EVALUATION OF THE POPULATION STATUS OF GRIZZLY BEARS IN CANADA

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Abstract: The population status of grizzly bears (*Ursus arctos*) in Canada was evaluated within broad areas called grizzly bear zones. These zones are large, contiguous areas where the climate and landforms provide a common influence on vegetation and land-use activities, and thus on grizzly bear behavior and populations. Of the 14 grizzly bear zones that historically supported populations, 12 currently support populations. We describe past and current land-use activities that impact habitats and populations of grizzly bears and predict future impacts. Gross analyses at the level of the grizzly bear zone identified probable unsustainable annual kills and excessive female kills for many of the grizzly bear zones. Population status was evaluated by comparing an estimate of current numbers to the estimated potential of the land to support grizzly bears. Grizzly bears have been extirpated from 24% of their original range and 63% of the current range is designated at risk, either vulnerable or threatened. The 4 grizzly bear zones in which grizzly bears are not at risk face increased impacts from land-use practices within the next 5 years. We discuss the implications of the designation of population status and make recommendations to ensure the conservation of grizzly bears.

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The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), is responsible for providing a scientifically sound listing of wild species, subspecies, and separate populations at risk in Canada (Munro 1990). COSEWIC may recommend a national status designation after reviewing a commissioned or independently submitted status report.

In 1990, Banci (1991) evaluated the population status of grizzly bears (*Ursus arctos*) in Canada for COSEWIC. This paper is derived from this larger status review. In addition, it expounds upon the use of an ecological habitat classification to estimate numbers of grizzly bears; this methodology was the basis for the evaluation of population status.

In Canada, grizzly bears occur in Alberta, British Columbia, the Yukon, and the Northwest Territories. Management is a responsibility of provincial wildlife authorities except for grizzly bears in national parks, which are under the management authority of the federal government. The status of grizzly bears in Canada was first evaluated for COSEWIC by Macey (1979) who concluded that the grizzly bear was not endangered or threatened but that it was "extremely vulnerable." Since then, grizzly bear populations have continued to face pressures from land-use practices, habitat loss and alienation, over-harvesting, and illegal killing. In 1990, the Directors of provincial and territorial wildlife agencies in Western Canada agreed that an updated status report for grizzly bears in Canada was imperative.

The objectives of this paper are (1) to describe how the population status of grizzly bears was evaluated, (2) to present the current status of grizzly bears in Canada and discuss the implications of these designations, and (3) to provide recommendations for the conservation of grizzly bears.

The 1990 COSEWIC report on the status of grizzly bears in Canada was written by V. Banci and funded by the governments of British Columbia, Alberta and the Yukon. The grizzly bear zones were derived by W.R. Archibald, D.A. Demarchi, J. Gunson, T. Hamilton, and B. Smith. We thank J. Carey, R. Case, P. Clarkson, J. Gunson, T. Hamilton, J. Nagy, B. Pelchat, D. Poll, C, Rubik, S. Shurman, and B. Smith for providing material and information. An earlier draft of this paper was greatly improved by the comments from 2 anonymous reviewers.

METHODS

The Grizzly Bear Zones

The approach that we adopted departed from the usual format of COSEWIC reports because the status of grizzly bears was evaluated within large continuous "grizzly bear zones" instead of recommending one designation for Canada. The zones are areas where the climate and landforms provide a common influence on grizzly bear behaviour, grizzly bear populations, vegetation, and land-use activities (Fig. 1). Although the resulting zones resemble Pearson's (1977) grizzly bear ecotypes, and genetic differences may be present among bear populations within the zones, this was not an attempt to identify genetically similar or genetically isolated grizzly bear populations.

Grizzly bears in Canada are more or less a continuous breeding group from the Canada-United States border along the 49°N latitude north to the

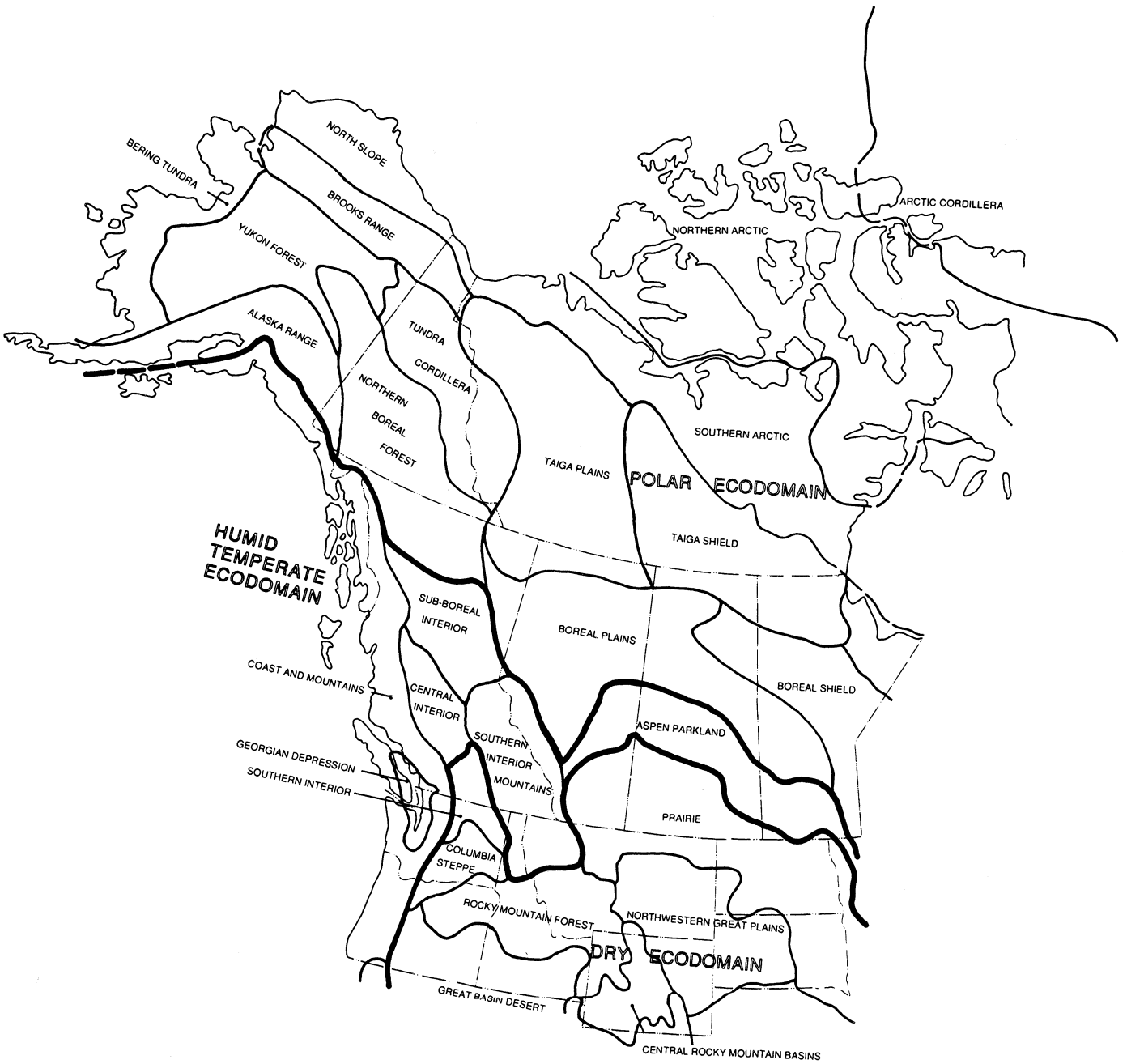

Fig. 1. Small-scale regional ecosystems of northern and western North America modified from Crowley 1967, Bailey 1976, Wiken 1986, and Demarchi 1988.

Arctic Ocean. The concept of grizzly bear populations occurring in states, provinces, territories, grizzly bear zones, management units, bear management areas, and in watersheds provides a framework for discussing management strategies. In this paper, we use "population" as a term of convenience to refer to a group of grizzly bears in a specific geographical area.

The grizzly bear zones were based on regional ecosystem classifications that were designed to represent global, continental, or subcontinental ecological processes. The objective of such classifications is to help stratify the world for understanding resource

management and conservation. The broadest levels were called Ecodomain and Ecodivision by Bailey (1983) and Crowley (1967), while Wiken's (1986) broad ecosystem level was named the Ecozone. These continental-level ecosystems are defined by the broadest level of climatic and physiographic similarity. Such broad level classifications, while important to a comprehensive understanding of ecosystems, may not be ideal for individual elements such as grizzly bears. The impact of society on the landscape has altered the appearance and function of many habitats. To develop a grizzly bear management strategy, each Ecozone/Ecodivision unit was evaluated for its effectiveness to support grizzly bears (Banci 1991). Boundary adjustments were made at the Ecosection level (Demarchi 1988) where land-use practices had altered the function of the Ecozone/Ecodivision. The greatest change to Wiken's (1986) Ecozone map was in British Columbia where a substantially greater analysis of Ecoregion-level processes has been conducted in recent years (Demarchi 1988, Demarchi et al. 1990). These adjusted units comprised the grizzly bear zones (Banci 1991).

Ecoregions can be classified at different sizes and can be identified at various scales and levels of detail in a hierarchy for any area. Ecoregions at 5 levels have been described for British Columbia (Demarchi 1988); they have been mapped along with biogeoclimatic zonation at a scale of 1:500,000 (B.C. Wildlife Branch 1989). Ecoregions at one level have been described for the Yukon (Oswald and Senyk 1977) and Alberta (Strong 1991). An example of an ecoregion stratification is the Border Ranges Ecosection within the Northern Continental Divide Ecoregion of southeastern British Columbia, northwestern Montana, and southwestern Alberta (Demarchi and Lea 1992).

Population Estimates

Our first step in determining population status was to assess numbers of grizzly bears and to determine how these numbers have changed through time. Densities have been directly estimated for only some populations within some of the grizzly bear zones (Banci 1991). However, this lack of information on grizzly bear numbers has not precluded the importance of population estimates, especially for management purposes such as determining sustainable harvests.

For a large and ecologically diverse area such as western Canada, intensive studies in each ecoregion are not available nor economically feasible. The estimates of grizzly bear numbers in this report were indirectly derived from conceptual and quantitative models (Nagy and Gunson 1989; Fuhr and Demarchi 1990; B.L. Smith and E.J. Osmond-Jones, Grizzly bear abundance in Yukon ecoregions, Yukon Dep. of Renew. Resour., Fish and Wildl. Branch, 1990, unpubl. data). The main premise of these models is that more grizzly bears will occur in good habitats than in moderate or poor habitats. Carrying capacity estimates based on an assessment of available habitat not only may be obtained cost-effectively but are likely more accurate than estimates based on other currently available indirect methods (Fuhr and Demarchi 1990). To estimate current populations, these habitat-based carrying capacity estimates must be adjusted for present land use, disturbance, and human-related mortality.

Only British Columbia has attempted to estimate historical, potential, and current habitat capability for grizzly bears at different map scales (Fuhr and Demarchi 1990). As this methodology provided the basis for the evaluation of grizzly bear status in all jurisdictions, it is described here in detail.

Habitat assessment involves a progressive stratification of the landscape using ecoregion, biogeoclimatic zonation, and biophysical habitat units with successional stages, proceeding from general ecological parameters to detailed soil and vegetative characteristics (Fuhr and Demarchi 1990). Biogeoclimatic zonation is used as a surrogate for climatic zonation because detailed climatic information is seldom available (Pojar et al. 1987). It also provides a framework for delineating plant community distribution. For example, within the Border Ranges Ecosection are found the following biogeoclimatic zones and subzones: AT: Alpine Tundra Biogeoclimatic Zone, ESSFdk: Dry Cool Engelmann Spruce–Subalpine Fir Subzone, and MSdk: Dry Cool Montane Spruce Subzone. Biophysical habitat units are similar homogeneous landform or terrain units that support the same climax vegetation and the resultant successional vegetation. Examples of habitat units within the Dry Cool Montane Spruce Subzone are the "LF": Lodgepole pine–falsebox southerly aspect, "SH": Spruce–horsetail moist floodplain, and "SS": Saskatoon–wild strawberry dry avalanche chute. This stratification is applicable for all wildlife species, not only grizzly bears.

Different methods for the assessment of grizzly bear habitat were used at small map scales (1:250,000 and 1:500,000), medium map scales (1:50,000 and 1:100,000), and large map scales (1:20,000 and 1:50,000). Small map scales show general ecological boundaries, ecoregion and biogeoclimatic zonation and may provide rough carrying capacity estimates for use at regional or provincial planning levels. However,

they do not show the extent of specific habitat types such as floodplains or avalanche chutes. Medium map scales provide a more detailed stratification of ecoregion, biogeoclimatic zonation, and biophysical habitat unit. Biogeoclimatic units may be subdivided according to the importance of such habitat units and may also be subdivided on the basis of access and forest-harvesting activities if these are thought to have affected grizzly bear numbers. This would be done if a current population estimate rather than a potential carrying capacity estimate was required. Similar methods are used for mapping at large map scales but carrying capacity estimates have not been calculated at this detailed level. Habitat units at large map scales are only given interpretations of potential season of use by grizzly bears and a subjective importance ranking.

For both medium and small scale mapping, habitat units were subjectively ranked according to their potential degree of use as high, medium, low, or nil, depending on how well the habitat met the seasonal needs of grizzly bears and the suspected importance of the habitat in their annual life cycle. These rankings were kept within a provincial prospective, rather than a local one. It is important that habitat quality and present use by grizzly bears in representative areas be confirmed in the field. With experience, this method can be used to establish density estimates from habitat quality and the amount of sign present (Fuhr and Demarchi 1990). Experience in different ecosystems and in areas with relatively well-established grizzly bear populations is also important as density estimates are often subjective. When necessary, this information can be extrapolated to areas of similar habitat that have not been surveyed. Also, use of altered habitat or areas with higher human activity can be compared to more remote areas for making present population estimates and for calculating historical grizzly bear numbers.

The southern Flathead River (North Fork of the Flathead River) drainage in British Columbia was chosen as a pilot project for medium-scale mapping and was used to compare medium- and small-scale mapping (Fuhr and Demarchi 1990). Grizzlies in this area have been the focus of a long-term telemetry project (McLellan 1989) and biophysical data existed for the area (Lea et al. 1988). Relative ratings for habitat units were derived from the Flathead project, discussions with other biologists, and in comparison with other areas (Fuhr and Demarchi 1990). Ratings corresponded to these habitat potentials: 45 km^2/bear = low, 15 km^2/bear = medium, and 5 km^2/bear = high. These density estimates were provincial in scope and not specific to the Flathead area. Calculations were made for current carrying capacity (by using the present seral state) and potential carrying capacity (by using the seral state that is optimal for grizzly bears), on 3 subareas of the Flathead project area. Estimates of present carrying capacity compared closely to the present population estimates determined by radiotelemetry.

Two areas, the Flathead Basin and the Hart Ranges in east-central British Columbia, were used to develop specific relationships between carrying capacity and ecoregion/biogeoclimatic units to calculate carrying capacity at small map scales (1:250,000 to 1:500,000) without detailed habitat stratification. Carrying capacity estimates for small scale mapping, 135 km^2/bear = low, 45 km^2/bear = medium, 15 km^2/bear = high, were derived from discussions with biologists and comparisons with densities determined from intensive studies in other areas. Differences in the relative habitat ratings between small and medium map scales are due to the degree of habitat stratification and detail of map scale. Relative importance was assigned to biogeoclimatic units that had been digitized and the area calculated. Relative ratings were verified using habitat-use surveys in the Flathead Basin and with Landsat imagery for the Hart Ranges.

Provincial potential grizzly bear populations were estimated using 1:500,000 map scales. Each biogeoclimatic unit within an ecoregion was ranked as high, medium, low, or nil, thus providing a basis for comparing the value of the various areas of the province. Field confirmation of the predicted importance of habitat units to grizzly bears has been conducted in several areas of British Columbia, although not uniformly. The area of each biogeoclimatic unit was determined and relative carrying capacity for small map scales applied. Three estimates of grizzly bear numbers were calculated: (1) "historical potential," what the habitat was capable of supporting before European colonization; (2) "current potential," what the habitat is capable of supporting; and (3) "current numbers," what the habitat actually supports.

Current potential reflects the impact of activities that have permanently altered the potential of the habitat to return to the climax vegetation, for example, stream impoundments and human settlements. Current numbers considers the impacts of land-use activities that do not affect the potential of the land to return to the climatic climax, such as logging, grazing, cultural activities such as hunting or problem-bear control, and habitat that is unavailable to bears because it has been alienated or fragmented by roads and access.

Regional wildlife management specialists estimated

current numbers of grizzly bears by evaluating the current potential populations based on the above factors (Fuhr and Demarchi 1990). Clear criteria were not available for that evaluation process since different levels of information were available to the regional biologists on the extent and impact of activities. In essence, estimates of current numbers are best guesses based on the experience and knowledge of biologists regarding the distribution and abundance of grizzly bears in their regions, and where available, on quantitative data.

Estimates of current potential and current numbers for Alberta and the Yukon were derived from models that extrapolated densities and habitat-capability information from intensive studies to other areas (Nagy and Gunson 1989; B.L. Smith and E.J. Osmond-Jones, Grizzly bear abundance in Yukon ecoregions, Yukon Dep. of Renew. Resour., Fish and Wildl. Branch, 1990, unpubl. data). The approach in Alberta was similar to that used in British Columbia except that historical potential was not calculated. In addition, the loss of habitat was considered to be twice the actual measured disturbance (Nagy and Gunson 1989). In the Yukon, populations for the 22 ecoregions were estimated based on extrapolations from 8 northern interior studies, based on a ranking of 9 habitat components thought to influence grizzly bear abundance (B.L. Smith and E.J. Osmond-Jones, Grizzly bear abundance in Yukon ecoregions, Yukon Dep. of Renew. Resour., Fish and Wildl. Branch, 1990, unpubl. data).

For the Northwest Territories, a systematic assessment of habitat capability for grizzly bears was not available and estimates of current and potential capability populations were provided by government bear biologists (J. Nagy, P. Clarkson, N.W.T. Dep. of Renew. Resour., pers. commun.).

We did not attach statistical significance to the estimates of grizzly bear numbers. The importance and use of population estimates are relative: to provide a comparison of the numbers of grizzly bears the land base could support now, relative to what it supported before the presence of Europeans on this continent, and relative to what biologists feel the land actually does support at present, augmented by the quantitative data available (Fuhr and Demarchi 1990).

Current Numbers.—Inherent in evaluating current potential of the habitat to support grizzly bears to the current numbers of grizzly bears is a consideration of the impacts of land-use activities, access, habitat fragmentation, hunting, and other human-induced mortalities. The land-use activities that have affected grizzly bear habitat and those expected to occur in the next 5 years were identified for each grizzly bear zone using a variety of information sources (Bliss and Klein 1981, Bird and Rapport 1986, Demarchi and Demarchi 1987, Simpson 1987, Anon. 1989, Alberta Gov. 1990, B.C. Lands Branch 1990, CPA 1990, regional staff in wildlife agencies of Western Canada, pers. commun.). The present and predicted future importance of these factors were subjectively ranked (no impact, low, medium, high) based on the extent of activities in space and time.

Inspections of grizzly bears killed in Alberta, British Columbia, and the Yukon are mandatory. Compulsory reported kills are aged and sexed. Most hunter harvests in the Northwest Territories are reported; however there is no legal requirement to report subsistence kills and many defense kills are unreported (Banci 1991).

Sustainable mortality rates for grizzly bears are a function of population productivity. Under optimum conditions of low natural mortality and high productivity, Miller (1990) estimated that the maximum sustainable hunting rate was 5.7% for grizzly bears. Wildlife managers in Alberta, British Columbia, and the Yukon all reported using 4% as a conservative estimate of the maximum sustainable mortality for grizzly bear populations, including kills from all sources (Banci 1991).

Most jurisdictions appreciate that the sustainable harvest of females is less than that of males. Alberta recommends a maximum proportion of 35% females in the harvest (Nagy and Gunson 1989), and the Yukon and British Columbia 33% (B.L. Smith and E.J. Osmond-Jones, Grizzly bear abundance in Yukon ecoregions, Yukon Dep. of Renew. Resour., Fish and Wildl. Branch, 1990, unpubl. data; Banci 1991).

Grizzly bear mortality data were obtained from the 4 jurisdictions and analyzed for the past 5 years, 1985-89, to provide, for each grizzly bear zone, the average annual kill, trends in the proportion of females in the annual kill, the known nonhunting kill, and the estimated annual mortality rate. Harvest rates within grizzly bear zones were compared to a desirable maximum sustainable harvest of 4% with a maximum proportion of 33% females.

Designation of Population Status

COSEWIC recognizes 5 risk categories (Table 1). No basis exists for assigning population status to these categories. The status of grizzly bear populations was designated for each grizzly bear zone based on a comparison of current numbers to current potential.

Our designations (Table 2) were arbitrary and can be changed should future circumstances suggest better criteria.

As the determination of current and potential numbers of grizzly bears within the Northwest Territories was based on the opinion of bear biologists and not comparable to other zones, the same criteria could not be used to assess status. Government bear biologists were requested to provide their opinion of the status of grizzly bears within these zones (J. Nagy, P. Clarkson, N.W.T. Dep. of Renew. Resour., pers. commun.).

Table 2. Criteria used for the assignment of population status of grizzly bears to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) risk designations.

Status	Criterion: Current populations are
Extirpated	0% of current potential
Endangered	<10% of current potential
Threatened	10-40% of current potential
Vulnerable	40-75% of current potential
No designation required[a]	>75% of current potential

[a] COSEWIC does not have a "not at risk" category. We interpret "no designation required" to mean "not at risk."

RESULTS

The Grizzly Bear Zones

Detailed descriptions of the grizzly bear zones (Fig. 2) are available in Banci (1991).

Population Estimates

Historical and current potential and current numbers expressed as the numbers of grizzly bears within grizzly bear zones are presented in Table 3. Although a protocol for evaluating current habitat potential against current grizzly bear numbers is not available except for Alberta grizzly bear zones, the differences between current potential and current numbers reflect the impacts of land-use activities on grizzly bears and grizzly bear habitats (Table 4), and hunting and nonhunting mortalities (Table 5).

Table 1. Population status designations, as defined by the Committee on the Status of Wildlife in Canada (COSEWIC) (Munro 1990).

Species	"Species" means any species, subspecies, or geographically separate population.
Vulnerable Species	Any indigenous species that is particularly at risk because of low or declining numbers, occurrence at the fringe of its range or in restricted areas, or for some other reason, but is not a threatened species.
Threatened Species	Any indigenous species that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.
Endangered Species	Any indigenous species that is threatened with imminent extinction or extirpation throughout all or a significant portion of its Canada range.
Extirpated Species	Any indigenous species no longer existing in the wild in Canada but occurring elsewhere.
Extinct Species	Any species formerly indigenous to Canada but no longer existing anywhere.

Agriculture, range and grazing, forestry, mineral and petroleum exploration and development, hydroelectric power development, commercial fisheries developments, human settlement, population growth, and recreation all have affected the productivity and integrity of grizzly bear habitat (Table 4, Banci 1991). The magnitudes and the importance of these land-use activities vary within and among the 12 zones that still support grizzly bears. For example, access was of local concern in the Subarctic Mountains and Plains but this was a low impact within the entire zone or when compared to the impact of access in other zones (Table 4).

For the northern grizzly bear zones, the impacts on habitat from development and habitat alterations have been limited and current numbers approach the current habitat capability (Table 4). The greatest difference between current and historic habitat potential has occurred in (1) the Cold Boreal Plains, because of extensive agricultural development; (2) the Temperate Wet Mountains, because of forestry and extensive land alienation due to settlement and access, especially in southwestern British Columbia; (3) the Cool Moist Plateaus because of losses of productive riparian areas and wetlands, and agriculture and ranching activities; and (4) the Cool Moist Mountains because of reservoir impoundments, highway construction and land alienation. The greatest loss of current habitat potential has occurred in the Hot Dry Plateaus. Historically, this grizzly bear zone was the least productive for grizzly bears in British Columbia. Much of the habitat that did support grizzly bears has been lost because of land alienation for human settlement, agriculture, and ranching. Grizzly bears have been extirpated over most

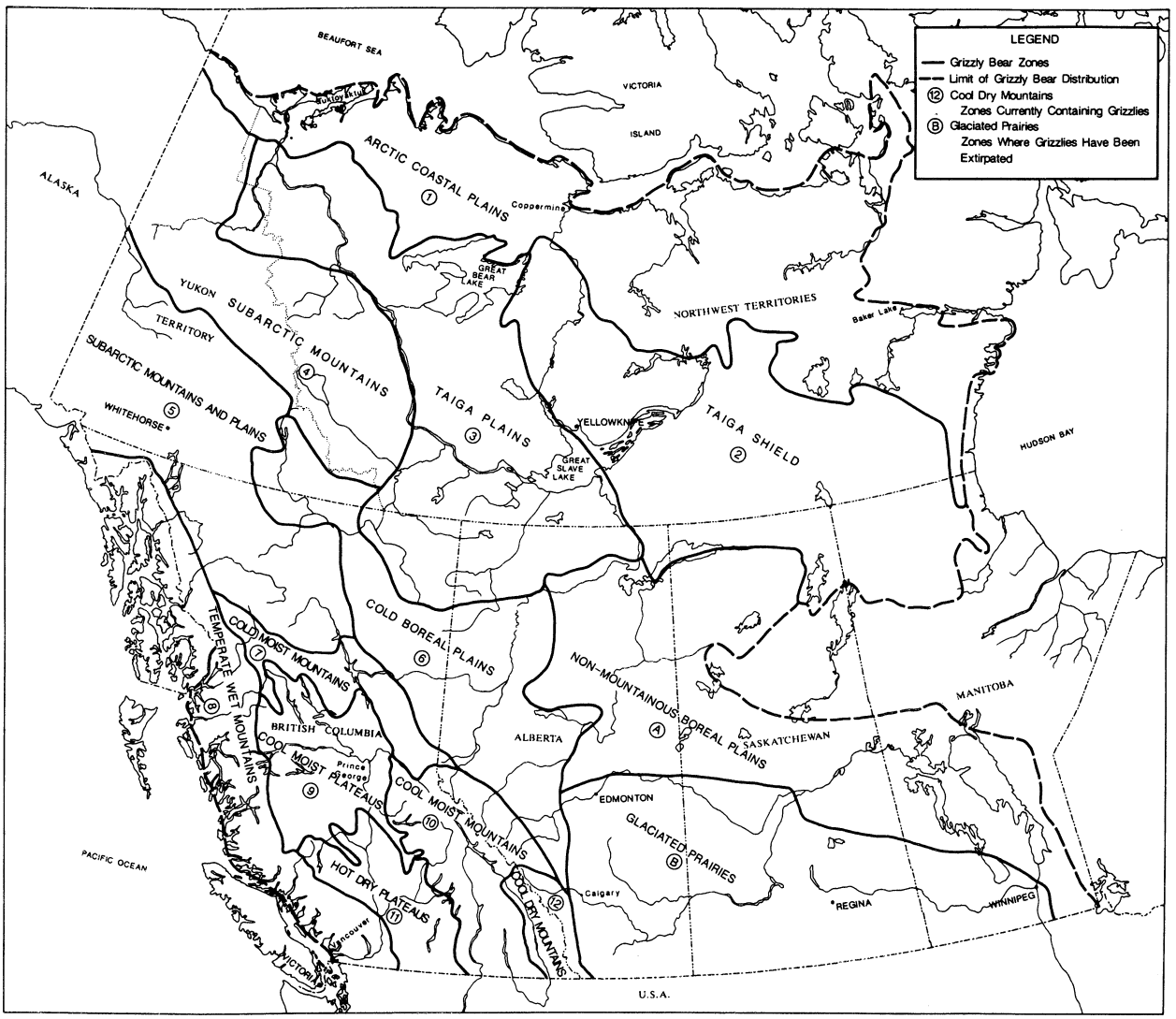

Fig. 2. The grizzly bear zones of Canada (from Banci 1991).

of this zone.

For all the grizzly bear zones, except the Taiga Shield, current and planned land-use activities indicate that impacts on grizzly bears and their habitat will increase over the next 5 years (Table 4). These activities include logging activities and the use of herbicides and pesticides in the grizzly bear zones where forestry is important, mining and petroleum exploration in the north, and hydroelectric power development in the British Columbia interior and coast. For many of the grizzly bear zones, the provision of access has been a pervasive problem associated with other land-use activities and we predict it to be an important future impact in other zones.

Mortality.—Based on an estimate of 4% maximum sustainable mortality, 3 of the 12 grizzly bear zones were overharvested during 1985-89 (Table 5). Most of the grizzly bear zones also had female kills that exceeded 33% in the total yearly kill (Table 5). If we conservatively assume that unreported losses are 50% of the known reported kill, a total of 5 grizzly bear zones have probably been overharvested.

Designation of Population Status

The current range of grizzly bears in Canada encompasses some 3.5 million km^2 (Fig. 2). Grizzly bears have been extirpated from 2 grizzly bear zones, representing 24% of their original range. This

Table 3. Population status, historic and current habitat potential, and current numbers expressed as numbers of grizzly bears within grizzly bear zones.[a]

Grizzly bear zone	Area (km^2)	Historic potential	Current potential	Current numbers	Potential realized	Status designation
1. Arctic Coastal Plains	754,900	2,990	2,990	2,860[b]	96%	No designation
2. Taiga Shield	467,700	830	830	790[c]	96%	Vulnerable
3. Taiga Plains	557,800	[d]	1,630	1,520[e]	93%	Vulnerable
4. Subarctic Mountains	397,400	[d]	2,600	2,540[f]	98%	Vulnerable
5. Subarctic Mountains and Plains	370,400	6,060	6,060	5,680	94%	No designation
6. Cold Boreal Plains	292,500	[d]	1,500	960	64%	Vulnerable
7. Cold Moist Mountains	92,500	3,870	3,870	2,940	76%	No designation
8. Temperate Wet Mountains	161,500	5,870	5,640	3,310	59%	Vulnerable
9. Cool Moist Plateaus	127,300	1,860	1,730	1,100	64%	Vulnerable
10. Cool Moist Mountains	129,300	[d]	4,700	2,540	54%	Vulnerable
11. Hot Dry Plateaus	66,200	1,040	570	140	25%	Threatened
12. Cool Dry Mountains	52,000	[d]	1,120	930	83%	No designation

[a] Nagy and Gunson 1989, Fuhr and Demarchi 1990, Smith and Osmond-Jones 1990, J. Nagy and P. Clarkson, pers. commun. (from Banci 1991).
[b] Based on 280 km^2/grizzly bear for Northwest Territories.
[c] Based on 560 km^2/grizzly bear for Northwest Territories.
[d] Alberta did not attempt to estimate historical populations. These estimates were not calculated for any grizzly bear zone also under Alberta's jurisdiction.
[e] Based on 420 km^2/grizzly bear for Northwest Territories.
[f] Based on 200 km^2/grizzly bear for Northwest Territories.

extirpation occurred in the Non-mountainous Boreal Plains because of agriculture, increased settlement, oil and gas development, over-hunting, and human intolerance. In the Glaciated Prairies, the loss of grizzly bears can be attributed to intentional eradication followed by substantial modification of the natural system because of extensive cereal grain cultivation, the appropriation of land for ranching and farming, and the extirpation of the bison (*Bison bison).*

Of the current range of grizzly bears, 63% contains populations which are at risk, either vulnerable or threatened. Seven of the 12 grizzly bear zones were designated as vulnerable and the Hot Dry Plateaus as threatened (Fig. 2, Table 3). There were 4 grizzly bear zones rated as "no designation required" (Table 3), a designation used by COSEWIC that we interpret as currently "not at risk."

DISCUSSION

The Grizzly Bear Zones

Traditionally, the evaluation of the population status of species in Canada has resulted in COSEWIC recommending a single designation for all of Canada. We believe that it is important to recognize that species of wide distribution and typically low densities may exhibit local physical and behavioral adaptations and unique population dynamics. To not recognize that "Temperate Wet Mountains" grizzly bears differ from "Cold Boreal Plains" grizzly bears, which differ from "Arctic Coastal Plains" grizzly bears, invites the danger of losing unique populations because of the perception, on a national scale, that the welfare of the species is husbanded by a single COSEWIC designation. Our approach to designating status provided a logical and

Table 4. Present and predicted future (within next 5 years) impacts of land-use activities on grizzly bear habitat within the grizzly bear zones.

	Grizzly bear zone																							
	Arctic Coastal Plains		Taiga Shield		Taiga Plains		Subarctic Mountains		Subarctic Mountains and Plains		Cold Boreal Plains		Cold Moist Mountains		Temperate Wet Mountains		Cool Moist Plateaus		Cool Moist Mountains		Hot Dry Plateaus		Cool Dry Mountains	
Land-use activity	Pres[a]	Fut[a]	Pres	Fut	Pres	Fut	Pres	Fut	Pres	Fut	Pres	Fut	Pres[a]	Fut[a]	Pres	Fut	Pres	Fut	Pres	Fut	Pres	Fut	Pres	Fut
Agriculture											H	H			L	L	H	H	L	L				
Range and Grazing									L	L	L-H	L-H	L	L	L	L	H	H	0-L	0-L	H	M-H	M-H	M-H
Forestry					L	L			0-L	0-L	L-M	M	H	H	H	H	L-H	M-H	H	H	H	H	H	H
Herbicides & Pesticides									L-M	L-H	L-M	L-H	L-M	L-H	L-M	L-H	L-M	L-H	L-H	H				
Mining	L	M	H(l)	H(l)	L-H	L-H	M	H	H(l)	H(l)	M-H	M-H	H	H	M	M	L-H	L-H	H	H	M	M	H	H
Petroleum	L	H	L	L	L-H	L-H	L-M	M-H	H(l)	H(l)	M-H	M-H	H	H	M	M	L-H	L-H					H	H
Hydroelectric Power			L	L					0-L	M-H	0-L	H	H	L	L	H	L-H	L-H	H	H	0-L	0-L	L-H	M-H
Commercial Fisheries[b]															M	M								
Land Alienation	L-M	M	L	L	0-M	0-M	L	L	L	L	L-H	L-H	H	H	H(l)	H(l)	H	H	H	H	H	H	H	H
Access	L	L	L	L	0-L	L-H	L-M	M	L	M	L-M	M-H	M	M	M	H	H	H	H	H	M-H	H	H	H
Recreation[c]	L	L	L	L	H(l)	H(l)	L	L	L	M	H	H	L	L	L	H	H	H	M	M-H	H	H	M-H	M-H

[a] Pres = Present; Fut = Future. Ratings reflect the relative impact of the land-use activity within a grizzly bear zone. A nil impact is indicated by "0," low = "L," moderate = "M," high = "H," "H(l) = a high but localized impact. A range such as "L-M," indicates that the land-use activity varies in impact from low to moderate across the zone.

[b] Includes fish hatcheries and spawning channels.

[c] And other human activity.

Table 5. Grizzly bear mortality data during 1985-89 and estimated yearly mortality rates within grizzly bear zones.

Grizzly bear zone	Annual kill[a]	Female kill[b]	Known nonhunting kill[c]	Estimated mortality rate	Estimated total mortality rate[d]	Estimated population size
1	20	exceeded	23%	<1%	1.0	2,860
2	<1	uncommon	100%	<1%	<1%	790
3	4	exceeded in NWT	29%	<1%	<1%	1,520
4	37	exceeded most years	5%	1.4%	2.2%	2,540
5	172	exceeded most years	7%	3.0%	4.5%	5,680
6	41	exceeded since 1985	21%	4.3%	6.3%	960
7	36	not exceeded last 2 years, exceeded previously	15%	1.2%	1.8%	2,940
8	70	exceeded most years	9%	2.1%	3.2%	3,310
9	59	exceeded most years	3%	5.4%	8.0%	1,100
10	75	>40% in 1989	9%	2.9%	4.4%	2,540
11	1	uncommon	33%	<1%	<1%	140
12	39	exceeded most years	19%	4.2%	6.3%	930

[a] Yearly average during 1985-89, except for grizzly bear zone 1, 1986-89.
[b] Refers to whether the proportion of females in the kill exceeded 33%.
[c] Percent of the total kill; nonhunting kills are underestimated for all zones.
[d] Assuming the nonreported kill is 50% of the known kill.

systematic means of recognizing differences among populations, of focusing concerns, and of identifying where management effort should be directed.

The 14 grizzly bear zones were not meant to represent 14 different subgroups of grizzly bears. Grizzly bears may move considerable distances and individual bears could even occupy different zones at different times of the year or in different years. However, grizzly bears are constrained by the ecological limits of habitats and by human influences. Thus, the grizzly bear zones do reflect differences in life-history parameters of grizzly bears.

Population Estimates

The estimates of grizzly bears we provide must be used with caution and relatively, in comparisons among zones and between historical and current potentials. We do not know the numbers of grizzly bears that occur in each grizzly bear zone. As managers, we are better at estimating population density in wilderness than in areas where the habitat suitability has been changed. No known reliable techniques exist to determine population density, population structure, productivity, and population size in forested regions of Canada to the level of accuracy implied by a 4% "safe" harvest calculation. There is much potential for error, including the possibility of poor land-area calculations, such as defining useable compared to unusable habitat, the reliability of using large-compared to small-scale maps, the problems of extrapolating densities from small research areas to much larger areas, and a lack of objective means of assessing habitat value for many areas of the country. Map scale, mapping intensity, and mapping methods are all potential sources of error in calculating carrying capacity for any species (Fuhr and Demarchi 1990). Biogeoclimatic zonation reflects climatic factors but not necessarily the abundance of bear habitats present. This source of error may be reduced by mapping at a medium scale so that habitats can be shown, but this is more time consuming. This error may be mitigated; familiarity with an area was shown to be important in assigning realistic ratings at small map scales (Fuhr and Demarchi 1990).

The models used to estimate grizzly bear habitat capability described in this paper have suggested areas of vulnerability and are hypotheses that can be tested. Numbers of grizzly bears are not provided by the models themselves but through the process of model verification and testing and by population and habitat inventory. Provincial and territorial management agencies are far from having verified and tested these models for grizzly bears in Canada. What the models have shown, however, and what we try to demonstrate, is that there are reasons for concern based on what

habitat assessment models for grizzly bears reveal. This is the first step at establishing the status of grizzly bears, not the final one.

Mortality.—The analyses of annual and female mortality rate were crude, based on very large areas and population estimates that are largely guesstimates. However, there is reason for concern considering that over-harvests were identified at such a gross scale and that we know that localized excessive harvests have occurred in the past in all the grizzly bear zones except the extreme northern zones (Banci 1991). An examination of mortality and of the distribution of kills in local grizzly bear populations, especially of females, is imperative when evaluating current numbers from the current habitat potential. Three of the grizzly bear zones with an estimated total mortality rate greater than 4% (Table 5) were designated as vulnerable (Table 3). However, 2 grizzly bear zones, the Subarctic Mountains and Plains and the Cool Dry Mountains, with estimated total mortality rates of 4.5% and 6.3% (Table 3), respectively, were designated as not at risk (Table 1). We encourage management agencies in these zones to examine their evaluation of current numbers and to take appropriate steps to reduce excessive kills.

The nonhunting kill is not well known and wildlife managers in every jurisdiction believe this source of mortality for grizzly bears has been underestimated (Banci 1991). Indications are that it can be high. In Alberta, during 1972-87, nonhunting losses were about 32% of the total yearly kill (Nagy and Gunson 1989). Estimates of the unreported kill in British Columbia have ranged from 25 to 100% of the known kill, depending on the area and extent of access (Banci 1991). In the Northwest Territories, there is no legal requirement to report subsistence kills and many defense kills are unreported (R. Case, N.W.T. Dep. Renew. Resour., pers. commun.). The unreported kill for Yukon grizzly bears is also unknown (B.L. Smith and E.J. Osmond-Jones, Grizzly bear abundance in Yukon ecoregions, Yukon Dep. of Renew. Resour., Fish and Wildl. Branch, 1990, unpubl. data). In a review of 66 mortalities of marked bears in 6 study areas in British Columbia and the United States, 58% were nonhunting kills (McLellan 1990). A further complication is that provincial and territorial parks have not maintained complete records on grizzly bear kills within protected areas (Banci 1991). If we assume that for every 2 bears legally killed, there is 1 unknown kill, 5 grizzly bear zones have been overharvested in recent history, compared to 3 if we only consider legal kills.

The conditioning of grizzly bears to garbage and human foods is associated with all the identified land-use and mortality factors, and is the overwhelming reason behind nuisance bear kills and many illegal kills (Banci 1991). Every jurisdiction has made some strides towards the goal of eliminating conflicts between human waste management and grizzly bears, but changes have been localized and garbage management is still a pressing concern.

Designation of Population Status

The designation of population status for the Northwest Territories grizzly bear zones, the Taiga Shield, Taiga Plains, and Subarctic Mountains, are not consistent with the specified criteria. Government bear biologists most familiar with these populations requested that they be designated as vulnerable despite that they estimated current numbers close to current potential. This is an example of how an assessment of potential and realized habitat capability could provide an objective means of evaluating status. The status designation may also reflect the concern that in northern ecosystems with low productivities, even a small drop in current capability is sufficient to place a grizzly bear population at risk.

Criteria do not exist for assigning population status to the COSEWIC risk categories. How large must a loss be before a population can be considered as being "at risk"? Designations of population status should reflect abundance, distribution, habitat integrity, population trends, and reproductive potential. However, correlating the assessment of the impacts of land-use activities, population capability, and current numbers with the COSEWIC designations was difficult, as was evident with the status designations for the Northwest Territories grizzly bear zones. Beyond ensuring a minimum viable population, how many grizzly bears are enough? The answer to this question is likely in the arena of political will and public tolerance and outside the realm of science.

Effort should be expended to ensure that the grizzly bear populations in those grizzly bear zones currently designated as vulnerable do not, in the future, deteriorate and warrant a designation of threatened. It is important to recognize that the current potential of many of the grizzly bear zones may never be realized because of current land-use impacts and current public attitudes. For example, unless attitudes change, the perception that grizzly bears and livestock do not mix will prohibit grizzly bears from regaining their potential in the Cool Moist Plateaus despite available habitat. In reality, we are at best faced with maintaining the status quo. In light of the predicted future impacts in land-use practices and prevailing public attitudes, this objective

is as difficult as attempting to increase numbers.

The 4 grizzly bear zones currently not at risk are facing increased impacts from land-use practices in the next 5 years: mining and petroleum exploration and development in the Arctic Coastal Plains and Subarctic Mountain and Plains, as well as in the Cold Moist Mountains and Cool Dry Mountains along with forestry activities, land alienation, and recreation (Table 4). We have suggested possibilities why grizzly bears in 7 zones are designated as vulnerable. We need to use that hindsight to ensure that the grizzly bear zones currently not at risk do not merit a more precarious designation in the future.

Despite the perception of developers and urbanites that Canada is largely an area of untouched wilderness, there are few areas that are not accessible by humans or in which all the natural resources have not been committed to development. The interest in touring, in recreation, in viewing wildlife, and in participating in what has been termed "nonconsumptive" use is intense and increasing in all jurisdictions that have grizzly bears (Mychasiw and Hoefs 1988, Nagy and Gunson 1989, van der Wetering and Smith 1989, B.C. Lands Branch 1990). It can no longer be assumed that there will be some areas of the country that will be left natural and untrammelled and that can serve as refugia for grizzly bears and other wildlife that require large areas of relative solitude.

Two major considerations need to be identified with respect to the threatened status of the Hot Dry Plateaus grizzly bear zone. The first is the importance of maintaining the genetic integrity of small isolated populations (Allendorf and Servheen 1986). An individual in one population is not genetically equivalent to that in another. Genetic differences among individuals in different populations can be reflected in the morphology and behaviour of grizzly bears and should be managed for, maintained, and enhanced, if possible. Within the overall goal of maintaining biodiversity, these small populations can be extremely important. Further, the underlying rationale for the approach we have undertaken, the designation of status at the level of the grizzly bear zone level and not the nation, is the recognition of the importance of the differences in grizzly bear populations among the different zones.

The second consideration involves the allocation of resources in light of current human activities and land-use practices. Historically, the Hot Dry Plateaus contained the least productive habitat for grizzly bears in British Columbia (Fuhr and Demarchi 1990). Current impacts are high and include land alienation, extensive access, ranching and grazing of cattle, and agriculture (Banci 1991). An estimated 140 grizzly bears occupy the zone; the current potential is 570 (Fuhr and Demarchi 1990). According to our criteria, to downlist this population to a "vulnerable" status, grizzly bear numbers would have to be increased to at least 230. This would entail considerable effort in changing current land-use practices and public attitudes. The allocation of considerable effort to a grizzly bear zone that is the least productive in the province, considering that 7 other grizzly bear zones have been designated as vulnerable, and that those zones that are not at risk now are facing continued and increased land-use impacts, is not an easy decision to make.

RECOMMENDATIONS

1. Grizzly bear population estimates provided by the habitat assessment methodology of Fuhr and Demarchi (1990) need to be verified and refined. A quantitative protocol is necessary for evaluating potential habitat capability estimates to current grizzly bear numbers. A Cumulative Effects Model (CEM) is one tool used to review the potential effects of a given land-use proposal (IGBC 1990). The use of a CEM as a means of understanding potential and actual grizzly bear population estimates needs to be investigated. Research should also continue on the development and testing of other indirect and direct population monitoring methods.
2. Strategies that consider zoning of human activities in areas thought to be critical for the long-term persistence of grizzly bears in each grizzly bear zone need to be developed.
3. Long-term land-use strategies and access-management plans that extend well into the future at the landscape, stand, and site level are required to ensure the persistence of grizzly bear habitats within grizzly bear zones.
4. The determination of sustainable harvest levels and the recognition of when sustainable levels are exceeded, including the documentation of wounding losses and mortalities unrelated to hunting, needs to be improved.
5. Changes in waste management must be implemented through legislation as the technology and knowledge to prevent garbage and grizzly bear conflicts exists (Bromley 1985, Westhaver 1988, IGBC 1989, van der Wetering and Smith 1989).
6. Compelling education programs are necessary to ensure proper waste and human-food management, to reduce the hunting mortality of females, and to

improve public attitudes.

7. The grizzly bear zones should not be regarded as management zones. They have proved useful in focusing on broad trends and impacts and in suggesting where management effort should be directed. However, any management action adopted because of this review must be administered on a larger map scale, not the grizzly bear zone level. A habitat-based approach that can identify impacts on specific populations and can quantify habitat losses is required. This local approach should be carried out within the context of the grizzly bear zones and the broad concerns identified for these zones.

8. Attempts should continue to extend and modify the grizzly bear zones described in this status report to include grizzly bears in the United States. Grizzlies are a transcontinental species and conservation requires international cooperation. We are not recommending that the methodology for estimating grizzly bear numbers in Canada be implemented in the United States. What is required is a recognition that shared populations of grizzly bears and their habitats are interdependent.

The British Columbia Wildlife Branch, in cooperation with the Montana Department of Fish, Wildlife and Parks, and the Alberta Wildlife Division, has prepared an ecoregion and vegetation zonation map of the Rocky Mountains between 46°N and 52°N (from Clark Fork in Montana and the Clearwater River in Idaho to the Columbia Icefields in British Columbia and Alberta) (Demarchi and Lea 1992). Using ecoregion classifications developed by Bailey (1980, 1983), Demarchi (1988), Gallant et al. (1989), Omernik (1987), Strong (1991), and Wiken (1986), regional ecosystems have been mapped irrespective of political jurisdiction. Within each regional ecosystem, vegetation zones based on concepts developed by Pojar et al. (1987) for British Columbia were also mapped.

This project is the first ecological map that can be used to plan conservation strategies for grizzly bears and other wildlife species of concern in eastern Washington, northern Idaho, northwestern Montana, southwestern Alberta, and southeastern British Columbia. The classifications used in this project will provide the ecological framework. However, detailed habitat mapping, habitat evaluation, and conservation strategies must follow. This overview classification will ensure that management agencies will not continue to attempt to manage grizzly bears in isolation of each other. We propose that this mapping model be continued between western Washington and southwestern British Columbia, Alaska, the Yukon, and northwestern British Columbia.

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