Grizzly Bears as a Filter for Human Use Management in Canadian Rocky Mountain National Parks

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Abstract—Canadian National Parks within the Rocky Mountains recognize that human use must be managed if the integrity and health of the ecosystems are to be preserved. Parks Canada is being challenged to ensure that these management actions are based on credible scientific principles and understanding. Grizzly bears provide one of only a few ecological tools that can be used to guide the management of human activities. Grizzly bear needs, as they relate to habitats, movement corridors, habituation and human risk management, were assessed from three spatial scales (regional landscape, landscape management unit, and area planning) and provide the basis for the implementation of numerous human use management actions. The relationship between the analysis of grizzly bear needs and the management actions are illustrated in the case studies.

Parks Canada's mission statement is:

> To protect for all time representative natural areas of Canadian significance in a system of national parks, and to encourage public understanding, appreciation, and enjoyment of this natural heritage so as to leave it unimpaired for future generations (Canadian Heritage 1994).

This mission statement makes reference to the following requirements:

- "representative natural areas" (implies a provision of ecological services)
- "encourage public understanding, appreciation and enjoyment" (implies a provision of experiential services)
- "to protect for all time" (implies a need for sustainability)

During previous eras, when human visitation was low and ecological understanding was limited, Parks Canada had little difficulty fulfilling the above requirements. However, as ecological understanding increased and social and economic conditions changed, with pressure for development and increased use in some of the more popular Canadian National Parks (Rocky Mountain Block of Yoho/Kootenay/Banff & Jasper), managing for a continued balance of protection and use proves difficult. These challenges were acknowledged by Parks Canada (Parks) when it revised both its operating policy (Guiding Principles and Operational Policies) and its legislative framework (the National Parks Act) to reflect the need to ensure protection of the ecological integrity of the parks while providing for a range of visitor opportunities.

This need for a balanced management is further emphasized through statements such as: "While ecological integrity is clearly the priority in the Park, it is recognized that tourism has been and will continue to be its primary form of human and economic activity" (Banff Bow Valley Study 1996). It is therefore essential to understand how tourism affects ecological integrity. "Equally important is how to manage this diverse phenomenon so Canadians may continue to enjoy the many experiences Parks offers and to obtain its substantial economic benefits without undermining ecological integrity." To achieve this objective, there is a need for both an integrated and a systems approach to the management of protected areas.

Within the context of the social and economic systems in which Canadian national parks operate, it has become apparent that the provision of viable ecological and experiential services will require the management of human use.

Human use management is the direction and guidance of people, their numbers, their behaviour, permissible activities, and necessary infrastructure. The objective of human use management is to allow people to enjoy a national park without damaging its ecological integrity; while it may require some restrictions, it should not be seen as limiting people's freedom. Alternatives for managing access and use will vary from relatively low-key approaches, such as better signage and education, to more active approaches such as closures, quotas, and permits. Our challenge in developing an effective human use strategy is to determine which combination of approaches will address both visitor and ecological needs in a manner that supports both. Currently, there is little direct management of human use in the Rocky Mountain National Parks.

Human use management involves two aspects of the visitor opportunity—supply and demand. Supply relates to the amount of use (determined according to activity types, locations, and timing) that can be provided in a park, subject to defined ecological and social objectives. Supply targets can be expressed in a number of different ways (user numbers, satisfaction rates, educational/knowledge change, etc.). Once the supply of the visitor opportunity is defined, demand can be managed to achieve a better balance between the two. Demand will have to be actively managed and will require the involvement of internal and external groups. Parks Canada has made advances in defining use relative to ecological objectives, but it is only at the preliminary stages of defining socially based supply targets or managing demand.

Acknowledging that human use management will be difficult, Parks must move forward to develop tools to help it

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meet that mandate. There must be an attempt to determine which ecological systems are sensitive to human activities and how they will be useful in guiding the management of these activities. It is proposed that large carnivores generally and grizzly bears (*Ursus arctos*) specifically represent a sensitive ecological system.

Within the Central Rockies Ecosystem (figure 1), including Yoho, Kootenay, Banff, Jasper, and Mount Revelstoke/ Glacier National Parks, there have been considerable resources devoted to large carnivore research, monitoring, and management in the past decade. The conservation of large carnivores is an issue that transcends both geographic and administrative boundaries. The recognition of the social and ecological role that the species fulfills has made it the focus of many research and land use planning initiatives. Table 1 summarizes the current perspectives on conservation of grizzly bears.

Three case studies will be presented to illustrate how grizzly bears are being used to help define acceptable human use management strategies. The studies represent approaches taken at the landscape, watershed (landscape management unit), and sub-watershed (area planning) scale. Some of the work presented reflects work in progress, while others were recently completed.

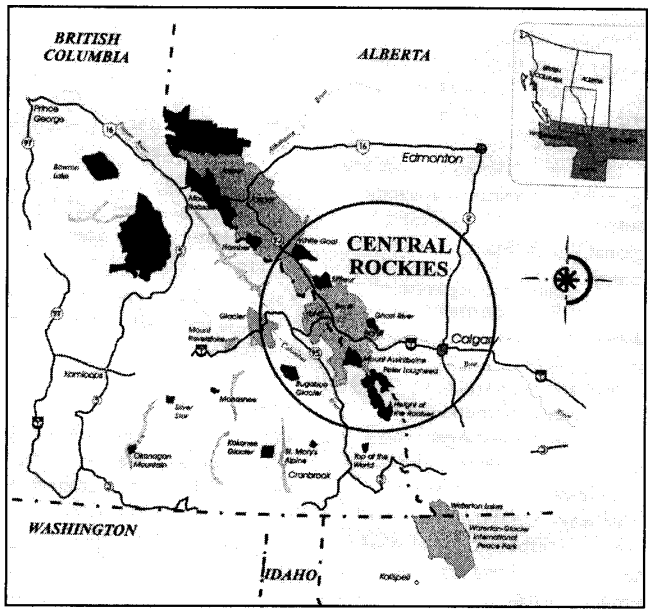

Figure 1—Central Rockies Ecosystem.

Table 1—Current thought related to the management of grizzly bears (Paquet, P., personal communication).

Issue	Conserving grizzly bears in human dominated landscapes	Human disturbance is the single largest threat to sustaining grizzly bear populations Developing innovative and cooperative strategies are key to improved conservation
Goal	Sustain the natural environment and meet human needs	Means reducing the potential for one seriously to encroach upon the other
Objective	Conserve free-ranging and self-sustaining grizzly bear populations	Implies conservation of all biological diversity and maintenance of ecological integrity
Problem	Ecological	How probability of persistence changes with habitat degradation, small population size, and population isolation
	Social	What probability of persistence and environmental quality is compatible with economic goals, and acceptable to society
	Management	How to achieve ecological and social objectives within constraints of legislation
Direction	How to progress toward sustainability	Require mechanisms to address pragmatic issues such as economic needs and conflicts that inevitably arise between humans and grizzly bears
Current regional problems	Conflicts	Spatial needs of grizzly bears and potential overlap with humans have generated social, political and environmental conflicts Heated political controversies, reduced public funding, and diminished management options Environmental concerns have been subsumed to commercial needs Human population pressures and associated land uses have supplanted large areas of natural habitat Conversion of extensive portions of habitat from optimal to unsuitable conditions Ongoing destruction of habitat is confining increasing numbers of grizzly bears into small and insular patches
Implications		Additional ecological impoverishment will occur because intensity of human activity is increasing

Case Study A: Regional Landscape

The landscape approach presents work being completed as part of a rewrite of the Park Management Plans for Yoho and Kootenay National Parks.

The Rocky Mountain National Parks have recognized that human use, which includes the direct physical use and the associated infrastructure and support services, is the single greatest stressor on the integrity of park ecosystems. In the absence of global economic collapse or major restrictions to international travel, historical growth trends in the tourism sector and the continued attractiveness of the Canadian Rockies as a tourism destination suggest that human use, if unmanaged, will continue to increase into the next millennium (Petersen 1999).

The need for integrated management is based on the fundamen ority when considering park zoning and visitor use in a management plan" (Parks Canada 1988). The basis for this management must be thorough consideration of both ecological and social objectives.

Yoho and Kootenay National Parks support and encourage sustainable human use and provide a range of visitor opportunities that enhance the opportunity to understand, appreciate, and respect the natural and cultural resources, while at the same time ensuring that the resource base is protected and allowed to function according to natural processes. Applicable strategic management goals include:

- To influence visitor expectations and manage human use aimed at enhancing the visitor experience, protecting ecological integrity, and supporting viable wildlife populations.
- To manage human use to ensure the ecosystem continues to support viable populations of carnivores (wolves and bears).

To develop facilities and services within a park that supports ecological integrity, it is critical that the objectives for human use and resource protection be coupled in a planning context. To accomplish this, Parks has developed and implemented the following integrated planning approach for use in the development of their management plans.

The approach first attempts to visually present the relationship between the ecological and human use objectives from a landscape perspective. It then subdivides the park into smaller geographic planning units (landscape management units—LMU) in which actions to manage human use are proposed. These geographic units, originally defined as bear management units, are based generally on the home range of an adult female grizzly bear.

The second step of the planning process involves the completion of a situational analysis for each LMU. This task includes assessment of the existing issues related to a comprehensive listing of ecosystem issues developed for the park (wildlife, vegetation, aquatics, social, and cultural). This exercise revealed that the following ecologically based issues were the most important for an integrated planning approach: grizzly bear habitat effectiveness, wildlife movement corridors, wildlife mortality, wildlife disturbance, and significant/rare habitats.

Carnivore Management Unit Habitat Effectiveness

Parks Canada has endorsed the application of the habitat effectiveness model as a tool for managing human use (Parks Canada 1997). Habitat effectiveness is a component of the Cumulative Effects Model (Gibeau 1998 as cited in Jalkotzy and others 1998, USDA Forest Service 1990, Weaver and others 1986) (figure 2). The analysis determines, for each of the units, the effectiveness of the habitat after human use impacts have been considered. For management purposes, a habitat effectiveness target has been defined and is used to guide future management of the type, nature, location, and intensity of human use.

Wildlife Movement Corridors

A fundamental requirement for maintaining viable populations of wide-ranging species is the opportunity for individuals and populations to interact and move throughout the landscape. These wildlife corridors are important for movements within the Parks, as well as for providing linkages to adjacent Provincial lands. Two areas in which aggressive action is required are:

- Pinch points—where corridors pass through a topographically constrained area in which there is a high level of human activity.
- Fracture zones—high use transportation corridors (Trans-Canada Highway, Canadian Pacific Railway) can block wildlife movements and must be mitigated to allow safe crossings for wildlife species.

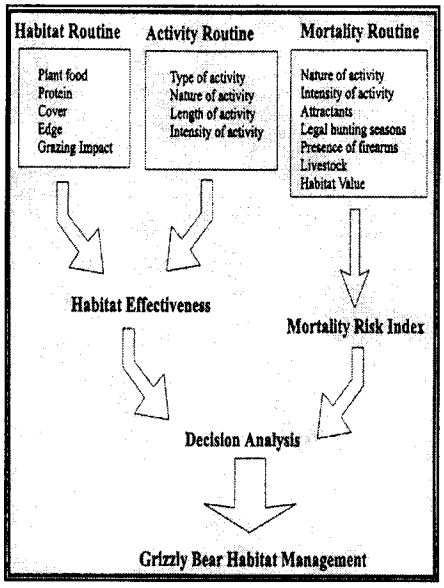

Figure 2—Cumulative effects assessment model.

Significant/Rare Habitats

These units are significant because they contain rare/endangered species or ecosystems, have limited geographical representation, or are critical to the life requirements of wildlife species.

Wildlife Mortality

Human-caused mortality has the potential to negatively impact the viability of wildlife populations (Benn 1998). This can be the result of direct mortality (highways) or indirect mortality from management actions taken in response to wildlife habituation to humans. Parks Canada has committed to reducing the number of grizzly bears killed as a result of human activity to less than 1% of the population annually (Parks Canada 1997).

Wildlife Disturbance

Increasing shoulder-season (fall/winter/spring) visitor use has the potential to disturb wildlife during critical and/or vulnerable stages of life cycle.

The visual representation of these issues and their objectives as GIS mapping layers provides a geographic sense of the constraints within which human use must be managed.

Social Context

The marketing position of Yoho and Kootenay has been expanded upon and now forms the basis for the social objectives of the planning units. Yoho and Kootenay are positioning themselves as a transition park, in which people can develop their skills and abilities to understand and participate in protected areas issues and related activities. The Parks will manage their internal and external visitor services to provide a range and progression of appropriate opportunities. To achieve this, all of the planning units have been rated according to the "experience level" that they are offering: from 1—where opportunities for trail activities and solitude are limited but all basic and essential services are provided—to 6—where solitude will be provided and infrastructure development will be minimal. It is envisioned that people can work their way through the opportunities in the Parks according to their existing skill levels or as their abilities advance. Levels of interpretation and infrastructure development should match the type of experience provided. Visitor surveys can then be used to detect whether people are being provided with the pre-trip information that directs them to appropriate areas and whether people are advancing their skills and understanding as they move through the various planning units within the Parks.

The units were rated against a series of social descriptors: visitor encounter expectations, motivation, degree of self sufficiency, level of infrastructure development, appropriate activities, trip duration, access, and substitution. These descriptors were selected from a more comprehensive list because they provided the best overview of the social conditions to be expected/provided in a unit. This step in the process is critical because it is through the acceptable match between motivations/expectations and benefits that satisfaction is achieved.

Lessons Learned

What was learned during this integrated planning process was the following:

1. The management of summer human use became a focus largely in response to the availability of the grizzly bear habitat effectiveness model. There is a need to develop similar models for species (such as wolverine) that could provide direction for the management of winter human use.
2. The habitat effectiveness model is one of very few ecological models that provide clear direction regarding acceptable levels of human use. Unfortunately, within the model, the only significant use values are above or below a threshold of 100 users/events per month. This number is very restrictive and difficult to apply in areas with high current levels of human use (for example 1,000-10,000 users/events per month). However, for the management of critical grizzly bear habitat areas and for social objectives of wilderness/solitude, the model parameter of <100 users/events per month proved to be a useful planning tool. In these areas, it was easy to integrate social and ecological objectives.
3. Where grizzly bear habitat values are lower, and the realities of existing use would make it impossible to manage within the low use category (<100), the areas will be managed ecologically to minimize the potential for bear habituation and bear/human encounters, provide for movement corridors, minimize mortality, and provide access to critical habitats.
4. Habitat effectiveness model limitations include:

- The model does not accept habitat changes (such as artificial habitats created by ski hills).
- There needs to be additional research into the impacts on bears of various "disturbance event" management options.
- The model is useful to provide a feedback mechanism between management experiments and model results (that is to test changes in habitat effectiveness caused by implementation of management decisions).
- Ecological gains can be shown even when they are not reflected in the resulting habitat effectiveness values.

Case Study B: Landscape Management Unit

This case study will present work that is occurring within the Moraine Lake area of Banff National Park. It reflects work at a landscape management unit scale.

Moraine Lake is an important area that receives 500,000 to 600,000 visitors per year. With only one commercial overnight facility, the majority of the 8,000 visitors/day are there as day users. Many of the front and backcountry trails within the area have been subject to management closures during the period 1995 to 1998. These closures have been in response to the activities of both habituated resident and other migratory grizzly bears. Although the management actions were warranted and justified to ensure public safety

and the survival of the bears, there were resulting impacts to the visitor opportunities in the area. Therefore, Parks Canada determined in early 1999 that there was a need to define the issues and determine whether there were other ways to manage for ecological health and public safety while still maintaining public access to the visitor opportunities. A planning process was initiated and a working group, which included representation from internal and external interests (including environmental, business, natural resource, cultural, operational, and local communities), was assembled. Members of the working group prepared background papers that defined the issues from their perspectives. The background papers provided an opportunity for exploration of the issues and identification of linkages between the interest groups and enabled more comprehensive understanding of the current situation. The working group then identified short- and long-term actions to address the identified issues.

The issues coalesced around two central themes: "sense of arrival" and bear/human conflict. The former related to crowding of day use facilities during the peak season, congestion and conflicting patterns of use in the parking area, and impacts on staff/visitors/operators during closures of popular backcountry areas and trails. The latter issue related to the need to provide both safe visitor opportunities and for the ecological needs of the resident and transitory grizzly bears.

The working group identified numerous short-term actions to address the issues related to sense of arrival. The focus of the actions was on an effort to use enhanced communication to encourage a voluntary change in the behaviour of visitors to the area. The behavioural change was in the areas of transportation to/from the site and discontinuation of overflow parking. Communication products (brochures, signs, radio, Internet) will provide visitors with accurate expectations about the congestion, etc., that will be encountered if they plan to visit the Moraine Lake area during the peak periods. The communication also stresses the use of public transportation and car pooling as alternative access options. The goal of these initiatives is to reduce congestion through a voluntary change of public behaviour.

To manage bear/human conflict, the Park is attempting to pilot a new use management option that could be employed as a proactive measure to reduce the likelihood of an encounter. It is proposed that if bear/human conflicts are reduced, there will be less need for closures of trails, areas, and facilities. The new approach is a change to the existing bear management policy, which has only two options available — either a warning or a closure. A new "Restricted Access" option which requires that, in addition to regular enhanced bear safety precautions, hikers travel in a minimum group size of six and horse stock users in a minimum group size of two has been proposed for implementation between a warning and a closure. Mountain bike use is being restricted until scientific information is available to provide some direction for either an acceptable groups size or alternative risk management mitigative measures (such as continuous noise making device, trail sight lines, speed, etc.).

Although only a small number of grizzly bears may use the Moraine Lake area, current human use levels and patterns create considerable potential for it to become a mortality sink. If this were to occur, it would have serious implications for the grizzly bear population in a much broader area (Benn 1998).

The long-term issue for both the frontcountry and backcountry is that there is a need to define a use capacity target for the area based on ecological and social objectives. This will be a longer term planning issue that will be controversial and require considerable public input and consultation. In the short term, data gaps and required ecological (core security area and linkage zone analysis, habitat effectiveness, and bear risk assessment) and social (transportation, visitor satisfaction, and quality/nature of experience) information is being collected.

Lessons Learned

The short-term actions are being implemented for the 1999 visitor season. It is too early to determine how much enhanced communication convinced people to voluntarily change behaviour in the frontcountry. Similarly, any ecological gains achieved through the restricted access option will not be known until the strategy is evaluated in the fall of 1999. In the Moraine Lake case study, grizzly bear issues have provided direction for visitor access (type, timing, and amount), group size, and the management of risk related to bear/human conflicts.

For high-use areas such as the Moraine Lake study area, the grizzly bear habitat effectiveness model is of little utility. However, the species is still valuable in that, as illustrated, it can be used to assist with the development of more creative human use management options.

Case Study C: Area Planning

This example presents a completed project within the O'Hara Valley area of Yoho National Park (figure 3). A series of bear/human encounters in this area convinced park management to commission an independent bear hazard assessment of the area's trail network. In response to the report's recommendations for public safety and a mandated concern about general human impacts to the ecological requirements of a viable local and regional grizzly bear population, a number of indeterminant trail closures were effected. Park management was subsequently challenged, regarding both the science supporting the actions and the use of the closures themselves as a necessary and appropriate management response.

Consequently, a four year "Lake O'Hara socio-ecological research project" was undertaken. The collaborative project used ecological and social data in a computer-based decision support model to provide recommendations to park management on methods to resolve the land allocation issue between grizzly bears and humans.

The modelling components included: grizzly bear suitability (ecosite capability, habitat capability, and habitat linkage), bear encounter risk (noise, visibility, tread, use, rub trees, habitat suitability, and large mammal carcass), and human suitability (preference and use). To generate a final map layer for each of the models, principles of pairwise comparison, weighted valuation, and multi-criterion evaluation were used to analyse the data. The final maps were then overlaid and management recommendations based on the divergence and convergence of conflicting land use requirements.

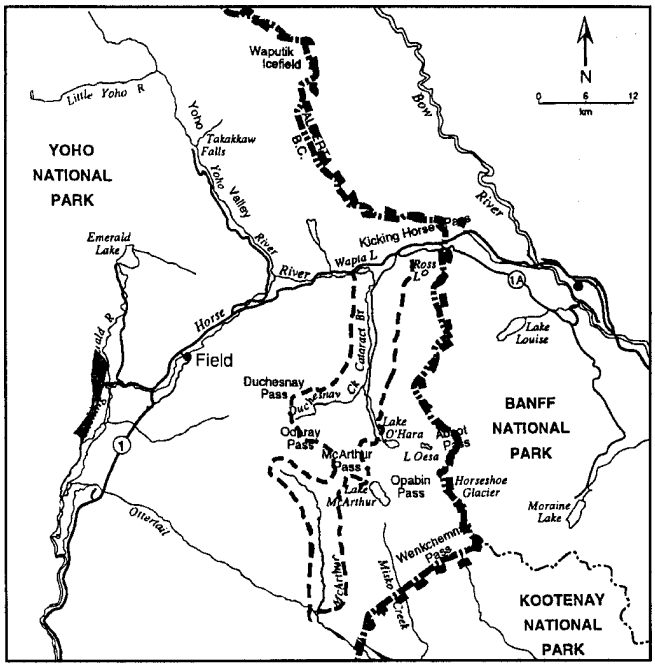

Figure 3—Geographical location of Lake O'Hara.

The specific objectives of each of the research components are detailed below.

Social (Wright and Kelly 1997)

The main objectives of the social component of the project were:

1. To learn more about the type of visitor experience hikers currently have in Lake O'Hara.
2. To identify the types of recreation features that are important to visitors.
3. To assess how visitors feel about trail closures and other management actions for managing bears and people in parks.
4. To examine the preferences and current patterns of use of trails in the Lake O'Hara area and how they may coincide with potential grizzly bear habitat.
5. To provide park management with recommendations to manage the Lake O'Hara area for the benefit of both humans and bears.

Through the integration of onsite visitor survey information, a trail level of use assessment and a visitor photography exercise, the project's central research questions were addressed.

Geographical Information System (GIS) (Donelon and Paquet 1998)

Two software packages were used to develop the GIS component of the decision support model. IDRISI for Windows Version 2.0 provided the primary software environment and was used for its spatially based decision support modelling modules, to develop raster layers used in the model and for graphic output, including a Digital Elevation Model, Slope Model, and Aspect Model.

MapInfo Professional Version 4.1 was the secondary software application and was used for digitization and spatial database queries and to create the graphic output for map files.

Ecological (McCrory and others 1999)

Data collected by the field researchers included:

1. Bear use/activity (hair sticks and direction lines, sand track pits, ground tracking, sightings, DNA hair collection, permanent bear habitat transects, camera/video installations, bear movement trails, access and egress points, and habitat use).
2. Vegetation (scat collection, scat decomposition rates, berry and pine nut phenology and productivity, vegetation transects, eco-site classification, and habitat microsites).

The methodology used for the Lake O'Hara study closely represents a "human dimensions" approach—efforts to make decisions that are more responsive to the public and that, in the long term, increase the effectiveness of decisionmaking (Knight and Gutzwiller 1995).

"People must have a shared understanding and be able to communicate clearly about the resources and issues in order to make decisions and reach agreement. Information systems that aid solving complex problems by augmenting the user's knowledge are called decision-support systems (DSS's). Supporting learning and communication are basic functions of a DSS" (O'Brien and others 1995). DSS will typically provide a set of tools that support the process of problem structuring, understanding the problem, producing alternative solutions, evaluating them, and facilitating group processes in decisionmaking (Gurariso and Werthner in O'Brien and others 1995).

Grizzly Bear Suitability Model—One of the first objectives of the decision support model (Donelon and Paquet 1998) was to develop a Grizzly Bear suitability model for the study area. Based on available information and data collected by researchers on the project, three separate criteria were identified for use in the development of the suitability model. These were ecosite capability, grizzly bear habitat classification, and habitat linkage (comprised of cost surface, slope, and distance to human features layers). Each of the suitability criteria were spatially mapped with a common classification scheme with classes of 1-10. The data collection and GIS analysis were also segregated into three temporal classes. Pre-berry season (to July), berry season (July and August) and post-berry season (September on). Figure 4 illustrates one of the bear habitat suitability model outputs.

A panel of grizzly bear experts were used to develop the final grizzly bear suitability model. The process involved the application of Satey's pairwise comparison matrix to develop linear weighted values of importance for each of the three criterion in the model (ecosite capability, habitat capability, and habitat linkage). These weighted values were then used to combine each of the criterion, through Multi Criterion Evaluation (MCE), to produce a final grizzly bear suitability map for the study area.

Bear Encounter Risk Model—The bear encounter risk model for the study area is comprised of seven criteria. These consist of three trail design features (noise, visibility, and

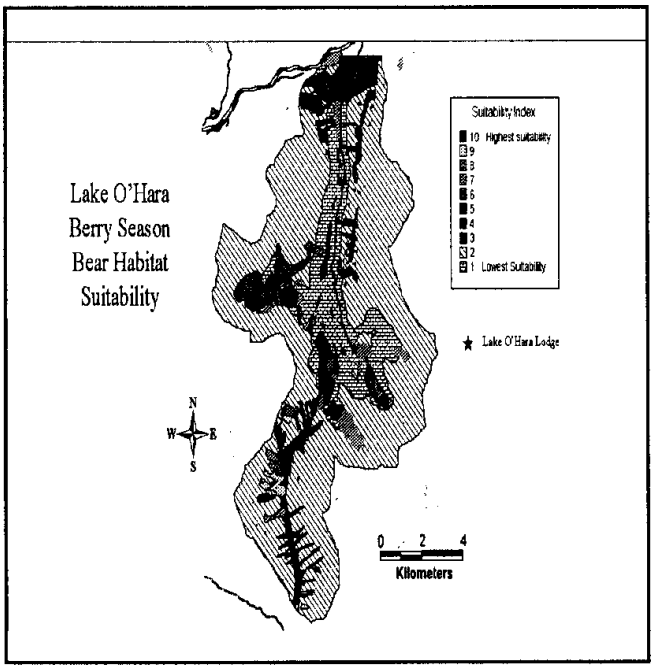

Figure 4—GIS model output of grizzly bear habitat suitability.

tread design), bear use, bear habitat suitability, availability of large mammal carcasses, and the occurrence of rub trees. The relationship between these criteria and risk management are contained within table 2.

Table 2—Encounter risk criteria.

Criteria	Comments
Noise	Amount of noise proximal to trail (affects potential for and severity of an encounter)
Visibility	Line of sight distance and amount and thickness of cover (affect likelihood of an encounter)
Tread design	Width and roughness of trail surface (less maintained trails require more attention when travelling upon and detract from ability to detect the presence of a bear)
Bear use	Index of use (bear movement occurrences) within 150 m buffer along each trail
Rub trees	Trail segments classified based upon the number of rub trees found within 150 m of the trail
Habitat suitability	Criterion from suitability model Boolean image isolating habitats within 100 m of trail segment Highest habitat value adjacent to trail segment selected for suitability value
Large mammal carcass	Likelihood of large mammal carcasses being present (proximity/availability of carcasses alters bear behaviour and affects nature and severity of potential encounter)

To create the final bear encounter risk map the bear experts again used Satey's pairwise comparison and MCE.

Human Preference—In the absence of a clear rationale for completing a pairwise comparison, it was determined that it was acceptable to develop the final human preference map by using equal weighted values for the two criteria.

Criteria	Origin	Comments
Use	Trail counters	Strong correlation between survey and trail counter use estimates
	Visitor survey	Counter data extended to trails without counters
Preference	Visitor survey	Illustrated preference relative to the respondents knowledge of the area

To conclude the decisionmaking process, a meeting was convened between Parks Canada management staff and the research project steering committee. The intent of the meeting was to expose managers to the process and content of the decision support system and to facilitate their discussions so that a final decision could be made about the management scenario to be implemented in the Lake O'Hara area. The format of the meeting was very informal to encourage questions and open discussion on the components to the model and the sensitivities and assumptions within it.

Lessons Learned

As a case study attempting to develop a new computer support model to aid in decisionmaking, it was a success. Although the cost of this test application was significant (±$150,000), it was felt that when applied again considerable efficiencies could be achieved.

One of the advantages of the GIS environment to modelling and decisionmaking is that it is dynamic and thereby allows updates to the maps and background information at any time. This provided the opportunity to both segregate or combine model layers to better explain the results of the field research.

Park managers appreciated the visual format of the model and were able to come to a consensus decision on the management scenario that seemed to best meet the requirements of the mandate, while still providing for an acceptable level and quality of visitor experience.

Conclusion

It has been shown through the previous three case studies that grizzly bears can be used as a filter for managing human use. In the regional landscape case study, habitat effectiveness, movement corridors, significant habitats, disturbance, and mortality were all useful to define acceptable levels, types and timings of human activities. In the landscape management unit case study of Moraine Lake, the grizzly bear was used within a risk and ecological management framework and provided guidance for defining appropriate types of human use. The area planning case study of Lake O'Hara illustrated a fine-scale application of a decision support model that addressed the competing land uses

between grizzly bears and humans. Each application has built on the successes and corrected the failures of previous efforts.

Despite the accomplishments to date in taking a more integrated approach to planning and management, work will continue to more fully incorporate human dimensions research into the decisionmaking process.

Although human use management in the Rocky Mountain National Parks can be partially guided through application of grizzly bear related models and constraints, there is a fundamental question regarding an overall appropriate use threshold. Current research and monitoring within national parks is focused largely on the understanding of ecological systems and the assessment of ecological impacts resulting from existing levels of human use and development. Parks Canada will need to refocus its existing science program to begin to investigate the social and economic issues surrounding human use and the setting of capacity targets.

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