GRIZZLY BEAR HABITAT EFFECTIVENESS MODEL FOR BANFF, YOHO, AND KOOTENAY NATIONAL PARKS, CANADA

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Abstract: Changes in land use are currently accelerating development pressures in the Central Canadian Rocky Mountains. Given the existing and proposed human influences in the region, cumulative effects are a major issue, especially for carnivores. I quantitatively and qualitatively assess of the effects of human actions on grizzly bears (*Ursus arctos horribilis*) and their habitat. Since 1985, a cumulative effects model (CEM) for grizzly bears has evolved into the consolidated form used by the US Department of Agriculture (USDA) Forest Service. The habitat effectiveness model presented in this paper follows the USDA Forest Service CEM with minor changes to allow our data to conform to the process. I analyzed a study area of approximately 9,300 km^2, and results indicate that much of the 3 National Parks are only moderately productive habitat, excluding human influences. Adding the effects of humans, the modelled ability of the landscape to support bears is significantly reduced. The model suggests widespread habitat alienation in what is supposed to be core refugia for grizzly bears, questioning the ability of the landscape to support a viable population. This situation we find ourselves in is a particularly difficult one, given that incremental recreational development has never been considered a threat to the protected status of Canadian national parks. In the Canadian Rockies, mountain national parks function as *de facto* core refugia for grizzly bears. With continued erosion of grizzly bear habitat in what is supposed to be core refugia, time is clearly not on the park manager's side. Swift, and in some cases, drastic, management action is needed if we are to stem grizzly bear extinction within the ecosystem.

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As demands on the land increase, cumulative effects result from individually minor yet collectively significant uses occurring over space and time. Cumulative effects analysis (CEA) assess the effects on a system of spatial and temporal perturbations resulting from human activities (Beanlands et al. 1986). This is a fundamental paradigm shift for wildlife conservation, as we can no longer wait for scientific proof of simple cause and effect relationships (Davies 1992). CEA explicitly deals with effects, and most importantly, whether those effects exceed or fall short of thresholds compatible with population goals of a given species or guild of species. Hence, CEA and its subsequent models are tools to perform proactive conservation (Weaver et al. 1987) of threatened or sensitive species and landscapes.

Changes in land use are currently accelerating development in the Central Canadian Rocky Mountains. Unparalleled development has occurred in the mountain national parks since 1980 including hotels, ski areas, campgrounds, golf courses, backcountry lodges, and an extensive network of equestrian, hiking, and ski trails. Two major transcontinental transportation routes, the Trans Canada Highway and the CP Rail mainline, bisect Banff and Yoho National Parks. This area can be described as one of the most intensively developed landscapes in the world where grizzly bears still survive (S. Herrero, Univ. of Calgary, AB, Canada, pers. commun., 1995). The result is a loss of connectivity as well as potential loss of viability for carnivore metapopulations. Given existing and proposed human activities in the Central Rockies area, cumulative deleterious effects are affecting wildlife, especially carnivores. CEA is becoming a recognized legal and policy approach to environmental impact assessment (Spaling and Smit 1993). Parks Canada recognizes that proactive measures are necessary now to ensure long-term viability of carnivore metapopulations (Apps 1993).

A CEA for grizzly bears has several components (Mattson and Knight 1991), including: (1) detailed habitat description and capability analysis; (2) comprehensive accounting of all current and proposed human activities and developments; (3) establishment of population threshold levels; and (4) population viability analysis. CEA must be done on some meaningful spatial and temporal scale (Comm. Appl. Ecol. Theory to Environ. Problems 1986) and must include the entire population to meaningfully assess human impacts with respect to the population's chances for survival (Shaffer and Sampson 1985, Gilpin 1987, Grumbine 1990).

Herein I discuss the application of a tool developed to quantitatively and qualitatively assess the effects of human actions on grizzly bears and their habitat. Since 1985, a cumulative effects model (CEM) for grizzly bears has evolved into the consolidated form presented by the US Department of Agriculture (USDA) Forest Service (1990). The model includes the past and present human impacts on grizzly bears and their habitat. The habitat effectiveness model I present follows the USDA Forest Service CEM with minor changes to allow our data to conform with the process. This model is an analytical aid to decisions affecting conservation of grizzly bears in the Rocky Mountains.

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STUDY AREA

Banff, Yoho, and Kootenay National Parks form a contiguous area of approximately 9,300 km^2 along the continental ranges of the Central Canadian Rocky Mountains (Fig. 1). Topographic features include rugged mountain slopes, steep-sided ravines, and flat valley bottoms. The climate is continental with long, cold winters and short, cool summers. The aspect and elevation of the mountainous topography modifies climate somewhat. Topography, soil, and local climate strongly influence vegetative communities. Vegetation can be classified into major ecoregions: montane (1,300 to 1,600 m), subalpine (1,600 to 2,300 m) and alpine (2,300+ m). The montane region is dominated by dry grasslands, wet shrubland, and forests of Lodgepole pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), white spruce (*Picea glauca*) and aspen (*Populus tremuloides*). Subalpine areas are forested with mature stands of lodgepole pine, Engelman spruce (*Picea engelmanii*), subalpine fir (*Abies lasiocarpa*), and subalpine larch (*Larix lyallii*) interspersed by areas of wetland shrub. A mosaic of low shrubs and herbs characterize alpine areas.

METHODS

Several types of data were required to produce a habitat effectiveness model; each data set had inherent assumptions and errors. All analyses were based on 1:50,000 scale mapping; therefore, data are probably not sufficiently accurate for evaluating mitigation scenarios on an activity-by-activity basis. Data compilation and analysis were facilitated by Spans® GIS (Intera Tydac Technologies Inc) and Quattro Pro® (Borland International Inc) spreadsheet program.

The study area was subjectively divided into bear management units (BMU) based on topographic features, human facilities, and areas of known high bear use. This division of the landscape was done to: (1) assess existing and proposed activities without having effects diluted by a large area; (2) correlate grizzly bear use to habitat ecology; (3) identify contiguous complexes of habitat which meet year-long needs of grizzly bears; and (4) prioritize areas where management needs require closer scrutiny (USDA For. Serv. 1990).

Habitat Component

Grizzly bear habitat data were taken directly from a habitat evaluation of the 4 mountain parks by Kansas and Riddell (1995). This study applied a food habits model to the Ecological Land Classifications (ELC) of the Western Region of Parks Canada. For their model, Kansas and Riddell (1995) identified key bear foods through food habits and habitat-use data from previous studies (Russell et al. 1979, Hamer and Herrero 1983, Hamer et al. 1985, Raine and Riddell 1991). They assigned a value from 0 to 10 for ELC polygons in each park to reflect their importance for grizzly bears for each month. To reduce the volume of data, similar ELC polygons were grouped into "functional units" and also assigned a value from 0 to 10 for each month.

I used functional unit values to evaluate potential habitat for each BMU each month following the USDA Forest Service (1990) CEM habitat routine. Months were grouped into spring (April, May, and June), summer (July and August), and fall (September and October) after calculations were complete. Readers should refer to the USDA Forest Service (1990) CEM for these computational formulas.

The output from this routine is the habitat component for the effectiveness model. In essence, our habitat component is a qualitative assessment of the spatial and temporal distribution of grizzly bear foods for the 3 parks. The habitat evaluation generated a table of values from 0 to 10, rating potential grizzly bear habitat in each BMU based on spatial and temporal distribution of foods for each season. A BMU rated 0 is interpreted as of no value to grizzly bears, whereas a BMU rated 10 translates to the best possible habitat available in a given season.

Disturbance Component

The disturbance component for the effectiveness model uses human activity maps from previous ecosystem studies (Komex International 1995). These maps use vector, point, and polygon data categorized into 7 classes on an exponential scale based on park visitation records and personal observation. These data became the basis for delineation of the types and intensity of human uses and their associated disturbance values. The major assumption of the human activity model is that it accurately reflects human use at an ecosystem scale. Underlying assumptions of the disturbance component are listed in the USDA Forest Service (1990) CEM.

Following the USDA Forest Service (1990) CEM, our human use model was stratified based on: (1) motorized or nonmotorized type of activity; (2) point or linear nature of activity; (3)high or low intensity of activity; and (4) cover or noncover security class. Linear activity included highways and trails. Point activity included campgrounds, lodges, and other developments. High use was defined as >100 vehicles or people/month, low use was defined as <100 vehicles or people/month. The USDA Forest Service model used 80 vehicles or parties/month as the division between high and low use. Based on the ELC, cover was defined as forested ecosites and noncover, grassland and alpine ecosites.

Once stratified, each activity group was assigned a disturbance coefficient and associated zone of influence. The zone of influence (measured horizontally) identified the area in which grizzlies would be affected by the activity; the coefficient identified the degree of disturbance within the zone of influence. The degree of habituation of a bear population and the type of human activities (recreation, resource extraction, or hunting) influences bear behaviour. The consequences of bears habituating to or avoiding people were incorporated into disturbance coefficients and associated zones of influence. Disturbance can influence bear use through actual displacement and change in use patterns reducing the time available for a bear to use an area (e.g., 24 hour to nocturnal only use). These factors were considered in coefficient development.

Disturbance coefficients are rated on a scale of 0 to 1 based on how grizzly bears would respond to a given activity (e.g., what percent of the bears would still use the habitat within the zone of influence for what percent of a 24-hour period). For example, a disturbance coefficient of 0 implies total displacement - none of the habitat within the zone of influence would be available to the bear. A disturbance coefficient of 1 indicates no disturbance - the accessability to the habitat within the zone of influence is not affected by the activity. A disturbance coefficient of 0.5 indicates that an area's ability to support bears is 50 % of potential. Either half of the bears have been displaced or all the bears can use the area only half of the time, or any combination. The result is the same: the ability to support bears is reduced by 50 %.

For this model, disturbance coefficients and zones of influence from the Yellowstone ecosystem (May 1993) were adopted for the types and intensities of human use (Table 1). Coefficients from the Yellowstone ecosystem were chosen because (1) there is no empirical data on human influences in the Canadian Rocky Mountains; (2) this study area has similar types of human influences on grizzly bears given a protected core surrounded by multiple-use lands; and (3) more research has been done on human effects in the Yellowstone ecosystem than other areas. Consultation with knowledgeable individuals (D. Mattson, Univ. of Idaho, Moscow, 1994; T. Puchlerz, USDA For. Serv., Missoula, MT, 1994; pers. commun.) concurred the Yellowstone situation is analogous to the 3 Canadian mountain parks. Some minor modifications to Yellowstone's security cover classes were necessary to allow our data to fit the model. Yellowstone's model incorporates 5 security classes whereas, this model only incorporates 2.

I multiplied disturbance coefficients by the habitat value within that affected portion of a polygon to compute disturbance values. Disturbance within overlapping zones of influence were cumulative, hence coefficients were multiplied together. Again, readers should refer to the USDA Forest Service(1990) CEM for detailed methodology and formulas.

The disturbance component generated a table of numeric values from 0 to 10 rating the realized ability of grizzly bears to continue using habitats influenced by human activity. The same units of measurement are used as the habitat component allowing comparisons between inherent habitat quality and altered conditions. A BMU rated 0 is interpreted as of no value to grizzly bears, whereas a rating of 10 translates to the best possible habitat left. The disturbance component illustrates alienation within BMU unit by season. Output from this routine measures the ability of bears to continue using habitat influenced by human activity.

Habitat Effectiveness

Habitat effectiveness is the comparison of the habitat and disturbance components and reflects an area's actual ability to support bears. Comparison of the habitat and disturbance components produces a table of habitat effectiveness values for each BMU that represent the percentage of potential for that area by season. These numeric values are interpreted simply as what percentage is left after accounting for human disturbances imposed upon the area.

Interpretation of habitat effectiveness as a percent of pristine cannot be translated into number of bears lost. The CEM process is still under development, and the information needed to state actual effects on the grizzly bear population (numbers of bears) is not known. Therefore, it oversteps the bounds of the model to attempt to determine the number of bears that could be supported by restoring an area to natural conditions. Likewise, population losses resulting from further development cannot be determined. The numbers generated by the model are for comparison of alternatives only.

RESULTS

The habitat component provides a measure of the inherent potential or productivity of the landscape for spring, summer, and fall. Values range from very high capability such as BMU 40 (8.0 spring, 8.1 summer, 8.4 fall) to low capability such as BMU 1 (1.9 spring, 1.5 summer, 1.7 fall). Habitat component results for summer were categorized into very high (>7), high (5.0 to 6.9), moderate (3.0 to 4.9) and low (<2.9) potential (Fig. 2). Values for spring and fall were similar to summer values (Table 2).

The disturbance component is used to compare and contrast habitat productivity when human influences are considered. Model output depicts dramatic declines from potential in some BMUs. For example, in Banff National Park 18% of the BMUs were inherently low potential in summer. However, when human disturbance was added, 48% of the BMUs in Banff National Park had low realized productivity. Disturbance components for summer were categorized into very high (>7), high (5.0 to 6.9), moderate (3.0 to 4.9) and low (<2.9) realized grizzly bear habitat (Fig. 3). Values for spring and fall were similar to summer values (Table 2).

The habitat effectiveness value quantifies the extent of landscape available to bears when human influences are considered. Figure 4 displays habitat effectiveness for summer categorized into 4 percentages of potential. For many BMUs the model suggests that the ability of the landscape to support bears has been significantly reduced. For example, BMU 19 is 78.6% of potential in the summer (Table 2). In other words, it is 21.4% disturbed.

To summarize the analysis and give perspective on the entire landscape, all 40 BMUs can be combined. In total, my analysis covered 9,344 km^2 of *de facto* core refugia within the Central Canadian Rockies. Using summer values, the area has a modelled potential habitat value of 4.4, a realized habitat value of 3.6 and a habitat effectiveness value of 83.1%.

DISCUSSION

It becomes obvious that a significant portion of the landscape is only moderately productive habitat (Fig. 2). Much of this is due to unproductive land within individual BMUs. For example, BMU 1 is 70% rock and ice. Much of the mountain national parks are not inherently prime grizzly habitat; this is a new concept for many and an important realization in understanding the basis for CEA. National parks in the Canadian Rocky Mountains were originally selected for their scenic and tourism value, which is inherently not good habitat. Better habitat lies to both the east and west in human-dominated multiple-use lands. Yet the disturbance component suggested wide spread habitat alienation in areas considered core refugia for grizzly bears in the Canadian Rocky Mountains. This questions the ability of the landscape as a whole to support a viable population.

There has been considerable discourse regarding habitat threshold levels beyond which grizzly bears are eliminated. In the U.S., researchers have been working toward establishing meaningful ecological thresholds, but how to do this remains unclear. One way of establishing thresholds is to view them as some acceptable percentage of being wrong (D. Mattson, Univ. of Idaho, Moscow, 1994, pers. commun.). In the case of the grizzly bear in the U.S. and Canada, the implications of being wrong have serious consequences: extinction. If the threshold were set at 80% habitat effectiveness, would a manager be comfortable with a 20% chance of being wrong?

In the absence of clearly defined ecological thresholds, I suggest we add a sociological component to our view of thresholds. What percentage of human induced degradation are we willing to accept within core refugia or areas managed as preserves. How degraded can wilderness areas be and still be called wilderness? These are tough questions with no simple answers. In the U.S. early CEM models suggested a 70% threshold in the multiple-use landscape of the Kootenai National Forest. In Yellowstone National Park, 80% has been suggested as a threshold level. If we were to use 80% habitat effectiveness as the benchmark, 44% of the BMUs in Banff National Park are close to threshold (Fig. 4).

There are however, still some bears residing in BMUs that are below the suggested threshold. This can be explained in some cases by the behavioral concept of persistence of individuals. In long-lived species such as grizzly bears, individuals will persist and accept the disturbance despite non-viability because it is home. Once the individual passes on, a new bear will reject the area due to high levels of human disturbance.

This habitat effectiveness model aggregates the past and present human effects on grizzly bears and their habitat but does not project into the future. The model quantifies concerns about the viability of the bear population within the area of analysis, but it does not confirm them. Results from long-term empirical work initiated in 1994 test the model and provide further evidence to justify concern. However, because of time constraints conservation biologists must be willing to express an opinion based on available evidence, accepted theory, comparable examples, and informed judgement (Primack 1993).

A reasonable prediction stemming from the model is that if management practices do not change, we will continue to erode grizzly bear habitat and, if unabated, the population will become extinct. To that end, an independent external review panel was established in 1995 to evaluate current management practices in Banff National Park and make recommendations for change.

CONCLUSION

A number of related factors make this situation particularly difficult. First, much of the mountain national parks are not inherently prime grizzly habitat, which is a new concept for many. Secondly, the model suggests the ability of the landscape to support bears has been significantly reduced by widespread human presence. Finally, traditional types and levels of human activities are widely accepted within national parks and have not been viewed as detrimental to grizzly bears.

The status of national parks as protected areas, and therefore refugia for large carnivores, has been taken for granted since their creation >100 years ago. Incremental recreational development has never been considered a threat to this protected status. As we approach the close of the twentieth century we need to reconsider this paradigm. With continued erosion of grizzly bear habitat in what is supposed to be core refugia hanging in the balance, time is clearly not on the park manager's side. Swift, and in some cases drastic, management action is needed if we are to stem the progression of extinction within the ecosystem.

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Table 1. Disturbance coefficients and zones of influence for Banff, Yoho, and Kootenay National Parks habitat effectiveness model, 1995.

Type of activity	Zone ofinfluence (meters)	Intensity of use	Security class	Coefficient
Linear motorized	800	High	Cover	0.37
			Non-cover	0.16
		Low	Cover	0.73
			Non-cover	0.64
Point motorized	800	High	Cover	0.37
			Non-cover	0.16
		Low	Cover	0.73
			Non-cover	0.64
Linear non-motorized	400	High	Cover	0.65
			Non-cover	0.56
		Low	Cover	0.88
			Non-cover	0.83
Point non-motorized	400	High	Cover	0.50
			Non-cover	0.33
		Low	Cover	0.88
			Non-cover	0.83

Table 2. Summer values for bear management units (BMUs) in Banff, Yoho, and Kootenay National Parks habitat effectiveness model, 1995.

BMU	Potential	Realized	Habitat effectiveness
1	1.5	1.0	66.6
2	3.1	2.7	87.1
3	3.4	2.9	85.3
4	2.4	2.3	95.8
5	3.0	2.2	73.3
6	2.3	2.2	95.6
7	2.6	2.5	96.1
8	3.5	2.6	74.3
9	4.5	2.1	46.6
10	3.5	3.1	88.6
11	3.2	2.5	78.1
12	2.6	2.5	96.1
13	4.0	3.8	95.0
14	4.1	3.8	92.7
15	4.4	3.8	86.4
16	5.5	3.8	69.1
17	5.2	3.9	75.0
18	5.3	4.0	75.5
19	5.6	4.4	78.6
20	4.8	4.7	97.9
21	5.3	4.8	90.6
22	7.4	3.6	48.6
23	3.5	2.9	82.8
24	4.0	3.5	87.5
25	5.1	4.7	92.1

Table 2. Continued.

BMU	Potential	Realized	Habitat effectiveness
26	3.5	2.9	82.8
27	3.9	3.5	89.7
28	4.7	4.1	87.2
29	4.4	4.1	93.2
30	3.0	2.0	66.6
31	4.8	3.9	81.2
32	3.6	2.8	77.7
33	4.3	4.2	97.7
34	4.3	3.6	83.7
35	4.8	3.9	81.2
36	5.6	5.0	89.3
37	6.9	6.1	88.4
38	7.8	6.7	85.9
39	6.9	5.6	81.1
40	8.1	6.9	85.2

Figures not included

Fig. 1 Central Canadian Rocky Mountains. Banff, Yoho, and Kootenay National Parks are shaded.

Fig. 2 Potential grizzly bear habitat for bear management units in Banff, Yoho, and Kootenay National Parks, 1995.

Fig. 3 Realized grizzly bear habitat for bear management units in Banff, Yoho, and Kootenay National Parks, 1995.

Fig. 4 Grizzly bear habitat effectiveness for bear management units in Banff, Yoho, and Kootenay National Parks, 1995.