MANAGING FOR GRIZZLY BEAR SECURITY AREAS IN BANFF NATIONAL PARK AND THE CENTRAL CANADIAN ROCKY MOUNTAINS

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Abstract: The need for security areas in which grizzly bears (*Ursus arctos*) may rarely encounter humans and maintain wary behavior is not explicitly addressed by cumulative effect modeling (CEM). In addition, CEM does not assess the value to bears of small areas left between zones of human disturbance. We developed a predictive GIS based model of adult female grizzly bear security areas in the Central Canadian Rocky Mountains to provide agency planners with a tool that addresses these shortfalls. Our study area included 4 major jurisdictions: Alberta provincial lands, British Columbia provincial lands, Kananaskis Country improvement district in Alberta, and National Park lands in both provinces. Starting with the total land base in each jurisdiction, we progressively removed areas of unsuitable habitat (e.g., rock and ice), habitat within 500 m of high human use (>100 human visits/month), and areas of insufficient size based on an average daily feeding radius (polygons <9 km^2). We identified the remaining lands as secure areas. We then tested the hypothesis that female grizzly bear use of security areas differs from the landscape as a whole based on radio telemetry data. Of the 4 jurisdictions in the Central Canadian Rocky Mountains, the largest percent of secure habitat was on British Columbia provincial lands. Of the land surface area of the Banff, Yoho, and Kootenay National Parks, 48% is unsuitable for grizzly bears, primarily because it is composed of rock and ice. This is unfortunate, because it is assumed that these national parks form productive core refugia for grizzly bears. By reconstructing past human use and forecasting into the future for Banff National Park and Kananaskis Country, we demonstrate progressive loss of security areas. We found that an average of 69% of the land within grizzly bear home ranges was secure using our sample of 28 radiocollared adult females. Resource selection indices from these bears demonstrated selection of security areas within their home ranges. Existing mortality and translocation data, combined with our findings of low security and high habitat fragmentation within some adult female home ranges, give quantitative substance to the assertion that grizzly bears in and around Banff National Park and Kananaskis Country exist in one of the most human-dominated landscapes where they still survive. Access and development management are key to grizzly bear persistence in the region.

Ursus 12:121–130

Key words: Alberta, Banff National Park, British Columbia, Canadian Rocky Mountains, foraging radius, fragmentation, grizzly bear, habitat, home range, security areas, *Ursus arctos*

As omnivores and apex predators, grizzly bears possess little resiliency (Weaver et al. 1996) and are one of the first species to be lost from an area as a result of land development activities. The status of the grizzly bear population and habitat are indicators of ecological integrity in Banff, Yoho, and Kootenay National Parks and the significantly larger regional ecosystem, the Central Canadian Rocky Mountains, upon which grizzly bears depend. The combination of a bear's biological traits, interacting with people's proclivity to develop and use grizzly bear habitat, usually results in compromised grizzly bear populations and habitat. By maintaining a healthy grizzly bear population, we suggest that most other elements and processes of the terrestrial ecosystem will also be maintained.

Typically in the past, aesthetically pleasing lands not suitable for other economic uses were set aside as reserves with little consideration for whether they provided high quality habitat for sensitive species. By default however, our National Parks have become the core refugia even though, as Caughley (1994) pointed out, species in trouble end up living not in the habitat most favorable to them, but in the habitat least favorable to the agent of decline. Such is the case with grizzly bears. As we open the twenty-first century, managers are recognizing that the ability of our National Parks to support bears has been significantly reduced by widespread human presence (Gibeau 1998).

Human access is one of the most influential factors affecting grizzly bear habitat security (Interagency Grizzly Bear Committee 1998). Although grizzly bear mortality can be regulated and influenced by changes in human attitudes, it seems unlikely that humans will tolerate much contact with animals like grizzly bears: first, because they directly compete with humans for space and foods (Mattson 1990) and second, because interactions with them can be potentially hazardous (Herrero 1985). Thus, there is a strong case for preserving "security" areas where grizzly bears will be relatively free from encounters with humans; that is, where bears can meet their energetic requirements while at the same time choosing to avoid people (Mattson 1993). Such security areas would foster the wary behavior in grizzly bears that most managers consider desirable (Mattson 1993), given that habituated bears have a significantly elevated mortality risk (Mattson et al. 1992).

Since the development of a cumulative effects model (CEM) for grizzly bears in the mid-1980s (Weaver et al. 1987, U.S. Department of Agriculture [USDA] Forest Service 1990), there have been significant advances in understanding the management of grizzly bears and substantial accumulation of empirical data about their ecology (see Gibeau et al. 1996, Mattson et al. 1996, Weaver et al. 1996, Mace and Waller 1997, and references therein). However, the CEM does not explicitly address the need for habitat security whereby bears maintain wary behavior, nor does it assess the value of small areas left between zones of human disturbance. To address this problem, Mattson (1993) developed the idea of micro-scale security areas where bears can forage for 24–48 hours safe from human disturbance. Micro-security areas include a core zone (based on foraging radius) surrounded by a disturbance-free buffer zone (based on displacement distances).

The Interagency Grizzly Bear Committee (IGBC) in the United States endorsed an approach for providing habitat security for grizzly bears at the larger scale of bear management units (BMU; IGBC 1998). A BMU is a discrete area of contiguous habitat for management purposes that would also incorporate the year-round needs of an adult female grizzly bear. Based on research by Mace and Waller (1997), interagency managers in the Northern Continental Divide grizzly bear ecosystem in northwest Montana specified that >68% of a BMU be in "secure status for several years" (USDA Forest Service 1995). Security areas help reduce the incidence of habituated bears, bears killed in self-defense, and bears removed by management agencies because of unacceptable behavior.

In an era where humans significantly influence the landscape, even within areas considered to be refugia, agency managers need effective tools to assist in delineation and planning of important and productive sites for bears. To that end, we developed a predictive model of security areas in the Central Canadian Rocky Mountains, where adult female grizzly bears will have a low human encounter rate based on an average daily feeding radius. We further tested the hypothesis that female grizzly bear use of security areas differed from use of the landscape as a whole based on radio telemetry data.

STUDY AREA

The Central Canadian Rocky Mountains, with an area of roughly 41,000 km^2, straddles the continental divide of Alberta and British Columbia. Topographic features include rugged mountain slopes, steep-sided ravines, and flat valley bottoms. The climate is continental with long,

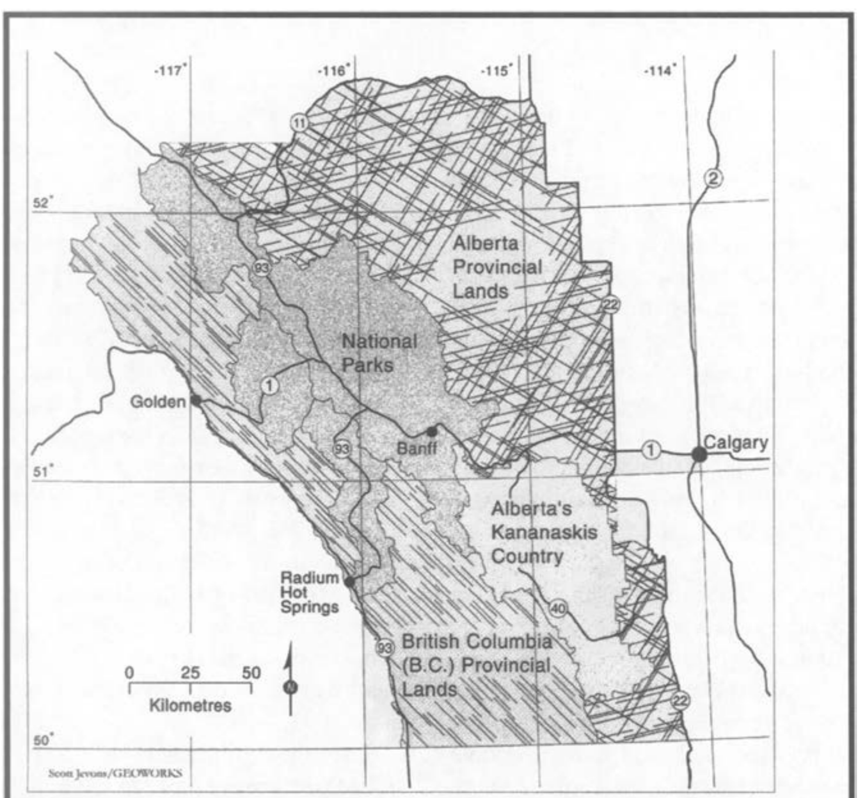

Fig. 1. The Central Canadian Rocky Mountains divided into 4 government jurisdictions: (1) National Parks including, Banff, Yoho, and Kootenay; (2) British Columbia provincial lands, (3) Alberta provincial lands, and (4) Kananaskis Country improvement district.

cold winters and short, cool summers. The aspect and elevation of the mountainous topography modifies climate somewhat. Topography, soil, and local climate strongly influence plant communities. The landscape can be classified into major ecoregions: montane (1,300–1,600 m), subalpine (1,600–2,300 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.

Management of the landscape is divided into 4 major governmental jurisdictions: (1) National Parks, including Banff, Yoho, and Kootenay; (2) British Columbia provincial lands, (3) Alberta provincial lands, and (4) Alberta's Kananaskis Country (Fig. 1). Differing agency mandates oversee preservation, tourism, forestry, oil and gas extraction, mining, agriculture, and stock grazing. Native councils, towns and municipalities, commercial developers, and residential owners diversify land administration even further, making this one of the most intensively developed landscapes in the world where grizzly bears still survive.

METHODS

Much of the basis for security area analysis relies on defining the average daily foraging radius and subsequent daily area requirements for an adult female grizzly bear. We used a subset of radio telemetry data from intensive tracking of wary (Herrero 1985:51) adult female bears gathered between 1994–1998 by the Eastern Slopes Grizzly Bear Project in the Central Canadian Rocky Mountains to establish a mean daily movement distance. These data were calculated from the largest linear distance of >2 relocations/day and do not reflect total distance traveled over the course of a day, which may be much greater. The calculated average daily foraging radius among all bears sampled is one half of the mean daily movement distance. Therefore, the minimum daily area requirement is simply the area of a circle (πr^2) based on the daily foraging radius.

Multi-annual home range data for adult female grizzly bears based on radio-telemetry were obtained from the Eastern Slopes Bear Project east of the Continental Divide (n = 19) and the concurrent West Slopes Bear Research Project (Woods et al. 1997) in a contiguous study area west of the Continental Divide (n = 9).

Several types of geographic information were compiled for analysis in MapInfo Professional® (MapInfo Corporation, Troy, New York, USA) and Idrisi® (Clark University, Worcester, Massachusetts,USA) geographic information systems including:

1. Elevation — A 1:50,000 scale digital elevation model compiled from National Topographic System series maps was used to derive an elevation cut at 2,500 m. That elevation was the upper limit of useful grizzly bear foraging through analysis of a grizzly bear habitat model (Kansas and Riddell 1995) for Banff, Yoho, and Kootenay National Parks. More than 99% of grizzly bear telemetry locations (n = 7,380) between 1994-1998 from the Eastern Slopes Grizzly Bear Project were located below the 2500 m level.

2. Satellite Image — A Landsat Thematic Mapper image was used to derive a layer representing vegetated area. The unsuitable areas of snow and ice, rock and bare soil, and water were reclassified out of the image leaving the area actually available to bears.

3. Human Activity — Human activity data from Central Canadian Rocky Mountains used in a habitat effectiveness model (Gibeau 1998) formed the basis of this layer. The most recent data available from all 4 jurisdictions were compiled to form a single map of human activity across the region. These maps categorized vector, point, and polygon data of all motorized roads, trails, and facilities into high and low use (USDA Forest Service 1990, Gibeau 1998) based on visitation records and expert opinion. Any area receiving >100 human visits/month during the active bear foraging season (May–Oct) was considered to be high use. These data became the basis for delineating the types and intensity of human uses and their associated disturbance buffers. Our mapping could not keep up with continued development, especially on Alberta provincial lands, therefore, these maps only portray a minimum amount of human activity on the landscape. Historical human use maps for Kananaskis Country and Banff National Park were compiled from circa 1950 records and personal interviews (Banff-Bow Valley Study 1996). Future human activity projections for Kananaskis Country were based on a build-out scenario from the existing recreational policy and a 6% annual visitor growth rate for Banff National Park (Banff-Bow Valley Study 1996). The major assumption of the human activity maps is that they accurately reflect human use at an ecosystem scale.

Analysis

The initial stage of GIS analysis was to remove areas from the landscape that were unsuitable for foraging for bears. This was accomplished by combining the vegetated cover map with the 2500 m elevation cut. All vegetated lands below 2500 m were considered available lands for security areas.

Next, all high human use features for the past, present, and future were buffered by a 500 m zone of influence following standards developed by IGBC (1998). We consider this a minimum zone of human influence in comparison to research results from Yellowstone National Park (Mattson et al. 1987, 1992; Reinhart and Mattson 1990; Green et al. 1997). Once the buffered high human use data were prepared, these files were imposed on the map of available/unsuitable lands. This removed all areas within the zone of influence from further consideration. Interim maps depicting habitat patches of all sizes were generated once the area of available landscape outside the zone of influence had been determined.

After removing unsuitable lands and lands within 500 m of high human use, we eliminated all remaining polygons smaller than the minimum daily area requirement for an adult female grizzly. Based on this analysis, results were tabulated into 4 categories: (1) unsuitable landscape, (2) land base in security area, (3) land not secure due to high human use, (4) and land not secure due to small size. Historical and future scenarios for Kananaskis Country and Banff National Park were prepared in the same manner.

We used the program CALHOME (Kie et al. 1996) to calculate minimum convex polygon (MCP) home ranges for adult female grizzly bears. We chose the 99% MCP to measure potential female grizzly bear occupancy, excluding only extreme outliers. The home range polygons were then converted to GIS map layers. For each adult female home range we prepared a tabulation of the unsuitable landscape, land base in security area, land not secure due to high human use, and land not secure due to small size.

Comparison of the observed telemetry data from weekly aircraft relocations and the security analysis map provided use and expected values to evaluate resource selection of security areas. In the context of this study, availability was defined as the home range of an individual animal. Both Johnson (1980) and White and Garrott (1990) point out that the home range of an animal already represents some prior selection because of territoriality or food resources. Availability of security differed for each individual bear depending on its home range configuration. This form of third-order selection (Johnson 1980) pertains to the use made of security areas within the home range. Radio telemetry data from each collared individual were overlaid onto the security analysis map to determine the proportions of security used and available within the home range.

The *G*-test for goodness-of- fit (Zar 1984) was employed to test the hypothesis that adult female grizzly bears used security areas in proportion to their availability. The *G*-test was selected because of the ability to partition between and among variables (Sokal and Rohlf 1981). The assumptions that all expected values be >1 and <20% be less than 5 was met (Zar 1984, Krebs 1989). Given the goodness-of-fit test rejects the null hypothesis that use is equivalent to availability, the statistical test reviewed by Neu et al. (1974) and Byers et al. (1984) provided a method for further evaluation of resource selectivity (Alldredge and Ratti 1986, 1992; White and Garrott 1990). Bonferroni confidence intervals (Neu et al. 1974, McLean et al. 1998) led to conclusions about whether security areas were used more, in proportion to, or less than their availability.

We used Spearman correlation coefficients to investigate the degree of association between home range size, the proportion of the land base in security areas, and the amount of land not secure due to high human influence (SAS Institute Incorporated, Cary, North Carolina, USA). Results of all statistical tests were considered significant at $P < 0.01$.

RESULTS

We analyzed 227 daily movement episodes from 16 wary adult female grizzly bears to produce a mean daily movement distance of 3.4 km (range 0.2–16.3. km, SE = 0.18 km). Therefore, the calculated average daily foraging radius was 1.7 km with a 9.0 km^2 minimum daily area requirement.

Available areas for grizzly bears were ones left after those covered with rock, ice, water, and bare soil and >2500 m elevation were removed. Thus 48% of the National Park landscape was unsuitable for foraging for grizzly bears. This contrasts with only 12% unsuitable on Alberta provincial lands, 21% unsuitable in Alberta's Kananaskis Country, and 27% unsuitable on British Columbia provincial lands.

We defined security areas and land not secure due to human use or size for each jurisdiction in the Central Canadian Rocky Mountains by comparing a map of the available landscape with a minimum daily area requirement of 9.0 km^2 based on an adult female's daily foraging radius (Fig. 2). Alberta's Kananaskis Country, with an intensive recreation mandate, had the greatest percent of land base (40%) not secure due to human use. Alberta provincial lands followed closely behind with 33%, then British Columbia provincial lands (28%) and National Parks (25%). The percent of land base where adult female grizzly bears have a low probability of encounters with people (secure) depends on the amount of productive land available to a bear and the extent of human influence.

A progressive loss of security areas is evident by reconstructing past human use, beginning with the 1950s,

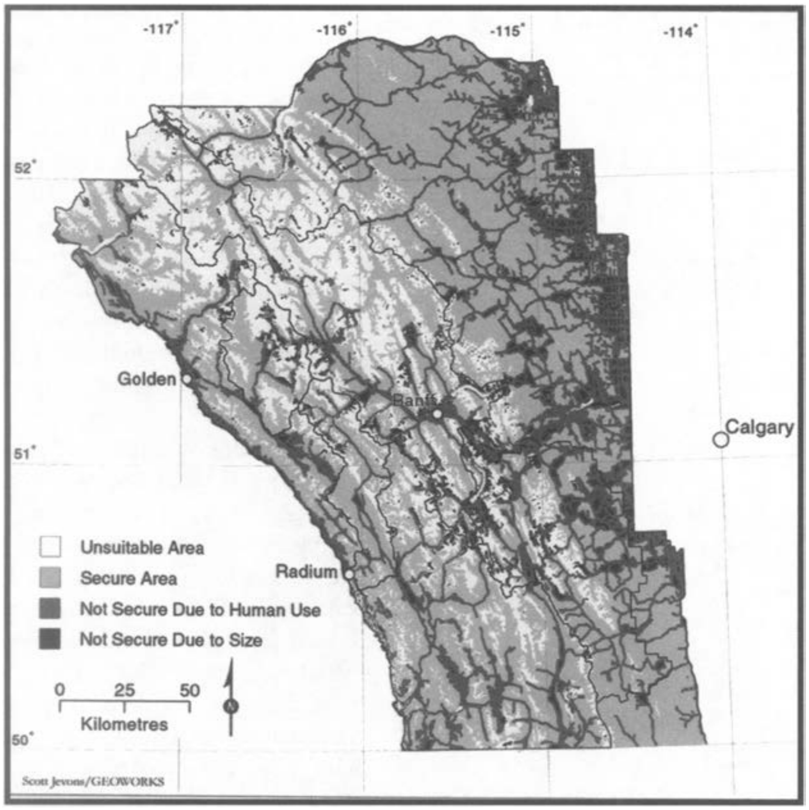

Fig. 2. The Central Canadian Rocky Mountains categorized by security area classes, 1999.

and forecasting future use for Kananaskis Country and Banff National Park (Fig. 3). The average size of secure habitat patches in Banff National Park ranged from 218 km^2 in the 1950s, to 56 km^2 currently, and finally 43 km^2 in the future. Corresponding to the decrease in patch size we found an increase in the number of patches from 13 historically to 39 both currently and into in the future. The same pattern existed throughout Kananaskis Country. Fragmentation and insularization of habitat within both jurisdictions was evident, accompanied by a loss in the ability to foster the wary behavior in grizzly bears that most managers consider desirable.

Our model identified an average of 69% (range 32–100%, SE = 4.2%) of the available land within individual home ranges of adult female grizzly bears as secure (Table 1). Bears with the highest degree of human influence within their home ranges tended to have the least security (bears ES24, ES26, ES47). Several bears had lower than average security despite average or lower than average human influence due to a high percent of land not secure because the remaining potentially secure areas were too small (bears ES18, ES41, ES61).

Individual *G*-tests for goodness of fit were significant ($P < 0.01$) for 26 of 28 bears, rejecting the hypothesis that

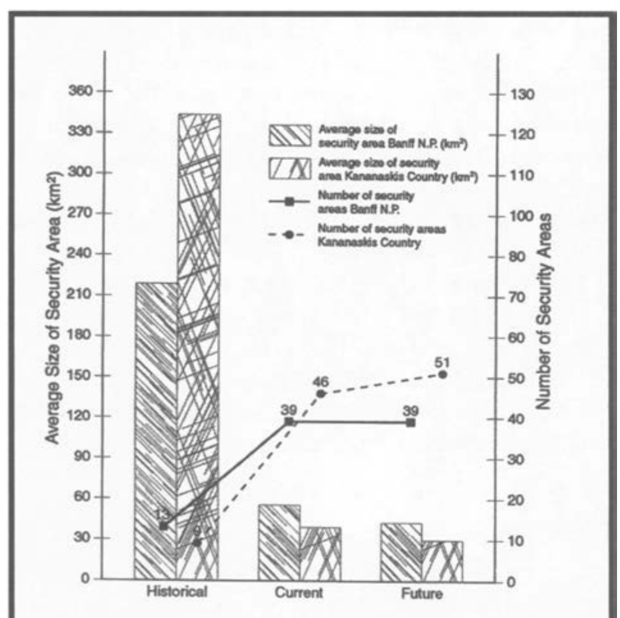

Fig. 3. Analysis of grizzly bear security areas for Banff National Park and Kananaskis Country for past (1950s), present (1999), and future (2020s).

Table 1. Percent of the available land base in security classes for 28 adult female grizzly bears in the Central Canadian Rocky Mountains, 1999.

Bear ID	Home range size (km^2)	Secure	Not secure due to human use	Not secure due to small size
ES17	111	55	39	7
ES18	236	38	42	20
ES24	279	32	57	11
ES26	427	46	46	8
ES28	307	72	21	7
ES30	268	59	38	3
ES31	79	50	41	10
ES32	328	53	37	10
ES33	218	67	29	4
ES36	617	60	28	12
ES37	884	53	40	7
ES40	206	84	12	4
ES41	189	67	17	16
ES46	321	67	29	4
ES47	245	34	60	7
ES55	180	52	36	12
ES57	282	73	27	0
ES61	232	50	34	16
ES62	150	63	34	3
WS35	49	81	9	10
WS42	131	81	6	13
WS44	220	100	0	0
WS71	78	100	0	0
WS74	35	100	0	0
WS282	78	99	0	1
WS284	59	99	0	1
WS289	109	99	0	1
WS295	37	100	0	0

adult female grizzly bears use security areas in proportion to their availability. Further evaluation of resource selection using Bonferroni confidence intervals indicated that 18 of 26 bears used secure areas more than expected. Six bears used secure areas in proportion to availablity, while only 2 bears used secure areas less than expected. One of the 2 bears that used secure areas less than expected was habituated to human presence (M. Gibeau, personal observation).

The proportion of land in security areas was negatively correlated with both home range size (r_s = -0.559, $P <$ 0.01) and the amount of land not secure due to high human influence (r_s = -0.556, $P < 0.01$). This association between security and home range size demonstrates that smaller home ranges tend to be more secure.

DISCUSSION

Our results quantitatively characterized grizzly bear habitat at the landscape level for the Central Canadian Rocky Mountains. This area supports a grizzly bear population with, we assume, a significant degree of genetic exchange within it, and isolation from populations north and south. Four major land use jurisdictions are in the area. Each has a unique land base, different management policies, and different grizzly bear management. A large percent (48%) of the land surface of the combined national parks (Banff, Kootenay, and Yoho) in our study area is unsuitable for grizzly bears, primarily because it is composed of rock and ice. This is unfortunate, because it has been assumed that national parks form productive core refugia for difficult to maintain species such as grizzly bears. In the Alberta provincial lands of the Central Canadian Rocky Mountains, the percent of unsuitable land was much less (12%), indicating more productive land, but conflicts with multiple human uses are predicted to increase. British Columbia provincial lands also have less unsuitable land (27%) than National Parks, but there too, multiple human uses are expected to rise.

The concept of secure habitat, an area where an adult female grizzly bear can meet her daily foraging needs with a low probability of disturbance by people, was central to our research. Mattson et al. (1992) found that grizzly bears with access to secure habitat maintained desirable wary behavior, had low probabilities of becoming habituated or food-conditioned, and had significantly less mortality than did non-wary adult females. Resource selection indices from our sample of radiocollared individuals substantiated that adult female grizzly bears selected security areas, or at least avoided areas that were not secure.

Our results characterized habitat security at the level of an adult female grizzly bears' home range and on average at the landscape level. For 28 adult female bears throughout the region, an average of 69% of the home range was secure. Female bears within Banff National Park, however, averaged only 60% security within their home ranges. Although female bears in Banff National Park currently have less secure habitat than average, Park land use is probably more predictable than land use of the surrounding areas (Parks Canada 1997).

The largest percent of secure habitat within a jurisdiction was on British Columbia provincial lands (68%). Alberta's Kananaskis Country (52% secure habitat) and Alberta provincial lands (63%) did not meet the current target level of 68% considered to be adequate security set by the USDA Forest Service (1995) in the Northern Continental Divide grizzly bear ecosystem in northwest Montana. Kananaskis Country, dedicated primarily to recreation and resource development, also had the largest percent of land in the zone of human influence. This area is also dedicated to maintaining all wildlife populations, thus these objectives conflict, and this conflict could increase. Only the combined National Parks (68%) and British Columbia provincial lands (68%) met the USDA's target level. A more refined analysis of Banff National Park, however, revealed that only 12 of 27 bear management units (48%) exceed target levels (Eastern Slopes Project, unpublished data).

These results give quantitative substance to the assertion that grizzly bears in and around Banff National Park and Kananaskis Country exist in one of the most human-dominated landscapes where they still survive. This was also demonstrated in the habitat effectiveness model applied to Banff, Yoho, and Kootenay National Parks (Gibeau 1998). The effect of this development has been high grizzly bear mortality, even in Banff National Park, especially in the female cohort during the 1970s and early 1980s (Benn 1998). Because Banff National Park had the lowest percent of its lands not secure due to high human use between 1971-96, 95 out of 107 mortalities occurred in the zone of human influence. Outside of the National Parks, Benn (1998) found that 89% of 172 mortalities in Alberta and 71% of 303 in British Columbia were within the zone of human influence. This further supports the function of secure habitat in buffering grizzly bears from mortality.

Analysis of security areas (for only Banff National Park and Kananaskis Country) clearly demonstrated the decreasing size over time of relatively undisturbed habitat units. This habitat fragmentation has occurred throughout Banff National Park and Kananaskis Country, but is dramatic in the Bow River Valley. The decreasing size of security areas was paralleled by a significant decrease in total amount of security area available throughout Banff National Park and Kananaskis Country.

We can surmise, but cannot conclusively demonstrate, that compromised habitat security and habitat fragmentation are decreasing grizzly bear population size and possibly long-term population viability. Doak (1995) reached a similar conclusion regarding the linkage between habitat degradation and potential population depression in the Yellowstone ecosystem. We cannot demonstrate demographic and viability effects because baseline data from the past do not exist. However, existing mortality and translocation data (Benn 1998) combined with our findings of low security and high habitat fragmentation within adult female home ranges, present converging evidence for grizzly bear population decline across the region.

MANAGEMENT IMPLICATIONS

In the past, habitat effectiveness modeling was the primary tool used to measure the impact of human activities on bears (USDA Forest Service 1990, Gibeau 1998). The model provided managers with a broad scale measure of the quality and quantity of a bear's foraging opportunities when human activities were considered. The model fell short, however, in estimating the human encounter rate and mortality risk that is equally important as foraging opportunities for population persistence. Security area analysis now provides managers with a measure of the human encounter rate for adult female grizzly bears at a much more refined scale than the habitat effectiveness model. Security areas help reduce the number of habituated bears, bears killed out of self-defense, and bears killed by management agencies because of unacceptable behavior.

Management agencies in southern Canada now realize that grizzly bears require special consideration to maintain healthy populations. Many management options have been evaluated in the United States and need only to be applied and refined in southern Canada. Much of this experience can be summarized, arguably, into management of human access (IGBC 1998).

The need to control human access has been acknowledged in Banff National Park, although the mechanisms for doing so are not fully apparent. Management strategies such as those employed in Denali National Park (Schirokauer and Boyd 1998) and Yellowstone National Park (Gunther 1994, 1998) have proven successful. Strict control of human access has been achieved through seasonal area and/or trail closures, day use and party size restrictions, and limiting travel to mid-day only. For example, in Yellowstone's Pelican Valley bear management area, the "area is closed April 1 through July 3. From July 4 through November 10, the area is open to day-use only between the hours of 9 a.m. and 7 p.m." (Gunther 1998:3). The explicit acknowledgment to manage areas for grizzly bear security has been key to management success (National Parks Service 1982).

To facilitate use by bears, these security areas of no or low human use should remain in place for at least 10 years (IGBC 1998). In our opinion, however, given the long life span of grizzly bears, this duration must be measured in generations and not merely in calendar years.

The National Parks alone can not sustain a regional grizzly bear population. Some of the best chances for grizzly bear persistence come from outside National Parks (McLellan et al. 1999), and hence a cooperative and coordinated management approach is critical. The nucleus of an interagency grizzly bear planning committee has been formed in the Canadian Rockies, although its existence seems tenuous without continued commitment from all jurisdictions. There is a clear need for complementary management guidelines that provide security for grizzly bears as they cross jurisdictional boundaries.

Although the concept of providing security areas appears logical and relatively straightforward, perhaps the most challenging steps ahead will be implementing new management prescriptions to achieve security for grizzly bears. As humans, we have never been particularly accepting of land-use policy that restricts individual rights and privileges. In the end, grizzly bears may prove to be the ultimate challenge in whether humans can coexist with nature.

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LITERATURE CITED

ALLDREDGE, J.R., AND J.T. RATTI. 1986. Comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management 50:157–165.

———, AND ———. 1992. Further comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management 56:1–9.

BANFF-BOW VALLEY STUDY. 1996. Banff-Bow Valley: At the crossroads. Technical report of the Banff-Bow Valley Task Force. Prepared for Minister of Canadian Heritage, Ottawa, Ontario, Canada.

BENN, B. 1998. Grizzly bear mortality in the Central Rockies Ecosystem, Canada. Masters Degree Project. Faculty of Environmental Design, University of Calgary, Alberta, Canada.

BYERS, C.R., R.K. STEINHORST, AND P.R. KRAUSMAN. 1984. Clarification of a technique for analysis of utilization-availability data. Journal of Wildlife Management 48:1050–1053.

CAUGHLEY, G. 1994. Directions in conservation biology. Journal of Animal Ecology 63:215–244.

DOAK, D.F. 1995. Source-sink models and the problem of habitat degradation: General models and applications to the Yellowstone grizzly. Conservation Biology 9:1370–1379.

GIBEAU, M.L. 1998. Grizzly bear habitat effectiveness model for Banff, Yoho, and Kootenay National Parks, Canada. Ursus 10:235–241.

———, S. HERRERO, J.L. KANSAS, AND B. BENN. 1996. Grizzly bear population and habitat status in Banff National Park: A report to the Banff Bow Valley Task Force by the Eastern Slopes Grizzly Bear Project. University of Calgary, Alberta, Canada.

GREEN, G.I., D.J. MATTSON, AND J.M. PEEK. 1997. Spring feeding on ungulate carcasses by grizzly bears in Yellowstone National Park. Journal of Wildlife Management 61:1040–1055.

GUNTHER, K.A. 1994. Bear management in Yellowstone National Park, 1960–93. International Conference on Bear Research and Management 9:549–560.

———. 1998. Bear management area program, Yellowstone National Park. Information paper No. BMO-5, Bear Management Office, Yellowstone National Park.

HERRERO, S. 1985. Bear attacks: Their causes and avoidance. Lyons and Burford, New York, New York, USA.

INTERAGENCY GRIZZLY BEAR COMMITTEE. 1998. Grizzly bear/motorized access management taskforce report. U.S. Department of the Interior, Fish and Wildlife Service, Missoula, Montana, USA.

JOHNSON, D.H. 1980. The comparison of usage and availability measurements for evaluation of resource preference. Ecology 61:65–71.

KANSAS, J.L., AND R.N. RIDDELL. 1995. Grizzly bear habitat model for the four contiguous mountain national parks: Second iteration. Report for Canadian Parks Service, Calgary, Alberta, Canada.

KIE, J.G., J.A. BALDWIN, AND C.J. EVANS. 1996. Calhome: a program for estimating animal home ranges. Wildlife Society Bulletin 24:332–344.

KREBS, C.J. 1989. Ecological methodology. Harper and Row, New York, New York, USA.

MACE, R.D., AND J.S. WALLER. 1997. Final report: grizzly bear ecology in the Swan Mountains. Montana Fish, Wildlife, and Parks Department, Helena, Montana, USA.

MATTSON, D.J. 1990. Human impacts on bear habitat use. International Conference on Bear Research and Management 8:33–56.

———. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone ecosystem. Cooperative Park Studies Unit Report. University of Idaho, Moscow, Idaho, USA.

———, B.M. BLANCHARD, AND R.R. KNIGHT. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432–442.

———, S. HERRERO, R.G. WRIGHT, AND C.M. PEASE. 1996. Science and management of Rocky Mountain grizzly bears. Conservation Biology 10:1013–1025.

———, R.R. KNIGHT, AND B.M. BLANCHARD. 1987. The effects of developments and primary roads on grizzly bears habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research and Management 7:259–273.

MCLEAN, S.A., M.A. RUMBLE, R.M. KING, AND W.L. BAKER. 1998. Evaluation of resource selection methods with different definitions of availability. Journal of Wildlife Management 62:793–801.

MCLELLAN, B.N., F.W. HOVEY, R.D. MACE, J.G. WOODS, D.W. CARNEY, M.L. GIBEAU, W.L. WAKKINEN, AND W.F. KASWORM. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, Washington and Idaho. Journal of Wildlife Management. 63:911–920.

National Parks Service. 1982. Final environmental impact statement, grizzly bear management program. U.S. Department of the Interior, National Park Service, Yellowstone National Park, Wyoming, USA.

Neu, C.W., C.R. Byers, J.M. Peek, and V. Boy. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38:541–545.

Parks Canada. 1997. Banff National Park management plan. Ministry of Canadian Heritage, Ottawa, Ontario, Canada.

Reinhart, D.P., and D.J. Mattson. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. International Conference on Bear Research and Management 8:343–350.

Schirokauer, D.W., and H.M. Boyd. 1998. Bear–human conflict management in Denali National Park and Preserve, 1982-94. Ursus 10:395–403.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry: the principle and practice of statistics in biological research. Second edition. W.H. Freeman, San Francisco, California, USA.

U.S. Department of Agriculture Forest Service. 1990. CEM-A model for assessing effects on grizzly bears. U.S. Department of Agriculture, Forest Service, Missoula, Montana, USA.

———. 1995. Flathead National Forest plan amendment #19: Allowable sale quantity and objectives and standards for grizzly bear habitat management. U.S. Department of Agriculture, Forest Service, Kalispell, Montana, USA.

Weaver, J.L., R.E.F. Escano, and D.S. Winn. 1987. A framework for assessing cumulative effects on grizzly bears. Transactions of the North American Wildlife and Natural Resources Conference 52:364–376.

———, P.C. Paquet, and L.F. Ruggerio. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10:1013–1025.

White, G.C., and R.A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, USA.

Woods, J.G., B.N. McLellan, D. Paetkau, M. Proctor, C. Strobeck. 1997. West Slopes Bear Research Project, Second Progress Report. Parks Canada, Box 350, Revelstoke, British Columbia, Canada.

Zar, J.H. 1984. Biostatistical analysis. Second edition. Prentice-Hall, Englewood Cliffs, New Jersey, USA.