BRITISH COLUMBIA GRIZZLY BEAR
HABITAT CLASSIFICATION AND RATING

A multi-scale, ecosystem-based approach to evaluating Grizzly Bear habitat using British Columbia’s Ecoregion, Biogeoclimatic, and Broad Ecosystem Classification systems

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EXECUTIVE SUMMARY

A multi-year project was initiated to apply Grizzly Bear habitat quality ratings to two levels of the Provincial Ecosystem Classification. Habitats were subjectively rated for their ability to produce known plant foods in a 6-class system, enabling the production of habitat capability and suitability maps and associated summaries of habitat quality by area.

The intended audience and appropriate uses for this species account and the accompanying maps and spatial databases for Grizzly Bears are:

- For researchers who need a spatial method to index vegetative forage and habitat quality across the province;
- For resource managers who use spatial data and maps for conservation and management decision making at the provincial, regional and sub-regional scales;
- For education and public outreach regarding the natural history of Grizzly Bears in BC;
- To show the relative value of different ecosystems at two different levels of ecosystem classification that support Grizzly Bears in BC;
- To demonstrate application of the standardized Wildlife Habitat Ratings (WHR) methods for classification, mapping and interpreting Grizzly Bear habitat capability and suitability;
- To revise the 1999 Grizzly Bear habitat databases to a more recent version of Biogeoclimatic Ecosystem Classification (BEC, version 7); and
- To set a current provincial baseline for potential future analyses (e.g. climate change modelling).

Users of this report and the accompanying maps and databases should keep in mind that these habitat ratings represent only the vegetative (plant food) component of Grizzly Bears’ diet. Other factors, such as the location, abundance and temporal occurrence of spawning Pacific salmon, ungulates, small mammals, and insects are difficult to quantify and compile spatially but should not be ignored when evaluating land use and resource extraction proposals that could affect Grizzly Bear behaviour and demography.

Two products were created:

1. **Ecosections combined with BEC** were rated to the Variant level for habitat capability; and

2. **Ecosections, BEC, and the Broad Ecosystem Inventory (BEI)** classifications were rated for both habitat capability and suitability.

The products reported here are only appropriate for broad strategic and tactical assessment and planning across large land areas such as entire Grizzly Bear Population Units, Wildlife Management Units or Regional Study Areas defined for Major Project Assessments. Larger scale habitat mapping is required for stand or site level application during operational assessments or planning. Terrestrial Ecosystem Mapping (TEM)\(^1\) at 1:20,000 or direct mapping of Grizzly habitat

\(^1\) Predictive Ecosystem Mapping (PEM) has also been interpreted for Grizzly habitat suitability. However, when PEM-derived maps have been evaluated using collared bear information, they have not been reliable.
at that scale will more accurately define the amount, quality, distribution and connectivity of Grizzly Bear habitats.

Over 11,300 map polygons of 1,125 unique combinations of Ecosection and BEC Variant were rated for their capability within the currently occupied range of Grizzly Bears in British Columbia. Similarly, 59,032 occupied BEI polygons of 25,968 unique habitats were rated for both their inherent capability to support Grizzly Bear plant foods and their habitat suitability based on forest cover data circa 19902. Formerly occupied range was also rated to enable estimates of historic habitat quality. Benchmark habitats were established for comparing Ecossections/BEC Variant and BEI ratings and are part of the WHR standard methods. Map summaries reported here highlight the diversity of valuable Grizzly Bear habitats across the Province as influenced by highly variable physiography and elevation, (topography), continentality (from the coast to the interior), latitude (south to north), climate (e.g. precipitation, frost free growing days), and the consequent influences on plant community structure and food plant productivity.

This report concludes with recommendations for the future of Grizzly Bear habitat classification and mapping in BC. These were: 1) to integrate the long history and value of the existing ecological land classification and its interpretation for wildlife with some of the new approaches from remote sensing; 2) assignment of seasonal forage values to ecosystems using stable isotope signatures for diet analyses; and 3) eventually, it may be possible to develop an empirically-based estimator of current Grizzly Bear carrying capacity based on both the bottom-up habitat factors measured here and the top down influences of human caused mortality using digital data such as road density or secure core habitat. Continued work on 1:20,000 scale grizzly habitat mapping and interpretation for operational decision making is strongly recommended.

FUNDING AND TECHNICAL SUPPORT

This version of the project was supported by the Ecosystems Branch and the Knowledge Management Branch of the Ministry of Environment and Climate Change Strategy. Although most of the work was completed with staff resources, some funding was provided to Jeremy Ayotte (Phyla Biological Consulting) by the Grizzly Bear Trust Fund.

The habitat capability and suitability ratings for this project were drafted by a team consisting of Grizzly Bear species experts, a provincial habitat expert, and a data manager. Tony Hamilton and Robin Munro provided their Grizzly Bear behaviour and habitat use expertise. Diana Demarchi served as project and data coordinator because of her knowledge of the ecosystem classifications and data structure and the Wildlife Habitat Ratings standards. Dennis Demarchi served as habitat expert, due to his extensive knowledge and development of the four ecosystem classifications used in this project, and of the habitats in various areas of the province. This project complies with the Wildlife Habitat Ratings Standards of the Resource Information Standards Committee (RIC 1999).

The forest cover data is from 1990 because of the methods used to produce the BEI dataset. BEI polygons were manually drawn and digitized for the entire province and took years to complete making it difficult and costly to update. The underlying ecological data supporting BEI is still relevant, but seral stage information should be treated with caution.
ACKNOWLEDGEMENTS

An earlier version of this report was reviewed by Dr. Alton Harestad, whose comments greatly improved both structure and content. The authors would also like to thank Shelley Marshall, Garth Mowat, and Stephen MacIver for providing editorial comments; and a special recognition to Robin Munro for contributing both her Grizzly Bear knowledge and her understanding of the Wildlife Habitat Rating (WHR) approach.
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1.0 Introduction

The impetus for this project came from a desire to update similar work done by Tony Hamilton, Dennis Demarchi, and Kristin Karr in 1999 (Hamilton et al. 1999) - a map of Grizzly Bear habitat ratings using the Provincial Ecosystem Classification\(^3\) current at that time. That product was used for sub-regional planning, including setting baseline Grizzly habitat conditions for several Land and Resource Management Plans and was the basis for the capability summaries behind the expert-based Grizzly Bear population estimates prior to 2008 (Hamilton et al. 2004, Hamilton 2008). Significant changes to the spatial locations and classification of the Ecoregion and Biogeoclimatic units have prompted this update of the 1999 Grizzly Bear habitat interpretations. Rating Grizzly Bear habitat using BEI data began in the 1990’s, and that work has now been revised and completed. Ratings at that scale are now available for the whole province, potentially useful for regional-scale resource management planning, major project proposal assessments, and other strategic land use evaluations. An additional part of this project was to deliberately correlate the two sets of ratings such that values at the smaller scale Provincial Ecosystem Classification scale are consistent with interpretations at the larger 1:250,000 BEI level.

Understanding the quality, quantity, trend and connectivity of Grizzly Bear (Ursus arctos) habitat in British Columbia, and being able to convey that information effectively by classifying and ranking habitats on large and small scale maps, is an essential component of the Provincial conservation program for the species. Grizzly Bear population density, trajectory and distribution/occupancy in British Columbia are a function of both “top-down” factors such as direct human-caused mortality and “bottom-up” factors such as the availability of seasonally important foods. The abundance, distribution, availability and annual and multi-year productivity of important Grizzly Bear foods such as huckleberry and blueberry (Vaccinium spp.), all five species of Pacific Salmon, and whitebark pine cone seeds (Pinus albicaulis) directly influence Grizzly Bear movements, implantation success, human-caused mortality risk and cub survivorship (e.g., see Ciarniello et al. 2007a, McLellan 2015, and Lamb et al. 2017). Although there have been repeated suggestions that the consumption of terrestrial prey species affects Grizzly Bear density in BC, “evidence for the functional importance of terrestrial meat is inconclusive” (Mowat and Heard 2006) and for populations examined by McLellan (2011), population density was inversely related to the amount of terrestrial meat in the diets of Grizzly Bears and American Black Bears (Ursus americanus).

Significant differences in diet of grizzly males and females have been detected in some BC studies. For example, in the coast-interior transition region, males are more likely to travel away from their core home ranges to feed on spawning salmon than are females (Apps et al. 2014). In addition, varying strategies used by both sexes may occur in diverse landscapes, such as described for the mountain and plateau bears identified by Ciarniello et al. (2007a). The multi-

\(^3\) The Provincial Ecosystem Classification refers to the combination of the Ecoregion and Biogeoclimatic Ecosystem Classifications, and results in a list of unique combinations of Ecossections and BEC Zones, subzones, variants, and phases.
BC Grizzly Bear Habitat Classification and Rating

scale, hierarchical, commonly-applied ecological land classification and mapping approach used in BC (Demarchi et al. 2000, Ecosystems Working Group 1998, and Demarchi 2011) is a strong foundation for translating such diverse, ecosystem-specific food and habitat values into conservation and management actions.

British Columbia supports approximately 15,000 Grizzly Bears that use widely different habitats that include wet and drier forests, early-seral berry patches, shorelines and estuaries at sea level, and meadows and avalanche tracks up to 2,400 m elevation. Some of the highest densities of Grizzly Bears are found along the extremely wet mainland BC coast where annual rainfalls can exceed 2.5 m, but an increasingly rare group of Grizzly Bears seasonally uses the dry, shrub-dominated big sagebrush (Artemisia tridentata) benches along the Fraser River Valley near Lillooet and other very dry areas of southern-interior BC. Grizzly Bear habitat productivity is often linked to forest successional stage. Although several of their preferred and critically important berry species (e.g., black huckleberry, Vaccinium membranaceum) produce fruit in old forests, bears find the highest volumes of berries in early-seral burns and clear-cuts. Being able to describe, assess, and map this huge diversity of food and habitat opportunities is a fundamental requirement for meeting a variety of Grizzly Bear habitat and population objectives that include sub-regional recovery, bear use by the viewing and hunting sectors, and the protection or management of key seasonal foraging habitats.

The status and trends of Grizzly Bear populations varies widely across the province in the 55 Grizzly Bear Population Units (GBPUs), from highly threatened and genetically isolated populations at risk, to healthy populations. Wherever they reside, there is a concern about how land management and resource use affect the welfare of Grizzly Bear populations and the habitats they depend on, often with a focus on the incremental risks from various sources of human-caused mortality. Prior to 2018, An average of approximately 300 Grizzly Bears were reported killed per year from resident and non-resident hunting, and conflict kills by Conservation Officers and others. Illegal activity and other unreported human causes create additional pressure on BC Grizzly Bears. Studies from B.C. (southwestern), Alberta, Montana, Idaho, and Washington suggest that unreported kills may equal the reported number of kills, although this ratio likely declines in more remote areas. Debates about the legal hunt, which was closed in the winter of 2017, continuously put Grizzly Bears in the media spotlight, and central to those debates was the scientific basis for the GBPUs-specific population estimates[5], the mortality limits derived from them (McLellan et al. 2016) and estimates of illegal, unreported mortality[6].

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4 Grizzly Bear Population Units were proposed in 1997 after the independent Grizzly Bear Scientific Advisory Committee met to discuss the Grizzly Bear Conservation Strategy (Ministry of Environment, Lands and Parks, 1995). These units were subsequently adopted and modified by the Fish and Wildlife Program to better align with Wildlife Management Units (WMU’s). Current status of GBPUs is available at: http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html [last accessed September 11, 2017] and current line-work and previous versions are available at: https://catalogue.data.gov.bc.ca/dataset/grizzly-bear-population-units [last accessed September 11, 2017].


6 The Provincial government announced a closure of all Grizzly Bear Hunting in British Columbia on December 18, 2017, during the technical review of this report.
The expert habitat-based approaches used to estimate Grizzly Bear population size that were commonly applied in British Columbia from the late 1980s until 2008 ranked different ecological units by their expected natural food supply under the premise that food availability translated into population density (Fuhr and Demarchi 1990, Hamilton et al. 2004, Hamilton and Austin 2004, Hamilton 2008). 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 redesigned 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 habitat capability ratings more transparent;
2) including an explicit estimate of the contribution of terrestrial and marine meat sources to population density (Hamilton and Austin 2004);
3) removing some of the subjectivity by applying the best available mapped information 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 (Hamilton and Austin 2004).

Despite those changes, the expert-based approach to the translation of habitat supply, human influence on habitat, and mortality history into current Grizzly Bear population estimates had become overly complicated, not transparent and remained largely subjective. The expert-based approaches were superseded by the more empirically-derived regression model approach described by Mowat et al. (2013). The model relates Grizzly Bear density to ultimate measures of ecosystem productivity, mortality, and extrapolations from 89 reported densities from data collected in the field from around western North America, including numerous mark-recapture studies. Researchers working in BC pioneered the use of systematic hair collection for mark-recapture based inventories of Grizzly Bear (Woods et al. 1999). However, these inventories can be expensive, logistically difficult and result only in spot estimates for specific locations; relatively little information is forthcoming about population trend. Similarly, the habitat metrics in the Mowat et al. (2013) model are temporally static and not sensitive to changing habitat productivity from logging, wildfire, human developments, or climate change. Estimates based on the mark-recapture based inventories are most reliable when there is little ecological difference and/or geographic distance from the census area to the areas predicted by the model. Priorities for inventory and monitoring have been proposed, with emphasis on areas where few inventories have been conducted (Apps 2010). However, uncertainties around the current estimate have resulted in some regional staff modifying the regression model outputs through the application of local expert-based opinions (Ministry of Forests, Lands, and Natural Resource Operations 2012), including assumptions about habitat quality, distribution and food supply. Unfortunately, these modifications expose the current (2012) estimate to the same criticisms regarding subjectivity directed against the expert-based system used prior to 2004.

Grizzly Bear habitat in British Columbia has been described and mapped using remote sensing, with a focus on the concepts of “greenness” (Green Vegetation Index, Crist and Vickie 1984), and wetness (Forsythe and Wheate 2003). In addition, the Resource Selection Functions (RSF) that have been applied in several British Columbia Grizzly Bear radio-collaring studies help to characterize and locate important seasonal habitats. These RSFs have also linked habitat value
for bears to greenness and openness (Ciarniello et al. 2007b, Ciarniello *et al.* 2015, Proctor *et al.* 2015). A comprehensive body of work by Clayton Apps (e.g. Apps 2004, Apps et al. 2016) has related DNA detections to a wider variety of habitat inputs, including LANDSAT image analyses for greenness and wetness. Although greenness, in particular, has been repeatedly correlated with Grizzly Bear forage value, it is simply an index of leafy green productivity (Proctor *et al.* 2015). Similar to the Normalized Difference Vegetation Index (NDVI) applied by Mowat *et al.* (2013), habitats identified may or may not have Grizzly Bear forage value. The value of remote sensing, greenness, and derived RSF and other modelling approaches is complicated by the extremely wide ecological diversity of Grizzly Bear habitats in BC at various spatial scales. This diversity includes forested and non-forested lands, successional habitats of various ages and structural stages, a huge variety of slopes, aspects and elevations, and anthropogenic ecosystems. BC’s hierarchical ecosystem classification and mapping framework (Demarchi *et al.* 2000, Ecosystems Working Group 1998, and Demarchi 2011) can not only characterize that diversity and identify current habitat value (suitability) across the province at multiple scales but also provides the opportunity to assess potential habitat changes over time.

This report summarizes interpretations of two scales of habitat classification and mapping at 1:2,000,000 and 1:250,000. BC’s Ecoregion, Biogeoclimatic, and BEI data were used to stratify and rate Grizzly Bear habitat into six forage value classes meant to represent the relative value that vegetation food contributes to population density (RIC 1999). Ratings were assigned based on descriptions of ecological units (climate, geology, terrain, physiography, and vegetation), Grizzly Bear research and inventory results, and local, experiential knowledge.

This suite of information can contribute to: regional and sub-regional strategic planning; setting the sub-regional context for major project environmental assessments; education and outreach; and setting priorities for additional research and/or analyses. Two of the benefits of this approach are to provide provincial consistency in the habitat interpretation for ease of communication, and the ability to compare habitats across regions at these scales.

### 1.1 Objectives

The broad-level objectives of this project were:

1. to describe the methods and assumptions for creating two Grizzly Bear habitat maps for British Columbia: a) habitat capability based on the Provincial Ecosystem Classification; and b) habitat capability and suitability based on Broad Ecosystem Inventory;
2. to guide users in the potential application of these maps; and
3. to provide recommendations for future habitat identification and classification (*Section 5.0*).

### 2.0 Taxonomy

**Scientific Name:** *Ursus arctos*

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5 Our team has, collectively, over 100 years of experience in Grizzly Bear habitat use and evaluation throughout British Columbia.
Species Code: M-URAR
Common Name: Grizzly Bear
Subspecies: There is only one subspecies of Grizzly Bear (U. a. horibilis) in British Columbia.
Provincial Red- and Blue-list: Blue-listed
Provincial Status Rank: S3 (2015)
Global Status Rank: G4 (2000)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status: Special Concern (2012)
Federal (SARA) Status: Special concern, western population

Species taxonomy and nomenclature follows The Vertebrates and Invertebrates of British Columbia: Scientific and English Names (RISC 2008).

2.1 Phylogenetic History and Habitat Adaptation of Grizzly Bears in BC

The current suite of habitats used by Grizzly Bears in British Columbia is the result of behavioural adaptation over many generations to the province's unique topography, bedrock and surficial geology, climate and disturbance regimes. At one time, British Columbia was completely covered in glacial ice, except for a few small refugia on the coast and the summits of the highest mountain peaks. The maximum extent of the Fraser Glaciation in British Columbia was 14,000 years ago (Clague 1989, Clague and Ward 2011, Margold et al. 2013). British Columbia experienced fluctuating warming and cooling trends over the last 10,000 years, including the Holocene Ice Age from 1350-1870 A.D. (Ryder 1989, Pielou 1991). The majority of tree species distribution and ecosystem patterns developed 7000 to 4000 years ago (Clague and MacDonald 1989). A variety of climatic and geological influences and recolonization from geographic refugia created the huge diversity of forested and non-forested ecosystems that are found in British Columbia today.

The first major area to re-vegetate after glaciation was at the intersection of the western Cordilleran and the eastern Laurentide ice sheets on the western margins of the Interior Plains in the northeastern area of the province. Tundra vegetation attracted the grazing ungulates from Beringia and their human predators were apparently not far behind (Fladmark 1986, Mackie et al. 2011), although a recent publication suggests that North American humans may have arrived earlier by water (Pedersen et al. 2016). Regardless, Grizzly Bears were part of the southward migration, eventually populating much of western North America, including Manitoba, possibly Ontario (McLoughlin 2012) and the central plains of the US Midwest as far south as north central Mexico (Brown 1985, Naughton 2012). In BC, Grizzly Bears eventually occupied the mainland portion of the province with a few exceptions on Vancouver Island, Haida Gwaii, and the other smaller coastal islands. A Grizzly Bear skull collected on Whidbey Island in Washington State dates from 9000 years BP (Mustoe and Carlstad 1995); however it may have been transported there by humans. The only fossil specimens from British Columbia were located on Haida Gwaii (Ramsey et al. 2004, Sutherland Brown 2013), an area not currently occupied by the species.

Physical isolation does not appear to have prevented colonization of the near coastal islands; Grizzly Bears are excellent swimmers and a family group was seen on Hardwicke Island in 1999,
less than three kilometres from Vancouver Island. Since that time, 15 Grizzly Bears have been verified on Vancouver Island and a sibling pair was transported off Cormorant Island in 2016. Grizzly Bear occupancy, as demonstrated by productive adult female residents, appears to be expanding west in parts of coastal BC (Service et al. 2014).

The availability of spawning salmon aided Grizzly Bear dispersal and colonization of many areas of the province, including several otherwise less productive Interior ecosystems such as the lower Chilko River. The availability of ungulates (neonates, adults, and winter-killed carcasses), kills made by Grey Wolf (Canis lupus), Cougar (Puma concolor) and American Black Bear, and the availability of smaller prey such as American Beaver (Castor canadensis), marmots (Marmota spp.) and ground squirrels (Spermophilus spp.) may have also influenced Grizzly Bear distribution. American Black Bears are also occasionally fed on by Grizzly Bears.

Historic wildfires and other natural disturbances created a diverse mosaic of seral forests (Voller and Harrison 1998) and associated feeding opportunities for Grizzly Bears in BC. Abundant, productive, non-forested ecosystems in valley bottoms and sub-alpine habitats (e.g., fens, avalanche tracks, meadows) provided important seasonal plant forage including the nutrient-rich bulbs and corms like glacier lilies (Erythronium grandiflorum and E. montanum) and western springbeauty (Claytonia lanceolata). Insect colonies and nests were abundant and important food sources (ants, wasps, and possibly estivating moths). Mature forests provided essential Grizzly Bear resources including berries under open (patchy) canopies, Whitebark pine seeds cached by Red Squirrels (Tamiasciurus hudsonicus) and raided by bears, and skunk cabbage (Lysichiton americanus) found in the swamp forests of the coast and wet (Interior Cedar Hemlock) subzones of the southern interior.

The richness and diversity of habitat opportunity in British Columbia resulted in some of the highest densities of the species on the continent. The first phylogenetic analysis using mitochondrial DNA by Waits et al. (1998) indicated that British Columbia’s Grizzly Bears originated from two maternal lines that separated prior to colonizing North America but had cohabitated Beringia (Leonard et al. 2000). Neither of the British Columbia clades described at that time were closely related to the Brown Bears (Ursus arctos middendorffi) on Admiralty, Baranof, and Chichigof Islands in nearby southeast Alaska (Talbot and Shields 1996).

Subsequent analysis of nuclear DNA of Grizzly Bears in North America has been examined extensively, enabling description of male-mediated gene flow (Proctor et al. 2012). Although there is some evidence for naturally evolved genetic differences among BC’s Grizzly Bears (e.g., Ciarniello et al. 2009) human-caused population isolation has caused recent loss of genetic diversity for some southern fringe Grizzly Bear populations within the province (Ross 2002, Paetkau et al. 2008, Proctor et al. 2012, Apps 2014, McLellan et al. 2016). Cronin et al.’s (2012) suggestion that there are considerable genetic differences among Grizzly Bears in BC and Alberta is not fully supported, other than those readily explainable by Isolation-by-Distance (Proctor et al. 2012) and natural fragmentation in highly mountainous areas of the coast. Development-related fragmentation, including highly concentrated areas or periods of human-caused mortality has fractured previously functional core habitats.
2.2 BC Grizzly Bear Conservation and Management Categorization

Grizzly Bears in Canada were considered a single unit and designated “Not at Risk” in April 1979 by the Committee on the Status of Endangered Wildlife in Canada (Banci 1991, Banci et al. 1994). In April 1991, COSEWIC endorsed a split into two “populations” (Prairie population and Northwestern population). The Prairie population was designated Extirpated at that time, with their status being re-examined and confirmed in May 2000 and again in May 2002. In May 2012, the entire species was re-examined and the Prairie and Northwestern populations were considered a single unit. This newly-defined Western population was designated Special Concern by COSEWIC (McLoughlin 2012).

Special Concern species “may become threatened or endangered because of a combination of biological characteristics and identified threats.” These are particularly sensitive to human activities or natural events but are not endangered or threatened at the species level. In Canada, Grizzly Bears occur in the following provinces and territories: British Columbia, Alberta, Saskatchewan, Manitoba, Yukon, Northwest Territories and Nunavut (McLoughlin 2012). COSEWIC status ranks are adopted and applied by the BC Ministry of Environment’s Conservation Data Centre, a member of the global NatureServe network, and stand as the current conservation status for BC Grizzly Bears.

COSEWIC supports status designation below the species level for separate designatable units. For example, in BC, distinct populations of Caribou (Rangifer tarandus) (Heard and Vagt 1998), Painted Turtle (Chrysemys picta) and Sockeye Salmon (Oncorhynchus nerka) have multiple status designations. COSEWIC’s criteria for recognizing designatable units within a species are based on evolutionary significance and discreteness/isolation. However, a COSEWIC qualifier specifies that “disjunctions that are a product of human disturbance (as opposed to natural factors) do not qualify as discrete”5, disregarding the well-documented evidence for human-caused Grizzly Bear genetic and demographic population isolation in Southern BC (Proctor et al. 2012, Apps 2014) as a ranking criteria under the COSEWIC system.

The International Union for the Conservation of Nature (IUCN) does not make the same distinction between anthropogenic and natural fragmentation (IUCN 2012). A recent global review of Brown Bear status (Ursus arctos) by McLellan et al. (2016), undertaken for the IUCN, did recognize the evidence for human-caused demographic and genetic isolation in BC and ranked five areas differently from the remainder of Grizzly Bear distribution in the province (Table 1). This ranking recognizes that population-level declines and range contraction are independent of the nationally recognized “Western” evolutionary significant unit.

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### Table 1 - Isolated Bear Populations in British Columbia

<table>
<thead>
<tr>
<th>Population Name</th>
<th>Jurisdiction</th>
<th>Population Size</th>
<th>No. of Mature Adults</th>
<th>Population Area (km²)</th>
<th>Population trend</th>
<th>IUCN Red List Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stein/Nahatlatch</td>
<td>Canada (BC)</td>
<td>15-25</td>
<td>8-14</td>
<td>7,710</td>
<td>slight decline</td>
<td>CR - Critically Endangered</td>
</tr>
<tr>
<td>North Cascades</td>
<td>Canada USA</td>
<td>&lt;10</td>
<td>6</td>
<td>25,000</td>
<td>unknown</td>
<td>CR - Critically Endangered</td>
</tr>
<tr>
<td>Fountain Valley and Hat Creek</td>
<td>Canada (BC)</td>
<td>&lt;10</td>
<td>6</td>
<td>1,400</td>
<td>unknown</td>
<td>CR - Critically Endangered</td>
</tr>
<tr>
<td>South Selkirks</td>
<td>Canada USA</td>
<td>93</td>
<td>52</td>
<td>6,800</td>
<td>slightly increasing</td>
<td>VU – Vulnerable</td>
</tr>
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<td>Yahk-Yaak</td>
<td>Canada USA</td>
<td>48</td>
<td>26</td>
<td>11,520</td>
<td>stable</td>
<td>EN - Endangered</td>
</tr>
</tbody>
</table>

#### 2.3 Provincial Range and Distribution

Outside of Threatened Units, current occupancy / range mapping of Grizzly Bears in BC is based on records of adult female occupancy. Males are regularly detected outside of Grizzly Bear Population Unit boundaries. However, such records are often either human-bear or livestock-bear conflicts. In any case, the range and distribution of Grizzly Bears in BC reflects a balance among ecological productivity, habitat suitability, forage abundance and social tolerance. Currently un-occupied parts of the Province may have suitable and effective (and even linked) habitats, but may be well beyond the limits of public acceptance.

Several sightings, genetic records, and Grizzly Bear mortalities have been recorded for Vancouver Island since 1990; however, no resident females have been confirmed. Grizzly Bears have been detected as far west as Kyuquot, but most Vancouver Island records are in the vicinity of Sayward and near Port Hardy. Further north on the coast, Service et al. (2014) have documented an apparent westward population expansion on to Princess Royal Island. Although male Grizzly Bears have been detected on Princess Royal for many years, it’s only recently that females have been confirmed, including a female with cubs in the spring of 2016. The Kitloople-Fjordland GBPU boundary may be adjusted to the west as a consequence of these sightings.

Further range expansion has been recently confirmed for the north and northeast areas of the South Chilcotin GBPU. Unfortunately, although most records have been confirmed livestock depredation-related conflicts and mortalities, the evidential record is now strong enough regarding adult female residency to move the former South Chilcotin GBPU boundary north and east to the Chilcotin River.

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On a smaller scale, consideration is being given to shifting the southwestern boundary of the Granby-Kettle GBPU south and west, based on new detections of females in the lower Kettle River. Similarly, occasional Grizzly Bear detections have been confirmed in Eastern Washington State, in the “wedge” between the Kettle River on the west, and the Columbia River on the east. These bears are presumed to be expanding south from a long-known group of BC Grizzly Bears in Sheep Creek, south and west of Rossland.

Grizzly Bears have been detected fishing in the Upper Pitt River in recent years, generating a considerable amount of media attention, given the proximity to Vancouver. A collared female Grizzly from the Whistler Area has also made a seasonal foray into the Indian River drainage, suggesting that the Garibaldi-Pitt GBPU remains occupied. No females have been detected in the Garibaldi Pitt other than the collared female that originated in the Squamish Lillooet GBPU and crossed Highway 99 near Whistler. Only two Grizzly Bears have been detected in the North Cascades GBPU since 2010 (a large male on 5 occasions, and an unknown sex bear in October 2015) despite a well-publicized hotline for sightings, and careful record keeping on human-bear and bear-livestock conflicts.

A new GBPU for BC is being considered for the Clear and Marble Ranges on the east side of the Fraser River from Lillooet. An adult female was confirmed in 2007 in the Upper Botanie River drainage. Subsequently, a sub-adult male was killed in conflict with humans near the community of Fountain Valley. Although there is considerable suitable habitat available, no public consultation has yet occurred, so the social carrying capacity or acceptance of population re-establishment has not been determined. This is one of the three BC Units rated critically endangered in the recent IUCN global Brown Bear Status report and Table 1 (McLellan et al. 2016).

Occupancy verification was recently conducted in the Nulki GBPU near Vanderhoof, and east into the Francois GBPU. The extirpated area between Prince George and Quesnel may be larger than previously thought. One of the most interesting questions about Grizzly Bear distribution in BC relates to the extreme Northeastern corner of the province. The Governments of North West Territories and Alberta do not regard their adjacent jurisdictions as occupied, and when jurisdictional range maps are compared, it becomes obvious that both the northern and eastern boundaries in BC need revision. Occupancy in that part of BC is speculative, based only on a few observations by a Petitet River trapper, active in the 1990’s.

The Grizzly Bear range that was evaluated for this project was the terrestrial portion of the province, excluding the coastal islands. Within this Grizzly Bear historic range, all the habitat units were evaluated and given a rating for Grizzly Bear to produce maps of historic capability, current capability and current suitability.

2.4 Provincial Ecosystem Classifications

2.4.1 Ecoregions

The Ecoregion Classification System was first adopted by the Ministry of Environment in 1985 to serve as a framework for recognizing small scale ecosystems in British Columbia. The Ecoregion Classification helps us to understand and to depict the wide habitat diversity of the province. Since 1985, the Ecoregion Classification has been revised five times to reflect more detailed
mapping. The fourth revision Ecoregion units was mapped at 1:250,000 using Landsat, topographic, Biogeoclimatic and marine ecosystem information, while the fifth revision has been mapped based on the earlier concepts plus detailed vegetation zonation mapping. The most current digital (GIS) database is Version 2.1 (2006), but the supporting reports and descriptions is the third edition, drafted in 2011 (Demarchi 2011).

Ecoregion Classification Units are broad ecological units based on climatic processes, physiography, and general animal and plant distribution. Ecosections are smallest geographic unit in the classification and link groups of Biogeoclimatic units together, such that repeated physiographic and macroclimatic processes can be identified and characterized. The major practical difference between the Ecoregion Classification System and BEC is that, in mountainous terrain, Ecoregion 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 Ecoregion Classification with the BEC systems allows discrimination within BEC units across Ecosections and assists with the identification of synergies across BEC units (Demarchi et al. 2000, Mah et al. 1996) such as their collective habitat capabilities for supporting Grizzly Bears.

2.4.2 Biogeoclimatic Ecosystem Classification

Ecosystem studies carried out by Vladimir J. Krajina and his students at the University of British Columbia from 1950-1970 resulted in the development of the BEC system (Krajina 1965 and 1972). Further development and implementation of the BEC system by the BC Ministries of Forests and Environment has resulted in a provincial ecological land classification and mapping system (RIC 1998). BEC is a hierarchical classification system with three levels of integration: local (vegetation and site classifications), regional (zonal or climatic classification), and chronological (seral progression; Meidinger and MacKinnon 1989).

The classification is being revised as new data are collected in formerly poorly sampled areas. Some of the gaps that are gradually being filled include non-forested ecosystems (e.g., wetlands, grasslands and alpine areas), forested ecosystems in remote areas with little forest harvesting (e.g., northwestern part of the province), and young seral ecosystems (Ministry of Forests, Lands and Natural Resource Operations 2014).

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., sub-regional 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). Linking Grizzly habitat value to the BEC system enables: 1) effective communication through application of broadly applied mapping and classification and nomenclature; 2) grouping or splitting ecosystems according to conservation or management requirement at multiple scales and resolutions; and 3) examination of habitat suitability through time, such as during the succession of forested ecosystems from recent disturbance to old growth.

The Biogeoclimatic subzones and variants that were rated for Grizzly Bears are included within the following BGC zones: Boreal Altai Fescue Alpine (BAFA), Bunchgrass (BG), Boreal White and
Black Spruce (BWBS), Coastal Douglas Fir (CDF), Coastal Mountain-heather Alpine (CMA), Coastal Western Hemlock (CWH), Engelmann Spruce – Subalpine Fir (ESSF), Interior Cedar-Hemlock (ICH), Interior Douglas-fir (IDF), Interior Mountain-heather Alpine (IMA), Mountain Hemlock (MH), Montane Spruce (MS), Ponderosa Pine (PP), Sub-Boreal Pine – Spruce (SBPS), Sub-boreal Spruce (SBS), and Spruce – Willow – Birch (SWB).

2.4.3 Broad Ecosystem Inventory

A classification system based on broad terrestrial ecosystems, called Broad Ecosystem Inventory (BEI)\(^8\) was developed for the regional wildlife and habitat plans that were underway in the late 1980s (Ecosystems Working Group 1998). Between 1998 and 2000 additional 1:250,000 map sheets were completed for the province.

The BEI was designed to be mapped at 1:250,000 using three main attributes: physical, such as slope and aspect; temporal conditions (seral stages of forest types); and physiognomic plant associations (climax vegetation plus associated seral stages).

Broad Ecosystem Units (BEUs) can be thought of as physiognomic and vegetative subunits of BEC Variants, with an attempt to identify the important distinctions among forests and non-forests and coarsely-defined terrain, land cover types and ecosystems. BEUs also establish a current seral stage for the forested (successional) units, and distinguish those forests as broadleaf or conifer-dominated. BEUs can also be described as groups of BEC Site Series.

3.0 Methods

Our habitat interpretation process followed the provincial RISC standard Wildlife Habitat Rating methods, which is an expert opinion, subjective approach. The only life requisite considered for this project was “Food” in the “Active” season:

- The seasonal delineation used was mid-April to mid-October, but actually varies by the time of year, elevation, and latitude;
- The life requisite rated was “Food” but only the plant food component of Grizzly diet was considered (animal protein, such as salmon, wild ungulates and rodents were considered but after examination of the available data, the animal protein contribution to the diets of Grizzly Bears was dropped);
- Grizzly Bear food plant species distribution and abundance information provided in the BEI standards manual (Ecosystems Working Group 1998) was consulted for the BEI ratings.

\(^8\)The official name of this dataset according to the published standards manual is “Broad Terrestrial Ecosystem Classification” (Ecosystems Working Group 1998), but is more commonly known as “Broad Ecosystem Inventory” (BEI) as referred to in this report.
3.1 Multi-Scale Approach

Grizzly Bears concurrently use (and appear to select) habitats at multiple scales and resolutions: for preferred food plants associated with specific microsites, for specific microsites within associated stands, and for specific stands within broader ecosystems. Collectively, that pattern of use describes their seasonal and annual home ranges within broader ecologies and geographies. Alternatively, some studies suggest Grizzly Bears select their home ranges first, then choosing stands and (third order) microsites within those stands that have requisite plant foods available on a seasonal basis. Regardless, as a result, a system of habitat classification chosen to describe, conserve and manage BC Grizzly Bear habitat should be hierarchical across scales and resolutions and able to incorporate succession through time. The combined Ecoregion and BEC systems do just that.

BEI is the largest scale that provides complete ecosystem spatial coverage for the entire province (resolved only to 1:250,000); therefore it was the logical choice to use the Wildlife Habitat Rating method for a wide-ranging species like Grizzly Bears. While the mapped units are much more generalized than those for TEM, BEI is important for looking at larger landscapes including sub-regional, regional and provincial levels. Although the successional information presented in BEI is at a coarse level, it enables an approximation of how Grizzly Bear habitat suitability changes after disturbance.

There are other ecosystem interpretations for Grizzly Bears available at 1:20,000 using either Terrestrial Ecosystem Mapping (TEM) or Predictive Ecosystem Mapping (PEM). A compilation of many of those projects has been assembled, but additional work is needed to compare the interpretations there were generated in those projects across the province, as well as to address inconsistencies and gaps in the compiled ratings dataset. As mentioned, users of PEM-derived grizzly habitat suitability maps should be cautious, particularly when dealing with seasonally important non-forested habitats like estuaries, wetlands, avalanche chutes and sub-alpine or alpine meadows.

3.2 Grizzly Bear Habitat Rating Products

Two products were created:

1. **Ecosections combined with BEC** were rated to the variant/phase level for habitat capability; and  
2. **Ecosections, BEC, and the Broad Ecosystem Inventory** classifications were rated for both habitat capability and suitability.

Ratings classes 1-3 were summarized within the Ecoregion classification and by habitat type to show patterns in the distribution of the higher value units (Appendix 2). The specific ratings for both products are included with the spatial files associated with this report. The provincial 6-class rating scheme was used for both Ecosections/BEC and BEI versions (RIC 1999).

3.3 Provincial Benchmarks
Benchmark ecosystems are reference units against which other habitats can be compared for their ability to produce major Grizzly Bear food plants. Benchmarks were originally meant to represent habitats capable of producing the highest densities of Grizzly Bears in the province. Although that is no longer the case, the following benchmarks were chosen to facilitate habitat comparisons within three dominant climatic regimes (interior, coastal and northern - Figure 7). Again, the “Food” life requisite was rated for only for the “Active” season.
**Interior Benchmark**

<table>
<thead>
<tr>
<th>Ecoregion:</th>
<th>Flathead Valley (FLV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogeoclimatic Zone:</td>
<td>Engelmann Spruce – Subalpine Fir (ESSF)</td>
</tr>
<tr>
<td>Biogeoclimatic Subzone(s)/Variant:</td>
<td>Elk dry cool (dk1)</td>
</tr>
<tr>
<td>Habitats (BEUs):</td>
<td>Engelmann Spruce - Sub-alpine Fir Dry Forested (EF)</td>
</tr>
<tr>
<td>Site Modifier:</td>
<td>None</td>
</tr>
<tr>
<td>Stand Structure:</td>
<td>Seral stage 1</td>
</tr>
</tbody>
</table>

This is designated as the Interior Benchmark because of the amount of research demonstrating the importance of the ESSFdk1 to the Flathead Grizzly Bear population – older burns that produced extensive berry fields of black huckleberry (*Vaccinium membranaceum*) (McLellan 2015). The group of site series that form the EF Broad Ecosystem Unit includes the most productive black huckleberry producers in BC.

*Figure 1 - Example of the Flathead Valley Ecoregion ESSFdk1 landscape*

*Figure 2 - Example of the Engelmann Spruce - Sub-alpine Fir habitat type*
**Coastal Benchmark**

Ecosection: Kimsquit Mountains (KIM)

Biogeoclimatic Zone: Coastal Western Hemlock (CWH)

Biogeoclimatic Subzone(s)/Variant: Central moist sub-maritime (ms2)

Habitats (BEUs): Sitka Spruce – Black Cottonwood Riparian (SR)

Site Modifier: None

Stand Structure: Seral Stage 6

This is designated as the Coastal Benchmark because the Kimsquit study (Hamilton 1987, and Hamilton and Bunnell 1987) highlighted the importance of the CWHms2 including its extensive floodplains, estuaries, avalanche chute run-outs and fans, skunk cabbage swamps, and forested and non-forested wetlands. The Floodplain SR Broad Ecosystem Unit includes the 3 floodplain high, mid and low “benches” commonly found along major rivers in the CWH and the blue-listed Sitka Spruce Devil’s Club site series. The SR offers Grizzly feeding opportunities in multiple seasons across structural stages from herb/shrub units to old-growth forests (Fig 3).

![Figure 3 - Example of the Kimsquit Mountains Ecosection, CWHms2 landscape](image1)

![Figure 4 - Example of the Sitka Spruce – Black Cottonwood Riparian habitat type](image2)
BC Grizzly Bear Habitat Classification and Rating

**Northern Benchmark**

<table>
<thead>
<tr>
<th>Ecosection:</th>
<th>Muskwa Foothills (MUF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogeoclimatic Zone:</td>
<td>Boreal White and Black Spruce (BWBS)</td>
</tr>
<tr>
<td>Biogeoclimatic Subzone(s)/Variant:</td>
<td>Fort Nelson moist warm (mw2)</td>
</tr>
<tr>
<td>Habitats (BEUs):</td>
<td>Boreal White Spruce - Trembling Aspen (BA)</td>
</tr>
<tr>
<td>Site Modifier:</td>
<td>None</td>
</tr>
<tr>
<td>Stand Structure:</td>
<td>Seral Stage 1</td>
</tr>
</tbody>
</table>

South-facing slopes in the Muskwa Foothills Ecosection, BWBSmw2, Boreal White Spruce - Trembling Aspen (BA) Broad Ecosystem Unit, seral stage 1, are designated as the Northern Benchmark because they offer several seasonally-preferred Grizzly Bear foods. Grizzly Bears can graze on a variety of grasses and herbs in the spring; and soopalallie (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*), and highbush-cranberry (*Viburnum edule*) in the fall.

![Figure 5 - Example of the Muskwa Foothills Ecosection, BWBSmw2 landscape.](image1)

![Figure 6 - Example of the Boreal White Spruce - Trembling Aspen habitat type.](image2)
3.4 Ratings Assumptions

The concepts of land use capability and suitability were defined by Hills et al. (1970) and applied across Canada under the Canada Land Inventory (Rowe 1978). The system has been used by the BC Ministry of Environment for rating wildlife habitat since the mid-1960's (Demarchi et al. 1983, Fuhr and Demarchi 1990), Resources Inventory Committee (RIC) 1999, Bonner and Demarchi 2000, and Demarchi et al. 2000.
For this report, the following definitions were applied:

- **Habitat capability** is the inherent, idealized ability of the land to support Grizzly Bears. Different ecological units are rated by capability based on their relative vegetative forage productivity independent of the current structural stage of forested habitats or proximate human influence.

- **Habitat suitability** is a rating of the land’s current ability to support Grizzly Bears when current structural stage has been accounted for (also without human influence).

The basic principles of the rating approach applied here can be expressed in a simple grid (Figure 8). The best Grizzly Bear habitat potential in BC occurs in areas with wet climates and high relief. Conversely the poorest habitat potential occurs in areas with the driest climates and lowest relief.

<table>
<thead>
<tr>
<th>Precipitation Regime</th>
<th>Topographic Relief</th>
<th>Valley – Flat</th>
<th>Plateau – Rolling</th>
<th>Hilly – Undulating</th>
<th>Mountainous – Gentle</th>
<th>Mountainous – Rugged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Very Low</td>
<td>Very Low</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Mesic</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Moist</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Very High</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Wet</td>
<td>Very Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8 - Topographic relief and precipitation regime - a matrix illustrating the trend in Grizzly Bear habitat ratings moving from dry to wet habitats and from low to high relief.

Other assumptions made when rating the ecosystems for Grizzly Bears in this project were:

- Some BEI habitat types were too small to be rated due to the coarseness of 1:250,000 mapping scale (e.g., open forests versus dense forests within the Douglas-fir, ponderosa pine, or Douglas-fir/ponderosa pine forest units; or narrow riparian forests along lake and river shores). Special consideration was given to units which are difficult to detect at this scale, including a more detailed interpretation of known associated ecosystems, which were noted in the rationale.

- The ratings were not delineated by season – ratings reflect all foraging seasons.

- As ecosystem diversity increases so does habitat quality for Grizzly Bears.

Gentle, south-facing slopes with high berry production are amongst the best Grizzly habitats in the province and as such, were frequently used as references for rating other ecosystems. Units with huckleberry species such as black huckleberry (*Vaccinium membranaceum*) and other
Vaccinium species, soopalallie (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*), and highbush-cranberry (*Viburnum edule*) were identified and considered more during the rating process. Extensive floodplains, estuaries, riparian areas, avalanche chute run-outs and fans, and forested and non-forested wetlands were also often rated high or very high based on provincial lists of preferred Grizzly Bear plant foods and ecosystem descriptions. The vegetation descriptions in the Broad Terrestrial Ecosystem Classification and Mapping manual (*Ecosystems Working Group* 2000) and the applicable Field Manuals for Describing Terrestrial Ecosystems were invaluable for determining the habitat ratings specifically, the plant species abundance by site series charts.

### 3.5 Map Scale

Habitat attributes were derived from 1:250,000 Ecoregion, BEC, and BEI mapping.

#### 3.5.1 Map Production

The creation of the look-up table was the first of several steps that lead to the production of the two maps. A simple summary program was run on the map databases to create a ratings table template consisting of a single row for every unique ecosystem combination, with columns for its overall land area, and its frequency of occurrence. Each rated unit was linked back to the digital map database for presentation (Figure 9).

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9 There are several regional field guides provided by the Biogeoclimatic Ecosystem Classification Program that are available either from Crown Publications or from the following website: [https://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/regional/index.html](https://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/regional/index.html) [last accessed, April 6, 2016].
Because BEI polygons can contain either one or two ecosystem components, this causes the dilemma of how to present multiple ecosystem values in a single map display. There are 3 basic ways to display multiple habitat ratings on a map that has composite polygons:

1. **Highest Value** - the ecosystem component with the highest rating is used to rate the entire polygon, irrespective of its proportion within the polygon. This method over-represents habitat potential, but it does provide a meaningful display of the distribution of high value habitats. This approach also accounts for bears that meet their needs by exploiting many small but highly suitable sites. The highest value ecosystems are commonly those with the lowest proportions and land areas in composite polygons.

2. **Weighted Average** - each component is assigned an individual rating and weighted for its proportion. Derived values are averaged for the polygon. This method gives a meaningful overview map of habitat potential for a species, but de-emphasizes valuable habitats that occur within polygons that also have components with low value.

3. **Maximum Area** - the rating for the ecosystem component that accounts for the largest area of the polygon is applied to the entire polygon. This method is useful for illustrating what most of the polygon consists of, but does not represent high value habitat if it occupies only a small portion of the polygon.
These map presentation methods do not affect data analyses or land-area-by-class summary tables or graphics. Each composite polygon in BEI contains a decile or proportion estimate for each member ecosystem component. It is simple programming to use that proportion of the total polygon area to assign the right land area to habitat rating class assigned to it. Weighted average and Maximum Area maps should be accompanied by such summaries.

4.0 Results and Discussion

There are two fundamental ways to describe influences on Grizzly Bear population health: the first, a top-down approach, begins by estimating population size. Inventories that first lead to current estimates of the numbers of bears can be modified to enable longer-term identification and evaluation of ultimate or proximate limiting factors through multi-year research and monitoring programs. Single-year inventories do not provide adequate assessment of changes from historical populations (typically due to changes in estimation techniques), nor do they enable estimates of future numbers of bears. Multi-year programs are difficult to extrapolate from and are expensive. Regardless, when limiting factors are identified, Grizzly Bear habitat and population objectives can be met through conservation and management designed specifically to increase or decrease the influence of those factors on population abundance, distribution and trend.

The second, a bottom-up approach, can start with examination of Grizzly Bear plant food availability at multiple spatial scales as reported here. The Provincial Ecosystem Classification provided a basis for extrapolation by classifying ecological gradients spatially and temporally within a commonly applied ecological land classification designed to improve land stewardship. Ecosystem interpretation for Grizzly Bears at these larger scales provided an opportunity to examine current habitat availability and consider future habitat availability from successional changes and climate change adaptation. Although speculative, these interpretations of habitat quality also enabled an evaluation of the historic potential and habitat conditions in areas of BC no longer occupied by Grizzly Bears.

The ratings logic and rationale for both map products are documented in the accompanying ratings tables.

4.1 Product 1: Ecosections and Biogeoclimatic Ecosystem Classification

Earlier in this project, there was an attempt to include animal protein (salmon, wild ungulates and rodents) as part of bottom-up food availability for Grizzly Bears, but there were large gaps in the data, and most of the information was not comparable to the mid-scale ecosystem mapping that was available for the plant food component. Even though salmon spawning areas have been mapped, the spawning areas are localized to particular stream reaches and their spatial attraction and population influence is largely unknown. The fundamental relationships among various Grizzly Bear food categories and population density and trend remain speculative (Mowat and Heard 2006, McLellan 2011), although an initial look at the influence of salmon availability through stable isotope analyses has been conducted (Adams et al. 2017).
A summary of the 11,308 Ecosection/BEC polygons occupied by Grizzly Bears in BC resulted in 1,125 unique combinations of units. The following 3 graphs, generated from the Capability map database, illustrate trends in the Ecosection/BEC habitat capability ratings and are summarized by Ecosection.

Habitat ratings deliberately vary between Ecosections with different topographic relief (Figure 10). Examination of four Ecosections that cross the central interior of the province (from west to east) suggests that as the land becomes more complex topographically, the habitat becomes more diverse and there is a greater range of Grizzly Bear habitat potential. Ratings increase from the lower elevation (flat to rolling) Cariboo Basin to the more complex terrain in the low plateau of the Cariboo Plateau, increase again in the higher hills and mountains of the North Shuswap Highlands and finally result in greater area of Class 1 and 2 capability assignments in the high rugged mountains and narrow valleys of the Northern Kootenay Mountains. An increase in the amount of low quality habitats also results from greater topographic and ecosystem complexity. For example, although there is a large amount of Class 6 habitat in the Northern Kootenay Mountains (NKM) Ecosection, due to the presence of the rock and ice in the Interior Mountain Alpine (IMA) zone, the other BEC Units in the NKM rated as very high for Grizzly Bears raise the overall capability.

Figure 10 - Variability by Topographic Relief: Percentage of Ecosection and BEC Capability Rating. This cross-section of the interior of the province represents increasing topographic complexity which results in an increase in climatic variability.
Similar rating trends in the BC Interior occur across Ecossections with different precipitation regimes. The influence of precipitation on the assigned capability ratings is apparent in a comparison of roughly the same landforms and physiography across the dry Thompson Basin, the moderate Cariboo Plateau and the wetter Bowron Valley (Figure 11). The driest units were assigned the lowest values because the food production was assumed to be very seasonal and limited to just a few species in the late spring period.

![Figure 11 - Variability by Precipitation Regime: Proportion of Ecossection and BEC Variant Capability Ratings, in three areas of the interior of the province that have similar landforms but different moisture regimes. These three areas are representative of much of the low elevation areas in the interior of the province.](image)

Greater diversity of opportunity is reflected in higher capability ratings across three different Ecossections in the Kootenay Region (Figure 12). For example, the East Kootenay Trench Ecossection, a relatively level basin, has six different BGC zone, subzone, and variant combinations, the Elk Valley Ecossection, a wide basin surrounded by steep mountains, has 14, and the Northern Kootenay Mountains Ecossection, a rugged mountainous area with narrow river valleys has 21. That increase in Biogeoclimatic units is caused by an increase in landform complexity with a corresponding increase in the number of zonal climate regimes.
Habitat capability ratings were assigned to all lands currently occupied as well as those currently unoccupied by Grizzly Bears and the map was examined for patterns. Although approximately 22% of BC’s historically occupied area appears to have had no seasonal Grizzly Bear plant food, 50% of the province may have had moderate to very high Grizzly Bear habitat capability (Class 1=4% + Class 2=29% + Class 3=17% = 50%) (Figure 13).
4.2 Product 2: Ecossections, Biogeoclimatic Ecosystem Classification, and Broad Ecosystem Inventory

A summary of the 59,032 broad ecosystem polygons occupied by Grizzly Bears in BC resulted in 25,968 combinations of units (Ecosection/BEC/BEU/modifier/seral stage) that were rated for their habitat capability and suitability.

The spatial and temporal availability of berry-producing habitats can be critically important for sustaining BC Grizzly Bear populations from the bottom-up (McLellan 2015, Proctor et al. 2017). The accuracy of the BEI product (product 2) is limited by the coarse generalization of the age/seral stage information. Better structural stage and canopy closure delineation is available through a combination of Vegetation Resource Inventory (VRI) and TEM.

Early seral mesic forests were ranked as significant berry producers in the province (Figure 14) with the units in the ESSF BGC zone ranked as the highest. A comparison of Grizzly Bear habitat ratings of zonal (mesic) habitat units illustrates that values assigned to recent disturbance (seral stage 1) are significantly different across six mountainous BGC Zones. Early seral mesic habitats in the wetter mountainous zones (CWH, ICH and ESSF) were rated higher than the drier SBS, MS and SBPS Zones (Figure 14).

Repeated investigation of berry production in BC has indicated that south-facing habitats are more likely to produce berry crops (e.g. Proctor 2017). A comparison of ratings assigned to different aspects within the Engelmann Spruce – Sub-alpine Fir Dry Forested Broad Ecosystem
Unit (EF) illustrates how moderately warm southerly aspects were assigned the highest potential habitat value and the steep, warm and cool, northerly aspects the lowest (Figure 15).

![Habitat Classification and Rating](image)

**Figure 15 - Variation of habitat ratings due to aspect in Engelmann Spruce -Sub-alpine Fir Dry Forested Broad Ecosystem units.**

In many of British Columbia's forests, berry and other understory production is limited by canopy closure. Berry and spring forage productivity declines as stands mature and canopies begin to close. A comparison of ratings assigned to four coniferous seral stages of the Engelmann Spruce -Sub-alpine Fir Dry Forested Broad Ecosystem (EF) unit indicates a typical pattern (Figure 16). The open canopy, (early) seral stage one was ranked as the highest habitat potential, reflecting the presence of berry producing shrubs and succulent herbaceous vegetation. Climax and old growth forests (seral stage six), with their relatively open canopies have a moderate ability to support Grizzly Bear forage, while the dense canopies of seral stages two and four (young and maturing forests) have low potential to support Grizzly Bears (Figure 16).
5.0 Recommendations

5.1 Habitat Identification and Classification

Successful conservation and management of Grizzly Bears in British Columbia is complicated by the diversity of ecosystems they live in. In addition, objectives for Grizzly Bears should be specific to populations, sub-populations/breeding units, and at times even individual bears - particularly in Threatened populations. Habitat quality evaluation and reporting is likewise complicated by multiple spatial scales and resolutions. This report, and the maps that accompany it, provide information about Grizzly Bear habitat capability and suitability only at a coarse scale, limiting this work only to strategic, regional or provincial applications and decision-making. Users are again reminded that these maps are based only on subjective evaluations of plant food availability. Many other factors influence Grizzly habitat capability, suitability and effectiveness. Local empirical information should always be applied either in support or to replace these products.

There are a number of recommendations that follow from this work:

- Grizzly Bear habitat evaluation across BC should continue using the multi-scale, hierarchical approach applied in this report. Habitat ratings using the full hierarchical classification - from regional ecosystems (Ecosections) to Biogeoclimatic site series and structural stages should be employed wherever possible. The ratings tables applied here should be revised.
and linked to any Ecosetion, BEC unit or BEI map or map database updates as they become available.

- Grizzly Bear researchers – particularly those that are capturing and radio-collaring bears – are encouraged to help fill current gaps in food habits, movement patterns, and use of ecosystems by season. Researchers should also consider enhancing the understanding of Grizzly Bear diet – habitat relationships through further diet or stable isotope analyses (e.g. Adams et al. 2017).

- Practitioners should also ensure that high value ratings at smaller map scales are reflected in larger scales for the same locations, with one exception. Larger scale maps may identify valuable habitats masked by the coarse resolution of the smaller scales maps for the same area. For example, many wetland units are small and difficult to delineate at a 1:250,000 map scale, but can be delineated more precisely at 1:5,000 or even 1:20,000.

- Larger scale habitat suitability and capability should be evaluated to assign the appropriate habitat class and that habitat’s location. That is, rating decisions should be made in the context of the suite of habitats available to bears in the area. A typical approach is to use known or hypothetical adult female home ranges for the Ecoregion to define a Regional Study Area (RSA) around a project’s footprint or Local Study Area (LSA). Equivalent scale and quality mapping should be produced for the entire RSA, not just the LSA. The size of the RSA corresponds to the hypothetical extent of all adult female home ranges that overlap the LSA. If this approach is applied, the loss, alteration or alienation of any seasonally valuable habitats in the LSA can then be evaluated in their appropriate home range context. Questions like: “are there seasonally equivalent habitats available in these home ranges” can then be addressed in order to design appropriate mitigation, compensation, and/or monitoring.

- Larger scale maps should always be evaluated on a seasonal basis in recognition of changing Grizzly Bear plant food phenology and associated movement patterns. Research to-date has not established a clear relationship between ecological classification and denning; probably because den site selection is mostly driven by site-level characteristics such as aspect and soil-parent material. Grizzly Bear ratings should continue to be assigned for the active seasons only.

- The draft compilation of existing large scale (1:20,000) Grizzly habitat mapping our team has begun should be completed. Each project’s maps, ratings tables and species accounts should be assembled, assessed for their quality and consistency, and either archived or made accessible via a map of maps in an interactive GIS interface. Eventually, master season-specific ratings tables for the full suite of Ecosetion /BEC unit/ site series / structural stage combinations in BC should be assembled, peer reviewed, and published.

- Grizzly habitat evaluations and maps from Predictive Ecosystem Mapping (PEM) should be archived. Evaluation of PEM products using radio-collared bears has repeatedly demonstrated that PEM, because of its reliance on Vegetation Resource Inventory (VRI) and its emphasis on forests, does not adequately represent highly suitable non-forested
habitats. This may not be true for all PEMs, so it is important to note the limitations of this information and verify the appropriate ecosystem units through adequate field sampling.

- For BEI and TEM, mapped polygons may be composed of more than one habitat unit, therefore, an appropriate data presentation method should be considered: weighted average, highest value, or maximum area, as described in Section 3.5. Choice of the presentation method should be done carefully, as it may affect subsequent interpretation of the map. Irrespective of presentation method, area summaries by capability or suitability class should reflect the unit’s proportions as chosen by the mapper.

- Habitat classification work in the future, irrespective of scale, should be kept up to date with remote sensing for change detection (and for accommodating climate change). New methods include LIDAR (Light Detection and Ranging), phenological monitoring, and automated change detection. It is also worth mentioning that the ecosystem base data that was used in this project is in vector format, which was common at the time it was created. Although it is impressive and beneficial to have a vector dataset covering the entire province, it is difficult to update. A raster format is much more common currently because of its processing speed; it can easily be combined with multiple themes and is more readily updated. It may be possible to integrate the long history and value of the existing ecological land classification and its interpretation for wildlife and some of the new approaches from remote sensing and other more recent approaches. Field verification of assigned suitability and capability classes will always improve the utility and application of any new approaches.

- Ongoing work designed to improve the BEC classification (e.g. MacKenzie and Meidinger 2017), for non-forested and successional ecosystems at the site series level will improve the quality of Grizzly Bear habitat interpretations.

- Finally, it may be possible to develop an empirically-based estimator of current Grizzly Bear carrying capacity based on both the bottom-up habitat factors and the top down influences of human caused mortality. Further refinement and improved accuracy and precision of Grizzly Bear habitat maps will be the basis of the bottom-up part of that work (see Proctor et al. 2017).
6.0 References


BC Grizzly Bear Habitat Classification and Rating


BC Grizzly Bear Habitat Classification and Rating


Proctor, M.F., C.T. Lamb, and A.G. MacHutchon. 2017. The grizzly dance of berries and bullets:
The relationship between bottom up food resources, huckleberries, and top down mortality risk on grizzly bear population processes in southeast British Columbia. Trans-border Grizzly bear project. Kaslo, BC.


Rowe, J.S. 1978. Revised working paper on methodology philosophy of ecological land classification in Canada. Ecological Classification Series Number 7; Ottawa.


Appendix 1- Input Ecosystem Data Evaluation

The base ecological mapping has been modified over the years, which has affected how the two products relate to each other. The following table identifies changes to the input data for the different versions.

**Table 2 - Decisions for resolving ecosystem base mapping issues.**

<table>
<thead>
<tr>
<th>Product</th>
<th>Situation</th>
<th>Solutions</th>
</tr>
</thead>
</table>
| BEI     | The only version of BEI data is from 2000. | • The BEI dataset was archived in 2000 and has not been updated since.  
• The 2000 version of Ecosections and BEC was also used in order to make the polygons match. |
| BEI     | The seral stages mapped for the 2000 version of the BEI dataset came from forest cover mapping and LANDSAT imagery from the early 1990s. | • No solution; updated seral information for BEI was not available. |
| BEI     | Certain BEI units such as wetlands, smaller avalanche chutes, riparian, were not mapped as extensively as they are on the landscape, this is due either to the fact that those units are small and are difficult to identify at 1:250,000; or they are considered non-forested and were not delineated in as much detail as forested units. | • Expertise with either what is actually on the landscape or how those units were delineated in order to effectively rate those habitat units were used and those decisions are documented in the accompanying ratings notes. |
| BEC     | The BEC polygons are periodically updated and the Ecosections have been updated to incorporate those changes. | • The version of Ecosections and BEC that was current when the project was initiated was used - Ecosections v.2010 and Version 7 (2008) of BEC. There have been 2 subsequent versions of BEC, currently Version 9 (2014), but the Grizzly Bear ratings have not been updated to match this version.  
• A newer version of Ecosections and BEC than BEI because there were substantial changes and improvements so the current version was the best option. It did make it more difficult to compare to the BEI but thorough comparisons to the rating products were made in order to be as consistent as possible. |
| Both BEI and BEC | Certain BEC units were not mapped as precisely in some areas as others, such as some of the BWBS, SWB, and AT in the north were not delineated at the same scale of resolution as those in the south. | • In these cases, the zonation classification from the BEI system was used for the northern regions. Those adjustments are described in the accompanying ratings notes. |
### Appendix 2 (page size 11”x17”) – Distribution of Highest Rated Habitats by Ecoprovince.

<table>
<thead>
<tr>
<th>Generalized Elevation</th>
<th>Ecosystem Group</th>
<th>Broad Ecosystem Unit Name</th>
<th>Broad Ecosystem Unit Code</th>
</tr>
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<tbody>
<tr>
<td>sub-alpine</td>
<td>Non-forested Sub-alpine and Alpine</td>
<td>Subalpine Meadow</td>
<td>SM</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Sub-alpine Parkland and Krummholz</td>
<td>Engelmann Spruce - Subalpine Fir Parkland</td>
<td>FP</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Krummholz</td>
<td>Subalpine Fir - Mountain Hemlock Wet Parkland</td>
<td>WP</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Krummholz</td>
<td>Whitebark Pine Subalpine</td>
<td>WB</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Central and Northern Forests</td>
<td>Subalpine Fir - Mountain Hemlock Wet Forested</td>
<td>EW</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Central and Northern Forests</td>
<td>White Spruce - Subalpine Fir</td>
<td>SF</td>
</tr>
<tr>
<td>low</td>
<td>Central and Northern Forests</td>
<td>Boreal White Spruce - Trembling Aspen</td>
<td>BA</td>
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<tr>
<td>mid</td>
<td>Coastal Forests</td>
<td>Amabilis Fir - Western Hemlock</td>
<td>FR</td>
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<tr>
<td>low</td>
<td>Coastal Forests</td>
<td>Coastal Western Hemlock - Douglas-fir</td>
<td>CW</td>
</tr>
<tr>
<td>low</td>
<td>Coastal Forests</td>
<td>Coastal Western Hemlock - Western Redcedar</td>
<td>CH</td>
</tr>
<tr>
<td>sub-alpine</td>
<td>Southern Interior Forests</td>
<td>Engelmann Spruce - Sub-alpine Fir Dry Forested</td>
<td>EF</td>
</tr>
<tr>
<td>low - dry</td>
<td>Southern Interior Forests</td>
<td>Ponderosa Pine</td>
<td>PP</td>
</tr>
<tr>
<td>mid</td>
<td>Forested Wetlands and Riparian</td>
<td>Engelmann Spruce Riparian</td>
<td>ER</td>
</tr>
<tr>
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<td>Hybrid White Spruce - Black Cottonwood Riparian</td>
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<tr>
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<td>Forested Wetlands and Riparian</td>
<td>Sitka Spruce - Black Cottonwood Riparian</td>
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<tr>
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<td>Western Redcedar - Black Cottonwood Riparian</td>
<td>RR</td>
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<tr>
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<td>Non-forested Aquatic and Wetlands</td>
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<tr>
<td>low</td>
<td>Non-forested Aquatic and Wetlands</td>
<td>Estuary</td>
<td>ES</td>
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<td>mid</td>
<td>Shrub and Herb Dominated</td>
<td>Avalanche Track</td>
<td>AV</td>
</tr>
<tr>
<td>low - dry</td>
<td>Shrub and Herb Dominated</td>
<td>Big Sagebrush Shrub / Grassland</td>
<td>SS</td>
</tr>
<tr>
<td>low - dry</td>
<td>Shrub and Herb Dominated</td>
<td>Bunchgrass Grassland</td>
<td>BS</td>
</tr>
</tbody>
</table>

- **SM** - Boreal Mountains
- **FR** - Taiga Plains
- **FR** - Boreal Plains
- **FR** - Sub-boreal Interior
- **FR** - Central Interior
- **FR** - Georgia Depression
- **FR** - Coast and Mountains
- **FR** - Southern Interior
- **FR** - Southern Interior Mountains

### Notes

- **Benchmark habitats**

- **The best habitats** are, i.e. anywhere there is Class 1 habitat and in some cases Class 2 if that’s the highest rating for that particular Ecoprovince.