annual adult female mortality and 27% annual female fecundity. See text for additional details.

Impact of differential inbreeding depression severity: Table IV-3 and Figure IV-5 give the results of alternative sets of models in which the severity of inbreeding was either reduced to 1.0 or increased to 6.0 lethal equivalents. Inspection of the stochastic growth rates and probabilities of population decline in the Table suggest that the effects of an increase of nearly 100% in the number of lethal equivalents harbored by the simulated grizzly bear metapopulation—from 3.14 to 6.00—are only very modest at best. This conclusion supports the view that the risk to the population is not fundamentally a genetic one.

Table IV-3. Projections for the Central Rockies Ecosystem grizzly bear metapopulation under three levels of inbreeding depression and varying rates of mortality. Breeding rate set at 27% of adult females breeding each year.

Input parameters			**Simulation results**								
# Lethal	%eAF							P[below 10]			
Equivalents	Mortality		stoch r	SD(r)	N_{100}	SD(N)	P[decl]	NE	SE	NW	SW
1.00	2.4		0.018	0.080	374	65	90	0	0	0	0
	4.0		0.012	0.082	330	74	97	0	0	0	0
	6.0		0.003	0.085	253	83	99	1	5	0	0
	10.1		-0.011	0.094	121	57	100	16	36	0	3
3.14	2.4		0.017	0.079	361	65	93	0	0	0	0
	4.0		0.009	0.082	305	76	98	0	2	0	0
	6.0		0.001	0.085	229	81	100	1	6	0	0
	10.1		-0.012	0.094	111	45	100	16	37	0	4
6.00	2.4		0.014	0.080	334	69	97	0	0	0	0
	4.0		0.008	0.081	287	77	100	0	1	0	0
	6.0		0.000	0.085	219	79	100	1	6	0	0
	10.1		-0.012	0.094	104	44	100	17	40	0	4

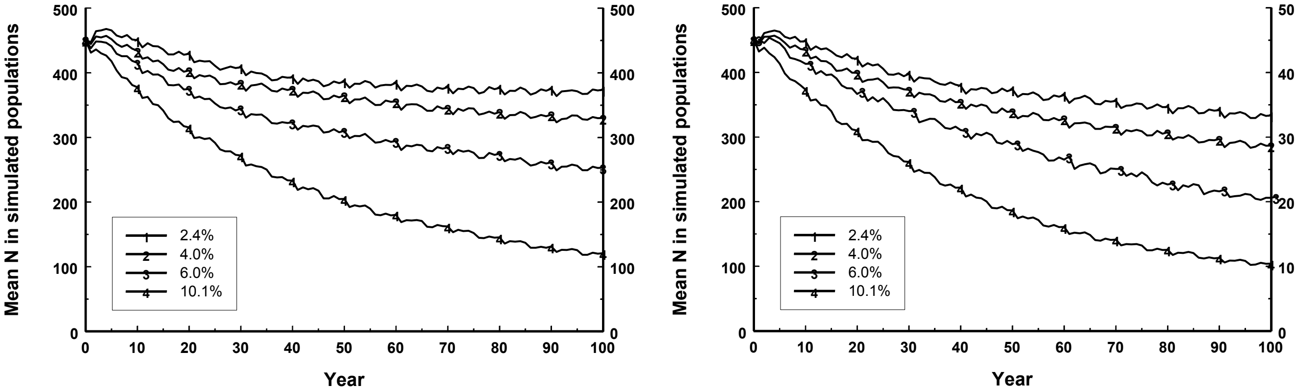


Figure IV-5. Projected size of simulated grizzly bear metapopulations of the Central Rockies Ecosystem under alternative levels of annual adult female mortality. Left panel, low inbreeding depression severity (1.0 lethal equivalent); right panel, high inbreeding depression severity (6.0 lethal equivalents). Annual rate of adult female fecundity = 27%. See text for additional details.

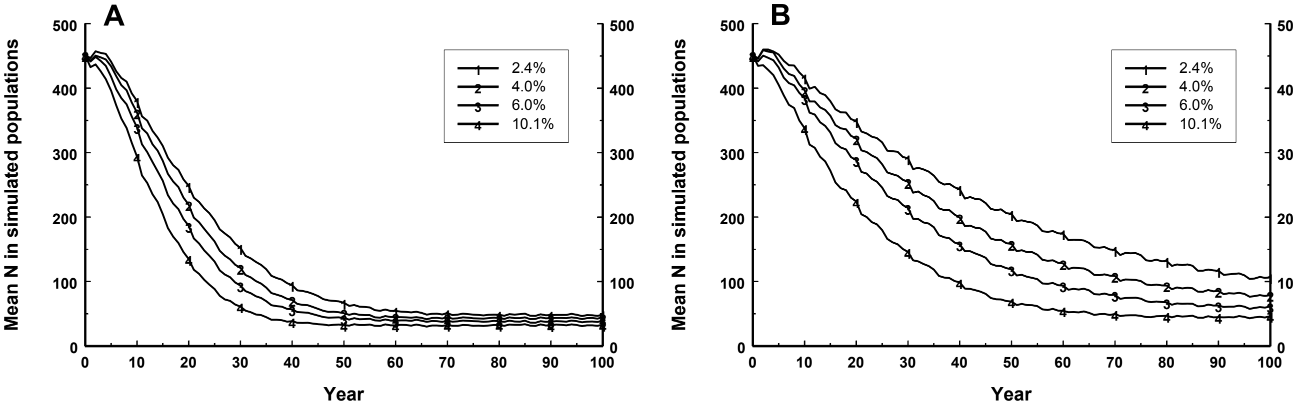
The very slight impact imposed by inbreeding depression is no doubt the result of the exchange of individuals (dispersers) between the populations as well as the in-migration of individuals across the “soft” metapopulation boundaries, primarily to the north and south of the CRE. This is also reflected in the metapopulation heterozygosity values tallied at the end of the 100-year simulation (results not shown in the Tables): the extent of metapopulation genetic variation retained in nearly all simulations was 97-98%. Thus, as long as the continuity of habitat along the Rocky Mountains remains, there would not seem to be a danger of serious additional losses of genetic diversity. (The current low level of diversity remains a mystery, perhaps reflecting a severe bottleneck at some time in the past.)

Local human population growth and its impact on adult female grizzly bear mortality: As shown in Table IV-4, an annual increase in adult female mortality of 4% over the first ten years—commensurate with an equivalent rate of human population growth in the area over the same time period—results in rapid rates of grizzly bear metapopulation decline and high probabilities of individual populations declining below 10 individuals. Even if some mitigation efforts lead to a reduced impact on mortality, leading to a 2% annual increase, the metapopulation declines at an annual rate of at least 1%. Strong mitigation efforts leading to a 2% decrease in annual mortality through years 1 – 10, as expected, result in a considerable increase in the stochastic population growth rate and no risk of individual population declining below 10 individuals. However, even under this most optimistic set of scenarios, the risk of metapopulation decline below current numbers is at least 38% and could be as high as 98% if annual adult female mortality rates approach 10%. These and the other results described in this section point to the difficulty in maintaining grizzly bear populations at their current sizes in the face of increasing human population pressures.

Table IV-4. Projections for the Central Rockies Ecosystem grizzly bear population with 4% annual increase, 2% annual increase, or 2% annual decrease in adult female mortality over 10 years, under varying rates of initial mortality. Breeding rate set at 27% of adult females breeding each year.

Input parameters			**Simulation results**								
% change	Init. %eAF							P[below 10]			
in mortality	Mortality		stoch r	SD(r)	N_{100}	SD(N)	P[decl]	NE	SE	NW	SW
4% incr.	2.4		-0.021	0.096	49	12	100	56	90	5	20
	4.0		-0.022	0.100	44	11	100	68	92	7	22
	6.0		-0.023	0.106	39	9	100	81	97	12	38
	10.1		-0.026	0.119	33	8	100	90	98	23	56
2% incr.	2.4		-0.010	0.090	107	53	100	12	43	0	3
	4.0		-0.015	0.094	79	31	100	25	63	1	8
	6.0		-0.018	0.099	62	20	100	42	75	2	15
	10.1		-0.022	0.109	46	13	100	75	90	6	27
2% decr.	2.4		0.035	0.075	464	46	37	0	0	0	0
	4.0		0.029	0.077	437	51	59	0	0	0	0
	6.0		0.023	0.078	410	55	78	0	0	0	0
	10.1		0.010	0.081	327	66	98	0	0	0	0

The results from this set of models are summarized graphically in Figure IV-6 (metapopulation size projections) and Figure IV-7 (projected probabilities of metapopulation decline).



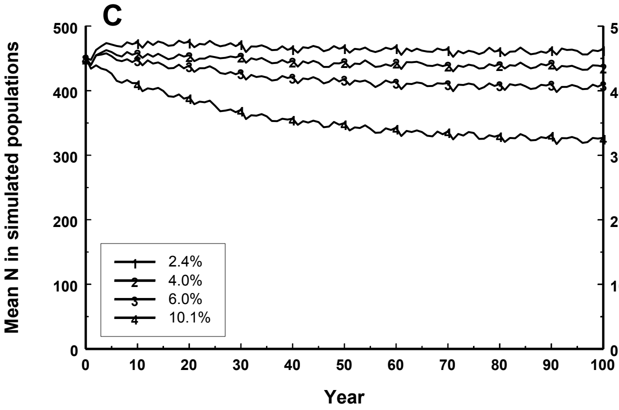


Figure IV-6. Projected size of simulated grizzly bear metapopulations of the Central Rockies Ecosystem under alternative levels of annual adult female mortality and human-mediated changes in those same rates (simulation years 1 – 10). (A), 4% mortality increase; (B), 2% mortality increase; (C), 2% mortality decrease. See text for additional details.

Population dynamics of the SE quadrant: Inspection of the figures and tables above indicates that the southeast quadrant of the Central Rockies Ecosystem metapopulation harbors the population most vulnerable to decline. Because of the similar demographic characteristics assigned to each population, the majority of this risk stems from the fact that this population is the smallest of the four components, and therefore most sensitive to random fluctuations in demographic rates. Consequently, we wanted to focus on evaluating some of the risk this simulated population experiences. Figure IV-8 shows that while the risk of the population shrinking to just 10 animals is quite low for all but the highest level of adult female mortality, the population does decline in size across all measures of annual adult female mortality. The risk of decline below 10 individuals approaches 40% when mortality increases to 10.1% annually.

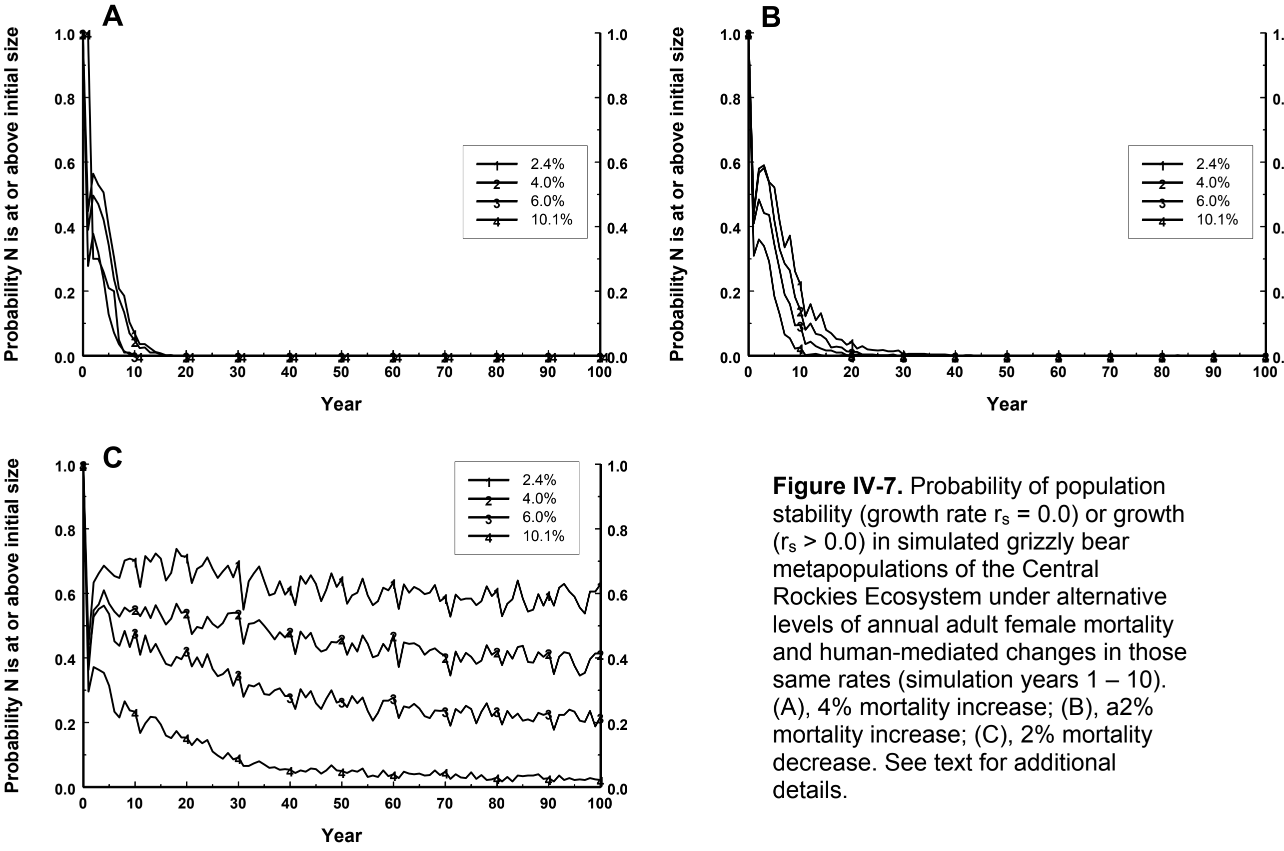


Figure IV-7. Probability of population stability (growth rate $r_s = 0.0$) or growth ($r_s > 0.0$) in simulated grizzly bear metapopulations of the Central Rockies Ecosystem under alternative levels of annual adult female mortality and human-mediated changes in those same rates (simulation years 1 – 10). (A), 4% mortality increase; (B), a2% mortality increase; (C), 2% mortality decrease. See text for additional details.

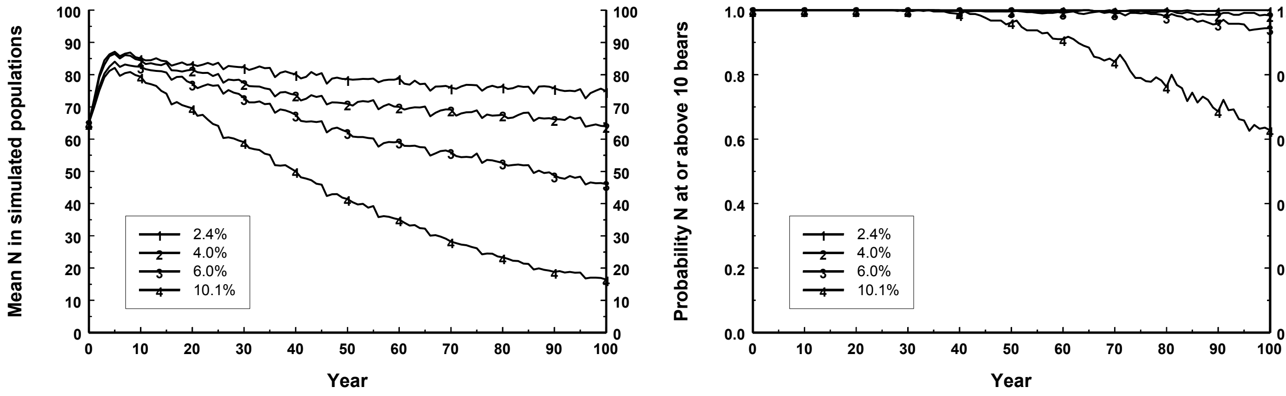


Figure IV-8. Projected size (left panel) and risk of decline below 10 individuals (right panel) of simulated grizzly bear population inhabiting the SE quadrant of the Central Rockies Ecosystem under alternative levels of annual adult female mortality. Annual rate of adult female fecundity = 27%. See text for additional details.

Summary and conclusions

Population viability analysis using the simulation modeling package *VORTEX* was applied to the grizzly bear population inhabiting the Central Rockies Ecosystem. Both demographic sensitivity analysis and risk assessment techniques were employed to investigate the population biology of grizzly bears in the CRE and the ways in which our understanding of this information can help to shape our ability to make better conservation management decisions throughout the region. Our analyses showed us the following:

- Grizzly bear population viability is highly sensitive to adult female mortality. If this mortality is (or becomes) as high as in some other populations, the CRE grizzly bear population could be in trouble. Moreover, low fecundity in the area places extra emphasis on keeping adult female mortality low.
- The Central Rockies Ecosystem grizzly bear population is not presently secure. The regional and provincial goal of maintaining the present number of bears – in other words, managing to prohibit population decline – may not be met under current conditions.
- The impact of the rapidly growing human population throughout the region could be severe. It is likely that the grizzly bear population cannot sustain increases in mortality (or decreases in fecundity) due to the increased risk of human-bear contact accompanying this growth, so it will be imperative that the impacts of humans be reduced even while the numbers of humans in the region increase.

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

5

Human Impacts – Physical Components

Human Impacts – Physical Components

Working Group Participants:
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Harrie Vredenburg, University of Calgary (Facilitator)

Human-use Impacts on Physical Components of Grizzly Bear Habitat

Terms of Reference:
To examine the effect of physical land use components of human activity, without consideration of human use levels issues, and make recommendations to mitigate potential impacts of various land use activities. The issues considered here correspond best to habitat "greenness" (quality), rather than demographic parameters such as mortality.

Problem statement

Physical developments on the landscape have the potential to significantly affect grizzly bear habitat. Historically, human activities such as fire management, oil and gas development, and logging have been the economic drivers of land uses that can strongly influence grizzly bear habitat.

Land Use Effects Rating

Table V-2. Estimated direct effects of human activities on grizzly bear habitat.

Type of activity	Type of effect	Rationale
Road building	Negative	
Logging	Negative/Positive	Highly dependent on conditions and forests practices
Residential	Negative	
Grazing	Neutral	All the land has been allocated
Mining	Negative	
Oil and Gas Drilling	Negative	
Seismic	Neutral	Based on current practice of hand-cut lines
Pipeline	Positive	
Fire management	Negative	
Recreation Development	Negative	
Gas Plant	Negative	

Information on current and possible future land use activities was taken from the *Atlas of the Central Rockies Ecosystem*. (Komex 1995), which compiles land use plans for all jurisdictions in the area (Figure V-1) (*Editor's Note*: Figure V-1= page 29 from *Atlas*). The *CRE Atlas* further characterizes the CRE landscape by levels of development (Table V-1 and Figure V-2). (*Editor's Note*: Table V-1 = page 28 from *Atlas*, Figure V-2 = Page 30 from *Atlas*). We evaluated direct human impacts on grizzly bears on the basis of specific activities related to particular industries. For each activity, we evaluated the expected effect (positive, negative, or neutral) in terms of changes in grizzly bear habitat (Table V-2). The types of effects are based on *forecasts* over the next 100 years assuming best management practices. They are *not* based on current conditions.

Land use change over time

The study area (entire CRE) was divided into 4 quadrats: SE, SW, NE, and NW. Forecasted land use change is based upon comparing existing land-use in the area (from the existing grizzly bear habitat security model) to proposed land use types approved by existing management plans (Figures V-1 and V-2).

In general, we forecasted only low to moderate changes in most land uses for most areas (Table V-3). This prediction occurs because existing land use is already relatively intense throughout much of the CRE. For example, almost all watersheds on BC provincial lands are roaded to the edge of parks and wilderness areas. However, there is substantial potential for high increases in the NE quadrant of CRE (Ram and Clearwater Rivers) when existing land use is compared to that approved in land-use plans.

Table V-3. Forecasted change in level of activity in CRE quadrant over next 100 years. Low means little in no change, moderate means approximately double amount of activity, high means approximately three times as much activity.

Type of activity	SE Quadrant	NE Quadrant	NW Quadrant	SW Quadrant
Road building	Low	High	Low	Low
Logging	Moderate	High	Moderate	Moderate
Residential	High	Moderate	Moderate	High
Grazing	None	None	None	None
Mining	Low	Low	Moderate	Moderate-High
Oil and Gas Drilling	Moderate	High	Low	Low
Seismic	None	High	Low	Low
Pipeline	Low	High	Low	Low
Fire management	High	High	High	High
Recreation Development	High	Moderate	Moderate	Moderate
Gas Plant	Low	Moderate	Low	Low

Strategies and actions

Our analysis of current and future land use conditions for CRE suggests that core protected areas alone will not sustain viable grizzly bear populations in the CRE. State-of-the-art management of development activities on intense recreation and multiple-use lands will be required. Five activities will most directly affect grizzly bear habitat: timber harvesting, fire management, oil and gas development, recreational developments, and residential developments. We recommend the following land-use strategies and management actions for all areas designated as occupied grizzly bear habitat.

Overall Land-Use

Strategy- All land use will take place within the context of cumulative effects models that utilize grizzly bears as key indicators.

Actions-

1) Prepare a grizzly bear habitat map for all lands within the CRE.
2) Prepare a map of existing land uses.
3) Develop a CEM to evaluate the effects of current and proposed land uses.

Specific land uses

Timber Harvesting

Strategy- Timber harvesting activities must duplicate ecological processes to sustain important components of grizzly bear habitat such as plant food sources, cover, and den-sites.

Actions-

1) Enforce harvesting guidelines that enhance food sources such as huckleberry, buffalo berry, hedyserum, and ant-producing logs.
2) Silvaculture treatments must be immediately post-harvest to minimize periods of open access. Roads must be bedded immediately upon completion of silvaculture.
3) Roads must be gated until bedded.
4) Configure cutting patterns to minimize needs for fire suppression on adjacent lands, and facilitate prescribed burning in non-commercial land use zones and areas.
5) Cutblocks must be designed to provide lines of sight not exceeding 300m.
6) In areas of low denning potential, winter logging is required.

Fire Management

Strategy- Natural fire regimes will be maintained, through planned or random ignition, in all areas not zoned for timber harvesting or other commercial activities.

Actions-

1) Where feasible, fires should not be suppressed.
2) Where the long-term fire regime is altered by suppression, prescribed burns will be conducted.

Oil and Gas Development

Strategy- To reduce infrastructure as much as possible

Actions

1) Wherever possible, existing linear developments must be re-used.
2) Well sites must be avoided in areas of high quality grizzly bear habitat (e.g., by directional drilling).
3) Seismic lines must be hand-cut and heli-portable.
4) Access roads must be put to bed immediately unless it can be shown that they are needed.
5) Functional roads must be gated during drilling and production.

Recreation Development

Strategy- To locate developments away from high quality grizzly bear habitats.

Actions

1) Proposed developments must be reviewed in the context of bear habitat quality, and fragmentation potential.
2) Development footprints must be minimized.
3) Facilities must be designed to allow maintenance of natural fire regimes on adjacent lands.

Residential Development

Strategy-to minimize human residence in occupied grizzly bear habitat.

Actions-

1) No new residential developments will be permitted in high-quality grizzly bear habitat.
2) Where residential developments exist in grizzly bear habitat, corridor management plans will be implemented to minimize fragmentation.

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM
(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

6

Human Access Impacts on Habitat

Human Access Impacts on Habitat

Working Group Participants:
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Robert Forbes, BC Wildlife
Guy Greenaway, Ekois Environmental Communication
Paul Galbraith, Parks Canada
Bill Hay, CPR
Doug Mead, Shell Canada
Bart Robinson, Yellowstone to Yukon Project
Francis Westley, McGill University (Facilitator)

Objective

To provide inputs to the *VORTEX* model that quantify the impacts various types of access have on grizzly bear population viability in the Central Rockies Ecosystem (CRE).

Working Assumptions/Axioms

I. Eighty-five percent of adult grizzly mortalities in the CRE result from human/grizzly encounters; grizzly/human encounters result from human access to grizzly territory.

II. Grizzly bear mortality is directly correlated to:
  1) The frequency of grizzly-human encounters, and
  2) The lethality of those encounters.

Mortality = f[(Human Encounter Rate)(Lethality of Encounter)]

III. In terms of access, the rule of thumb is that mortality correlates to:
  1) The number of roads and trails in a given region;
  2) The number of people using those roads and trails;
  3) The activities pursued by the people using those roads and trails and, specifically;
  4) The use of firearms by the people pursuing those activities.

IV. As access expands, human beings exploit it, which leads to the decline of bear populations.

Methods

1. Identify types of access and their attributes.
2. Identify and rate impacts (high, moderate, low) associated with each type of access.
   a. Mortality
   b. Displacement (of bears from habitat, especially security areas)
   c. Reduced reproduction (through stress to the population)
   d. Habitat reduction and degradation
3. Create scenarios that capture the current state of affairs, and a probable / possible future.
4. Allow for spatial and temporal variation (i.e., different jurisdictions within the CRE over time) of impacts.

Types of access and attributes

Motorized, Non-dispersed	Motorized, Dispersed*	Non-motorized†	Railway/Train	Air
Density (km of road per km2 of study area)	Noisy/quiet	Invasion of otherwise secure habitat?	Attractant/Non-Attractant	Noisy/Quiet
Frequency (use)		Surprise encounters		
Timing (seasonal use; day or night use)				
Industrial/Public				
Permanent/Temporary				
Noisy/Quiet				
Presence/Absence of Firearms in Vehicle				

* Activities include: ATV and snowmobile backcountry travel.

† Activities include: back-country skiing; hiking, horseback riding; mountain biking; boating and rafting; climbing, photography, hunting, fishing, and bear research.

Types of Access and Mortality and Displacement Impacts

Access Type	Mortality Impact	Displacement Impact
Motorized, non-dispersed	Moderate	High
Motorized, dispersed:		
ATVs	High	High
Snowmobiles	Low	Low
Trains/Railway	Low	Low
Air	Low	Moderate
Non-motorized		
Skiing	Low	Low
Hiking, backcountry	Moderate	Low
Hiking, frontcountry	Moderate	Moderate/High
Horseback Riding	Moderate	Moderate
Mountain Biking	Moderate	High
Climbing	Low	Low
Camping, non-dispersed	Low	High
Camping, dispersed	High	Moderate
Hunting, non-grizzly big game	High	Moderate
Fishing	Moderate	Moderate
Livestock Grazing	High	High
Bear Research	Low	Low

Causes of mortality in CRE

1. Firearms
   - Backcountry hunting, recreation, and protection
   - Agricultural-related practices
2. Poor backcountry "housekeeping" (distinguish between recreational and industrial camps)
   - Garbage at camps
   - Gut-piles
   - Agricultural refuse
3. High numbers of people in high grizzly density areas
4. High ignorance/low tolerance of people in grizzly territory
5. Increased access to grizzly habitat equals increase grizzly mortality
6. Road and railway collisions
7. First Nation kills on reserves

Mortality categories and percentages

Category One: 44% to 60% involve firearms

Category Two: 35% to 44% are animal control mortalities (problem wildlife involving attractants)

- 8% to 10% of Category Two mortalities take place on First Nations Reserves
- 17% of Category Two mortalities are ranching related

Scenarios

I. Current: Status-quo management

An analysis of the data available to the workshop participants suggests:

- Management is a major issue, affecting mortality, displacement and carrying capacity.
- The CRE study area already has a high density of roads and, in the national and provincial parks, a high density of trails. Nearly all major valleys are roaded.
- Acknowledging considerable regional differences[1], the current grizzly mortality for the area as a whole can be roughly estimated at four percent.
- Given changing industrial practices, it is estimated that few new roads will be opened to public access in the next 10 years.
- Given the overall four percent annual rate of population increase in the area, it is estimated that use of existing roads and trails will increase at four percent per year. This trend is predicted to continue for the next 10 years. Given the demographics of the people moving into the area, and their general desire for a "mountain amenity" lifestyle, the four percent figure is conservative.

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[1] Primary regions were defined as 1) west of the continental divide; 2) east of the continental divide and north of the Bow River; and 3) east of the continental divide south of the Bow River. In region 1, mortality is six percent (3.8% legal hunting and animal control kill, 2.2% estimated non-reported kills); in region 2, mortality is nine percent (3.8% legal hunting; 5.2 percent all other mortalities); in region 3, mortality is 3% (all mortalities – there is no legal hunting south of the Bow River).

Based on the above, it is estimated that without mitigative or restorative measures, human/grizzly encounters will increase significantly, resulting in an estimated increase in non-licensed-hunting grizzly mortalities of four percent per year for the next ten years.

High mortality access activities

Activity	Coef of HE[†]	Causes
Big game hunting	0.5	Firearms/ increased encounter
ATV's	0.4	Firearms / attractants / increased encounters
Camping (back-country)	0.6	Attractants / firearms / human protection
Camping (front-country)	0.4	Attractants / firearms / human protection
Livestock (?)*	0.8 (?)	Attractants

[†] Percentage of grizzly bear habitat value lost as a result of a given activity

* Livestock concentrations incompatible with high density grizzly populations

High displacement access activities

Activity	Coef of HE	Causes
Non-dispersed motorized access (roads) • paved (?) • gated • class of road • speed limit • usage pattern • bear density	0.3	Sensory disturbance
Back-country (ATV)	(0.33-0.75) 0.55	Sensory disturbance
Front-country camping	0.4	Sensory disturbance Habitat loss
Horseback riding	0.4	Sensory disturbance

Enhanced management scenarios

(should address hunting, ATV's, dispersed camping, livestock farming, roads, non-dispersed camping)

What could we do to reduce growth in mortality by 2% (from predicted 4% down to residual 2%)?

Overall strategies	Specific actions
A. Limit encounters	• Legislation i) Legislation to restrict / close access ii) Crown jurisdictional responsibility iii) AB requires review of enabling legislation • Physical blockage (mechanism in place – licence of occupation) • Human use strategies (limit # of people to < 100/month) i) public notice

	ii) avoid recreational development in high GB use. • Avoidance i) seek alternative forms of access ii) promote frozen road access iii) promote winter industrial activity (e.g., logging) iv) oil and gas remote operation of wells — responsibility of industry and government • Limit attractants i) Food, garbage and meat storage/handling
B. Encourage commitment to existing plans	• Implement Grizzly Bear Management Plan / Grizzly Bear Management Framework for the Northern East Slopes Region / South western Alberta Grizzly Strategy
C. Managing encounters to reduce mortality	• Education i) if you see a bear, don't automatically shoot it — how to camp in bear country <u>Hunter Education</u> ii) how to identify species iii) basic bear behaviour iv) establish hunter safety and awareness as a hunting licence requirement (e.g., pamphlets) v) stuff on how to protect the bear (not just themselves) (web site – great interest) <u>Other Recreationists Education</u> i) existing publications distributed ii) distribute via fishing licences iii) television iv) programming through Calgary Zoo through Discovery Channel v) offer Bear Awareness programs more broadly vi) seize opportunities to promote bear messages (e.g., human deaths by bears); canned 4 minute messages ready to go vii) get communications people together to create strategy viii) incentive-based communication • Aversive conditioning i) for bears around access points ii) Rocky Mountain Grizzly Bear Planning Committee is convening workshop in Mar/Aprl to put it on the ground iii) increase the effectiveness of existing efforts iv) Karelian Bear Dogs and Bear Shepherding (Wind River Bear Institute) • Hire a CRE grizzly bear field specialist

C. Increase awareness / empowerment	• increase awareness amongst general public • increase awareness amongst political decision-makers

Restoration scenarios

(To address the residual 2% mortality)

Overall strategies	Specific actions	Barriers and Opportunities
A. Restore secure areas	• Close access and restore security • Create new camping and recreational areas in low grizzly density areas to compensate for closure of facilities and limiting access to high grizzly density areas.	• Public opposition • Need to provide alternative access • Lack of resources • Need to consider • Fear and negative attitudes to grizzly bears • Suite of values that include: i) materialism ii) consumerism iii) pro-gun
B. Population enhancement	• Bring bears in to enhance genetic diversity	
C. Impose visitor quotas	• In high use areas	
D. Re-locating access facilities		
E. Reforest seismic lines		
F. Grizzly bear conservation areas	• Re-routing roads • Access for specific human uses	
G. Restrict livestock use		
H. Communications program designed to change prevalent "common sense" about grizzly bears and their management.	• Specific research to determine values of public re grizzly bears and their needs. • Implement mechanisms to compensate those who make real land sacrifices for grizzly protection., • Compile and share success stories regarding grizzly bear protection and management (e.g Southwest Alberta Grizzly Study. • Create/support pilot programs to demonstrate possibility of management successes while achieving on the ground conservation. Examples: altering access to the Smith Dorrien road; support of the Elk Lakes Grizzly Bear Conservation Area plan and coordinating that plan with Peter Lougheed Provincial Park.	

Scenario three recommendations:

1. Select restoration pilot project(s) for high profile communications vehicle (one which create success story for grizzly population recovery). Possible areas could include the Smith-Dorrien Road, the Elk Lake Grizzly Bear Conservation Area, and the Fairholme Benchlands.
2. Re-examine existing overflight and jetboat regulations and consider extending legislated restrictions.
3. Establish tighter quotas and controls on high-use areas (consider Lake O'Hara management schemes for such areas).
4. Open new camping/recreational areas in low-density grizzly areas in exchange for existing closing/restricting camping/recreational areas in high-density grizzly areas.
5. Select an area for "holistic" restoration – a multi-stakeholder approach with a social and economic component as well as ecological.
6. Hold a follow-up workshop based on the findings of this workshop, but dedicated to developing vision, strategies and actions for the long-term.
7. Managing access present status quo alone is not going to do it; have to gone to restore some security, current access
8. Adult female mortality is really critical (focus on adult female home ranges)

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM
(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

7

Human Impact – Secure Areas

Human Impact – Secure Areas

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Vision:

Establish and maintain a viable population of grizzlies by accommodating individual security needs in high quality habitat, with emphasis on the survivorship of adult females.

Security area

Definition of Security Area – a 9 km^2 area of relatively high habitat quality which provides the daily resource requirements for an individual adult female grizzly bear in a location which is free from human disturbance. The 9 km^2 bubble surrounds an adult female bear and moves with the animal around the landscape in the bear's home range.

The requirements of adult females are focused upon here because of their slow maturity, low reproductive rates, and role in cub rearing. Critical to the fate of populations, first and foremost, is survival of adult female bears.
These areas are primarily in protected areas but may also be located in unprotected areas of low human activity.

Background

- 4 Gov't. jurisdictions (Federal, Provincial Alberta, Provincial B.C., and Municipal) in the Central Rockies Ecosystem
- Large amounts of public land
- Grizzly bears exist today but may not in the future – some major holes where GBs aren't. Fragmentation is significant.
- Share common concern
- Areas that have legislated protection as core areas contain many 9 sq. km. security areas but some of these areas do not function as security areas because they are of low quality habitat – some don't function as core areas
- Variability of level of legal protection
- Some areas function as security areas, but are not protected under protected area legislation.
- There is scientific uncertainty about core area requirements for female grizzlies

- Limited public awareness of the scope of the problem to achieve long term viability of GBs
- Managers are not confident of science or public support for the necessary land management requirements.
- The public is unaware of the necessary management requirement and the consequences of their own behaviour – economic, recreational, etc.
- Growing use and development
- Inadequate/inconsistent policy implementation
- Some policies are unsettled
- Policy may be ahead of the science
- Fear of getting ahead of public opinion
- Competing mandates within resource management agencies
- Ambitions for building more tourism facilities in protected areas
- Science may be inadequate to define the problem convincingly
- Uneven access to decision-makers by the public.
- Internal/systemic momentum for development
- Short term thinking and changing mandates of governments.
- Today's grizzly bear population has lower rates of mortality than 10 years ago
- Gaps exist in the information on habitat loss and the change in the numbers of grizzlies historically.
- Big changes from the 60's. Today there is more oil and gas exploration and subsequently more human access by roads on the East Slopes.
- Possible recent slight increase in the grizzly bear populations but this increase might be before the population crash.
- Three times as many people in the backcountry in Kananaskis
- Increased access due to Hwy 40 and Smith Dorrien
- In some areas, road closures may have helped shift the patterns of human access
- Day use has increased everywhere.
- Overnight use has increased in K-country and declined in BNP

Probable future

- If we do not stop putting pressures on the landscape we will loose bears.
- Continued increase in human use and decrease in available habitat.
- Grizzly bears displaced from habitat in areas of human use.
- Increase in mortality of subadult cohorts adjacent to human use features due to conflict of habituated bears with people.
- Management can commit to managing the cohort specific mortality.
- More impact due to visitation.
- Confidence limits on models may make it difficult to interpret scenarios.
- Trends in tourism, growth of Calgary, Canadian economy, growth of amenities.
- Increased awareness and acceptance of public.
- Risk of losing grizzly bears.
- Inadequate behavior change. Have not asked for behaviour change by user groups. Lake O'Hara is an example of how behavior change could work.
- Increased human use such as tourism and industrial activity.

- Need to identify security areas.
- Increased commercial transportation through highway and railway.
- Increased human access and habitat fragmentation will result in loss of security areas and integrity.
- Security areas become islands with no connections in between them. Other security areas will be lost.
- Road access from BC and Alberta crown land results in increased access to remote areas.
- Inter-jurisdictional land use conflicts.
- New trends will create pressure e.g., Quads, mountain bikes, snowmobiles
- Protected areas will loose security areas over time.

Possible future

- Public support manifested in legislation, policy and management actions appropriate to achieve viable population levels throughout CRE
- Sufficient security areas with high quality habitat to sustain viable populations
- Available habitat is sufficient to withstand natural and human caused perturbations
- Land use management plans secure grizzly bear habitat requirements in policy
- Lands are legally protected instead of by policy e.g. Bighorn Wildland.
- Canadian public is aware of the need and support legislation, policy, plans and management practices to sustain grizzly bears.
- Thresholds of human use and tolerance of bears is known and understood.
- Investments by agencies, private sector, and public reflect the importance of sustainable grizzly populations.
- Appropriate visitor management strategies in place.
- Security areas established on multiple use lands and maintained in protected areas.
- Habitat requirements for endangered species will be legislated.
- Science is more conclusive.
- Science is more directly linked to policy and management decision making.
- Composition, structure and function will be evolutionarily linked to pristine conditions of the past.
- Local grizzly bear population is linked to other populations in the north, south, and west through Yellowstone to Yukon.
- Include Traditional Ecological Knowledge.
- Management is confident and committed to implement decisions, is accountable and has the.
- Courage to implement the Precautionary Principle.
- Burden of Proof is reversed so that development proponent proves that there will be no significant effect of the proposed development.
- Long term plans survive change in government.
- Integrated management plans exist across agencies.

Gap analysis

Constraints

Incomplete knowledge of bears and human activities.
Science is evolving.
Particular constituencies are resistant to restrictions on their activities (Case of tyranny of the minorities).
Different policies between jurisdictions.
Infrastructure causing fragmentation (no successful mitigation currently available)
Change required to the land use regime in the Sheep, Highwood, Old Man, Cataract.
Lack of engagement of BC in inter-jurisdictional efforts.

Opportunities

There is enough information to act!
Precautionary principle applies to protected areas.
Improve inter-agency coordination and cooperation.
Research and develop successful mitigation of infrastructure in order to have linked home ranges for female grizzly bears.
Protect Big Horn Wildland, Highwood, Upper Old Man River, Cataract, & Sheep River as Security Areas.
Limit Human Use to existing levels in the Red Deer, Panther, Siffleur, and Upper Clearwater.
Alberta Heritage Act review provides opportunity for grizzly bear protection through protection of grizzly bear security areas.

Actions

Principles / Actions for Optimizing Secure Habitat Areas

- Protect existing security areas now
- Maximize connectivity (especially when considering management activities such as prescribed burns.
- Strategic relocations of human use where security can be increased.
- Maintain flexibility to adapt to changing conditions for grizzly bears.
- Communicate rationale for implementing management actions.
- Maximize security areas for grizzlies by temporal and spatial closures of trails, campsites, facilities etc. located within secure areas. Consider seasonal uses.
- Strategic relocation of facilities (e.g., parking lots, trails, campgrounds) away from security areas.
- Manage human use on a case by case basis in areas of high quality habitat and high use (e.g., Moraine Lake, Skoki) with Lake O'Hara techniques.
- Establish existing levels of human use as ceiling for currently well functioning areas i.e. Clearwater watershed, Ram watershed, Big Horn, Siffleur, Panther, Red Deer watershed, Old Man

Future actions

The context for population and habitat viability modeling for grizzly bears involves human actions and habitat changes which in turn affect the status of grizzly bear population and demographic inputs to the vortex model which will provide analysis of population viability.

Our group focused on the requirements by grizzly bears for secure areas and high quality habitat. To do this we looked at the concept of a security area within the Central Rockies Ecosystem (Gibeau and Herrero in press). A security area is the 9 km^2 of habitat used by a female grizzly bear every day. This 9 km^2 area moves with the bear within her home range. Ensuring that as much of the home range as possible contains connected security areas, enhances the survival of adult females - the key to population survival (Gibeau and Hererro in press). Mace's concept of secure "core" areas within an individual home range calls for 60 to 67% of the home range to be roadless and free of human disturbance. Disturbance has a zone of influence that extends beyond the trail, road or building. Many jurisdictions in North America consider the zone of influence to be 500 meters around human activities. Disturbances occurring at a rate higher than 20 human parties per week are generally considered to cause significant behavioral changes in grizzly bears.

Using Gibeau and Herrero's analysis of usable security areas in the eastern slopes portion of the Central Rockies Ecosystem, combined with existing knowledge of habitat productivity and satellite habitat (greenness) data showing which areas are most productive for grizzly bears, we were able to make the specific recommendations.

We focused on the Eastern Slopes of Alberta regardless of jurisdictional boundaries. This is in effect a call for a joint management response from the governments of Alberta and Canada to manage the grizzly bear as a unit. We note that this should also involve the Government of British Columbia, however our group had neither the security areas information for British Columbia or participants who had a high level of knowledge of the province's landscapes, issues and policy. We recommend that similar work should be done for the British Columbia portion of the Central Rockies Ecosystem. We are concerned about road access from the province to the edges of what would otherwise be remote secure areas in protected areas in Alberta.

The societal context for our recommendations begins with the existing land use regime in place in the eastern portion of the study area. The vast majority of the area is described as "protected" at some level. The western most part is in Banff National Park, which is legally protected by the National Parks Act. Peter Lougheed Provincial Park, Elbow Sheep Wildland Park, and Bow Valley Wildland Park protect other portions under the Provincial Parks Act. The ghost wilderness area protects a small portion under the Wilderness Areas, Ecological Reserves and Natural Areas Act. Also described as protected, but not legally protected, is the area know as the Bighorn wildland which is zoned prime protection and critical wildlife under the Integrated Resource Plan of the Eastern Slopes policy. Five areas we focused on are not considered protected as they are zoned for some other uses. These are the Lower Kananaskis Valley near Evans-Thomas, the Upper Highwood, the Spray Lakes Valley, Volcano Ridge / Quirk Creek area and the watershed around the Sheep River.

The significant amount of land described as protected might suggest security for grizzly bears is not an issue. Unfortunately this is not the case. The area also contains western Canada's major east-west transportation artery (road and rail), several tourist roads, townsites and heavy recreational use. These pressures are all growing. Maintaining or restoring security areas for grizzly bears will require a focused management response.

Legal frameworks and policies exist in much of the landscapes to enable an adequate management response. Gibeau's map showing security areas (pg 33 Grizzly Bear Population and Habitat Status in Kananaskis Country and the Bow Valley Study) illustrates where this management response might best be focused on important opportunities to protect security areas for female grizzly bears. We believe there is sufficient information to act. However, in the face of scientific uncertainty, we believe that the precautionary principle should be applied and that the burden of proof should shift to those asserting that further development in security areas, inside or outside of protected areas is good. (The precautionary principle is enshrined in the Banff National Park Management Plan).

We make some general and some specific recommendations to maintain and increase security areas in legally protected areas. In landscapes which are not yet legally protected we took a slightly different approach. In the case of the Bighorn Wildland we recommend that its policy protection be upgraded immediately to a Wildland Provincial Park. It contains some of the largest security areas found by Gibeau and Herrero (In press). We recommend that the Big Horn Wildland be managed to maintain security areas for grizzly bears. In the case of land zoned for other human uses , we considered survival of individual grizzly bears important to the viability of the population. To maintain areas of high security and high habitat value we recommend that no new facilities be built in the area.

These recommendations are based on scientific observation of grizzly bear behavior and requirements for survival of the population. We strongly believe there is an adequate base of scientific information on which to base good management decisions that will increase the probability of long term grizzly bear persistence.

Science

- Overlay habitat quality data with security area information with bear demographic data;
- Monitor effectiveness of management practices (i.e., adaptive management);
- Undertake research to refine relationships between changes in grizzly bear behavior to levels of human use and security area buffer requirements.
- Incorporate results of threshold values and risk to individual bears into management practices;
- Develop better human use data to help guide recommendations (e.g., Lake O'Hara);
- Evaluate existing facilities and use within the CRE to determine compatibility with grizzly bear security areas.

Specific management actions

The following specific recommendations were made based on information available at the workshop. This is not intended to be an exhaustive list. We recommend a comprehensive analysis along these same lines be completed for all lands within the Central Rockies Ecosystem.

Recommendations:

- Protect existing high quality secure areas in protected areas, e.g., Clearwater River
  The Clearwater river in Banff is partly in Banff National Park and partly in the Bighorn Wildland. The Banff section is know to be of rich habitat and currently provides good security
  Actions:
  → Determine levels of human use
  → Coordinate between federal/ provincial jurisdictions

- Develop a joint visitor use management framework that enshrines existing levels of use. Area of the Clearwater that is in the province needs to be protected as part of Big Horn Park and managed to provide security areas.

  Ram River
  The Ram river watershed is wholly in the Bighorn Wildland and is adjacent to Indianhead creek in Banff National park which has very high wildlife values and low levels of human use.
  Actions:
  → Determine levels of human use
  → Coordinate between federal/ provincial jurisdictions
- Develop a joint visitor use management framework that enshrines existing levels of use. Needs to be protected as part of Big Horn Park

  Red Deer River
  Like the Clearwater, this is partly in Banff National Park and partly on provincial lands.
  Actions:
  → Determine levels of human use
  → Coordinate between federal/ provincial jurisdictions

- Develop a joint visitor use management framework that enshrines existing levels of use. The area of the Clearwater that is in the province needs to be protected as part of Big Horn Park

  Siffleur Wilderness
  This drainage is partly in Banff National Park and partly in the Siffleur wilderness. It provides high quality secure habitat as presently managed.
  Actions:
  → Maintain status quo
  → Do not downgrade the status of the Siffleur Wilderness Area during reclassification from the Natural Heritage Act

Panther/ Dormer

These rivers are partly in Banff National Park and partly in Alberta lands.

Actions:
- → Banff portion: Maintain status quo by ensuring current levels of use are not increased.
- → Area of the Panther that is in the province needs to be protected as part of Big Horn Park

Spray River in Banff

This drainage has been partially closed to provide security. It has been effective and is an example of a positive management action.

Actions:
- → Do not reopen the closure.
- → Make current closure permanent.
- → Protect existing habitat quality secure areas in unprotected areas

Evans Thomas

This area in Kananaskis Country is important habitat in an already seriously compromised environment from a security point of view.

Actions:
- → Do not build golf course and condos on the highly productive alluvial fan.
- → Legislate into protected area

Shark Ridge/ Upper Spray

This area of high quality habitat currently functions as an important security area and wildlife movement corridor.

Actions:
- → Do not build ski resort and alpine village.
- → Legislate into protection by adding this area to Peter Lougheed Park or another protected area in the Spray valley.

Upper Old Man

Actions:
- → Legislate into protection by adding this area to Peter Lougheed Park

- Restore security in High quality habitat areas.

Mount Norquay

Mount Norquay and Forty Mile creek have high quality habitat in an area where security is heavily compromised. Security can be improved without materially compromising human use.

Actions:
- → Refocus access to Forty Mile creek via Edith pass and access to Elk Lake via Stoney creek.
- → Close Norquay hill and road to summer use
- → Close trail from Norquay to 40 Mile Creek
- → Close trail from Stoney Squaw to Elk Lake

Moraine Lake
This area has heavy human use that has compounded the security area putting both people and bears at risk. To provide more security and a better visitor experience, we recommend gated access at the Lake Louise end and visitor use be managed as it is at Lake O'Hara.
Actions:
→ Lake O'Hara style human use
→ Determine level and use by humans
→ Develop strategy to control human use

Skoki
This area's open sunny meadows are important for grizzly bears yet there is high human use.
Actions:
→ Lake O'Hara style human use
→ Determine level and use by humans
→ Develop strategy to control human use

Cascade River
This area is important to grizzly bears and has high human use.
Actions:
→ Develop a strategy to improve habitat security, particularly from Stoney Creek to Panther River

Mount Allen/ Lake Louise/ Fortress
Each of these ski areas has high habitat quality. Grizzly bear security is compromised by summer use.
Actions:
→ No summer use

- Combined effort for BC/AB/Feds to cooperate and work collectively and treat grizzly bears within CRE as one population with one management plan (Real need for BC to become more involved).

- Utilize the proposed Alberta National Heritage Act as a means to ensure the protection of grizzly bear security areas i.e. through legislative protection. Entrenchment in the Act will provide a management tool to ensure a viable population.

- Use the proposed Endangered Species Act as another means to ensure the protection of grizzly bear security areas.

THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

8

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Literature Cited

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THE GRIZZLY BEAR OF THE CENTRAL ROCKIES ECOSYSTEM

(Ursus arctos)

POPULATION AND HABITAT VIABILITY ASSESSMENT

28 – 31 January, 1999

Section

9

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