Estimating Grizzly Bear (*Ursus arctos*) Population Size in British Columbia Using an Expert-Based Approach

by

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Prepared for
British Columbia Ministry of Water, Land and Air Protection

BRITISH COLUMBIA

June 25, 2004

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Suggested Citation:
Hamilton, A.N., and M.A. Austin. 2004. **Estimating Grizzly Bear (*Ursus arctos*) Population Size in British Columbia Using an Expert-Based Approach.** B.C. Ministry of Water, Land and Air Protection, Victoria, BC. 9pp.

Introduction

Expert-based approaches to estimating Grizzly Bear (*Ursus arctos*) population size have been applied in British Columbia since the late 1980s (Fuhr and Demarchi 1990; Hamilton and Austin 2002). An independent Grizzly Bear Scientific Panel reviewed these approaches and made a number of recommendations for improvement (Peek *et al*. 2003). A working group consisting of regional and headquarters biologists from the British Columbia Ministry of Water, Land and Air Protection re-designed the expert-based approach used in BC in response to the Panel's suggestions.

The working group updated the expert-based method by: 1) making the logic behind the capability ratings more transparent; 2) including an explicit estimate of the population density contribution of terrestrial and marine meat sources; 3) removing some of the subjectivity by applying the best available map layers of human influence to "step-down" (refine) habitat capability to suitability and effectiveness; and 4) developing a more objective means of incorporating population-level mortality history into current population estimates.

The conceptual structure of the expert-based approach is similar to that applied previously (Fuhr and Demarchi 1990; Hamilton and Austin 2002). *Habitat capability* is the inherent, idealized ability of the land to support a specific density of Grizzly Bears. Different ecological units are ranked by capability density based on their relative habitat productivity independent of the current structural stage of forested habitats or proximate human influence[1]. *Habitat suitability* is the land's current ability to support bears when current structural stage is accounted for, and *habitat effectiveness* is the density that would result when all human influences on habitat are factored in (e.g., "stepped-down" for alteration, alienation [displacement] or fragmentation). The final step in the expert-based process is another step-down for the historic influence of human-caused mortality on current population density.

Grizzly Bear population estimates are required for harvest management, habitat conservation during strategic land use or motorized access planning, recovery planning (e.g., to set targets and monitor population trends towards that target) and for review of major development projects. Goals and objectives for *habitat* protection or management are most useful when they are interpreted from specific Grizzly Bear *population* goals and objectives.

The basic premise of the expert-based system is that BC's ecological land classification can be used to initially stratify Grizzly Bear population densities into capability classes. Descriptions of ecological units (climate, geology, physiography, vegetation), Grizzly Bear research and inventory results, and local knowledge are interpreted in a relative ratings table that assigns a density class to each unique combination of Ecosection, Zone, Subzone, Variant and Phase[2] throughout the province.

Ecosystem studies carried out by Dr. V.J. Krajina and his students at the University of British Columbia from 1950-1970 resulted in the development of the Biogeoclimatic Ecosystem Classification (BEC) system (Krajina 1970). Further development and implementation of the BEC system by the BC Ministries of Forests and Environment has resulted in a universal

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[1] Habitat loss created by human settlement and reservoirs is removed from capability.
[2] Individual combinations of Ecosection, Zone, Subzone, Variant (where present) and Phase (where present) are subsequently referred to as Ecosection / BEC units.

ecological land classification and mapping system. BEC is a hierarchical classification system with three levels of integration: local (vegetation and site classifications), regional (zonal or climatic classification), and chronological (Meidinger and MacKinnon 1989).

A number of the essential foundations of the BEC system (Pojar *et al*. 1987; Meidinger and Pojar 1991, Steen and Coupé 1997) directly correlate to ecosystem productivity for Grizzly Bears (e.g., subregional variation in elevation, macro-topography, mean annual precipitation, mean annual temperature and extreme minimum and maximum temperatures, mean annual snowfall, number of months with snowfall, snowfall duration, frost-free growing days, macro-habitat diversity and small-scale vegetation patterns [see Schwartz *et al*. 2003]).

The Ecoregional Classification System (Demarchi 1996) provides an opportunity to further stratify Grizzly Bear densities at a smaller scale. Ecoregions are broad ecological units based on climatic processes, physiography, and broad animal and plant distribution. Ecosections link groups of Biogeoclimatic units together, such that repeated physiographic and macroclimatic processes can be identified and characterized (Demarchi *et al*. 1990). The major practical difference between the Ecoregional Classification System and BEC is that, in mountainous terrain, ecoregional classification stratifies the landscape into geographic units that circumscribe all elevations, whereas BEC delineates altitudinal belts of ecological zones within geographic units (Demarchi *et al*.1990). As such, combining the Ecoregional Classification with the BEC systems allows discrimination within BEC units across Ecosections and assists with the identification of synergies across BEC units. These combined Ecosection / BEC units have relatively uniform qualities as Grizzly Bear habitat, and by extension, bear density. Capability densities are thus assigned to each unique combination of Ecosection / BEC unit in one of 6 classes (Hamilton and Austin 2002). Capability class limits were fixed as percentages of the benchmark densities (RIC 1998).

A key weakness of the expert-based approach developed by Fuhr and Demarchi (1990) and subsequent iterations (e.g., Hamilton and Austin 2002) is their reliance on subjective assumptions. In addition, although the assignment of capability density classes is informed by existing inventory or research data, there is no objective measure of the uncertainty associated with the population estimates generated.

The Grizzly Bear Scientific Panel also recognized the lack of supporting evidence for individual density assignments by class (Peek *et al*. 2003). One of the Panel recommendations was that the Ministry re-calibrate the scale of densities associated with the various combinations of Ecosection / BEC units "by using additional benchmark density estimates, especially for categories 3 to 5" [1 to 50 bears / 1000 km^2].[3]

That is, the Panel recommended "benchmarking" capability density assignments against studies other than only the Khutzeymateen (MacHutchon *et al*. 1993) and the Flathead (McLellan 1989), both of which have large land areas ranked as "Class1" capability. The working group investigated the possible use of DNA sampling grids to provide the information required for the recommended re-calibration.

There has been some success in comparing DNA hair collection sites where bears were detected and where they were not detected (Apps *et al*. 2004; Boulanger *et al*. 2002).

[3] The panel actually referred to "various habitat categories," rather than to individual combinations of Ecosection, Zone, Subzone, Variant and Phase.

Although these studies did not specifically model Ecosection / BEC classification of bear detections, they demonstrated that examination of the Ecosection / BEC breakdown within the hair collection grids might be useful. However, it does not appear that any one DNA / Hair Mark-Recapture population estimate can be logically partitioned into its component Ecosection / BEC unit combinations. Since the hair collection periods were typically in late spring or early summer, the relative number of successful detections in any one Ecosection / BEC unit may not be reflective of the annual "density contribution" of that unit. In addition, since the pattern of detections results from a combination of factors, including human influences, attempting to separate the influence of Ecosection / BEC units from other factors that affect density may not be possible. Finally, it was obvious that there were no grids of sufficient uniformity of Ecosection / BEC units to more fully explore density partitioning. For almost every area in BC, Grizzly Bears resident on the DNA grids used multiple Ecosection / BEC units across their active seasons. More work on re-calibration for lower density classes may be necessary if the expert-based approach continues to be used in the future for estimating population size and would likely require examination of existing (or the collection of new) radio-collaring / density data.

Methods

The working group determined that an appropriate starting point for a revised estimate was a complete revision of the capability ratings table that reflected the vegetation contribution to Grizzly Bear density. An emphasis was put on providing better documentation of the rationale behind individual ratings. Rationales and supporting evidence are included for individual combinations of Ecosection \ BEC unit wherever possible. If no specific information was available at that level of the classification, rationales for ratings choice are provided for higher levels in the ecological classification hierarchy (e.g., at the subzone, rather than at the variant level).

Since the last province-wide application of the expert-based system (Hamilton and Austin 2002), a number of changes have been made to both the BEC (Eng 2003) and the Ecoregional classifications, resulting in a more spatially accurate and ecologically reliable base for density assignments. A simple area summary of the combined BEC and Ecoregional Classification of occupied Grizzly Bear habitat in British Columbia was conducted at the Ecoprovincial and Zonal levels of the Ecoregional Classification. That summary formed the basis of an investigation of the Grizzly Bear inventory and research literature. Ecoprovinces were treated as surrogates of Grizzly Bear ecotypes (Banci 1991; Banci *et al*. 1994). BC inventory and research projects were assigned to their appropriate Ecoprovinces. Studies from outside BC were examined for their ecological relevance. If enough similarities were found, they too were assigned to one of the ten Ecoprovinces that are occupied by Grizzly Bears. Patterns were sought in similarity of home range size, body size, denning duration, seasonal movements and habitat selection and, where available, population density. Reports were specifically examined for the authors' conclusions regarding factors contributing to both relative and absolute bear density and value of various Biogeoclimatic zones or equivalent elevational or ecological strata.

Ratings were assigned using a subjective assessment of the amount of seasonally available vegetative forage. In general, wetter units were ranked higher than drier (except the extreme "hypermaritime" outer coast), lower elevation units were ranked higher than upper elevation units, mountainous units were ranked higher than rolling or flatter units, and more diverse units were ranked higher than more uniform ones. BEC subzones in the interior have relative moisture and temperature assignments. For example, an “mw” subzone is “moist warm” (Meidinger and Pojar 1991, Table 1). At higher elevations, open “parkland” subzones were rated higher than their forested equivalents. On the coast, subzone designations reflect moisture and three classes of continentality: hypermaritime, maritime, and submaritime. For example, a “dm” coastal subzone is “dry maritime.” These subzone designations were also used to assist ranking capability. For example, maritime and submaritime subzones were typically ranked higher than either hypermaritime units. Variant labels were used to separate lower quality units from more productive ones. For example, montane (i.e., mid elevation) units were rated lower than valley bottom units in the same subzone.

Table 1. Biogeoclimatic subzone nomenclature: translation of two letter codes

Coast/Interior	Non-Parkland	Translation	Parkland	Translation	Other	Translation
Interior	dc	dry cold	dcp	dry cold parkland	dcw	dry cold woodland
Interior	dh	dry hot				
Interior	dk	dry cool	dkp	dry cool parkland	dkw	dry cool woodland
Coastal and Interior	dm	dry maritime or dry mild	dmp	dry maritime parkland or dry mild parkland	dmw	dry mild woodland
Coastal	ds	dry submaritime				
Interior	dv	dry very cold	dvp	dry very cold parkland		
Interior	dw	dry warm				
Interior	mc	moist cold	mcp	moist cold parkland		
Interior	mh	moist hot				
Interior	mk	moist cool	mkp	moist cool parkland	mks	moist cool ?
Coastal and Interior	mm	moist maritime or moist mild?	mmp	moist maritime parkland		
Coastal	ms	moist submaritime				
Interior	mv	moist very cold	mvp	moist very cold parkland		
Interior	mw	moist warm	mwp	moist warm parkland		
Both	un	unknown	unp	unknown parkland		
Interior	vc	very wet cold	vcp	very wet cold parkland		
Coastal	vh	very wet hypermaritime				
Interior	vk	very wet cool				
Coastal	vm	very wet maritime				
Interior	vv	very wet very cold				
Interior	wc	wet cold	wcp	wet cold parkland	wcw	wet cold woodland
Coastal	wh	wet hypermaritime	whp	wet hypermaritime parkland		
Interior	wk	wet cool				
Coastal and Interior	wm	wet maritime or wet mild	wmp	wet maritime parkland or wet mild parkland	wmw	wet mild woodland
Coastal	ws	wet submaritime				
Interior	wv	wet very cold	wvp	wet very cold parkland		
Interior	ww	wet warm				
Interior	xc	very dry cold	xcp	very dry cold parkland		
Interior	xh	very dry hot				
Coastal and Interior	xm	very dry maritime or very dry mild				
Interior	xv	very dry very cold				
Interior	xw	very dry warm				

Tables of climate data by BEC unit were also examined (see BEC Regional Field Guides, e.g., Steen and Coupe 1997). Generally, warmer units were ranked higher than cool or cold units; however, this was relative to a given zone only. If a zone was a relatively drier / warmer zone compared to the rest of the province, the drier or warmer units were typically ranked lower, in recognition of the effect of summer drought on forage supply (e.g., in the Southern Interior Ecoprovince). Comparisons of climatic summaries in Ecosections with a low number of BEC units were also instructive. For example, shorter denning seasons are likely when bears have the ability to move to lower elevation, warmer zones and subzones that have earlier spring green-up. Conversely, in the Boreal Plains, little elevational migration is possible. Denning duration in the Boreal Plains is likely to be more predictable from zonal climatic data and is probably a correlate with population density.

Generally, the same BEC unit was given the same rating across all Ecosections; however, there were some exceptions. Typically, the higher the diversity of zones, subzones, variants and phases within an Ecosection, the higher the individual BEC ratings within it. For example, the Montane Spruce Dry Cool (MSdk) subzone in the Flathead River drainage is found below an extremely productive Engelmann Spruce Subalpine Fir warm moist subzone (ESSFwm), and was ranked very high in terms of seasonally available vegetative forage. The same MSdk BEC unit in the rolling McGillvary Ranges to the west of the Rocky Mountain Trench is ranked one class lower because Grizzly Bears in the McGillvary Ranges do not have access to the type of productive subalpine habitat that is available in the Flathead River drainage. That is, the synergistic effects of multiple BEC units were considered by modifying ratings by Ecosection where appropriate. Ecosection names were also examined to ensure that ecosectional differences were acknowledged in the ratings table. In general, Uplands, Ranges, Mountains, Hills, Foothills, Valleys and Highlands were rated higher than Trenches, Basins, Plateaus, Lowlands and Plains for seasonally available vegetative forage.

Table 2 shows a number of density estimates relevant to BC. The Grizzly Bear Science Panel recommended using the best estimate of density (as opposed to the minimum used in previous provincial estimates) (Peek *et al.* 2003). Ratings were therefore linked to the midpoints of the density classes, and then modified for the incorporation of terrestrial and marine meat sources.

Table 2. British Columbia Grizzly Bear Population Densities from Research and Inventory Projects.

Study Area	Project Type	Population Estimate	Confidence Interval		Density Estimate (Bears / 1000 km^2)	Confidence Interval (Bears / 1000 km^2)		Reference
Glacier National Park	Mark-Resight	45			36	36	55	Mundy and Flook 1973
Mountain Creek Glacier National Park	Research				34	31	34	Hamer 1974
Flathead	Research				80			McLellan 1989
Columbia Mountains	Research		12		31			Simpson 1985
Khutzeymateen Park	Research	55				68	90	MacHutchon *et al*. 1993
South Selkirks	Research		16	21	23	20	27	Wielgus *et al*. 1994
Kootenay & Yoho Parks	Research					6	11	Raine and Riddell 1991
Nass Wildlife Area	Aerial Survey	57			21	21		Demarchi *et al*. 2000
Central Selkirks	DNA Mark-Recapture	262	224	313	26	23	32	Mowat and Strobeck 2000
Jumbo	DNA Mark-Recapture	39	34	62	25	22	40	Strom *et al*. 1999
Flathead	DNA Mark-Recapture	156	97	296	48	30	92	Boulanger 2001a
West Slopes 96	DNA Mark-Recapture	77	51	155	19	13	39	Boulanger 2001b
West Slopes 97	DNA Mark-Recapture	47	37	79	26	21	44	Boulanger 2001b
West Slopes 98	DNA Mark-Recapture	59	37	125	27	17	56	Boulanger 2001b
Prophet River	DNA Mark-Recapture	131	112	178	16	13	21	Poole *et al*. 2001
Granby Kettle	DNA Mark-Recapture	38	26	84	9	6	19	Boulanger 2000
Kingcome	DNA Mark-Recapture	102	77	163	42	32	62	Boulanger and Himmer 2001
Parsnip River Mountains	DNA Mark-Recapture	326	276	409	51	44	65	Mowat *et al*. 2002
Parsnip River - Plateau	DNA Mark-Recapture	34			12			Mowat *et al*. 2002a
Bowron River	DNA Mark-Recapture	76	63	104	31	26	42	Mowat *et al*. 2003b
Nation	DNA Mark-Recapture	39	34	49	5.5	4.8	7.0	Mowat and Fear 2004

Incorporation of Terrestrial and Marine Meat Sources

The contribution to Grizzly Bear population density from non-vegetative food sources was not well accommodated in the previous iteration of the expert-based system (Hamilton and Austin 2002; Austin and Hamilton 2002). For example, the area of the Coastal Western Hemlock Zone is not well correlated with the availability of spawning Pacific salmon.

Exploration of trophic relationships of bears (Hilderbrand *et al*. 1996; Jacoby *et al*. 1999), and body size and productivity relationships (Hilderbrand *et al*. 1999) using stable isotopes has greatly expanded in recent years (e.g., Robbins *et al*. 2004), although not without some controversy over methods (Robbins *et al*. 2002). The breadth of ecological information potentially obtainable from relatively simple chemical analyses of carbon and nitrogen in bone, hair and blood samples is a welcome addition to the suite of tools available for bear conservation, particularly since hair samples can be obtained without bear capture and handling. The working group chose to follow the precedent set by Hilderbrand *et al*. (1999) and assumed that there was a linear relationship between Grizzly Bear population density and meat derived from either terrestrial or marine sources.

Stable isotope data for British Columbia was obtained from published records (e.g., Nevin 2003), unpublished information (MacHutchon pers. comm. 2003) or laboratory analysis of hair samples collected during DNA inventories, compulsory inspection of hunted Grizzly Bears, and other sources. Samples were prepared for analysis at the University of Northern British Columbia, and then shipped to another laboratory for analysis. The dietary contribution of terrestrial and marine meat then determined using these results and formulas obtained from the published literature (Hilderbrand *et al*. 1996 [for salmon], and Hobson *et al*. 2000 [for Mule Deer]). Confounding influences of when samples were collected (e.g., pre- or post-moult), geographic variation in isotopic signatures across prey species, or mixed meat diets (e.g., both ungulates and salmon) were not examined. Hobson *et al*.'s (2000) Mule Deer (*Odocoileus hemionus*) formula was applied to all samples where salmon were not expected to dominate the diet. Simple estimates of the "percent meat" and the "percent vegetation" were reported for each Grizzly Bear Population Unit (GBPU) by averaging all samples for that GBPU. Where few or no samples were available, estimates of the proportion of meat in the diet were based on ecological similarity to known sample areas.

The density assignments for the classes in the vegetation-only habitat capability ratings table were determined from the DNA / Hair Mark-Recapture estimate for the Kingcome-Wakeman study area (42 bears / 1000 km^2; Boulanger and Himmer 2001) as the benchmark for coastal BC. Stable isotope data for the Kingcome-Wakeman GBPU indicated a nitrogen-15 (N-15) signature of 11.0268. Using the formula of Hilderbrand *et al*. (1996), the percent vegetation contribution in the diet was estimated at 32%. It was assumed, therefore, that 32% of the overall Kingcome-Wakeman capability density was being "carried" by the vegetative contribution in the diet, and, by inference, 68% was carried by the dietary contribution of Pacific salmon. These estimates led to a calibration of the vegetative contribution to density of each capability class coast-wide. Various starting points for the five class Ecosection / BEC capability rating system were iteratively applied to the Kingcome-Wakeman GBPU. Setting a Class 1 maximum density of 32 bears / 1000 km^2 resulted in a capability density of 44 bears / 1000 km^2 (pre-mortality history step-down), matching well with the published density for the area (Boulanger and Himmer 2001). Table 3 outlines the vegetation capability density classes for coastal British Columbia. A parallel calculation was completed for the BC interior using density and stable isotope information for the Flathead study area in southeast BC (Boulanger 2001a). Table 4 identifies the vegetation capability density classes used for the two interior GBPUs where the expert-based model was applied (South Chilcotin and Taiga).

A Statistical Analysis Systems, Inc. (SAS) program was written to calculate vegetation capability for bears based on the land areas of the assigned Ecosection / BEC density classes. Ocean, lakes greater than 100 km^2, agricultural (crop) areas, urban areas, and mines were assigned a nil capability density, and their land areas were removed from density determination. Glaciers were also assigned a nil density, but their land areas were kept for density calculations. The program then applied a simple formula to calculate the overall habitat capability estimate: overall habitat capability = vegetation only capability / (1-proportion meat in the diet). These overall capability estimates became the starting points for habitat suitability, habitat effectiveness and historic mortality step-downs.

Table 3. Vegetation Capability Ratings Classes for Coastal British Columbia.

Rating Class	Minimum Density	Mid-Point Density	Maximum Density
	Bears / 1000 km^2	Bears / 1000 km^2	Bears / 1000 km^2
1	24	28	32
2	16	20	24
3	8	12	16
4	2	5	8
5	0	1	2

Table 4. Vegetation Capability Ratings Classes for Interior British Columbia.

Rating Class	Minimum Density	Mid-Point Density	Maximum Density
	Bears / 1000 km2	Bears / 1000 km2	Bears / 1000 km2
1	44	52	59
2	30	37	44
3	15	22	30
4	3	9	15
5	0	1	3

Habitat Suitability and Effectiveness Step-downs

Other Panel recommendations relate to reducing the subjectivity in the step-down process (Hamilton and Austin 2002; Peek *et al*. 2003). The revised step-down is based directly on available Geographic Information System (GIS) maps and databases and literature-supported assumptions on the impact of mapped human activities on habitat suitability and effectiveness. Proportions of land affected by settlements, logged areas and human access (particularly motorized access) were directly measured. Roads (TRIM, TRIM II and TRIM Exchange), human densities (from the 1999 Canada-wide census), and forest age classes from the Baseline Thematic Mapper were created or obtained. Layers were overlain with ARCINFO (Environmental Systems Research Institute) and transmitted to the senior author as .dbf files for importing into SAS (SAS Institute). Provincial road densities were determined with a roving window of 1 km^2 and blocked into three categories: 0.0 to 0.6 km / km^2, 0.6 to 1.2 km / km^2, and > 1.2 km / km^2.

Grizzly Bear research literature was examined to assist in the designation of various step-down classes and the appropriate step-down coefficients. Where no specific information on impacts was available, an expert opinion approach was invoked. For example, it has been postulated that in the Sub-Boreal Spruce Zone, Interior Cedar Hemlock Zone and the Coastal Western Hemlock Zone, densely stocked, closed canopy mid-seral coniferous forests have lower habitat suitability for Grizzly Bears. Such forests lack the typical food-producing understories of old and early seral stands (Klinka et al. 1996). As a result, a 50% suitability step-down factor was applied to the "Young Forest" (FY) Baseline Thematic Mapper category within these zones.

The working group also discussed recent evidence about displacement from roads to estimate habitat effectiveness loss. Mace *et al*. (1999) and Gibeau *et al*. (2002) provide evidence that some Grizzly Bears will habituate to even the highest road densities and traffic levels, but other information defines a zone of influence from which most bears would be displaced, roughly proportionate to traffic volume (e.g., Wakkenin and Kasworm 1997). A surrogate for traffic volume was used: for roads within 50 km of communities of greater than 5000 people, land areas within road densities greater than 0.6 km / km^2 were assigned a step-down of 35% of habitat suitability. Outside these "high use" areas, land areas within road densities greater than 0.6km / km^2 were assigned a step-down of 15% of habitat suitability.

GIS overlay files were linked with the habitat capability estimates based on the Ecosection / BEC unit ratings (Table 3), and the appropriate step-downs for habitat suitability (Young Forest) and habitat effectiveness (road displacement) were applied using SAS.

<u>Historic Human-Caused Mortality Step-down</u>

The mortality history step-down was one of the steps of the expert-based system that was inconsistently applied across the province in previous iterations (Hamilton and Austin 2002, Austin and Hamilton 2002, Peek *et al*. 2003). A modelling approach was developed based on the use of population reconstruction to increase the consistency and objectivity of the mortality step-down. Known human-caused mortalities since 1980 were compiled for each GBPU. Mortalities were divided into two categories: Grizzly Bears that would have been alive in 1980 and those that would not have been because they were too young at the time of death. A correction for un-aged animals was applied based on the aged sample.

The total number of mortalities of Grizzly Bears that would have been alive in 1980 was used to calculate a 1980 population estimate. This calculation was based on an assumption of the proportion of all (natural and human-caused) Grizzly Bear mortalities included in the recorded data. A "benchmark" of 53% for this assumption was calculated from Table 2 in McLellan *et al*. (1999). This assumption was then varied iteratively based on factors such as hunting pressure and level of conflicts to arrive at the value used for each GBPU (Table 5). In addition, it was assumed that this approach only yielded 75% of the 1980 population, due to the mortalities of juveniles not being represented in the data from McLellan *et al*. (1999) and the fact that not all bears alive in 1980 were necessarily dead by 2002.

Table 5. Population Reconstruction for Estimating Historic Human-Caused Mortality Step-down.

GBPU	1980 Estimate	2003 Estimate	Habitat Capability 2003	Habitat Effectiveness 2003	Mortality Step-Down	% Mortality Known
Bulkley Lakes	270	355	490	449	21%	35.0%
Cranberry	225	341	405	376	9%	33.0%
Edziza-Lower Stikine	225	371	396	388	4%	34.0%
Garibaldi-Pitt			226	180	90%	
Khutzeymateen	162	376	475	447	16%	14.0%
Kingcome-Wakeman	110	230	253	239	4%	21.0%
Kitlope-Fiordland	154	346	370	365	5%	12.5%
Klinaklini-Homathko	81	109	152	144	24%	27.0%
Knight-Bute	120	173	216	192	10%	45.0%
Kwatna-Owikeno	320	316	347	336	6%	45.0%
North Cascades			319	233	90%	
North Coast	111	214	269	250	15%	18.0%
South Chilcotin	69	104	237	218	22%	27.0%
Squamish-Lillooet	27	56	165	134	58%	10.0%
Stein-Nahatlatch	36	61	217	173	65%	15.0%
Stewart	213	319	360	340	6%	44.6%
Taiga	42	92	128	123	25%	19.0%
Taku	433	595	650	642	7%	46.0%
Tatshenshini	236	360	395	392	8%	45.0%
Toba-Bute	44	75	99	86	12%	18.0%
Tweedsmuir	182	279	323	306	9%	36.5%

Once the estimated 1980 population was calculated for each GBPU, populations were modelled from 1981 to 2002, with the assumed potential rate of increase being the level of allowable human-caused mortality minus the assumed rate of unreported human-caused mortality for each GBPU (Austin *et al*. 2004). The resulting 2002 modelled population size was then compared to each GBPU's habitat effectiveness, and the difference was used as the mortality step-down. There was insufficient mortality data available to apply this technique in the Garibaldi-Pitt and North Cascades GBPUs. A subjective assumption of a 90% mortality step-down was applied instead.

The historic human-caused mortality step-down approach yields a population estimate based on mortality data without relying on the expert-based method. As a result, this information was used to test the expert-based approach. For example, if the reconstruction of the 1980 population estimate resulted in more animals than the habitat capability ratings indicated, this would have suggested that the capability ratings should be revised. In turn, by providing a habitat effectiveness value, the expert-based approach informed the process of setting the assumed proportion of known mortalities. The combination of the two potentially independent approaches to estimating population size is believed to increase the reliability of the results.

Results and Discussion

Table 6 and Figure 1 summarize the occupied habitat in British Columbia by Ecoprovince and Biogeoclimatic Zone. Four Ecoprovinces are dominant: Coast and Mountains, Northern Boreal Mountains, Southern Interior Mountains and Sub-Boreal Interior. Historically, both the Central and Southern Interior Ecoprovinces were fully occupied by Grizzly Bears, but a variety of human influences have largely extirpated the species from these areas of the province (Hamilton and Austin 2002). At just over 158,000 km^2, the Engelmann Spruce Subalpine Fir Zone is the largest, most well distributed Biogeoclimatic Zone occupied by Grizzly Bears in BC.

Table 6. Occupied Grizzly Bear Habitat in British Columbia by Ecoprovince and Biogeoclimatic Zone (km^2).

							Zone							
Ecoprovince Name	AT	BG	BWBS	CWH	ESSF	ICH	IDF	MH	MS	PP	SBPS	SBS	SWB	Grand Total
BOREAL PLAINS			23519		232							20	9	23781
CENTRAL INTERIOR	7989	18		211	13020	156	1951	19	8621		11348	26592		69924
COAST AND MOUNTAINS	42598			48914	6236	7441	177	29964				19	0	135351
GEORGIA DEPRESSION				63										63
NORTHERN BOREAL MOUNTAINS	53953		40979	0	10313	0		11				2766	77297	185320
SOUTHERN ALASKA MOUNTAINS	3141		0					5					325	3471
SOUTHERN INTERIOR	4875	69		595	6479	855	4260	83	2623	221				20060
SOUTHERN INTERIOR MOUNTAINS	17728		39		64442	34898	3433		5634	883	0	5180		132237
SUB-BOREAL INTERIOR	12409		6889		57526	3907						52897	538	134167
TAIGA PLAINS			68183										592	68775
Grand Total	142693	87	139610	49783	158249	47258	9820	30083	16877	1104	11348	87474	78761	773148

Figure 1: Occupied Area by Ecoprovince (km^2)

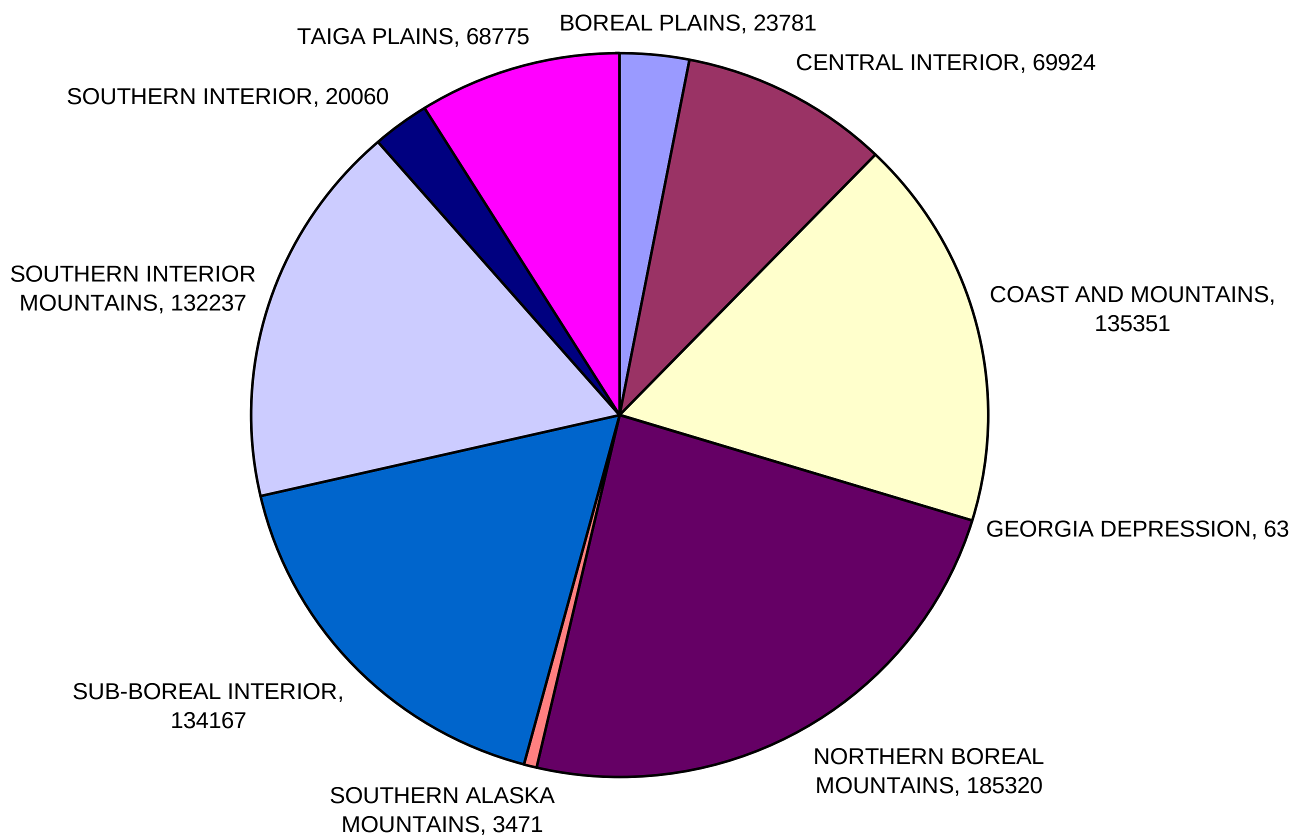

Table 7 reports the breakdown by Biogeoclimatic Zone of the provincial DNA / hair mark-recapture inventory grids by study area. Eight percent of the occupied area of BC has been sampled; however, some of the projects included in the summary did not produce useable population estimates. Some project areas overlapped between years, affecting their representation in the summary. No sampling has occurred in the Ponderosa Pine (PP), Bunch Grass (BG) or Sub-Boreal Pine Spruce (SBPS) BGC zones. Sampled areas range from 2% of the total of that Zone (Mountain Hemlock – MH) to 28% (Interior Cedar Hemlock – ICH) (Figure 3).

Table 7. Summary of Biogeoclimatic Zones by DNA Projects, 1996-2002 (km^2).

DNA Project	AT	BWBS	CWH	ESSF	ICH	IDF	LAKE	MH	MS	RES	SBS	SWB	Grand Total
Kettle-Granby	10			3305	5091	202	46		159	144			8956
Bowron	4			1261	22		27				990		2304
Burnt	31	17		919			1				258		1226
Central Selkirks	225			5486	4235	28	134			0			10108
Elk Valley	175			1648		8	6		568				2404
Elk Flathead	184			3991	384	57	8		1297				5921
Jumbo	640			819	84	4	2		102				1651
Kingcome	768		1084				14	584					2450
Nass	34		24	220	1164		78	0					1520
North Cascades	303		262	1202		151	3	63	243				2228
Parsnip	315			4534	122		126				4354		9452
Prophet	746	5456					25					2300	8527
West Slopes 96	516			2038	1189	64	29		237	27			4099
West Slopes 97	329			1061	391	0	3		92				1875
West Slopes 98	385			1241	683	12	10		16	5			2352
Grand Total	4663	5473	1370	27725	13365	526	513	648	2714	175	5602	2300	65075

RES=Reservoir

Figure 2. Occupied Area (km^2) and Area Sampled by DNA Grids by Biogeoclimatic Zone.

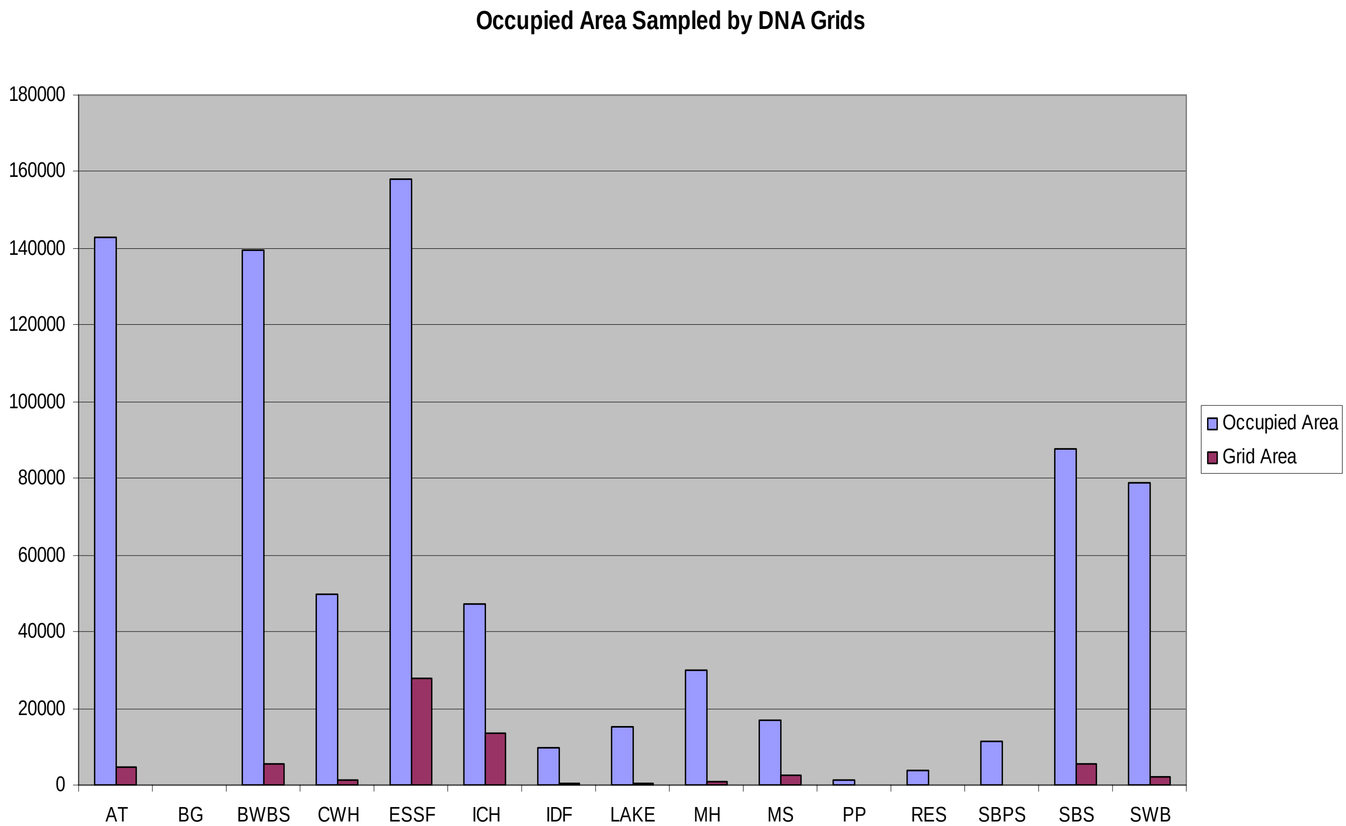

Table 8 presents the N15 stable isotope, calculated percent meat (including salmon) and percent vegetation in the diet for the GBPUs where the expert-based method was applied.

Table 9 shows the results of the application of the expert-based method at the GBPU level. As identified in Hamilton *et al*. (2004), the revised expert-based model was directly applied to 21 GBPUs, resulting in a total pre-mortality step-down or "effectiveness" estimate of just over 6000 Grizzly Bears in approximately 30000 km^2 of occupied habitat. Effectiveness densities range from 2 bears / 1000 km^2 in the Taiga GBPU to 55 bears / 1000 km^2 in the Khutzeymateen GBPU.

The 47 bears / 1000 km^2 population density estimate for the Khutzeymateen GBPU was compared to the research density estimate of 68-90 bears / 1000 km^2 for the smaller Khutzeymateen study area (MacHutchon *et al*. 1993). The eastern half of the Khutzeymateen GBPU has an extensive timber harvest, road development and human-caused mortality history, has fewer available salmon, and moves towards a less productive coastal-interior transition and therefore this result was considered reasonable.

The revised expert-based model estimates a total of 4878 Grizzly Bears in the 21 GBPUs where it was applied (Table 8), reflecting an overall mortality history step-down from estimated habitat effectiveness of 20%.

Table 8. N15 Stable isotope, Calculated Proportion Meat and Proportion Vegetation in the Diet of Grizzly Bears where the Expert-Based Method was Applied.

GBPU	N15	Proportion Meat	Proportion Vegetation
Bulkley-\Lakes	7.8724	42%	58%
Cranberry	8.9401	50%	50%
Edziza-Lower Stikine	10.2049	61%	39%
Garibaldi-\Pitt	10.4000	62%	38%
Khutzeymateen	12.0000	76%	24%
Kingcome-\Wakeman	11.0268	68%	32%
Kitlope-\Fiordland	10.0000	59%	41%
Klinaklini-\Homathko	3.6152	14%	86%
Knight-\Bute	10.4000	62%	38%
Kwatna-\Owikeno	10.0000	59%	41%
North \Cascades	4.6440	33%	67%
North \Coast	10.4000	62%	38%
South \Chilcotin \Ranges	4.6440	33%	67%
Squamish-\Lillooet	10.4000	62%	38%
Stein-\Nahatlatch	4.6440	33%	67%
Stewart	10.0000	59%	41%
Taiga	2.5000	0%	100%
Taku	10.2049	61%	39%
Tatshenshini	6.6458	31%	69%
Toba-\Bute	5.9388	26%	74%
Tweedsmuir	7.2704	37%	63%

Table 9. 2004 Grizzly Bear Population Estimate from the Revised Expert-Based Method.

Grizzly Bear Population Unit (GBPU)	Habitat Capability	Habitat Effectiveness	Area (km^2)	Habitat Effectiveness Density (Bears / 1000 km^2)	Current Population Estimate	Current Population Density (Bears / 1000 km^2)	Percent Current Population Estimate of Habitat Capability
Bulkley-Lakes	549	503	23521	21	407	17	74%
Cranberry	405	376	11649	32	341	29	84%
Edziza-Lower Stikine	396	388	17122	23	371	22	94%
Garibaldi-Pitt	226	180	6463	28	18	3	8%
Khutzey-mateen	475	447	8069	55	376	47	79%
Kingcome-Wakeman	253	239	5442	44	230	42	91%
Kitlope-Fiordland	370	365	10336	35	346	33	94%
Klinaklini-Homathko	152	144	13643	11	109	8	72%
Knight-Bute	235	207	6620	31	186	28	80%
Kwatna-Owikeno	347	336	10650	32	316	30	91%
North Cascades	319	233	9801	24	23	2	7%
North Coast	269	250	6776	37	214	32	80%
South Chilcotin Ranges	237	218	16125	14	104	6	44%
Squamish-Lillooet	165	134	5689	24	56	10	34%
Stein-Nahatlatch	217	173	7710	22	61	8	28%
Stewart	360	340	11342	30	319	28	89%
Taiga	128	123	50046	2	92	2	72%
Taku	650	642	32315	20	595	18	92%
Tatshenshini	395	392	19216	20	360	19	91%
Toba-Bute	99	86	7606	11	75	10	76%
Tweedsmuir	323	306	18458	17	279	15	86%
Total	**6570**	**6082**	**298599**		**4878**		

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Acknowledgements

The authors acknowledge the contribution and direction of the working group members over many productive hours of discussion and debate. Thanks to John Elliot, Doug Janz, Doug Heard, Gerad Hales and Bob Forbes, with chairing by Jenny Feick and Elizabeth MacMillan. Kristin Thurston was indispensable as the coordinator of the GIS requests to the Ministry of Sustainable Resource Management. Carol Ogborne and Stephen Sutherland did the actual GIS work, sometimes at short notice. Their hard work on our behalf was much appreciated. We also thank Carol Wrenshall for her ongoing work as the keeper of the provincial Grizzly Bear kill records. Doug Heard and Carolyn Yakel provided useful suggestions for revision of an earlier draft of this report. Gail Harcombe prepared the web-based version of the report.

Appendix 1 Ratings Table - Grizzly Bear Density Class Assignments to Ecosection/BEC Units.

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
BUR	Bulkley Ranges	AT un	5	729	Alpine Tundra units lack cross-seasonal habitat value, typically have a high proportion unvegetated, have poor soil development, and are often steep and rugged. Snow amounts and melt rates affect seasonal availability. Class 4 Alpine Tundra units are less rugged than class 5 and offer greater availability of vegetative forage.	More mountainous Ecosections are ranked 1 class lower to reflect lower proportion vegetated.
CRU	Cranberry Upland	AT un	4	415		
HEL	Hecate Lowland	AT un	5	7		
KIM	Kimsquit Mountains	AT un	5	392		
KIR	Kitimat Ranges	AT un	5	703		
MEM	Meziadin Mountains	AT un	4	179		
NAM	Nass Mountains	AT un	4	364		
NEU	Nechako Upland	AT un	4	7		
NSM	Northern Skeena Mountains	AT un	5	234		
SBR	Southern Boundary Ranges	AT un	5	713		
SSM	Southern Skeena Mountains	AT un	4	6		
ALR	Alsek Ranges	AT unp	5	3141		
BUR	Bulkley Ranges	AT unp	5	7		
CBR	Central Boundary Ranges	AT unp	5	5549		
CCR	Central Chilcotin Ranges	AT unp	5	4393		
CHP	Chilcotin Plateau	AT unp	4	1		
CPR	Central Pacific Ranges	AT unp	5	9148		
CRU	Cranberry Upland	AT unp	4	32		
EPR	Eastern Pacific Ranges	AT unp	5	4649		
HEL	Hecate Lowland	AT unp	5	24		
HOR	Hozameen Range	AT unp	5	440		
KIM	Kimsquit Mountains	AT unp	5	2027		
KIR	Kitimat Ranges	AT unp	5	3066		
KLR	Kluane Ranges	AT unp	5	2046		
LPR	Leeward Pacific Ranges	AT unp	5	1707		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
MEM	Meziadin Mountains	AT unp	4	1813	See above	See above
NAB	Nass Basin	AT unp	4	19		
NAM	Nass Mountains	AT unp	4	2116		
NBR	Northern Boundary Ranges	AT unp	5	3675		
NEU	Nechako Upland	AT unp	4	581		
NPR	Northern Pacific Ranges	AT unp	5	3701		
NSM	Northern Skeena Mountains	AT unp	4	2268		
NWC	Northwestern Cascade Ranges	AT unp	5	18		
OKR	Okanagan Range	AT unp	5	137		
OUF	Outer Fjordland	AT unp	5	9		
PAR	Pavilion Ranges	AT unp	5	3		
SBP	Southern Boreal Plateau	AT unp	4	1118		
SBR	Southern Boundary Ranges	AT unp	5	2440		
SCR	Southern Chilcotin Ranges	AT unp	4	2489		
SPR	Southern Pacific Ranges	AT unp	5	1540		
STH	Stikine Highland	AT unp	4	2340		
STP	Stikine Plateau	AT unp	4	1571		
TAB	Tatshenshini Basin	AT unp	4	1960		
TAG	Tagish Highland	AT unp	4	1658		
TEP	Teslin Plateau	AT unp	4	1530		
THH	Tahltan Highland	AT unp	4	2784		
TUR	Tuya Range	AT unp	4	64		
WCR	Western Chilcotin Ranges	AT unp	4	1868		
KLR	Kluane Ranges	BWBSdk 1	3	6	Drier and cooler than other BWBS subzones, the BWBSdk has a montane climate. Some site series / seral stages	
NSM	Northern Skeena Mountains	BWBSdk 1	3	18		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
SBP	Southern Boreal Plateau	BWBSdk 1	3	351	can be highly productive for bear foods, including several berries (e.g., soopalalie). The dk1 is a mountainous unit subject to mountain climate variations, including aspect. Some fire history.	See above
STH	Stikine Highland	BWBSdk 1	3	169		
STP	Stikine Plateau	BWBSdk 1	3	2996		
TAB	Tatshenshini Basin	BWBSdk 1	3	438		
TAG	Tagish Highland	BWBSdk 1	3	8		
TEB	Teslin Basin	BWBSdk 1	3	660		
TEP	Teslin Plateau	BWBSdk 1	3	3335		
THH	Tahltan Highland	BWBSdk 1	3	12		
CLH	Clear Hills	BWBSmw 1	4	3739	See Poole *et al.* 2001 - contains BWBSmw1.	Isolated unit
PEL	Peace Lowland	BWBSmw 1	3	84		
SCU	Sikanni Chief Upland	BWBSmw 1	4	7		
CLH	Clear Hills	BWBSmw 2	5	6455	Class 5 in the Taiga GBPU, because of low productivity, extensive uniformity, few bear foods and extensive Black Spruce bogs.	All Ecosections in Taiga Plains Ecoprovince ranked very low. Unit rated higher (4 vs. 5) in Ecosections with higher topographic diversity, creating more of a mosaic of feeding opportunities.
ETP	Etsho Plateau	BWBSmw 2	5	8575		
FNL	Fort Nelson Lowland	BWBSmw 2	5	16527		
MAU	Maxhamish Upland	BWBSmw 2	5	4343		
MUU	Muskwa Upland	BWBSmw 2	4	171		
PEP	Petitot Plain	BWBSmw 2	5	4891		
SCU	Sikanni Chief Upland	BWBSmw 2	5	3079		
TLP	Trout Lake Plain	BWBSmw 2	5	1492		
TAG	Tagish Highland	BWBSun	3	34	No information, treated as dk1	
KLR	Kluane Ranges	BWBSvk	4	654	Unusual unit in western Alsek and Tatshenshini area. Some bear foods under extensive Black cottonwood and Slide Alder stands, including several berries. Relatively low proportion vegetated.	
TAB	Tatshenshini Basin	BWBSvk	4	16		
SCU	Sikanni Chief Upland	BWBSwk 2	4	1		
CPR	Central Pacific Ranges	CWH dm	2	249	Can be highly productive in specific site series / seral stages, the dm matches other maritime subzones for grizzly bear forage capability. The CWHdm includes several very	
NWC	Northwestern Cascade Ranges	CWH dm	2	172		
OUF	Outer Fjordland	CWH dm	3	262		OUF barely occupied, very dry and rocky.

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
SPR	Southern Pacific Ranges	CWH dm	2	824	productive units, including floodplains and swamps.	
CPR	Central Pacific Ranges	CWH ds 1	2	705	The ds1 is highly variable across site series for bear forage, but includes extensive floodplain areas (Upper Squamish, Lillooet River valleys) with abundant berry species. Nutrient rich wetlands and fringes of bogs may contain abundant spring forage for grizzly bears.	
EPR	Eastern Pacific Ranges	CWH ds 1	2	1594		
HOR	Hozameen Range	CWH ds 1	2	6		
LPR	Leeward Pacific Ranges	CWH ds 1	2	169		
CCR	Central Chilcotin Ranges	CWH ds 2	2	17	Lower Klinaklini, Talchako, Bella Coola, Dean and Lower Kimsquit Rivers (all synonymous with high density grizzly populations) in part because of highly productive cross seasonal habitats including estuaries, floodplains, swamps, nutrient rich wetlands and a wide variety of berry feeding units.	
CPR	Central Pacific Ranges	CWH ds 2	2	195		
KIM	Kimsquit Mountains	CWH ds 2	2	264		
NPR	Northern Pacific Ranges	CWH ds 2	1	205		Ranked Class 1 to reflect NPR's exceptional cross-seasonal habitat value
WCR	Western Chilcotin Ranges	CWH ds 2	2	119		
CPR	Central Pacific Ranges	CWH ms 1	1	743	Higher elevations than the ms2, but ranked as class 1 or 2 because of two characteristics: the presence of highly productive avalanche chutes and extensive berry feeding areas (including recent clear cuts). Like other CWH units, has long growing season, offering several cross seasonal feeding opportunities.	
EPR	Eastern Pacific Ranges	CWH ms 1	2	3726		
HOR	Hozameen Range	CWH ms 1	2	177		
LPR	Leeward Pacific Ranges	CWH ms 1	2	243		
NWC	Northwestern Cascade Ranges	CWH ms 1	2	53		
KIM	Kimsquit Mountains	CWH ms 2	1	209	Highly productive cross seasonal habitats including estuaries, floodplains, and swamps, but also has extremely high potential for berry production. Historic wildfire history (with extensive berry productivity post fire).	
KIR	Kitimat Ranges	CWH ms 2	1	308		
NPR	Northern Pacific Ranges	CWH ms 2	1	762		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
CCR	Central Chilcotin Ranges	CWH un	2	13	Unsure because unclassified, treated like other CWH units.	
HEL	Hecate Lowland	CWH vh 1	2	1215	Very wet hypermaritime units not as productive for grizzly bears as maritime and submaritime units, but have good to moderate potential for foraging in a number of habitats including estuaries, swamps, nutrient rich wetlands, floodplains, and berry feeding habitats (including extensive salal habitats).	
HEL	Hecate Lowland	CWH vh 2	3	4116		
KIR	Kitimat Ranges	CWH vh 2	2	233		
SBR	Southern Boundary Ranges	CWH vh 2	3	86		
KIM	Kimsquit Mountains	CWH vm	1	35	Undifferentiated vm, but highly productive cross seasonal unit.	
KIR	Kitimat Ranges	CWH vm	2	2833	One of very few know "splits", this subzone appears less productive in the KIR and NAM, in part because of lower proportion vegetated (e.g., Kitlope).	
NAM	Nass Mountains	CWH vm	2	2		
CPR	Central Pacific Ranges	CWH vm 1	1	2429	CWHvm1 consistently excellent cross seasonal forage producer, with regularly occurring estuaries, floodplains, swamps, nutrient rich wetlands, and extensive berry feeding habitats. Occasional low elevation avalanche chutes can be highly valuable. Typically has excellent berry production in recent clearcuts and blowdown areas, wildfire rare (e.g., Vaccinium spp. on sidehills). Seral alder and cottonwood stands very high food producers.	
HEL	Hecate Lowland	CWH vm 1	2	18		Rare in HEL, ranked lower to reflect less habitat diversity within unit, few major river valleys.
KIR	Kitimat Ranges	CWH vm 1	1	3006		
NPR	Northern Pacific Ranges	CWH vm 1	1	739		
OUF	Outer Fjordland	CWH vm 1	3	1517		OUF very rocky, often on islands, barely occupied.
SPR	Southern Pacific Ranges	CWH vm 1	1	1161		
CPR	Central Pacific Ranges	CWH vm 2	2	2478	Montane vm unit typically lacks floodplains, no estuaries, fewer rich wetlands. However, vm2 has more avalanche chutes, and can be an excellent berry producer, both as old	
EPR	Eastern Pacific Ranges	CWH vm 2	2	1		
HEL	Hecate Lowland	CWH vm 2	2	110		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
KIR	Kitimat Ranges	CWH vm 2	2	2970	growth and early seral. Some potential for denning. Often midslope, the vm2 has higher suitability when diverse age classes and site series than when extensive areas of uniform site conditions.	
NPR	Northern Pacific Ranges	CWH vm 2	2	783		
NWC	Northwestern Cascade Ranges	CWH vm 2	2	73		
OUF	Outer Fjordland	CWH vm 2	3	356		Again, OUF very rocky, often on islands, barely occupied.
SPR	Southern Pacific Ranges	CWH vm 2	2	1913		
KIM	Kimsquit Mountains	CWH vm 3	2	33	Relatively rare montane unit, similar to vm2 for berry production.	
KIR	Kitimat Ranges	CWH vm 3	2	356		
NPR	Northern Pacific Ranges	CWH vm 3	2	358		
CBR	Central Boundary Ranges	CWH wm	2	896	Northern equivalent of vm1 - valley bottoms with high productivity in a wide variety of habitats including estuaries. The most northerly subzone of the CWH.	Ranked lower in more Northerly Ecosections, in part because the wm subzone likely also includes a less productive montane variant.
KIR	Kitimat Ranges	CWH wm	1	113		
MEM	Meziadin Mountains	CWH wm	2	2		
NBR	Northern Boundary Ranges	CWH wm	2	726		
SBR	Southern Boundary Ranges	CWH wm	1	1395		
MEM	Meziadin Mountains	CWH ws 1	1	141	Includes several very productive units, including floodplains, swamps, rich wetlands and extensive berry feeding units across seral stages.	
NAM	Nass Mountains	CWH ws 1	1	2209		
BUR	Bulkley Ranges	CWH ws 2	2	34	The ws2 is a montane unit, productive for berries across several site series and seral stages and regularly broken up by productive avalanche chutes. Occasional nutrient rich wetlands and swamps supplement cross seasonal habitat value.	
CPR	Central Pacific Ranges	CWH ws 2	2	511		
CRU	Cranberry Upland	CWH ws 2	2	446		
KIM	Kimsquit Mountains	CWH ws 2	2	1174		
KIR	Kitimat Ranges	CWH ws 2	2	581		
MEM	Meziadin Mountains	CWH ws 2	2	350		
NAB	Nass Basin	CWH ws 2	2	21		
NAM	Nass Mountains	CWH ws 2	2	2584		
NPR	Northern Pacific Ranges	CWH ws 2	2	608		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
SBR	Southern Boundary Ranges	CWH ws 2	2	2	See above	See above
WCR	Western Chilcotin Ranges	CWH ws 2	2	28		
HOR	Hozameen Range	ESSFdc 2	3	613	Long cold winters, cool short summers limit productivity of dc2. Like other ESSF units, dc2 can have moderate to high berry productivity.	
PAR	Pavilion Ranges	ESSFdc 2	3	143		
HOR	Hozameen Range	ESSFdcp	2	24	Parkland unit has higher proportion open forage units (e.g., meadows), berry productivity amongst krumholz.	
PAR	Pavilion Ranges	ESSFdcp	3	11		PAR barely occupied, very dry
CCR	Central Chilcotin Ranges	ESSFdv	3	19	No description in Cariboo Manual, but likely less productive than dc because of longer, colder winters and shorter growing seasons.	
SCR	Southern Chilcotin Ranges	ESSFdv	3	1093		
SCR	Southern Chilcotin Ranges	ESSFdvp	2	11	Parkland unit likely higher capability during mid to late summer.	
BUR	Bulkley Ranges	ESSFmc	2	1533	Moist cold unit, but has several good food producers, including avalanche chutes, meadows, wetlands, and occasional whitebark pine (bears dig pine nuts out of squirrel middens). Has some fire history, occasional Vaccinium shrubfield. Berry production moderate in oldgrowth.	
KIM	Kimsquit Mountains	ESSFmc	2	7		
NEU	Nechako Upland	ESSFmc	2	2572		
WCR	Western Chilcotin Ranges	ESSFmc	2	176		
BUR	Bulkley Ranges	ESSFmcp	2	439	Parkland similar to montane unit below, left as class 2 to reflect lower berry potential.	
KIM	Kimsquit Mountains	ESSFmcp	2	4		
NEU	Nechako Upland	ESSFmcp	2	3		
BUR	Bulkley Ranges	ESSFmk	2	561	Similar capability to the mc, with cross seasonal value from late spring to fall berries. Has higher cover of whitebark pine than mc.	
KIM	Kimsquit Mountains	ESSFmk	2	1163		
NEU	Nechako Upland	ESSFmk	3	22		NEU dropped a class because of lower habitat diversity on more subdued terrain.
BUR	Bulkley Ranges	ESSFmkp	2	169	Parkland similar to montane unit below, left as class 2 to reflect lower berry potential.	
KIM	Kimsquit Mountains	ESSFmkp	2	308		
KIR	Kitimat Ranges	ESSFmkp	2	4		
NAM	Nass Mountains	ESSFmkp	2	3		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
CCR	Central Chilcotin Ranges	ESSFmw	2	52	Higher snowfall than other ESSF units - snow can persist into June, however unit has wide diversity of food potential in avalanche chutes, wetlands, lake margins, and extensive berry production both in early seral and oldgrowth forests.	
CPR	Central Pacific Ranges	ESSFmw	2	117		
EPR	Eastern Pacific Ranges	ESSFmw	2	131		
HOR	Hozameen Range	ESSFmw	2	1598		
KIM	Kimsquit Mountains	ESSFmw	2	33		
LPR	Leeward Pacific Ranges	ESSFmw	2	1258		
NPR	Northern Pacific Ranges	ESSFmw	2	7		
SCR	Southern Chilcotin Ranges	ESSFmw	2	81		
WCR	Western Chilcotin Ranges	ESSFmw	2	711		
HOR	Hozameen Range	ESSFmwp	2	52	Parkland unit has higher proportion open forage units (e.g., meadows).	
BUR	Bulkley Ranges	ESSFwv	2	140	Most northerly ESSF subzone, wv has higher diversity of shrubs, including some coastal berry producers. Cross seasonal values in a variety of seral and disclimax units including avalanche chutes, wetlands, meadows. No whitebark pine, no growing season moisture deficits.	Synergistic with ICH for excellent cross seasonal values in Ecosections ranked as class 2.
CBR	Central Boundary Ranges	ESSFwv	2	679		
CRU	Cranberry Upland	ESSFwv	2	1411		
MEM	Meziadin Mountains	ESSFwv	2	1039		
NAB	Nass Basin	ESSFwv	2	821		
NAM	Nass Mountains	ESSFwv	2	11		
NSM	Northern Skeena Mountains	ESSFwv	2	3076		
SBP	Southern Boreal Plateau	ESSFwv	2	640		
SBR	Southern Boundary Ranges	ESSFwv	2	47		
SSM	Southern Skeena Mountains	ESSFwv	2	55		
STH	Stikine Highland	ESSFwv	3	1587		Lower proportion vegetated in these 4 northern ecosections.
TAG	Tagish Highland	ESSFwv	3	170		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
TEP	Teslin Plateau	ESSFwv	3	81		
THH	Tahltan Highland	ESSFwv	3	1724		
BUR	Bulkley Ranges	ESSFwvp	2	41	Like other ESSF units, the parkland unit of the wv has a higher proportion open habitats including meadows.	No differentiation by ecosection
CRU	Cranberry Upland	ESSFwvp	2	401		
NAB	Nass Basin	ESSFwvp	2	3		
NAM	Nass Mountains	ESSFwvp	2	6		
NSM	Northern Skeena Mountains	ESSFwvp	2	277		
SSM	Southern Skeena Mountains	ESSFwvp	2	4		
OKR	Okanagan Range	ESSFxc	3	526	Long, cold winters with rarely greater than 1m snowfall, extensive lodgepole pine, lower overall productivity for grizzly bears, some berry production (black huckleberry) and some fire history.	ESSFxc and ESSFxv are not above ICH (typically above MS or IDF) i.e., these Ecosections lack the synergistic effect of the very productive ICH/ESSF combination.
SCR	Southern Chilcotin Ranges	ESSFxc	3	173		
OKR	Okanagan Range	ESSFxcp	3	5		
SCR	Southern Chilcotin Ranges	ESSFxcp	3	17		
CCR	Central Chilcotin Ranges	ESSFxv 1	3	1775	High elevation forests with long, cold winters. Medium ranking because of some berry feeding capability.	
CHP	Chilcotin Plateau	ESSFxv 1	3	20		
CPR	Central Pacific Ranges	ESSFxv 1	3	40		
WCR	Western Chilcotin Ranges	ESSFxv 1	3	799		
CCR	Central Chilcotin Ranges	ESSFxv 2	3	1169	Similar to xc but most xv further east in the South Chilcotin GBPU. Some fire history.	
CHP	Chilcotin Plateau	ESSFxv 2	3	82		
BUB	Bulkley Basin	ICH mc 1	2	0	Drier, less snowy and warmer than the ICHvc, some fire history. Three hundred fifty to 900m, several non-forested feeding habitats including wetlands, lakeshores, and floodplains. Some areas of almost coastal like understories. Berry production locally high, several species, including post wildfire.	
BUR	Bulkley Ranges	ICH mc 1	2	65		
CRU	Cranberry Upland	ICH mc 1	2	185		
NAB	Nass Basin	ICH mc 1	2	2788		
NAM	Nass Mountains	ICH mc 1	2	3		
NSM	Northern Skeena Mountains	ICH mc 1	2	530		
SSM	Southern Skeena Mountains	ICH mc 1	2	62		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
CRU	Cranberry Upland	ICH mc 2	2	1048	Drier, warmer than ICHmc1, in Nass and Skeena valleys. Includes floodplain feeding habitats, wetlands, and extensive seral forests (including aspen) some with good berry production.	
NAB	Nass Basin	ICH mc 2	2	1297		
NAM	Nass Mountains	ICH mc 2	2	381		
SSM	Southern Skeena Mountains	ICH mc 2	2	21		
MEM	Meziadin Mountains	ICH vc	2	160	Very high snowfall and extensive lower elevation avalanche chutes, devil's club is extensive and heavily used by grizzly bears at lower elevations, Vaccinium common at higher elevations, no wildfires.	
NAB	Nass Basin	ICH vc	2	647		
NSM	Northern Skeena Mountains	ICH vc	2	113		
CBR	Central Boundary Ranges	ICH wc	2	264	Slightly drier than the vc, similar grizzly bear forage potential.	
NSM	Northern Skeena Mountains	ICH wc	2	573		
CCR	Central Chilcotin Ranges	IDF dk 1	5	1	Cooler and drier than the IDFdk2, very low grizzly bear forage potential in both forested and non-forested habitats. Long summer growing season moisture deficits. Most IDF units have only enough grizzly bear habitat potential to remain occupied; all are marginal except the ww subzone.	
OKR	Okanagan Range	IDF dk 1	5	302		
PAR	Pavilion Ranges	IDF dk 1	5	149		
SCR	Southern Chilcotin Ranges	IDF dk 1	5	224		
OKR	Okanagan Range	IDF dk 1a	5	2		
OKR	Okanagan Range	IDF dk 1b	5	43		
HOR	Hozameen Range	IDF dk 2	5	502		
LPR	Leeward Pacific Ranges	IDF dk 2	5	5		
NIB	Nicola Basin	IDF dk 2	5	3		
OKR	Okanagan Range	IDF dk 2	5	68		
PAR	Pavilion Ranges	IDF dk 2	5	75		
SCR	Southern Chilcotin Ranges	IDF dk 2	5	585		
HOR	Hozameen Range	IDF dk 2b	5	0		
LPR	Leeward Pacific Ranges	IDF dk 2b	5	0		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
SCR	Southern Chilcotin Ranges	IDF dk 2b	5	119		
CCR	Central Chilcotin Ranges	IDF dk 3	5	92		
CCR	Central Chilcotin Ranges	IDF dk 4	5	87		
CHP	Chilcotin Plateau	IDF dk 4	5	495		
CCR	Central Chilcotin Ranges	IDF dw	5	724		
CHP	Chilcotin Plateau	IDF dw	5	30		
WCR	Western Chilcotin Ranges	IDF dw	5	78		
LPR	Leeward Pacific Ranges	IDF un	4	20	Ranked class 4 because of potential as forage unit, respecting "unknown" status.	
SCR	Southern Chilcotin Ranges	IDF un	4	35		
EPR	Eastern Pacific Ranges	IDF ww	3	177	Transitional unit to coast, valley bottoms include several forage opportunities especially extensive riparian habitats, some wetlands. More "coastal" and quite unlike other IDF subzones.	
HOR	Hozameen Range	IDF ww	3	428		
LPR	Leeward Pacific Ranges	IDF ww	3	167		
SCR	Southern Chilcotin Ranges	IDF ww	3	51		
WCR	Western Chilcotin Ranges	IDF ww	3	402		
HOR	Hozameen Range	IDF xh 1	5	17	Extremely hot, dry units with extensive grasslands. Few grizzly bear forage opportunities, especially in summer and fall.	
OKR	Okanagan Range	IDF xh 1	5	82		
PAR	Pavilion Ranges	IDF xh 1	5	63		
SCR	Southern Chilcotin Ranges	IDF xh 1	5	16		
OKR	Okanagan Range	IDF xh 1a	5	2		
PAR	Pavilion Ranges	IDF xh 2	5	142		
SCR	Southern Chilcotin Ranges	IDF xh 2	5	118		
SCR	Southern Chilcotin Ranges	IDF xh 2b	5	19		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
FRB	Fraser River Basin	IDF xm	5	21	Extremely dry, barely occupied	
PAR	Pavilion Ranges	IDF xm	5	24		
CPR	Central Pacific Ranges	MH mm 1	3	2454	High snowfall unit, but medium forage potential because of wetlands, swamps, avalanche chutes and berry feeding habitats (e.g., Vaccinium spp.). Productivity strongly influenced by local topography (e.g., aspect). MHmm1 is the windward variant, so is wetter and warmer than the mm2, but similar potential.	
EPR	Eastern Pacific Ranges	MH mm 1	3	6		
HEL	Hecate Lowland	MH mm 1	3	36		
KIM	Kimsquit Mountains	MH mm 1	3	208		
KIR	Kitimat Ranges	MH mm 1	3	4783		
MEM	Meziadin Mountains	MH mm 1	3	70		
NAM	Nass Mountains	MH mm 1	3	489		
NPR	Northern Pacific Ranges	MH mm 1	3	1205		
NWC	Northwestern Cascade Ranges	MH mm 1	3	21		
OUF	Outer Fjordland	MH mm 1	4	132		Rated lower because most of OUF is on islands, at western edge of grizzly bear distribution.
SBR	Southern Boundary Ranges	MH mm 1	3	498		
SPR	Southern Pacific Ranges	MH mm 1	3	2074		
BUR	Bulkley Ranges	MH mm 2	3	1	Similar potential for grizzly bears as mm1. Leeward variant is cooler and drier with some forage species differences, but overall similar medium potential habitat value.	
CPR	Central Pacific Ranges	MH mm 2	3	1485		
CRU	Cranberry Upland	MH mm 2	3	66		
EPR	Eastern Pacific Ranges	MH mm 2	3	2908		
KIM	Kimsquit Mountains	MH mm 2	3	1366		
KIR	Kitimat Ranges	MH mm 2	3	516		
LPR	Leeward Pacific Ranges	MH mm 2	3	83		
MEM	Meziadin Mountains	MH mm 2	3	459		
NAM	Nass Mountains	MH mm 2	3	3914		
NPR	Northern Pacific Ranges	MH mm 2	3	1326		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
NWC	Northwestern Cascade Ranges	MH mm 2	3	44		
SBR	Southern Boundary Ranges	MH mm 2	3	9		
WCR	Western Chilcotin Ranges	MH mm 2	3	18		
CRU	Cranberry Upland	MH mmp	2	28	As with ESSF, the Parkland subzone of the MHmm has a higher potential to support grizzly bears because of similar berry productivity (amongst krummholz, but also some open meadow (almost avalanche chute-like) communities.	
HEL	Hecate Lowland	MH mmp	2	30		
KIM	Kimsquit Mountains	MH mmp	2	61		
KIR	Kitimat Ranges	MH mmp	2	1049		
MEM	Meziadin Mountains	MH mmp	2	173		
NAM	Nass Mountains	MH mmp	2	244		
SBR	Southern Boundary Ranges	MH mmp	2	500		
ALR	Alsek Ranges	MH un	3	5	Treated unknown subzone as similar to mm1 and mm2.	
CBR	Central Boundary Ranges	MH un	3	836		
NBR	Northern Boundary Ranges	MH un	3	1217		
SBR	Southern Boundary Ranges	MH un	3	1094		
TAB	Tatshenshini Basin	MH un	3	1		
THH	Tahltan Highland	MH un	3	10		
HEL	Hecate Lowland	MH wh 1	4	394	MHwh is similar to CWHvh (that it is above) in that hypermaritime climate creates more forested and non-forested bogs with less forage potential than maritime ecosystem counterparts.	
KIR	Kitimat Ranges	MH wh 1	4	44		
SBR	Southern Boundary Ranges	MH wh 1	4	25		
HEL	Hecate Lowland	MH whp	3	142	Parkland subzone given a higher rating to reflect greater forage potential in "open" plant communities.	
KIR	Kitimat Ranges	MH whp	3	37		
SBR	Southern Boundary Ranges	MH whp	3	20		
CCR	Central Chilcotin Ranges	MS dc 1	3	95	Variety of non-forested habitats that provide seasonal capability, including wetlands, lakeshores, and floodplains. Some berries, although sparse.	
SCR	Southern Chilcotin Ranges	MS dc 1	3	403		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
CCR	Central Chilcotin Ranges	MS dc 2	3	401	Similar to dc1.	
WCR	Western Chilcotin Ranges	MS dc 2	3	37		
HOR	Hozameen Range	MS dm 2	3	723	Warmer than the dc, but similar capability to produce bear forage in variety of non-forested and seral habitats.	
OKR	Okanagan Range	MS dm 2	3	142		
PAR	Pavilion Ranges	MS dm 2	3	66		
CCR	Central Chilcotin Ranges	MS dv	4	320	Very small subzone, lower capability than other MS units, colder.	
HOR	Hozameen Range	MS un	3	90	Assumed similar capability in unknown subzone as in other MS units.	
LPR	Leeward Pacific Ranges	MS un	3	35		
SCR	Southern Chilcotin Ranges	MS un	3	48		
WCR	Western Chilcotin Ranges	MS un	3	87		
CCR	Central Chilcotin Ranges	MS xk	4	70	All very dry MS units do not have much in the way of forage capable units.	
OKR	Okanagan Range	MS xk	4	462		
PAR	Pavilion Ranges	MS xk	4	54		
SCR	Southern Chilcotin Ranges	MS xk	4	248		
CCR	Central Chilcotin Ranges	MS xv	4	585		
CHP	Chilcotin Plateau	MS xv	4	1173		
NAU	Nazko Upland	MS xv	4	0		
WCR	Western Chilcotin Ranges	MS xv	4	629		
WCU	Western Chilcotin Upland	MS xv	4	0		
SCR	Southern Chilcotin Ranges	PP xh 2	5	58	Small unit, likely not occupied.	
NAU	Nazko Upland	SBPSmc	4	609	Some feeding opportunities on	

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
WCU	Western Chilcotin Upland	SBPSmc	4	0	lakeshores, wetlands and moderate to low berry productivity in some forested and seral habitats.	
CHP	Chilcotin Plateau	SBPSxc	5	3022	Limited forage opportunities in dry, cold uniform plateau habitat.	
WCU	Western Chilcotin Upland	SBPSxc	5	787		
BUB	Bulkley Basin	SBS dk	4	1368	SBSdk has several valley bottom units capable of grizzly bear forage production, including cottonwood dominated riparian areas and several berry feeding habitats, both seral and older units.	Lower rank than other SBSdk units because of lower topographic diversity.
BUR	Bulkley Ranges	SBS dk	3	21		
NEU	Nechako Upland	SBS dk	4	227		
BUB	Bulkley Basin	SBS mc 2	4	76	Non-forested units in the mc2 carry the bulk of the capability to support grizzly bears, although some berry production, particularly in early seral. Non-forested forage units include lakeshores, riparian areas and wetlands.	Lower rank than other SBSmc2 units because of lower topographic diversity.
BUR	Bulkley Ranges	SBS mc 2	3	2168		
CRU	Cranberry Upland	SBS mc 2	3	2		
NAU	Nazko Upland	SBS mc 2	4	58		
NEU	Nechako Upland	SBS mc 2	3	3304		
CBR	Central Boundary Ranges	SBS un	3	18	Unclassified subzone assumed to have similar habitat capabilities to other SBS units.	
SBP	Southern Boreal Plateau	SBS un	4	280		
STH	Stikine Highland	SBS un	3	719		
TAG	Tagish Highland	SBS un	3	180		
TEP	Teslin Plateau	SBS un	4	62		
THH	Tahltan Highland	SBS un	4	1473		
KLR	Kluane Ranges	SWB dk	3	74	Several berries, including crowberry, lingonberry and soopalalie support moderate capability for grizzly bear forage along with non-forested wetlands.	
TAB	Tatshenshini Basin	SWB dk	3	567		
STP	Stikine Plateau	SWB mk	3	6304	Moist cool unit has similar capability to dry cool, with different mix of non-forested but higher productivity in forested units.	
TEB	Teslin Basin	SWB mk	3	1		
TUR	Tuya Range	SWB mk	3	112		

ECOSECTION	ECOSECTION NAME	BECLABEL	CAPABILITY CLASS	AREA (KM2)	RATIONALE: ZONE	RATIONALE: ECOSECTION
SBP	Southern Boreal Plateau	SWB un	3	628	Unclassified subzone assumed to have similar habitat capabilities to other SWB subzones.	
STH	Stikine Highland	SWB un	3	1020		
STP	Stikine Plateau	SWB un	3	489		
TAB	Tatshenshini Basin	SWB un	3	20		
TAG	Tagish Highland	SWB un	3	149		
TEB	Teslin Basin	SWB un	3	292		
TEP	Teslin Plateau	SWB un	4	2245		
THH	Tahltan Highland	SWB un	3	100		
ALR	Alsek Ranges	SWB vk	3	325	Very snowy unit, mostly non-forested. Meadow communities have relatively high capability, as well as extensive floodplains.	
KLR	Kluane Ranges	SWB vk	3	927		
TAB	Tatshenshini Basin	SWB vk	3	58		