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by Brian Fuhr and Dennis A. Demarchi
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PREFACE

Before Europeans settled in North America, grizzly bears (*Ursus arctos horribilis*) were wide-spread west of the Mississippi River and Hudson Bay, from the deserts of northern Mexico to the barren ground of the Northwest Territory, Yukon and Alaska. As a result of habitat loss and predator killing programs, grizzly bear numbers have steadily declined. This loss of range occurred mainly from the southern - and eastern portions of the historical range, in the prairie region of Canada and in the United States south of Canada (Jonkel 1987). Using data supplied by wildlife agencies, Peek *et al*. (1987) estimate that currently, extensive grizzly populations remain in Alaska (32 000-43 000), the Yukon Territory (6000-7000), the Northwest Territories (4000-5000), Alberta (500-1000), and British Columbia (6000-7000); only remnant populations remain in the United States south of Canada (600-900).

While the distribution of grizzly bear in North America has been reduced since the arrival of European settlers, the American black bear (*Ursus americanus*) has not been affected at the same rate or to the same extent (Kolenosky and Strathearn 1987). Currently, the status of black bear populations varies from region to region, but most jurisdictions report stable or increasing populations (Servheen 1990). In areas that are unsuitable for intensive human settlement, black bear populations have changed little during the past century. In areas such as Mexico, the Great Plains, and the southeastern United States, where there has been extensive urbanization, land clearing and development, black bear populations have declined or disappeared (Kolenosky and Strathearn 1987; Servheen 1990).

Habitat selection, niche separation and population sizes between grizzly bears and black bears are unclear (C. Jonkel pers. comm.). Both grizzly and black bears utilize similar habitats except black bears do not ordinarily live in the treeless areas inhabited by grizzly bears (Jonkel and Miller 1970). They speculate that the extension of the range of black bears onto the tundra could be expected as a response to the extirpation of grizzly bears on the Ungava Peninsula and to a general decline of barren-ground grizzlies (*Ursus arctos richardsoni*). Grizzly bears can actually suppress black bear populations through predation (Jonkel and Cowan 1971), but black bears can also suppress grizzly bear populations through an unknown mechanism (C. Jonkel pers. comm.). For example, Jonkel and Cowan (1971) found that a forest in northwestern Montana that was used by black bears before a forest fire was used by grizzly bears after the fire. Also, in the dry interior mountains of northwestern Montana, black bears are normally found below 1675 m and grizzly bears are found above that elevation. On the southern coast of Alaska, grizzly bears are found along the shoreline and black bears at higher elevations (C. Jonkel pers. comm.).

Grizzly bears once occurred throughout mainland British Columbia, but unlike the black bear, they were never present on the archipelagos of the Hecate Lowland, the Queen Charlotte Islands and Vancouver Island (Cowan and Guiguet 1956). Cultural pressures, especially predator control, have caused their extirpation from areas that have been urbanized or intensively farmed (including ranching), such as the Lower Mainland, Thompson-Okanagan, Cariboo, and Peace River areas (Figure 1). Black bears remain in the populated, rural areas of British Columbia and have only been extirpated from the cities (Forbes and Tompa 1989).

Estimates for the number of grizzly bears in British Columbia vary, depending on the calculation concepts used. In the *Preliminary Grizzly Bear Management Plan for British Columbia*, the Ministry of Environment (1979) estimated the number of grizzly bears to be about 6660, based on density estimates calculated from broad-level topography and climate concepts at 1:2 million scale (B.C. Fish and Wildlife Branch 1977). The actual total presented on the map was 8000 with

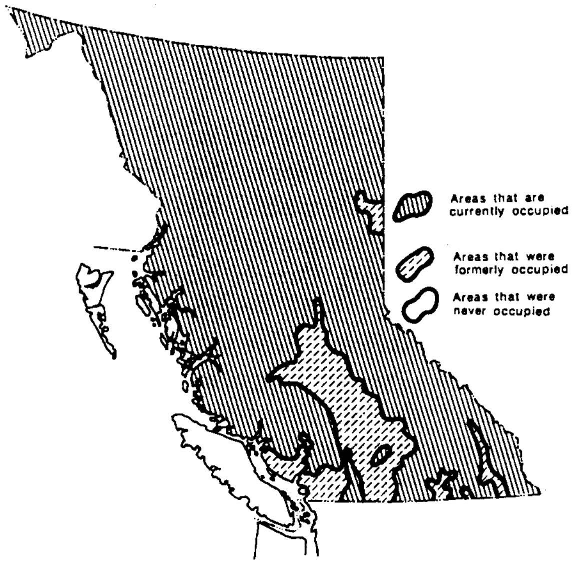

Figure 1. Historical and present distribution of grizzly bears in British Columbia.

estimated outside limits of 5000 to 11 000. Whereas, by using estimates that are based on 1:500 000 scale mapping of physiography, macroclimate and climatic climax vegetation potential, it can now be estimated that there was an historical potential for about 22 000 grizzly bears. Currently, there are estimated to be 13 000 grizzly bears (Appendix A).

Concern over uncertain population numbers or even declining populations in recent years has resulted in more restrictive hunting seasons and grizzly bear closed areas. The apparent excessive rate of legal and illegal kills in some areas has largely resulted from increased access and a lack of understanding of population dynamics, habitat use or the distribution of important habitats.

To that end, the provincial grizzly bear species statement currently being developed will provide a summary of the species, its habitat, public use and management strategy (A. Harcombe and R. Archibald pers. comm.). Harvest rates are being reviewed in this species statement and in regional wildlife plans. Regional habitat plans and the continuing efforts of regional staff have provided information regarding grizzly bear habitat and population status. Current research is steadily improving knowledge of population and habitat-related characteristics.

Grizzly bears are difficult to observe or census because they occur at low densities and their preferred habitat is dense shrublands or forests. The advent of radio-telemetry techniques has simplified this task somewhat, but it is ,:still very time-consuming and expensive and general distribution and behaviour observations are still lacking. Recent investigations to address these issues include studies in 1 the Kimsquit drainage of the central mainland coast (Banner et al. 1985; Hamilton et al. 1986), the Columbia Mountains (Simpson et al. 1985; Simpson 1987) and the Flathead River drainage of southeastern British Columbia (McLellan 1984).

Just as there are several approaches to ecosystem identification and classification there are several approaches to classification and mapping of grizzly bear habitat in western North America. Apart from the basic structured/non-structured dichotomy there appears to be Canadian and American approaches.

In the United States, habitat classifications that are used to identify grizzly bear habitats are apparently vegetationally inspired; i.e., they are based on physiognomic differences, climax stands or seral classes (Daubenmire and Daubenmire 1968; Pfister *et al*. 1977; Viereck *et al*. 1982). Higher levels, such as Ecoregions of the United States (Bailey 1981, 1983) are not used, nor are physiographic, terrain or soil parameters (Driscoll *et al*. 1984). Emphasis is placed on vegetation (food and cover requirements of grizzly bears), but not on the conditions that produce the vegetation, nor on the physical or climatic attributes that improve or restrict grizzly bear movement (Hadden *et al*. 1985; Mace 1987; Craighead *et al*. 1988). In several cases, the tools apparently dictate the classification rather than the other way around (Craighead *et al*. 1982). Digital satellite imagery, Geographic Information Systems and conventional aerial photography are tools and do not provide classification in themselves.

In Canada, habitat classification is usually a top-down, multi-disciplinary approach to parameter identification, moving from the very broad sub-continental down to specific habitat elements Lacate 1969; Hills *et al*. 1973; Wiken and Ironside 1977; Banner *et al*. 1985; Demarchi and Lea 1987*a*; Demarchi *et al*. in prep.). No one parameter or element is given dominance over others, for it is the combination of physical and biological parameters that defines each ecosystem. Even though, habitat unit names usually reflect the most obvious characteristics - vegetation.

In the habitat classification defined in this methodology, habitat units are delineated through a progressive stratification of ecoregions, biogeoclimatic zonation, and biophysical habitat units with successional stages. Different methods for the assessment of grizzly bear habitat are used at small map scales (1:250 000 and 1:500 000), for medium map scales (1:50 000 and 1:100 000) and for large map scales (1:5000 and 1:20 000). These maps are useful for providing habitat descriptions, season of use, en importance ranking and a method of calculating present and potential carrying capacity.

Small map scales use only the ecoregion and biogeoclimatic zonation levels of stratification and are given a habitat importance ranking. Medium map scales use more detailed stratification of ecoregion, biogeoclimatic zonation and biophysical habitat unit. Similar methods are used for mapping at large map scales but carrying capacity estimates have not been calculated for this detailed level. Habitat units of large map scales are only given interpretations of potential season of use and an importance ranking. Using the grizzly bear use interpretations along with the habitat unit descriptions, some important habitats and areas of habitat suitable for enhancement may also be identified. Carrying capacity can be estimated using the separate density estimates for small and medium map scales. When carrying capacity estimates are compared with present distribution and use, areas of underutilization may also be identified. This will hopefully provide a better understanding of the ecosystem as a whole and facilitate improved grizzly bear management.

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1. INTRODUCTION

The purpose of this methodology is to provide a method of mapping the extent and quality of grizzly bear habitat in British Columbia, based on knowledge gained during two pilot projects (Figure 2). Habitat quality is defined in terms of its rank on a provincial scale and its carrying capacity. This methodology is intended for reconnaissance level of inventory, i.e., to be conducted for broad scale[1] mapping (1:50 000 or smaller) with a minimum of field checking.

The methods presented in this report are similar to those presently used in mapping ungulate habitat (Demarchi *et al.* in prep.) and for calculating ungulate carrying capacity in British Columbia (Demarchi *et al.* 1983) as they pertain to any habitat-dependent, wide-ranging herbivore or omnivore. The grizzly bear habitat carrying capacity estimates (see Chapter 4) are the main addition to existing biophysical mapping methods. This methodology has been designed solely for the assessment of potential grizzly bear habitat; it therefore assumes no interspecific competition between grizzly and black bears. This methodology has not been tested on black bear populations; however, with minor modifications based on their biology, a similar approach could be used for assessing their habitats.

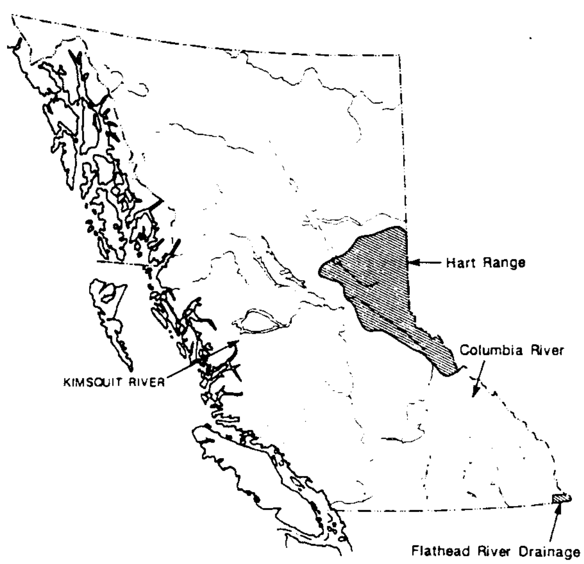


Figure 2. Location of provincial grizzly bear habitat study projects mentioned in the text.

Mapping at smaller scales (1:250 000 or 1:500 000) uses Ministry of Forests' biogeoclimatic zonation (Pojar *et al.* 1987; B.C. Ministry of Forests 1988) combined with Ecoregions of British Columbia (Demarchi *et al.* 1988). These provide physiographic and climatic subdivisions for ecological stratification and for identifying the geographical limits of various grizzly bear ecotypes within the province. Mapping at medium scales (1:50 000 or 1:100 000) defines ecological units having physical landscape features (which do not change over time), and vegetation communities (which may change over time). These biophysical habitat units form the basis for estimating season of use, importance rating and an estimation of carrying capacity (Demarchi and Lea 1987*a*; Demarchi *et al.* in prep.).

The general habitat information will aid in the protection, management and enhancement of grizzly bears and their habitats. Specific habitat information and actual grizzly bear use, however, should be verified by field inspection wherever possible. Interpretations of habitat maps should be appropriate for a given map scale and nature of the habitat data portrayed. For example, a general 1:50 000 scale habitat map would be appropriate for corridor selection for trail construction, while the actual location of the trail should be made only after an on-site inspection so that micro-habitats and current grizzly bear use are not overlooked.

[1] Map scales as described in this report (also used by the Ministry of Environment) are: small scale 1:250 000 to 1:500 000; medium scale, 1:50 000 to 1:100 000; large scale, 1:5000 to 1:20 000.

We would like to thank the following people for their assistance throughout this project. Bruce McLellan provided invaluable habitat use information and estimates of numbers of bears occurring in the Flathead area. This, combined with his hospitality in the Flathead, contributed greatly to this publication and our enjoyment of the project. Tony Hamilton gave us a much clearer view of coastal grizzly ecology and was helpful throughout the development of this methodology. His enthusiasm for his 'favourite topic' was inspiring.

Ted Lea and Ralph Archibald edited the draft methodology. Many other Victoria and Regional staff provided comments and helped shape the present form of this methodology. Testing of these methods and their application province-wide will continue as we enlarge our collective knowledge of grizzly bear habitat ecology in British Columbia. Liz Stanlake edited the final version, Darla Cooper did the word processing and Rick Thomas did the illustrations.

2. HABITAT CLASSIFICATION FOR GRIZZLY BEARS

2.1 Existing Methods Applied in British Columbia

The biophysical method of land evaluation applied in British Columbia was born from the Canada Land Inventory Program in the late 1960's and early 1970's (Lacate 1969; Walmsley 1977; Demarchi and Chamberlin 1977). It has been extensively used in recent years for ungulate habitat capability assessment (Demarchi *et al*.; Demarchi and Lea 1987*a*). This method of habitat assessment has been detailed in *Biophysical Habitat Mapping Methodology* (Demarchi *et al*. in prep.). As used here, these methods involve a progressive stratification of the landscape using ecoregion, biogeoclimatic zonation, and biophysical habitat units. This stratification proceeds from general ecological parameters down to detailed soil and vegetative characteristics. Ecoregions provide physiographic and climatic process information. Biogeoclimatic zonation is used as a surrogate for climatic. zonation because detailed climatic information is seldom available. It also provides a framework for delining plant community distribution. Larger map scales use more detailed units, described by permanent landscape features and vegetation. This stratification forms the structure of the map legends (Figs. 3, 5) corresponding to the sample maps (Figs. 4, 6).

Soils maps at 1:50 000 are available for much of the southern two-thirds of British Columbia. They are general in nature as they were produced for a variety of resource interpretations. When examined during .the course of the Flathead River area study, they were found to overestimate the area of floodplains and avalanche tracks when compared to the medium scale grizzly bear habitat map and the area of potential black huckleberry production was accurate only when the soils were further stratified by slope, aspect and elevation.

Methods of using forest cover information to predict coastal grizzly bear habitat quality are presently being investigated by the Research and Development Section of the Wildlife Branch (A. Hamilton pers. comm.). Habitat mapping based solely on forest cover mapping should be interpreted cautiously. The map scale allows detailed polygon delineation, but may not warrant a detailed bear habitat interpretation since the only input is a classification for forest cover with little field checking. A forest cover classification should only be used to interpret grizzly bear habitat potential where it is known to reflect specific habitat importance reliably.

Generally, classifications are designed and often modified to meet their objectives. For example, if the objective is forest cover or forest ecosystem classification, then those classifications meet their objectives but only partially describe grizzly bear habitat. A map of biophysical habitat types produced specifically for mule deer in the Flathead River drainage would be similar to that produced for grizzly bears, but might group some grizzly bear habitat units with others and distinguish different

ECOSECTION	BIOGEOCLIMATIC ZONE	DESCRIPTION	RATING
Hart Ranges (HAR)	Alpine Tundra (AT)	rocky, poorly vegetated alpine with deep snow	L
	Engelmann Spruce-Subalpine Fir (ESSF)	dense conifer forests in a wet climate, deep persistent snow, avalanche chutes common	H
	Sub-boreal Spruce (SBS)	dense conifer forests at-lower elevations, low gradient floodplains common	H
Nechako Lowlands (NEL)	Sub-boreal Spruce (SBS)	dense conifer forests with a wet climate and a rolling landform	M
	Engelmann Spruce-Subalpine Fir (ESSF)	dense conifer forests in a wet climate, rolling landform	M

Figure 3. Example legend small scale mapping: for the example portion of the Hart Range project see Figure 4

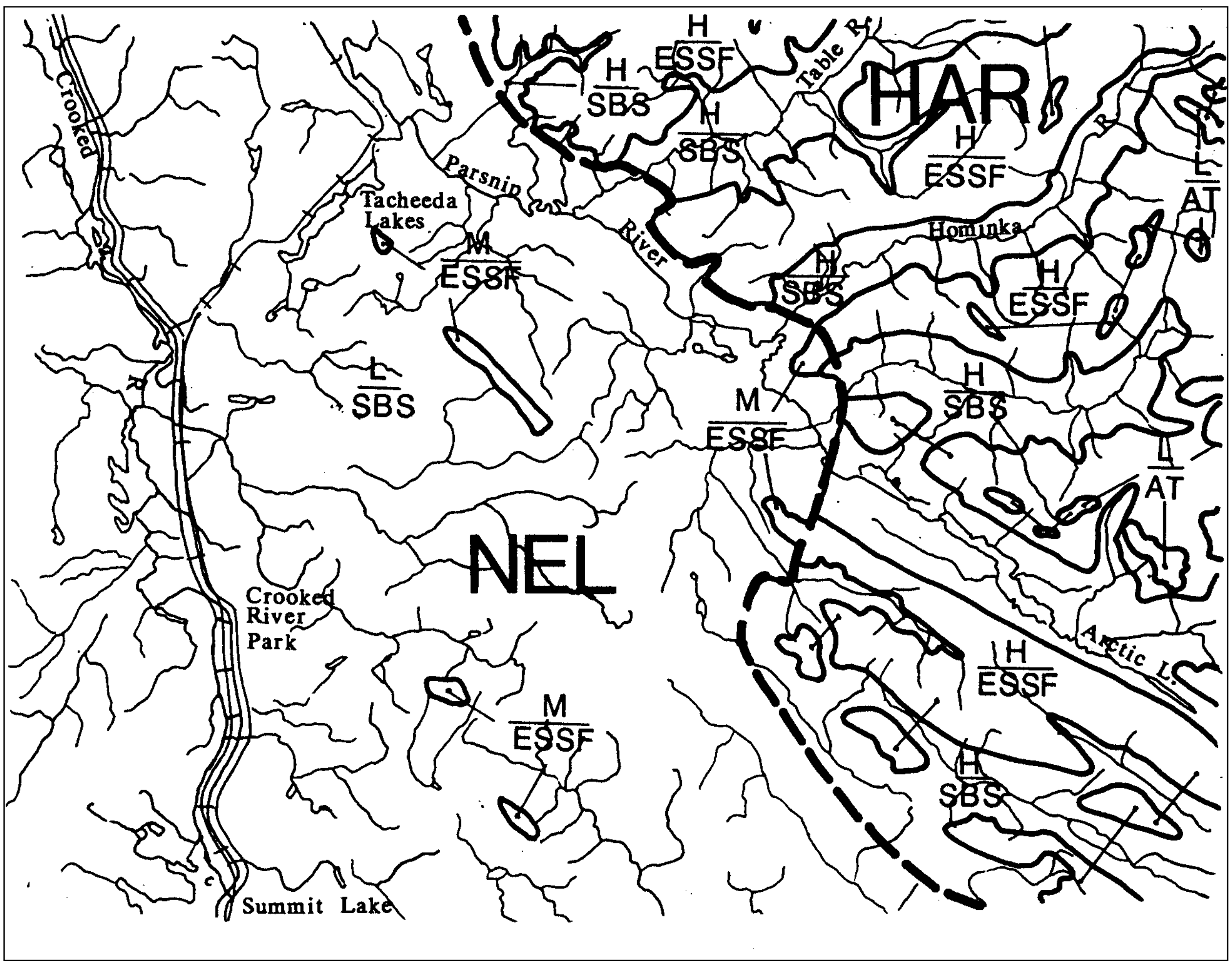
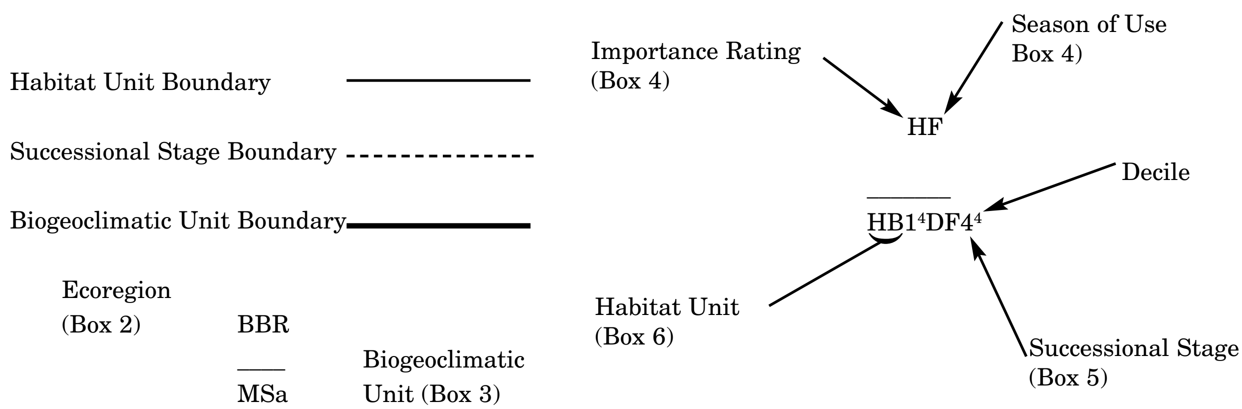


Figure 4. Example map: small scale (1:500 000) mapping in the Hart Ranges (see Figure 2)

Figure 5. A simplified legend for the example portion (Figure 6) of the grizzly bear habitat units and seasonal values for the lower flathead Valley (after Lea et al. 1988)

1. EXAMPLE MAP SYMBOLS



2. ECOREGION

BBR Border Ranges Ecosection. This Ecosection comprises the dry mountains and wide valleys of the Southern Rocky Mountains (Demarchi 1988).

3. BIOGEOCLIMATIC UNITS

MSdk Dry Cool Montane Spruce Subzone, This area occurs at low elevation of the Flathead Calley and has climax forests of spruce and subalpine spruce. Seral forests dominate and have lodgepole pine and western larch, with an understory .of pine grass and soopolallie. Most floodplains that are important for grizzly bears occur in this area

ESSFdk Dry Cool Engelmann Spruce - Subalpine Fir Subzone. This area lies between the Montane Spruce and the Alpine Tundra It has a colder climate and shorter growing season than the Montane Spruce. Its climatic climax forests of Engelmann spruce and subalpine fir have an understory of false azalea, grouseberry, queen's cup, bunchberry and moss. Most black huckleberry production occurs on southerly aspects in this area. Avalanche tracks ace common.

AT Alpine Tundra Zone. In this area the alpine is very sparsely vegetated and is dominated by rock. Some krummholz vegetation may be included

4. SEASON OF USE AND IMPORTANCE

Season of Use	Importance Rating
SP - spring	H - high
S - summer	M - medium
F - fall	L - low
A - annual	N - nil

5. SUCCESSIONAL STAGES

The successional stages shown on the map are taken from Ministry of Forests forest cover maps.

1. Recent disturbance (logging or fire)
2. Immature forests (<20 years)
3. Young forests (20 - 80 years)
4. Mature forests (>80 years)

Figure 5, *continued*

6. HABITAT UNITS			
MAP SYMBOL	NAME	BEAR USE	DESCRIPTION
	Montane Spruce Subzone (MSdk)		
LF	Lodgepole pine - falsebox southerly aspect	low-moderate spring & fall	steep southerly aspects with rapidly drained, droughty soils. Usually too dry to have good bear forage abundance.
LM	Lodgepole pine - pinegrass morainal	low - moderate fall	moderately sloping sites with deep materials and average moisture conditions.
LP	Lodgepole pine - pinegrass coarse fluvial	low - moderate spring & fall	sandy or gravelly gently sloping areas, dry and rapidly drained, generally in the main Flathead Valley.
SH	Spruce - horsetail moist floodplain	high spring & summer	variable floodplain and terrace units, often with a mosaic of moisture conditions and seral stages. Rare flooding.
SS	Saskatoon - wild strawberry dry avalanche dune	moderate all seasons	steep southerly aspects and drier moisture conditions than AH avalanche tracts. These areas may have early green-up and may produce some berrries, but are generally too dry for abundant forage
WC	Willow - cow-parsnip active floodplain	high spring & summer	frequently flooded and moist for much of the year. Very abundant bear food such as grasses, umbels and horse-tails. Willow and alder may be dense.
WS	Willow - sedge fan	moderate spring & summer	depressional areas with organic deposits. Willow, sedges and moss may be present
	Engelmann Spruce - Subalpine Fir Subzone ESSF dk)		
AH	Sitka alder - Indian hellebore avalanche track	high all seasons	moist avalanche tracts with abundant bear food, especially on lower portions of the slope. Dense alder is common.
DF	Douglas-fir - Idaho fescue shallow soils	low all seasons	steep southerly aspects with shallow soils result in dry conditions with low forage potential.
FA	Subalpine fir - false azalea mesic	low all seasons	extensive areas of subalpine forest on cool aspects and moderate slopes with low potential for forage.
HB	Black huckleberry - bear-grass southerly aspect	moderate-high fall	moderately steep southerly exposures with deep mat-erial, moister than DF type, better berry producing areas often associated with hot or repeated fire.
RO	Rock	nil use	areas of rock with sparse vegetation.
SH	Spruce - horsetail moist floodplain	high spring & summer	variable floodplain and terrace units, often with a mosaic of moisture conditions and seral stages. Rare flooding.
SS	Saskatoon - wild strawberry dry avalanche chute	moderate all seasons	steep, southerly aspects and drier moisture conditions than AH avalanche tracts. These areas may have early green-up and may produce some berries, but are gener-ally too dry for abundant forage.
	Alpine Tundra		
AT	Alpine tundra	moderate summer	alpine areas are dry and sparsely vegetated. Some areas of krummholz are included.
RO	Rock	nil use	dominant area of the Alpine Tundra zone.

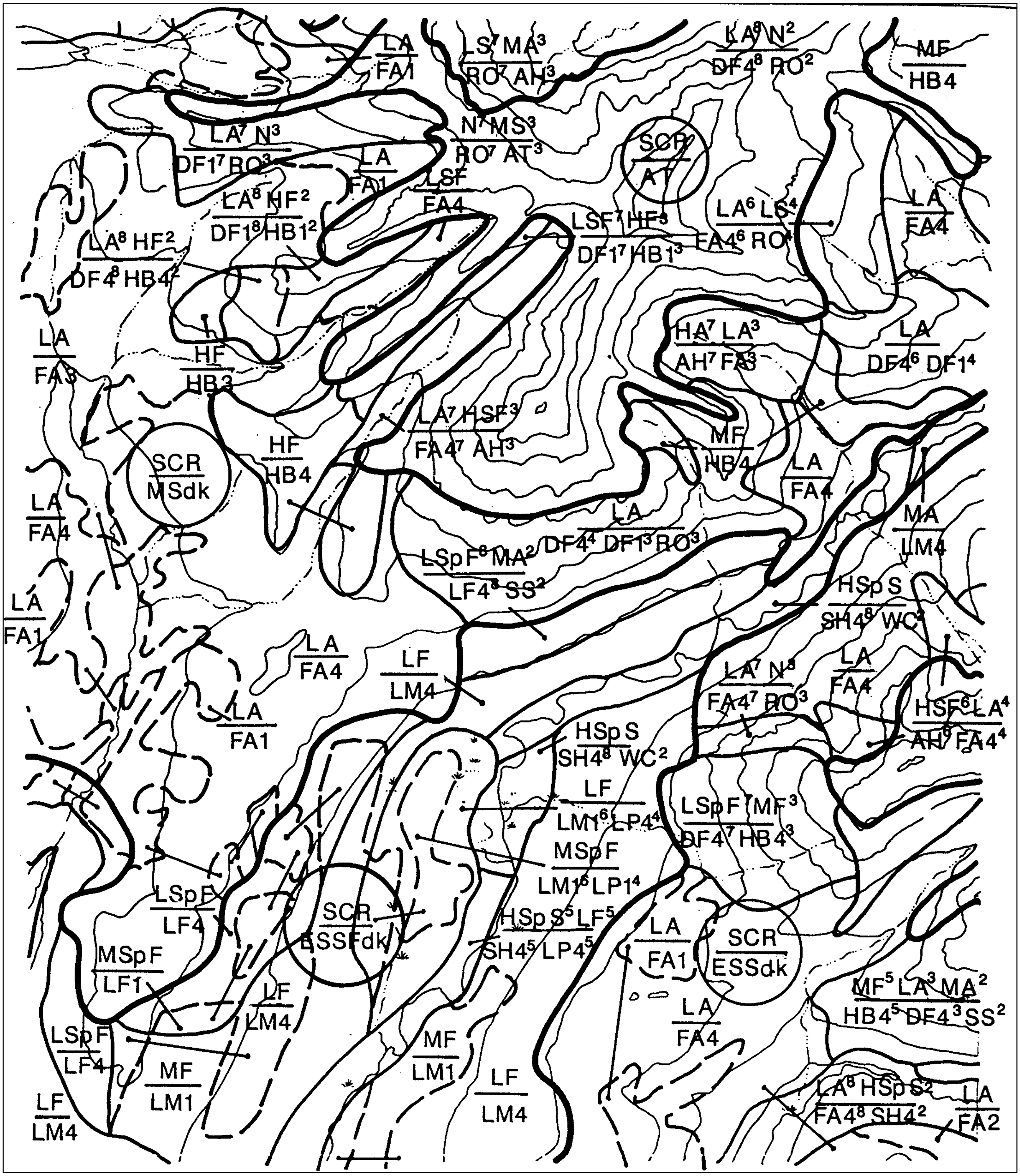


Figure 6. Example map: medium scale (1:50 000) mapping in the lower Flathead Valley (see Figure 4).

habitat units that highlight mule deer habitat. Multi-species oriented biophysical maps should have a good predictive ability for grizzly habitat, but may not adequately identify some seasonal areas of existing or potential habitat. They should still be adequate for habitat interpretations and carrying capacity estimates. Other map sources are best used only as input to such habitat maps. Inappropriate stratification will result in inaccurate carrying capacity estimates. Stratification depends on both map scale and survey intensity.

2.2 Stratification

The three levels of stratification that are used in this methodology are, from general to specific: ecoregion, biogeoclimatic zonation and biophysical habitat unit (Demarchi and Lea 1987*a*). At small mapping scales (1:250 000 to 1:500 000) only ecoregions and biogeoclimatic zonation should be used. At medium mapping scales (1:50 000 to 1:100 000) ecoregions, biogeoclimatic zonation and biophysical habitat units should be used. Separate carrying capacity estimates are given in Chapter 4 for the medium and smaller scale mapping scales. This is necessary because small mapping scales are much more general and do not provide the same degree of habitat stratification. A description of the three levels of stratification follows.

2.2.1 Ecoregion.— Ecoregions are geographical areas where the ecosystem produced by macroclimate and physiography (relief and landforms) is sufficiently uniform to permit the development of characteristic types of ecological associations (Bailey 1980, 1983). Ecoregions exist in different sizes and can be identified at various scales and levels of detail in a hierarchy for any area. Ecoregions at five levels have been described for British Columbia (Demarchi 1988; Demarchi et al. 1989). They have been mapped along with biogeoclimatic zonation at a scale of 1:500 000 (B.C. Wildlife Branch 1989). Ecoregions provide a method of stratifying grizzly bear habitat importance at a regional or provincial level. They are a less important stratification at more detailed levels (1:5000 to 1:20 000). A ranking for grizzly bear habitat importance of the 65 provincial ecoregions that historically supported grizzly bears appears in Appendix A.

2.2.2 Biogeoclimatic Zonation.--Biogeoclimatic zones can be considered as vegetationally defined topoclimatic zones. Within each terrestrial region bounded by climatic processes and landform parameters, these are climatic zones that are reflected by the plant and animal communities present (Pojar *et al*. 1987; Demarchi 1988). In mountainous areas they are often elevational belts; it is only on extensive plateaux, plains or lowlands that they represent regional ecosystems.

Biogeoclimatic zones abd sub-zones have been mapped for all of British Columbia (B.C. Ministry of Forests 1988; B.C. Wildlife Branch 1989). Information on climate, potential tree cover and climax communities on various sites can be * determined from the maps': and associated reports. The kinds of habitat units present and their potential importance for grizzly bears can be inferred from the combination of ecoregion and biogeoclimatic zonation. This provides the map units for small scale mapping and the framework for defining habitat units at medium map scales.

2.2.3 Biophysical Habitat Units.— Biophysical habitat units are defined as similar homogeneous landform or terrain units that can support climax vegetation and resultant successional vegetation (Demarchi and Lea 1987*b*). For a habitat mapping project, they focus on the characteristics that dominantly affect the vegetation and the potential habitat use of an area. Factors most often included are slope, elevation, aspect, surficial material, soil development, soil moisture, active geomorphic processes and potential vegetation. Identifying similar units is emphasized rather than the minor differences between land units (Demarchi *et al*. in prep.). This minimizes the final number of habitat units and thus simplifies map interpretation. In grizzly bear projects, mapping should focus on important bear habitats and be more general in less important areas. Map scale controls the minimum practical polygon size.

Each habitat unit is capable of producing similar potential vegetation even though their current successional stages may be different. A particular habitat unit may have a series of successional stages. For instance, the area may include a bum, cutover and climax forest as different successional stages. In the case of strongly edaphic or topoedaphic features only one successional stage may occur.

Successional stages not present in the study are not mapped, but should be described on the map legend. For example, if burns within a particular forested vegetation landscape were not present, but were suspected of having high berry production potential, they should be described on the legend. Also, potential successional stages with lower habitat suitability should be described so change in habitat quality over time can be predicted.

2.3 Scale of Mapping

Small map scales show general ecological boundaries (ecoregion and biogeoclimatic zonation) that may be interpreted for grizzly bear habitat importance. Maps of this nature may provide rough carrying capacity estimates and are used at regional or provincial planning levels within the Wildlife Branch. However, they do not show the extent of specific habitat types, such as floodplains or avalanche tracks. The abundance of important habitat types in a particular ecoregion and biogeoclimatic unit is very important in its interpretation. Biogeoclimatic units may be subdivided according to the abundance of such habitat units even though they are not mapped. Biogeoclimatic units may also be subdivided on the basis of access and forest harvesting activity if these are thought to have affected grizzly bear numbers in an area. This would only be done if a present population estimate rather than a potential carrying capacity estimate is required.

Medium map scales, such as the Flathead example, depict the physical aspect of habitats, which will change little over time, and vegetative aspects, which can change through logging, fire, grazing and subsequent succession. Edaphic habitat units, such as avalanche tracks or wet alpine meadows, have only one successional stage that is mapped. The interrelationship of these successional and edaphic habitats provides a perspective of *ecosystem functioning*, showing the changes that will occur over time, identifying areas with potential for habitat enhancement and showing areas of high priority for habitat protection. Such maps indicate the distribution and quality of habitat generally, depending on map scale and the detail of information used. More detailed mapping or on-site inspection is required before development or enhancement of a specific site is undertaken.

Habitat mapping at large map scales (1:50001:20 000) is intended for detailed habitat enhancement and management or for research support information (Hamilton and Archibald 1985; Demarchi and Lea 1987*b*; Demarchi *et al*. in prep.). Often only forest cover information is used to interpret habitat value for many species, including grizzly bears; however, such maps represent only the standing crop of trees and no landforms, soils, climate or understory attributes. Forest cover information should be used to augment habitat mapping to determine current successional stages (age) or broad climatic zones (species distribution). In tidal wetland areas, such as estuaries, habitat mapping should use the mapping and classification standard established by Hunter *et al*. (1983). In non-tidal wetland areas the wetland classification established by Runka and Lewis (1981) should be applied to describe mapped parameters.

Mapping of coastal habitats at 1:20 000 in the Kimsquit River valley of the Kitimat Ranges was undertaken in 1982 using a modified climax-based ecosystem classification. Three levels of ecosystem generalization (ecosystem association, successional stage and variant) together with landform and soil parameters were used to form the core of the coastal grizzly bear habitat classification (Banner *et al*. 1985; Hamilton and Archibald 1985). This new classification is similar to the biophysical habitat classification used by the Ministry of Environment (Demarchi and Lea 1987*b*; Demarchi *et al*. in prep.).

3. SEASONAL HABITAT USE BY GRIZZLY BEARS

3.1 Season of Use

Grizzly bears have unique and restrictive feeding habits and physiologies because of their long denning periods (5-7 months) and large size (Jonkel 1987). Craighead and Mitchell (1982) have outlined several feeding behaviour strategies exhibited by grizzly bears that enable them to exploit food sources. They usually feed on a wide variety of different food resources, switching foods according to their abundance through the year. There is also a degree of selectivity, bears often prefer certain high-energy and high-protein food items when available. In fact, grizzly bears will often "track" the phenologies of various plant species, and many of their seasonal activities are associated with the emergence and maturation of plants (Craighead and Mitchell 1982). However, in years when their preferred food items are scarce, bears will travel farther, often away from their normal home ranges. When food is abundant and concentrated, grizzly bears may aggregate, allowing many to share a common food source, such as a large carcass or a salmon run.

Season of use is a description of the dominant season of use of a particular habitat. For our purposes, it is best described as spring, summer, fall, winter or annual (Table 1). These are general categories because actual seasonal use is variable throughout the province. For example, the period of salmon importance in bear diet may be area specific. These categories should be modified where necessary to suit different ecotypes. Since the amount of information available on grizzly bear seasonal habitat use varies in the province, it. is necessary to summarize the assumptions made in a narrative legend on the map or in `an accompanying report. This format also allows future interpretations to be easily adjusted gas new information becomes available.

Season of use ratings can affect carrying capacity estimates. The season of use ratings are intended to highlight areas that have a disproportionate amount of use in a particular season or seasons. Some minor use will likely occur at other times of the year and should 'hot be indicated on the map. Extensive mapping or multiple season categories where, unwarranted, will result in over-estimation of carrying capacity. For instance, a map unit described as having high spring and summer use receives twice the weighting that a unit described as only having high summer use receives (see Chapter 4, Estimation of Carrying Capacity).

Animal protein sources may concentrate grizzly bear use on small areas, such as fish spawning areas or rodent colonies. The location of such activities may be indicated with on-site symbols and described on the map legend if they are too small to form map units. Only presently existing sources should be indicated on the map, since the identification of fish spawning capability or other interpretations is outside the scope of most projects. Potential for the enhancement of animal protein sources may be indicated in the narrative of a report or legend.

Table 1. Season of use categories.

Map Symbol	Season	Definition
Sp	Spring	from time of emergence from dens to full leaf flush
S	Summer	from full leaf flush to berry ripening
F	Fall	from berry ripening to time of denning
W	Winter	general areas of denning
A	Annual	the active season, excluding denning

3.2 Ranking of Potential Use

Habitat units are ranked according to their potential degree of use as high (H), medium (M), low (L) or nil (N). This depends on how well the habitat meets the seasonal needs of grizzly bears and the suspected importance of the habitat in their annual life cycle. The rationale for this ranking should be recorded in a narrative legend. These rankings should be kept within a provincial perspective, rather than a local one. For example, mappers should not be ranking many high or moderate use units in an area that has an overall low carrying capacity by provincial standards (see Appendix A). *Ecoregions of British Columbia* (Demarchi 1988; Demarchi *et al*. 1989) may be used as a guide.

3.3 Habitat Use Surveys

Habitat quality and present use by grizzly bears should be confirmed in the field to the extent possible. Representative areas should be surveyed to record habitat characteristics, food abundance and signs of use. This “transect method” has recently been described by McCrory *et al*. (1985). It has also been used in this project and in coastal British Columbia (A. Hamilton pers. comm.). With experience, this method can be used to establish density estimates from habitat quality and the amount of sign present. Experience in different ecosystems and in areas with relatively well established grizzly bear densities is 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.

4. ESTIMATION OF CARRYING CAPACITY

4.1 Introduction

The estimation of grizzly bear carrying capacity is difficult for a number of reasons. Most bear biologists agree that, grizzly bear carrying capacity depends on the amount and quality of habitat available. They agree that there are good, medium and poor regions of bear habitat that correlate to potential number of bears. Agreement stops here. We know that grizzly bear density can increase with food availability, but that food abundance itself may not be limiting, because social factors may be acting. Bears often concentrate their feeding on specific areas of high energy or high protein sources, causing seasonal shifts in use that ;are not always vegetationally related.

The correlation of bear density with habitat quality and quantity is the main justification for attempting to estimate density. We contend that carrying capacity estimates based,: on assessment of available habitat will have greater accuracy than estimates based on other indirect methods. These habitat-based carrying capacity estimates must be adjusted for present land use, disturbance and human-related mortality before a present population estimate can be made.

Separate carrying capacity estimates are necessary for different map scales, since more detailed scales allow better stratification and measurement of the areas of important habitat. Sections 4.3 and 4.4 describe two carrying capacity estimates. Small map scales only allow for the broad levels of stratification of ecoregion and biogeoclimatic zonation. The extent and quality of the habitat units occurring in the area may be used to assist ranking of biogeoclimatic units, but the areas of actual habitat units are not shown on the map. Such areas should not be used with this carrying capacity or a population underestimate will result. Medium map scales allow greater stratification and delineation of habitat units.

Large map scales should not be used to establish carrying capacity estimates, instead they should be used to identify important areas and present habitat condition for detailed habitat studies or enhancement. Large scale habitat units should be generalized to 1:50 000 before a carrying capacity estimate is attempted. Much higher density estimates would be required to be appropriate for 1:20 000 scale mapping. There is little - basis for establishing these and the potential for error in estimating carrying capacity is increased. At large map scales the importance of adjacent units and the duration of use of particular units confound estimation of carrying capacity, especially for a mobile species with low density such as the grizzly.

It must be accepted that map scale, mapping intensity and mapping methods are all potential sources of error in calculating carrying capacity for any species.

4.2 Existing Carrying Capacity Estimates

In 1977, the distribution and relative abundance of grizzly bears in British Columbia was mapped at 1:2 000 000, using information supplied by the regional wildlife biologists (B.C. Fish and Wildlife Branch 1977, 1978). These maps were updated in 1987. The abundance categories (moderate to plentiful, few to very few, and nil) were based on the available literature at that time and the estimates of regional biologists (Table 2).

Some density estimates of grizzly bears in North America are presented in Table 3. Most of these estimates are based only on the area encompassed by their study and on telemetry data, without stratification of habitat. It is often unclear how the estimate was made or if it included cubs. Some of these studies were used as a guide for establishing carrying capacity estimates for small scale mapping in this methodology (see Section 4.4). These studies were of little use for establishing carrying capacity estimates for medium map scales where a higher degree of habitat stratification occurs. Since high densities are common in some areas of British Columbia and habitat stratification techniques require higher carrying capacity estimates, the values used in this methodology are higher than most of those cited in Table 3. The estimates used in this paper include cubs of the year or yearlings in the company of a sow.

4.3 Carrying Capacity Estimates at Medium Map Scales

4.3.1 Introduction.-- The area of the southern Flathead River drainage in British Columbia (portions of 1:50 000 scale map areas 82G/1 and 82G/2E) was chosen as a pilot project for medium scale mapping but also was used to compare medium and small scale mapping (Lea *et al*. 1988). The grizzlies "of this area have been the focus of a long-term telemetry project (McLellan 1984, 1989; McLellan and Shackleton 1988*a*, *b*) and biophysical .data exist for the area.

Carrying capacity estimates (Table 4) were derived from the Flathead pilot project, discussion with other biologists and comparison with data from other areas. They are intended to be applicable . -where biogeoclimatic zonation and habitat units have been mapped at a scale of 1:50 000 or 1:100 000.

The density estimates presented for use with medium map scales are provincial in scope and not specific to the Flathead area. Cursory comparisons with other areas have indicated that these densities appear reasonable, but little information is available with which to test their accuracy. Carrying capacity estimates should be provincially rather than regionally applied to help maintain consistency in mapping.

It is difficult to apply carrying capacity estimates to the ranking of each habitat polygon on a map. This is mainly because duration of use would have to be considered, such as "bear use days", and importance may not be directly related to length of use. Duration of use

Table 2. Relative abundance estimates for grizzly bears used by the British Columbia Fish and Wildlife Branch in 1 977.

Rating	Density
Plentiful	>1 bear/64 km^2 (25 mi^2)
Moderate	1 bear/64-192 km^2 (25-75 mi^2)
Few	1 bear/192-1280 km^2 (75-500 m^2)
Nil	<1 bear/1280 km^2 (500 mi^2)

Table 3. Estimated densities of grizzly bears in various locations within North America In km^2/grisly bear (after Hating 1987).

Location	km^2/ grizzly bear	Source
SEMI-ARID STEPPE HIGHLANDS[a]		
Yellowstone National Park	50[b]	Blanchard and Knight (1980)
SOUTHERN INTERIOR MOUNTAINS		
- Cool, Dry Mountains		
Glacier National Park (USA.)	21.2	Martinka (1974)
Rocky Mountain East Front	71.6-74.2	Aune *et al*. (1986)
Mission Mountains	137	Dood *et al*. (1986)
South Fork Flathead River	49	Dood *et al*. (1986)
North Fork Flathead River	10.-15.6	McLellan (1984)
Banff National Park	70.-1205	Vroom (1974)
Jasper National Park	85.5-101.6	Russell *et al*. (1979)
- Cool, Moist, Rugged Mountains		
Cabinet Mountains	44	Kasworm (1985)
Columbia River (Revelstoke)	24.1	Simpson *et al*. (1985)
Glacier National Park (Canada)	18.1-285	Mundy and Flook (1973)
BOREAL PLAINS		
Swan Hills, Alberta	104.- 139	Nagy and Russell (1978)
SUB-ARCTIC HIGHLANDS		
Western Brooks Range	42.-44	Reynolds and Hechtel (1980)
Eastern Brooks Range	148	Curatolo and Moore (1975)
Northern Yukon	48	Pearson (1976)
Northern Yukon	33.-39	Nagy *et al*. (1983)
Alaska Range	35.-52.9	Reynolds and Hechtel (1984)
Denali National Park	24.-38	Dean (1976)
Nelchina/Upper Susitna	41	Miller and Ballard (1982)
Kluane National Park	22.8-27.2	Pearson (1975)
Mackenzie Mountains	86	Miller *et al*. (1982)
COAST MOUNTAINS		
Alaska Peninsula	16	Miller and Ballard (1982)
Northern Admiralty Island	3.2-4.2	Schoen and Beier (1982)
Kodiak Island	3.75	Troyer and Hensel (1969)

[a] Ecoprovince after Bailey (1980) modified in B.C. by Demarchi (1988)
[b] Garbage dump closed to bears.

information has not been well documented for most of British Columbia. In addition, the diversity and juxtaposition of habitats may be as important as the value of individual habitats. To calculate carrying capacity it is suggested that ecologically or geographically distinct areas of habitat be used. For example, if the total areas of units ranked moderate and high importance for a particular mountain block are calculated, then separate carrying capacity ratings can be applied. Calculations can be made for either present carrying capacity (by using present seral state) or potential carrying capacity (by using the optimal seral state). The following example from the Flathead study illustrates the calculation method.

4.3.2 An Example Calculation Using Medium Scale Mapping.-- Carrying capacity calculations were made on three sub-areas of the Flathead project area so that three separate

Table 4. Grizzly bear carrying capacity estimates for use with medium map scales (1:50 000 and 1:100 000).

Value rating	Area occupied by each grizzly bear
High	5 km²/grizzly bear
Moderate	15 km²grizzly bear
Low	45 km²/grizzly bear

estimates would be compared. They are: the area west of the Flathead River (Howell/Cabin area); the area east of and including the upper Flathead River (Commerce/Middlepass area); and the area east of and including the lower Flathead River (Sage/Kishinena area). These are subsets of the total area and have distinct physical and vegetative characteristics.

The area of moderate and high ranked habitat was totalled by season of use (see Table 5). Where a habitat polygon had more than one season of use, the area of the polygon was included in the total for each separate season of use. In this way polygons with more than one season of use are given greater importance in the carrying capacity calculation than are areas with only one season of use.

It does not appear from Table 5 that habitat for any one season is in short supply. This is an important criterion to evaluate in the carrying capacity calculation, since it allows the areas of all seasonal categories to be added. The carrying capacity estimate is then based on the total area of habitat rather than a calculation based on the area of habitat available during a single limiting season. The total area or space available to bears as well as habitat quality is considered in this way. However, if one season is thought to be limiting, then a calculation could be made on the basis of that season alone, with higher carrying capacity estimates than presented in Table 4. These densities would need to be approximately three times higher than the density presented in Table 4 (i.e., 1.6 km²/bear for high, 5 km²/bear for moderate and 15 km²/bear for low) if calculated using one season alone. Such calculations will be subject to greater error and should be avoided if possible. There is little basis for such density estimates, since detailed period of use for small areas will seldom be well known. Critical areas and periods of use should be indicated on the map and legend.

The area of seasonal ratings in Table 5 were combined to give the total area of moderate and high ranked habitat in each of the three sub-areas of the Flathead project. The areas of habitat ranked low and nil, are also presented. The area of low is not adjusted for more than one season of use even if it is shown, or very large totals would result. Finally the present carrying capacity estimate was made using the densities shown in Table 4 and the areas shown in Table 5. These estimates are shown in Table 6. They compare closely to the present population estimates (see Section 4.5.1).

4.4 Carrying Capacity Estimates at Small Map Scales

4.4.1 Introduction.-- Two areas (Flathead River drainage and Hart Ranges) were used to

Table 5. Total area (km) of all grizzly bear habitats for all seasons for 3 sub-areas in the Flathead River drainage.

Sub-area	High				Moderate				Low	Nil	Total[a]
	Sp[b]	Su	Fall	Total	Sp	Su	Fall	Total			
Howell/Cabin	14.5	14.5	12.6	41.6	11.7	10.7	36.5	58.9	313.6	20.4	400
Commerce/Middlepass	9.0	9.0	4.3	22.3	9.3	5.8	21.9	37.0	118.0	19.8	174
Sage/Kishinena	23.3	31.1	11.6	66.0	14.6	20.8	65.8	101.2	380.4	48.0	535

Value rating spans High, Moderate, Low, Nil and Total columns.

[a] Total area is less than the sum of high, moderate, low and nil ranked areas because of the multiple season of use consideration given to some moderate and high ranked units.
[b] Sp = Spring; Su = Summer

Table 6. A present carrying capacity estimate of high, moderate and low value habitats in the Flathead River drainage.

Sub-area	Density of grizzly bear and ranking			
	High 5 km^2 /bear)	Moderate (15 km^2/ bear)	Low (45 km^2/ bear)	Total
Howell/Cabin	8	4	7	19
Commerce/ Middlepass	5	3	3	11
Sage/Kishinena	13	7	9	29
Total study	26	14	19	59

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. This may not be as precise as using a more detailed scale of mapping, but large land areas can be covered quickly, providing for regional or provincial levels of assessment. Often detailed mapping is not appropriate for addressing general habitat questions and regional or provincial planning strategies. The suggested carrying capacity estimates for small scale mapping are presented in Table 7. They were derived from discussions with other biologists and comparisons with other areas (Table 3).

4.4.2 Example Calculations Using Small Scale Mapping.-- The total area of the Flathead River drainage project was used for this calculation. Because the entire area lies within the Border Ranges ecosection, only biogeoclimatic zonation was used as a stratification. Three subzones occur in the area: the Dry, Cool Montane Spruce Subzone (MSdk), at lower elevations including most of the important floodplains; the Dry, Cool Engelmann Spruce - Subalpine Fir zone (ESSFdk) including most of the important avalanche tracks and black huckleberry areas; and the sparsely vegetated Alpine Tundra Zone (AT). The MSdk and ESSFdk subzones were given high ratings because of the abundance of favoured habitats, and the AT zone was given a low rating because of its low forage availability in this area (Table 8). This estimate of 69 bears must be considered to be potential rather than current carrying capacity `since present seral stage was not considered.

The Hart Range area of east-central British Columbia contains extensive areas of high quality grizzly bear habitat. Present population estimates were done for 16 management unit areas at a scale of 1:500 000 using a stratification of ecoregions, biogeoclimatic units and Landsat interpretation of cover .types (Table 9 and Appendix A). Generally, biogeoclimatic units were rated higher `When they occurred in mountainous ecoregions than when they occurred in non-mountainous ecoregions; wetter forest zones rated higher than drier ones. These ratings were reduced by one class in areas of extensive access since it was assumed that previous hunting pressure; other human- related mortality and disturbance will have reduced present numbers in these areas. This was done primarily by a visual interpretation of 1:250 000 scale Landsat prints and regional knowledge of these areas. This reduction by one rating was subjective and not confirmed by direct observation, but was considered realistic for most areas with extensive access. Some reduction was necessary because present population estimates, rather than present carrying capacity, was required for harvest allocations decisions. These estimates are compared with the previously existing population estimates in Table 9.

Table 7. Grizzly bear carrying capacity estimates of high, moderate and low value habitats used with small map scales (1:250 000 and 1:500 000).

Value rating	Area used by each grizzly bear (km2)
High	15
Moderate	45
Low	135

Table 8. Potential carrying capacity estimate for three biogeoclima c zones within the Flathead River drainage.

Zone[a]	Area (ha)	Habitat Value	Density (km^2/ bear)	No. of grizzly bears
MS	292	High	15	19
ESSF	728	High	15	49
AT	89	Low	135	1

[a] MS: Montane Spruce Zone; ESSF Engelmann Spruce-Subalpine Fir Zone; AT: Alpine Tundra zone

4.5 Discussion: Medium and Small Scale Carrying Capacity Estimates

4.5.1 The Flathead Example.-- The medium and small scale estimates of carrying capacity in the Flathead River drainage were 59 and 69 grizzly bears, respectively. The medium scale estimate is a present carrying capacity estimate because present seral stages are used. However, with the exception of berry-producing areas, most grizzly bear habitat units were edaphic types without seral stages such as floodplains and avalanche tracks. If the huckleberry producing areas that were rated as moderate fall use were enhanced to high fall use rating, carrying capacity for grizzly bears would be increased by 17 bears to 76.

Although these estimates are relatively close to each other, substantial errors may be introduced in a number of ways. The small scale estimate is most subject to error because of the lack of habitat stratification. Ranking is based on a knowledge of occurrence of habitat types; a change of one rank can make large changes in the estimate. For instance if the Montane Spruce zone (see Section 4.4.2) had been ranked moderate instead of high, the carrying capacity would have been reduced by 9 to 60 bears; if the Engelmann Spruce Subalpine Fir zone had been ranked moderate instead of high, the carrying capacity would have been reduced by 16 to 53 bears. However, for many management applications the difference between the estimates of 69 and 53 is insignificant. The closeness of these estimates reflects the importance of the area of habitat as well as its ranking.

The high density estimates for medium, and small map scales are 5 and 15 km^2/grizzly bear, respectively. This difference is due to the degree of habitat stratification and detail of map scale. The degree of habitat stratification can also vary within a map scale depending on the detail of the survey, knowledge of habitat importance and the predictability of that importance. An example of detail of mapping is described here.

Soils maps for the Flathead River drainage area were available before habitat mapping for this project (Lacelle 1978). A potential carrying capacity estimate based on the soils information alone resulted in an estimate of 8.7 grizzly bears, compared with 76 from the habitat map. Again, for most management applications the difference between 87 and 76 is not significant. The assumptions made in habitat importance and period of use are more likely sources of significant error.

B. McLellan (per. comm.) considered that the medium map scale density estimates of. 5, 15 and 45 km^2 for high, medium and low ranked habitat were slightly low for the Flathead area. If the densities of 4, 12 and 36 km^2/bear are used, the present carrying capacity estimate

Table 9. A comparison of estimated grizzly bear populations for each Wildlife management Unit in the Hart Range Project area.

M.U.	Previous estimate[a]	Habitat method[b]	Difference (%)
7-1	42	33	-21
7-2	30	97	+223
7-3	75	120	+60
7-4	52	62	+19
7-5	60	90	+50
7-6	39	43	+10
7-7	13	29	+25
7-16	75	94	+123
7-17	40	108	+170
7-18	50	157	+214
7-19	101	82	-19
7-20	42	23	-45
7-21	112	140	+25
7-22	98	139	+42
7-23	87	235	+193
7-24	30	36	+20
Total	946	1508	+59

[a] from Wildlife Branch files.
[b] from this study.

would be 70 rather than 59 bears. However, the degree of familiarity with the area and effort in defining habitat units may have resulted in a higher level of stratification than would normally occur. This is an example of how the intensity of survey can affect the carrying capacity estimate.

4.5.2 The Hart Range Example.-- Before the Flathead River drainage and Hart Range studies, population estimates were largely based on average density applied to the area of the Wildlife Management Unit (M.U.). The habitat methods are essentially the same except that now the M.U. is stratified by habitat quality. This was shown to be particularly important in very mountainous areas such as M.U. 7-4 where a large area falls into a low or nil stratum. Overestimates of present population can easily result in such areas without habitat stratification.

Biogeoclimatic zonation was used to establish ratings for much of the area. However, in two M.U.'s (7-1 and 7-19), the biogeoclimatic zonation classification appeared to be in error. These areas were shown on the map as a much wetter climate than warranted, which would have resulted in a population overestimate. Biogeoclimatic zonation remains one of the most important prediction tools available for small scale mapping even though it must be interpreted with caution.

Biogeoclimatic zonation reflects climatic factors but not necessarily the abundance of bear habitats present. The population estimate for M.U. 7-23 was probably too high since this area has extensive rock outcrops. This source of error can be reduced by mapping at a medium scale so that habitats can be shown, but this is more time consuming. Familiarity with the area is important in assigning realistic ratings.

5 INTERPRETATIONS DERIVED FROM GRIZZLY BEAR HABITAT MAPS

In addition to the carrying capacity estimates described above, the habitat maps provide interpretations useful for grizzly bear manage ment including habitat protection and enhancement, population management and bear, hazard management. These interpretations and some examples form the Flathead pilot area are presented in this chapter. Even at the most detailed scale used in this methodology (1:50 000) the smallest unit that can be practically shown is 200 ha in area. These are planning levels of mapping that require more detailed study before an "on the ground" level of decision can be made. However, since most habitat protection and management decisions are presently done at a planning level 'and detailed mapping of large areas is presently impractical, these maps provide the best tools available.

5.1 Habitat Protection

Large scale maps provide an estimate of the extent and quality of habitat units, as well as describing their important seasons of use. In the Flathead River drainage, floodplains clearly form a very important spring and summer habitat that is easily disturbed and that cannot be replaced. Some habitat units such as the black huckleberry - bear-grass habitat unit vary in importance by successional stage and may improve or decline in importance over time. Field checking should be used whenever possible to confirm habitat unit descriptions and note current bear use.

Small scale maps such as those done for the Hart Ranges can be used to identify areas where important habitat units are more likely to occur. They may be used to establish referral priority and the relative importance of various areas.

5.2 Habitat Enhancement

There are some kinds of habitat units that have successional stages that change in importance over time. In the Flathead River drainage, black huckleberry or soopolallie availability depends on successional stage, site history and season. It appears that a variety of young and old-growth types on different kinds of sites will have the best chance of providing adequate fall range in most years. These areas have been identified on the maps. Logging and burning, thinning and burning, or burning of high capability areas are possible enhancement methods. The maps should be interpreted as being a first stratification of where to look for potential enhancement areas, rather than a map of suitable enhancement areas. The 1:50 000 map scale and low survey intensity do not permit more detailed interpretation. These maps can be used to identify areas where there appears to be a low diversity of different successional stages, because a high diversity of successional stages is important to ensure berry production in most years.

5.3 Population Management

The carrying capacity estimates, the distribution and quality of habitat, and the seasonal importance of various areas can all be used in addition to current methods of estimating populations and establishing rates of harvest. Comparisons of habitat with present access and imminent changes in access provide a stronger basis for more proactive regulations, harvest quotas, access restrictions and wilderness designation.

5.4 Bear Hazard Management

The medium scale maps show the distribution and seasonal importance of various habitat units. This may be used at a general planning level to identify possible areas of conflict with garbage, campsites and trails. However, the general nature of this mapping may omit small but important high use areas. Detailed planning of such facilities should use mapping of 1:20 000 scale or larger with adequate ‘ground checking of habitat quality and use. Studies of actual use should always be included for bear hazard management.

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Appendix A. Estimates of current grizzly bear habitat potential in British Columbia with comparisons of historical potential and current populations.

A.1 Introduction to habitat assessment calculations.

The calculation of potential grizzly bear populations can be determined using habitat classifications derived from physiographic, macroclimatic and climatic climax vegetation concepts, i.e., Ecoregion/Biogeoclimatic units (Demarchi 1988; Demarchi *et al*. 1989). All areas of the province have been mapped in this manner at a scale of 1:500 000 (B.C. Wildlife Branch 1989).

Each area of the province has been placed into Grizzly Bear Management Zones, which are groupings of ecoregion units with similar habitat characteristics as they affect grizzly bears (A. Harcombe and R. Archibald. pers. comm.). They are broad-scale grizzly bear ecosystems. These zones do not represent current population status as in most cases they consist of ecoregions where grizzly bears have either been extirpated or severely reduced along with ecoregions where their populations are secure.

Each biogeoclimatic unit within an ecoregion unit has been ranked high (H), medium (M), low (L), or nil (N), thus providing a preliminary basis for comparing the value of the various areas of the province (Table A.1, Figure A.1).

As well, each biogeoclimatic unit was digitized for each Management Unit and using assigned density ratings, the numbers of grizzly bears each area was capable of supporting before European colonization or is currently capable of supporting were calculated. These calculations assume that only habitat alterations, such as urbanization, cultivation, roads, railroads, stream impoundments, and open-pit mines, alter the potential to support or to revert back to the climax vegetation. Land-use activities, such as logging or grazing, or cultural activities, such as hunting or animal control, do not affect the potential of the land to return to the climatic climax (Demarchi *et al*. 1983). In addition, the actual number of grizzly bears present in each Management Unit has been estimated by regional wildlife management specialists by stepping down the potential populations based on land alienation, grizzly bears harvested, etc. All calculations were originally conducted on a Management Unit basis and then converted to an ecoregion unit basis. For this report only the summaries for each Grizzly Bear Management Zone are , presented (Table A.2, Figure A.1).

Comparisons between the historic potential and current population estimates have been made-to provide a perspective on the well-being of existing grizzly population, within each Grizzly Bear Management Zone. This information, was derived through different yet overlapping concepts, it presupposes that the current population estimates are correct, and that such a comparison is valid. Because of the nature of these calculations and estimates, no confidence levels have been calculated.

Table A.1. Current grizzly bear habitat potential for each biogeoclimatic unit within ecoregion unite occurring on the mainland of British Columbia (see Figure A.1).

Ecoregion unit	Code	Alpine Tundra	Spruce-Willow-Birch	Boreal White & Black Spruce	Sub-boreal Pine Spruce	Sub-boreal Pine Spruce	Engelmann Spruce-Subalpine Fir	Montane Spruce	Interior Douglas-fir	Ponderosa Pine	Bunchgrass	Interior Cedar Hemlock	Coastal Douglas-fir	Coastal Western Hemlock	Mountain Hemlock	Habitat importance for the entire eco-region unit
TEMPERATE WET MOUNTAINS																
Alsek Ranges	ALR	L-N[a]	M-L											H	M	L-N
Boundary Ranges	BOR	L-N		L-M	M		H					H		H	M	L-N
Nass Basin	NAB	M					H					H				M
Nass Ranges	NAR	M					H					H		H	H	H
Hecate Lowland	HEL													L	M	L
Kitimat Ranges	KIR	L					M							H-M	M	M
Outer Fjordland	OUF													L	M	L
Northern Pacific Ranges	NPR	L					M							H	M	M
Eastern Pacific Ranges	EPR	L					H		L					H	M	M
Southern Pacific Ranges	SPR	L					M							H	M	M
Northwestern Cascade Ranges	NWG	L												H-M	M	M
Fraser Lowland[b]	FRI,													N		N
Georgia Lowland[c]	GEL													L-N	L-N	
HOT, DRY PLATEAUS																
Okanagan Basin[b]	OKB							L	N	N	N					N
Thompson Basin[b]	THB								N	N	N					N
Okanagan Range	OKR	L					M-L	M-L	L	L	N					L
Southern Thompson Upland[c]	STU	L					M-L	M-L	N	N	N					L-N
Okanagan Highland	OKH	L					M-L		L	L		M-L				L
Eastern Thompson Upland	ETU						M	M-L	M-L			M				M-L
Northern Thompson Upland	NTU						M	M-L	M-L			M				M-L
Chilcotin - Cariboo Basin[c]	CCB								L		N					L-N
Clear Range[c]	CLR	L					M-L	L	N	N	N					L-N
Eastern Chilcotin Ranges	ECR	L					H-M	M-L	L	N	N			H		M-L
COOL MOIST MOUNTAINS																
Southern Columbia Maintains	SCM	L					H	L				M				M
Central Columbia Mountains	CCM	L					H					H				H-M
Shuswap Highlands	SHH	M				M	H	L	L			M				M
Quesnel Highlands	QUH	M				M	M		L			M				M
Northern Columbia Mountains	NCM	L				H	H					H				H-M
Upper French Trench	UFT				H							H				H
Big Bend Trench (f)	BBT						H					H				H
Northern Continental Ranges	NCR	L				H	H					H				H-M
Central Continental Ranges	CCR	L					H					H				H-M
COOL, DRY MOUNTAINS																
East Kootenay Trench[c]	EKT							L	L	L						L
East Purcell Mountains	EPM	L					H	M				H				H-M
McGillivray Range	MCR						M	M-L	M-L			M-L				M-L
Southern Continental Ranges	SCR	L					H-M	H-M	M-L			H-M				M
Border Ranges	BRR	L					H-M	H-M	M-L			H-M				H-M
COOL, MOIST PLATEAU																
Cariboo Plateau	CAP				L	L	M									L
Chilcotin Plateau	CHP						M	M	L							L
Nechako Plateau	NEP	M			L		M									M-L
Nazko Upland	NAU				L	L	M									L
Bulkley Basin[c]	BUB	M			M-L		H									M-L
Nechako Lowland	NEL	M			L		M									M-L
Babine Upland	BAU	M			M		H							H-M		H-M
Bulkley Ranges	BUR	L			H		H							H		H-M

Table A1, continued

Ecoregion unit	Code	Alpine Tundra	Spruce-Willow-Birch	Boreal White & Black Spruce	Sub-boreal Pine Spruce	Sub-boreal Pine Spruce	Engelmann Spruce-Subalpine Fir	Montane Spruce	Interior Douglas-fir	Ponderosa Pine	Bunchgrass	Interior Cedar Hemlock	Coastal Douglas-fir	Coastal Western Hemlock	Mountain Hemlock	Habitat importance for the entire eco-region unit
Western Chilcotin Ranges	WCR	L					H-M	M								M-L
COLD, MOIST MOUNTAINS																
Western Skeena Mountains	WSM	L		M	M		H					H				M
Eastern Skeena Mountains	ESM	L	M-L		H-M		H-M									M
Omineca Mountains	OMM	L		M	M		H									M
Hart Ranges	HAR	L		H	H		H					H				H-M
Hat Foothills	HAF	M		M	H		H									H-M
SUB-ARCTIC MOUNTAINS AND BASINS																
Muskwa Foothills	MUF	L	M-L	M-L			M-L									M-L
Muskwa Ranges	MUR	L	H-M	M-L												M-L
Kechika Mountains	KEM	L	M-L	M-L												M-L
Cassiar Ranges	CAR	L	M-L	M-L												M-L
Southern Boreal Plateau	SBP	L	M-L	M-L												M-L
Stikine Plateau	STP	L	M-L	M-L												M-L
Tuya Range	TUR	L	M-L	M-L												M-L
Teslin Plateau	TEP	L	M-L	M-L												M-L
Tahltan Highland	THH	L	M-L	M-L	H-M		H-M									M
Tagish Highland	TAH	L	M-L	M-L	H-M		H-M									M
Tatshanshini Basin	TAB	M-L	M-L	H-M												M
Icefield Ranges	ICR	L-N	L													L-N
COLD, BOREAL PLAINS																
Kiskatinew Plateau	KIP			L			M									L
Peace Lowland[c]	PEL			L												L
Sikanni-Beatton Plateau	SBU		M-L	L											L	
Fort Nelson Lowland	FNL			L												L
Liard Plain	LIP		M-L	L												L
Liard Upland	LIU	L	M-L	M-L												M-L
TYPICAL VALUE FOR EACH BIOGEOCLIMATIC UNIT		L	M-L	M-L	M	M	H-M	M-L	L	L-N	N	H-M	L	H-M	M	

[a] H - High, H-M - High to Moderate, M - Moderate, M-L - Moderate to Low, L - Low, L-N - Low to Nil, N - Nil
[b] intensively urbanized and farmed
[c] rural, mainly ranching
(f) extensive water impoundment

Table A2 Calculations of expected numbers of grizzly bears under historical and present habitat capability conditions and estimated current numbers of grizzly bears for each Grizzly Bear Management Zone (see Figure A.1).

Grizzly Bear Management Zone	Area (km^2)	Historic potential nos. (A)	Current potential	Currant population nos. (B)	% change - A vs B
Temperate, wet mountains	161 500	5870	5640	3310[a]	56[a]
Hot, dry plateaus	66 200	1040	570	140[b]	13[b]
Cool, moist mountains	105 800	5050	4350	2210[c]	44[c]
Cool, dry mountains	25 800	1010	990	810	80
Cool, moist plateaus	127 300	1860	1730	1100	59
Cold, moist mountains	92 500	3870	3870	2940	76
Sub-arctic mountains and basins	152 200	2140	2140	1920	90
Cold, boreal plains	124 000	990	960	760	77
Provincial totals	855 300	21 830	20 250	13 160	60

[a] Most of this reduction has occurred in the 5 southern ecoregions; of an historic potential for 1890 grizzly bears only 90 remain.
[b] Most of this reduction has occurred in the settled basin and plateau ecoregions; of an historic potential for 690 grizzly bears only 20 remain.
[c] Most of this reduction has occurred in the southern populated valleys, western highlands and upper Fraser Trench; of an historic potential for 2970 grizzly bears only 210 remain.

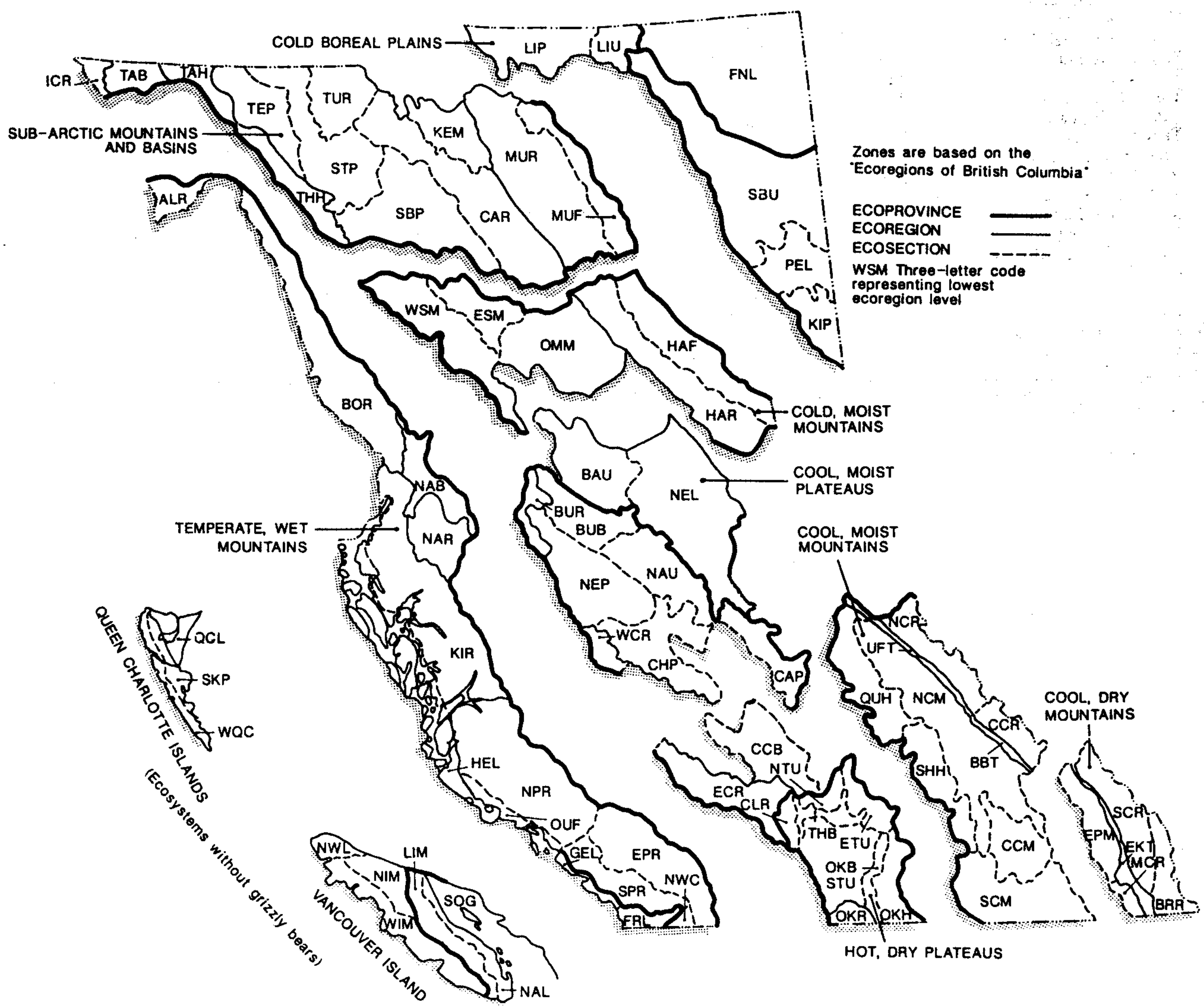

Figure A.1. Ecoregion units of British Columbia, grouped into Grizzly Bear Management Zones. Each ecoregion is identified by a three letter code (see Table A.1 and A.2).

Appendix B. Grizzly bear food items in British Columbia.

The following list of forage species was compiled from literature applicable to British Columbia (Table B.1). This should be considered a partial list since some grizzly bear ecosystems have little or no literature available pertaining to food habits. Most food habit studies reflect conditions in southeastern British Columbia, such as found in wetter areas lice the Columbia Mountains or drier areas such as the southern Rocky Mountains. Important ecoregions .for grizzly bears such as the Coast Mountains, the Northern Rocky Mountains, the Central Rocky Mountain, the Bulkley Ranges, the Skeena and Omineca Mountains, and the Northern Mountains and Plateaus have very little food habit information available. Studies in these areas would certainly lengthen the existing list.

A list of animal forage species .would be extensive, depending more on occurrence and availability than -on species. Commonly occurring groups include ungulates, salmon, rodents (especially ground. squirrels and marmots) and insects (especially ants and aestivating colonial insects such as lady-bird beetles and cutworm moths).

Table B.1. Plants used for forage by grizzly bears in British Columbia with an indication of the most commonly consumed parts.

Scientific Name[a]	Common Name[b]	Part Used[c]
Achillea millefolium	western yarrow	G
Allium spp.	wild onion	E
Amelanchier alnifolia	Saskatoon	F
Angelica spp.	angelica	E
Aralia nudicaulis	wild sarsaparilla	F
Arctostaphylos uva-ursi	kinnikinnick	F
Aster spp.	aster	G
Astragalus spp.	milt-vetch	G
Athyrium filix femina	lady fern	G
Betula glandulosa	scrub birch	G
Calamagrostis spp.	reedgrass	G
Carex spp.	sedge	G
Cicuta douglasii	Douglas water-hemlock	E
Cirsium spp.	thistle	E
Claytonia lanceolata	western springbeauty	F
Cornus sericea	red-osier dogwood	F
Corylus cornuta	beaked hazelnut	F
Crataegus spp.	hawthorn	F
Empetrum nigrum	crowberry	F
Equisetum spp.	horsetail	G
Erythronium grandiflorum	glacier lily	R
Festuca spp.	fescue	G
Fragaria spp.	strawberry	F
Hedysarum spp.	hedysarum	R
Heracleum sphondylium	cow-parsnip	E
Lathyrus ochroleucus	creamy peavine	G
*Ligusticum canby*i	Canby's lovage	G
Lomatium spp.	wild parsley	G
Lonicera involucrata	black twinberry	F
Lonicera utahensis	Utah honeysuckle	F
Lupinus spp.	lupine	E
Luzula spp.	woodrush	E
Lysichiton americanum	skunk cabbage	G
Mahonia spp.	Oregon-grape	F
Oplopanax horridus	devil's club	F,G

Osmorhiza chilensis	sweet-cicely	E
Oxyria digyna	mountain sorrel	G
Platanthera spp.	bog-orchid	E
Picea spp.	spruce	B
Pinus spp.	pine	B
Populus balsamifera	poplar or cottonwood	B
Pseudotsuga menziesii	Douglas-fir	B
Prunus virginiana	choke cherry	F
Rhamnus purshiana	cascara	F
Ribes spp.	current	F
Rosa spp.	rose	F
Rubes spp.	salmonberry/raspberry/blackberry	F
Salix spp.	willow	G
Sambucus spp.	elderberry	F
Scirpus microcarpus	small-leaved bulrush	G
Senecio triangularis	arrow-leaved groundsel	G
Shepherdia canadensis	soopolallie	F
Sorbus spp.	mountain-ash	F
Streptopus amplexifolius	clasping twistedstalk	F
Taraxacum spp.	dandelion	E
Tiarella trifoliata	three-leaved foamflower	G
Trifolium spp.	clover	G
Trillium ovatum	western trillium	R
Vaccinium spp.	blueberry/huckleberry	F
Valeriana dioica	marsh valerian	G
Veratrum viride	Indian hellebore	G
Viburnum edule	highbush cranberry	F

[a] Taylor, R.L., and B. MacBride. 1977. Vascular plants of British Columbia: a description resource inventory. Univ. of B.C. Press, Vancouver.

[b] Meidinger D. 1987. Recommended vernacular names for common plants of British Columbia. Ministry of For. and Lands, Victoria, B.C.

[c] Commonly wed parts: G - growing (above ground) portion: E - entire plant: R- root: F - fruit; B - bark.

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