Interim Assessment Protocol for Grizzly Bear in British Columbia

OCTOBER 2020

VERSION 1.2

Standards for Assessing the Condition of Grizzly Bear Populations and Habitat under British Columbia's Cumulative Effects Framework

PREPARED BY: Provincial Grizzly Bear Technical Working Group – Ministry of Environment and Climate Change Strategy & Ministry of Forests, Lands, Natural Resource Operations and Rural Development

British Columbia

CEF Cumulative Effects Framework

Disclaimer

The Interim Assessment Protocol (the Protocol) provides an initial standard method for assessing the current condition of the value selected for cumulative effects assessment across the Province of British Columbia. The Protocol is designed to use a multi-scaled approach to depict data at a broader (provincial) scale and to allow for refinements in data at a finer (regional) scale.

The assessment results based on this Protocol indicate the modelled condition of the value derived from Geographic Information System (GIS) analysis. Results are intended to inform strategic and tactical decision making, and may also provide relevant context for operational decision making. Engaging local value experts to identify additional regional scale information – if applicable – and to support interpretation and application of results is encouraged.

The Protocol outlined in this document is subject to a) periodic review to support continuous improvement and b) regionally specific modifications, consistent with criteria for enabling regional variability. Where regional modifications are approved, they will be documented in this protocol, and become the standard for assessment in that area. If applicable, regional modifications are listed in the appendices of this document.

Document Control

Version	Date	Comments
1.0	Jan 2017	• Interim Approved by NRS ADMs
1.1	Dec 2017	• Minor Copy Edit
1.2	Oct 2020	• Updates to the Population Status and Mortality indicators • Inclusion of climate change considerations for Grizzly bear

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Table of Contents

1 Introduction

Grizzly bear populations, habitats and movements have been well studied in British Columbia[1] (B.C.). There are a variety of assessment approaches at different scales and for a variety of land and wildlife management decisions that have been developed. There remains, however, uncertainty in their current state relative to historic occupancy, and strategic and operational management objectives are often lacking.

This protocol enables a provincially consistent assessment approach for understanding the current state of, and risks to grizzly bears and their habitats across B.C. The protocol assists in the articulation of conservation and management objectives. However, operational approaches still require regional interpretation. The supporting information and procedures are part of the Province's implementation of the Values Foundation and are intended to support land and resource management decision-making under the Cumulative Effects Framework (CEF) and its associated policy and procedure.

Values are things that the people and government of British Columbia care about.

The protocol is based on the scientific understanding of grizzly bear ecology. It is intended to provide a clear link to management action (practices, regulations, project mitigation, etc.). The protocol considers multiple ecological scales and their relation to context-specific decisions, such as provincial and regional policy implementation, major projects, and strategic resource and allocation decisions (e.g. licensed viewing permits, Timber Supply Review).

The CEF protocol is part of a suite of tools addressing Grizzly bear management, extending from conservation assessment to operational management and monitoring. These include the Federal and Provincial status of the Western Grizzly Bear population; the within Province ranking of conservation concern; and the Province's Grizzly Bear Management Plan. The conservation assessments provide a scientific evaluation of the state of grizzly bears, whereas the CE protocol describes indicators that are more tightly coupled with resource management objectives and practices to address risk to bears. The Grizzly Bear Management Plan enables further regional actions for managing factors that impact bears.

The outlined assessment approach is primarily a strategic, broad scale analysis. It relies on the availability of data covering the full extent of the province. More detailed information may be available at the regional or sub-regional level that can inform finer scale grizzly bear assessments for operational land and resource decision making. The protocol uses existing summaries of grizzly bear status, mortality data and results from spatial modelling.

[1] Province of BC. A Consistent Approach to Describing Values in Natural Resource Assessments: British Columbia's Environmental Values Framework. Available upon request.

1.1 Grizzly Bear Distribution, Ecology and Status

B.C.'s grizzly bear population is estimated to be 14,925 bears, which corresponds, roughly, to a quarter of the North American population, including Alaska (Morgan et al., 2019; Environmental Reporting BC, 2012). Grizzly bears historically occurred throughout B.C., except for some coastal islands, but are considered extirpated from much of southwest and south-central B.C. as well as the Peace Lowlands. The Western Grizzly Bear population, which includes B.C. bears, is listed as a species of 'Special Concern' under the Federal Species at Risk Act (SARA) (Government of Canada, 2011). Under this Act, the grizzly bear's decline to threatened status would necessitate a national recovery plan and would prohibit activities that harm grizzly bears. Sub-populations of the Western Grizzly Bear population are considered by the International Union of the Conservation of Nature (IUCN) for listing.

Grizzly Bear Population Units

B.C.'s grizzly bears exist as a set of interconnected populations, which can be divided into somewhat distinct sub-populations based on bear ecology. For management purposes the province has been divided up into *Grizzly Bear Population Units* (GBPU) which are a mix of bear biology and management need.

Under a 2017 global status review (McLellan et al, 2017), the IUCN has listed 5 isolated populations of Grizzly Bears in B.C. as 'Critically Endangered' (Stein-Nahatlatch, North Cascades, Fountain Valley and Hat Creek), 'Endangered' (Yahk-Yaak) or 'Vulnerable' (South Selkirks) (Environmental Reporting BC, 2012).

The Province of B.C. (the Province) ranks Grizzly Bear Population Units (GBPU) identifying areas of occupancy and their level of conservation concern (Figure 1).

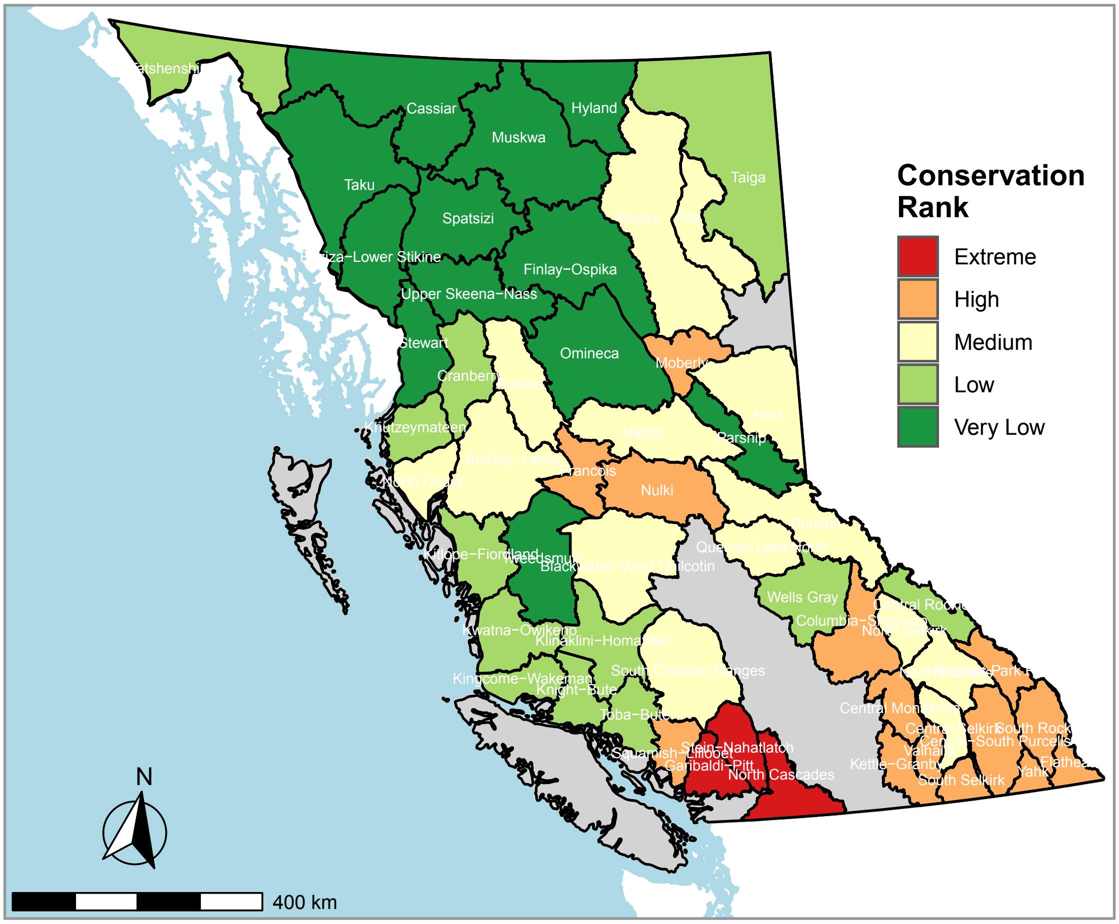

Figure 1. *2019 GBPU Conservation rank with compound ranks, M1 are the units with the highest conservation rank and M5 lowest, grey areas are not currently occupied by grizzly bears.*

Grizzly bears are wide-ranging, opportunistic omnivores with low reproductive and dispersal rates. Average adult female home ranges in B.C. are between 50 and 400 km^2 with smaller home ranges in higher productivity habitats (T. Hamilton, *pers comm*; Ciarnello et al., 2009). Male home ranges are larger, ranging from 500-2,000 km^2 with high variation, and overlapping with several females. A British Columbia Grizzly Bear Species Account summarizes information on grizzly bear biology, ecology and status in B.C. (BC MOECCS, 2019; Mowat et al., 2013).

1.1.1 Conservation threats

Threats to grizzly bears are characterized in the context of ecological risk, where risk to grizzly bears is defined as the probability of ongoing population decline and range reduction. This probability is related to the density of reproductive female grizzly bears (as an indicator of births), mortality and population fragmentation (as an indicator of isolation). When empirical data on grizzly bear vital rates are unavailable, metrics of mortality risk, potential density and fragmentation can be based on landscape condition. For example, when information on female density is lacking (as for some parts of B.C.), habitat availability and forage productivity can be used as a surrogate (Price & Daust, 2019; Daust & Price, 2017; Price & Daust, 2016). The effect of habitat on population viability is less well understood than the effect of landscape security on mortality; however, effective, productive habitat supports higher grizzly bear densities. Habitat and mortality interact; mortality is highest where people and grizzly bears overlap. Climate change impacts grizzly bears through multiple pathways (Daust & Price, 2017), including shifts in habitat and food availability and the potential for increased frequency of negative human/bear encounters. The scientific rationale for each component and associated indicators are discussed in more detail in the knowledge summary (BC MFLNRO & MOE, 2015).

Landscape Units

To assess mortality and habitat at the landscape scale the Province's Landscape Units are used. These units are analogous to the home range size of a female grizzly bear.

Provincial legislation and regulation provides explicit and implicit direction about sustaining grizzly bears and their habitats, including the:

- *B.C. Environmental Assessment Act* (BC EAA)- Major Project approval and environmental sustainability through Project certification requirements;
- *Forest and Range Practices Act* (FRPA)– Forestry and Range approval and conservation area designations, including Wildlife Habitat Areas and Specified Areas under the Identified Wildlife Management Strategy;
- *Land Act* – land use plan orders containing direction specific to grizzly bears; and
- *Wildlife Act* –associated policies and procedure regarding grizzly bear harvest and mortality management including access management.

The Province's Grizzly Bear Conservation Strategy summarizes direction for the management for grizzly bears to *"maintain in perpetuity the diversity and abundance of grizzly bears and the ecosystems on which they depend throughout British Columbia"* and *"to improve the management of grizzly bears and their interactions with humans"* (BC MELP, 1995). The grizzly bear policy summary provides a detailed list of all legal and non-legal objectives.[2]

1.1.2 Describing Grizzly Bears

A variety of different types of diagrams can be used to show important elements and processes in a linked human-ecological systems. Figure 2 is a modified version of a conceptual diagram where all arrows can be read as "influence". Components, functions and processes that describe the value are presented. Also shown are the factors that influence the functions and processes that were used to determine the condition of those components. These factors were assessed, wherever possible, to evaluate the risk from threats to grizzly bears. Also shown are how climate change may influence those factors, however those effects have not yet been spatially assessed but will be considered more explicitly in future versions of the protocol.

[2] Available upon request

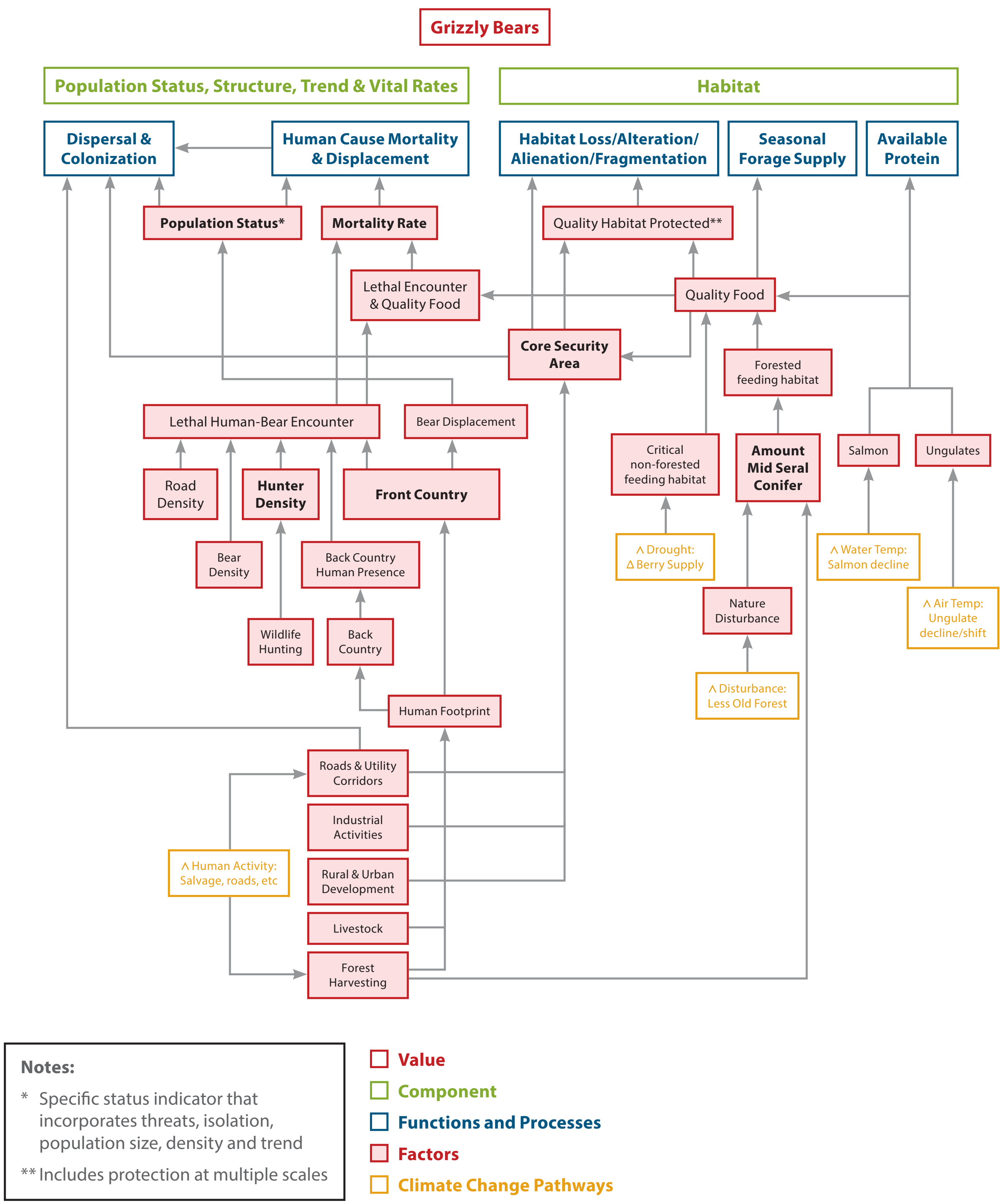

Figure 2. *Grizzly bear influence diagram describing the value's components (green), functions & processes (blue) factors considered to assess the risks from threats to grizzly bears (red) and the pathways of effect resulting from climate change (yellow). The bold boxes represent the core indicators chosen for this assessment. Several supplemental indicators are also assessed: Quality habitat protected, Quality food, Road density, and Bear density.*

1.1.3 Desired Outcomes

Formally endorsed statements about desired outcomes for grizzly bears provide the context for this assessment, including: 1) the distribution and sustainability of current densities of grizzly bears and their habitats; and 2) achieving habitat restoration and recovery where appropriate.

The assessment is structured to evaluate risks to meeting **broad provincial objectives** and component level regionally-**specific objectives**. The protocol can also be used to support meeting finer scale-**specific objectives within subregions**. Based on a review of existing direction for the management of grizzly bears. The following broad objectives are considered for viable GBPUs:

1. Ensure grizzly bear populations are sustainable, including managing for genetic and demographic linkage;
2. Continue to manage lands and resources for the provision of sustainable grizzly bear viewing opportunities; and
3. Where appropriate, restore the productivity, connectivity, abundance and distribution of grizzly bears and their habitats.

Grizzly bear specific objectives will be weighed and balanced against meeting other economic, social and cultural objectives during statutory decision making. One of the key benefits of the CEF will be the identification and transparency of multi-scale objectives for grizzly bears and their habitats before and after land and resource allocation decision making.

The state of grizzly bear populations in B.C. ranges from extirpated, through stressed, to expanding and healthy. The Province manages for more than just population viability. Goals vary from maintenance of occupancy and population stability, resilience and linkage, to objectives for population re-establishment, recovery, and habitat restoration, to ensuring groups of bears are available for commercial or recreational viewing. Management direction for GBPUs will be developed as part of FLNRORD's Provincial Grizzly Bear Management Plan.[3]

Objectives are the desired condition of a value (or component or indicator associated with a value) as defined in legislation, policy, land use plans or agreements with First Nations. Existing objectives are categorized as one of two types:

- **Broad objectives** qualitatively describe the overall desired conditions for a value or component. Typically scientific interpretation is required to identify population and habitat conditions that are consistent with broad objectives and suitable for assessment.
- **Specific objectives** quantitatively describe desired conditions for a value at component or indicator scales. At the indicator scale direct links to management actions can be made. At the component scale a suite of management action may be required to meet the specific component scale objective.

Components, and Functions & Processes

Components are the important structural elements and attributes of the value or its environment that can be assessed to describe its condition.

Functions & Processes are the energetic processes that define the components and can be either supporting (e.g. species dispersal) or disturbing (e.g. mortality) and can be caused by natural events (e.g. berry production) or human events (e.g. lethal human-bear encounters).

Factors

The collection of system elements and processes that can be used to describe functions and processes and the condition of components. Factors are translated into indicators for assessment.

[3] In preparation.

1.1.4 Assessing Risk to Grizzly Bears

Risk statements translate broad objectives to a format suitable for formal risk assessment. A summary of the methods for assessing risk to values is presented in more detail in Morgan et al. 2014.

Briefly, risk is the "probability of failing to achieve societal (broad) objectives for a value". To evaluate broad objectives for grizzly bears, the following **risk statements** were established for the assessment:

1. *Level 1 Risk is the probability of grizzly bear extirpation; and*
2. *Level 2 Risk is the probability of grizzly bear population and range decline.*

Briefly, the assessment considered the following steps:

1. The current status of all factors (ideally all natural, anthropogenic and climate change threats) that affect risk to the value;
2. Describe, with diagrams and text, the pathways by which factors affect the value;
3. Develop indicators for the main factors;
4. Describe the relationship between risk and the indicator level and describe associated uncertainty.

For this iteration of the provincial grizzly bear assessment, evaluating the risk statements is done through an interpretation of the cumulative risk associated with each of the factors considered. Further, each of the indicator risk relationships can be treated as a hypothesis and is informed by existing science and monitoring, and identifies further investigation that could be done to better inform the risk relationships. This version of the assessment focused on steps 1 to 3. Future assessment will refine step 4, the risk assessment. For this application a simple flag approach is used where if a critical reference point, or *benchmark*, is exceeded then the factor is considered to be potentially contributing to risk to meeting the broad objective.

Benchmarks reference points that support interpretation of the condition of an indicator or component. Benchmarks are based on our scientific understanding of a system, and may or may not be defined in policy or legislation.

Assessing Natural Resource Systems in Cumulative Effects Assessment

The ability of British Columbians to derive environmental, social and economic benefits from the land base is dependent on the condition of the natural resource system. The natural resource system is comprised of the ecological system that provides natural resources and the socio-economic system that contribute to the extraction, delivery, and processing of natural resources from which we derive benefits.

Cumulative effects assessment requires consideration of the condition of the components of natural resource systems, and this in turn requires assessment of system function and the influential processes that affect components over time.

2 Protocol Overview

2.1 Overview

The protocol is composed of a set of core indicators, and supplemental indicators and indices that are modeled to capture different aspects of grizzly bear ecology and link to general management actions (Figure 3). Metrics describe the specific aspect of the system being measured. The indicators and indices are chosen to inform a range of resource management decisions. The core indicators are the primary flags for identifying potential sources of risk to grizzly bears. The supplemental indicators and indices are intended to provide more detail and contextual information for informing decisions. A similar diagram is included in Appendix I, but also includes data source and rollup information relevant to the technical assessment.

The protocol is intended to provide a provincial standard for assessing grizzly bears, be repeatable and periodically updated. Further, it is intended to be a reference for regional or sub-regional assessment, however, different data sets can be used depending on availability. Similarly the techniques for generating metrics regionally and sub-regionally may depend on the skills and tools available for a specific application.

The protocol is also intended to highlight areas of concern for grizzly bear conservation. However, in some cases locating industrial activities in highly impacted areas may result in better outcomes for grizzly bears. For example, front country areas may already be somewhat compromised for supporting bears, or may have infrastructure (e.g. gates) and capacity for promoting grizzly bear conservation (e.g. presence of conservation officers) that can mitigate impacts from proposed human activities.

Factors affecting grizzly bears are divided into two components: population and habitat. At the population unit scale (GBPU), indicators are related to grizzly bear population status and mortality rates. At the finer landscape scale (LU), population metrics and indices are related to mortality issues including secure natal areas, quality food sites and human presence, and the density of hunters. The habitat component is considered at the LU and uses forage availability as its indicator, as well as identifying areas of existing habitat protection.

Indicators, Indices & Metrics

Indicators describe the factors of the system that are being measured, such as grizzly bear mortality.

Indices are a collection of indicators (used as contextual information).

Metrics are the specific measurement used (e.g. percent females that have died in a population), and are related to achieving some level of management performance or a specific objective.

Each of the indicators and indices has the following structure:

- **Type** – Core, supplemental or index;
- **Scientific Context** – An overview of the scientific basis for the indicator;
- **Management Context** – An overview of the different management decisions that could be informed by the indicator;
- **Indicator/Model Overview** – A general description of the indicator/model (model methods are presented in appendices), if climate change is a major factor for the indicator, and the specific rationale for the indicator is provided in knowledge summary;
- **Data Sources**;
- **Reporting Strata**;

- **Flags**; and
- **Validation** – Field based projects and existing data sets that were used in the development of the indicator or model. As well, data that can be used to validate model results.

A detailed listing of Indicators and key reference points, data sources and metadata is provided in Appendix II.

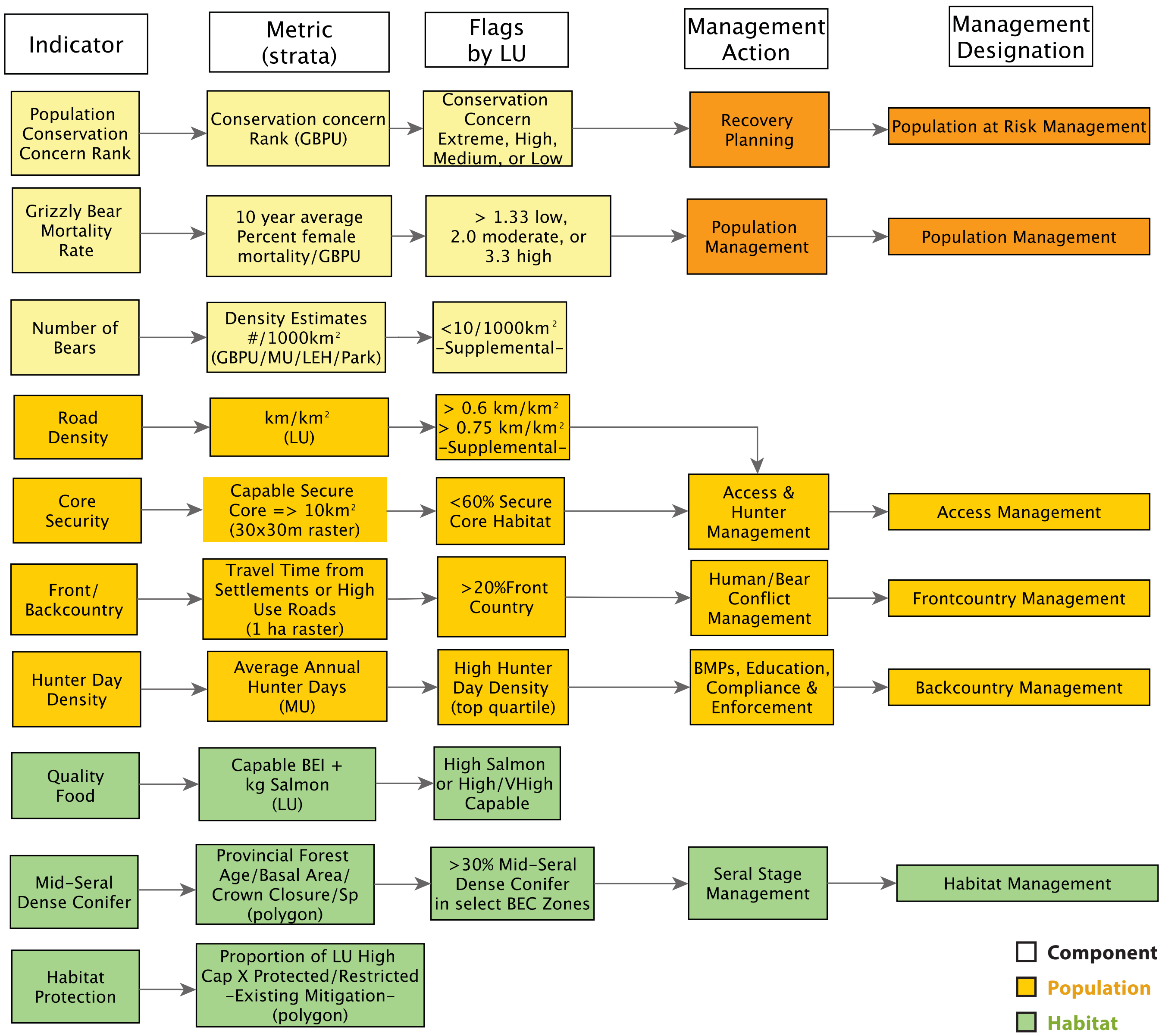

Figure 3. *Flow chart outlining components, indicators, metrics, flags, indexes and management actions. Yellow hued boxes designate population component-related factors and green designates habitat components.*

2.2 Spatial Strata Used in Assessment

Risk to grizzly bears is assessed at two spatial scales: GBPU (sometimes subdivided by Wildlife Management Units (WMU), Limited Entry Hunting (LEH) Zones, and park) and Landscape Units (LU). Assessment results are summarized at the LU polygon level for ease of interpretation and to assist with integrating indicators for presentation.

2.2.1 Grizzly Bear Population Units (GBPUs)

Across much of the province, grizzly bear sub-populations are not isolated units, but form one large population. GBPUs are used for conservation and management, but only a few reflect actual biological populations. Similarly WMU and the LEH Zones are used to capture aspects of bear ecology, and were historically used for managing the hunt. At the GBPU/WMU/LEH scale, assessments characterize risk to the abundance and distribution of grizzly bears within each unit and attempt to reflect regional variation in population management and grizzly bear population ecology.

2.2.2 Landscape Units (LUs)

LUs represent a finer scale and are analogous to the scale of one to several annual female home ranges depending on the size of the landscape unit and quality of the habitat. Habitat and mortality risk indicators can be calculated for each LU and scaled up to allow inference about effects at either a biological population or GBPU/WMU/LEH management scale.

2.3 Spatial Units Used in Assessment

The following spatial units support the assessment of potential risk to grizzly bears.

Area of Grizzly Bear Occupancy

- Assessments are required where grizzly bears are known to occur in B.C. (Figure 1).

Grizzly Bear Population Unit (GBPU)

- Assessments characterize risk to the abundance and distribution of grizzly bears within a population management unit.
- Grizzly bear population units are used for conservation and management, but only a few reflect biological populations.

Wildlife Management Units/Limited Entry Hunt Units

- Grizzly bear abundance is estimated for each occupied WMU in B.C.
- Grizzly bear harvest was commonly set by GBPU/WMU/LEH and varies by region.

Landscape Units

- Habitat, abundance, and mortality indicators are calculated for each LU.
- The distribution of secure and risky LUs allows inference about effects at the GBPU/WMU/LEH scale and could provide insights into risk to biological populations.

Grizzly Bear Forage and Habitats

- The protocol considers information on habitat abundance and productivity:
  - At the provincial scale, multi-season habitat capability is calculated using Broad Ecosystem Inventory maps (BEI), with the exclusion of large water bodies, and ice/glaciers.
  - For finer scale application, the distribution of winter, spring, summer and fall habitats, based on TEM or PEM or the direct mapping of stand level habitats can be considered where available.
  - Availability and accessibility of salmon within LUs and at the stream reach scale where available can be used to identify high value protein sites.
  - Ungulate and small mammal protein is not considered at this time due to lack of a suitable provincial inventory. Ungulate data is however being investigated for future iterations of the Provincial assessment and it is recommended that ungulate biomass be included in finer scale assessments where available.

3 Grizzly Bear Indicators

3.1 Grizzly Bear Population Component

3.1.1 Population Rank – Core Indicator

Scientific Context

BC is part of NatureServe's western hemisphere-wide network of nonprofit conservation programs. NatureServe is dedicated to providing scientific and technical support, and information for species status assessment. Species and ecosystems are assessed using standard criteria[4] including threats. The threats are based on IUCN classification.[5] The values obtained for criteria such as population size, long and short-term trend, genetic isolation and threats are entered into the 'Element Rank Calculator'[6] that was developed by NatureServe to provide a standardized ranking method. NatureServe modified the NatureServe Element Rank Calculator under the guidance of internationally recognized B.C.-based Grizzly Bear biologists Dr. Bruce McLellan and Dr. Michael Proctor to be used to enable the assignment of conservation concern rank to the Province's GBPUs[2].

The Province has applied the modified NatureServe ranking methodology and calculator to assign a conservation management concern rank for each of the Province's GBPUs. Each GBPU is assigned a rank that reflect the GBPU's population size and trend, genetic and demographic isolation, as well as threats to bears and their habitats (M1 to M5; ranked highest to lowest conservation rank). In general terms, categories M4 and M5 replace the previous 'Viable' category and M1-M3 are analogous to the previous 'Threatened' category, where M1 requires the most urgent conservation management focus.

This modified methodology is consistent with the Ministry of Environment and Climate Change's 2015 Guidance for Threats Assessments for Species and Ecosystems at Risk (BC MOE, 2015), and NatureServe's Conservation Status Assessments at the species level. The approach is also aligned with COSEWIC, IUCN, Natureserve and species-level threats analyses used in provincial and national recovery planning processes.

The NatureServe assessment considers a set of IUCN threats; specifically: 1) Residential & Commercial Development; 2) Agriculture & Aquaculture; 3) Energy Production & Mining; 4) Transportation & Service Corridors; 5) Biological Resource Use; 6) Human Intrusions & Disturbance; and 11) Climate Change. Indicators from the CE protocol (human caused mortality, hunter density, and road density) provide inputs to the Province's NatureServe assessment ranking of GBPUs, specifically road density (threat 4), bear mortality, mid seral forest condition and hunter density (threat 5), and front country (threat 6). The CEF protocol habitat protection indicators reflect the effects of threats 1 and 2 but are considered differently than in the NatureServe assessment.

The conservation ranking is a high level summary of overall threats, genetic isolation, trend and population size; whereas the CE protocol provides other specific indicators to make direct linkages to grizzly bear management objectives, practices and actions. The conservation concern ranking provides an effective 'roll up' of the conservation condition of a GBPU. However, it does not provide the direct management linkages that are part of the CE protocol.

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[4] For additional information on the NatureServe Conservation Rank Calculator, visit https://www.natureserve.org/conservation-tools/conservation-rank-calculator and Master et al., 2012.

[5] For additional information, visit http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme

[6] NatureServe. 2015. NatureServe Element Occurrence Viability Calculator Version 1. NatureServe, Arlington, VA.

Management Context	
Decisions related to: • Population recovery planning	
Indicator Description	**Flags**
• Population Rank	• Low or Very Low conservation concern (lower risk) • Extreme, High or Medium (higher risk; flagged)
	Reporting Strata
	• Grizzly Bear Population Unit (GBPU). • LU assigned as Extreme, High, Medium, Low or Very Low conservation concern depending on majority overlap with GBPU. If there is more than one GBPU overlapping then the "riskiest" status is applied.
Data Sources	**Validation**
• Provincial population (GBPU) rank	• Re-evaluation of population ranking using NatureServe methodology as new information becomes available and approved by Provincial Grizzly Bear Management Team.

3.1.2 Grizzly Bear Mortality Rate – Core Indicator

Scientific Context

Humans are the major cause of mortality in most grizzly bear population units and the majority of human-caused mortality occurs near human occupied areas or roads. Bears die at a disproportionate rate when they are close to active roads and people who use the roads are armed. Mortality may occur from mistaken identity (for a black bear), human-bear conflict (self-defence kill, management control kill, landowner defence-of-life and property), illegal kills, or vehicle and rail collisions.

Management Context

Decisions related to:

- Managing grizzly bear mortality. Historically, BC has used a maximum human caused female mortality limit of 1.33-2% with the higher end of that range associated with units verified to have higher recruitment rates. We have set a benchmark at 1.33% female mortality.
- Any relevant land use decision that could impact mortality for grizzly bears, including access, regulating hunters, education, presence of conservation officers, etc.

Indicator Description	Flags
• The percent female mortality of the estimated total GBPU grizzly bear population compared against mortality reference points, averaged over 2008 to 2017.	• The flag is by management unit and is triggered if the per cent female mortality is greater than 1.33%, such that: – 0 to 1.33% is negligible risk; – 1.33 to 2% is moderate-low risk; – 2 to 3.33% is moderate risk – Above 3.33% is high risk. **Reporting Strata** • At a minimum GBPU, but could also be defined at the WMU or LEH and National Park. • Extrapolated to the LU level, where the LU is flagged if the proportion of spatial overlap of the LU with a flagged mortality polygon (i.e. 1.33% mortality or greater) is greater than 10%.
Data Sources	**Validation**
• Provincial population estimates, compulsory inspection data, provincial estimates of unreported mortality.	• TBD

3.1.3 Number of Bears – Supplemental Indicator

Scientific Context

Current knowledge about bear density is limited. Some populations have been measured; others are estimated based on a regression model that relates landscape-scale factors to the known densities (Mowat et al., 2013). These model-based estimates are reviewed and sometimes revised by regional wildlife managers based on local knowledge. Lower densities are a conservation concern whether occurring naturally or resulting from historical effects. Bear densities are typically reported by the GBPU or WMU scales.

Management to population targets is common in adjacent jurisdictions (Alberta and United States). In B.C., provincial population objectives are being considered under the forthcoming Provincial Grizzly Bear Management Plan.[7]

Management Context

Decisions related to:

- Population recovery planning
- Estimating historic range occupancy
- Current population density
- Establishing licensed hunting allocations
- Conservation management.

For this assessment, the indicator is used to flag areas with low densities that could be a management concern.

Indicator Description	Flags
• Density Estimate – density (bears/1,000 km^2)	• Abundance: – Bear Density => 10/1000 km^2 (lower risk) – Bear Density < 10/1000 km^2 (higher risk; flagged) **Reporting Strata** • At a minimum GBPU, but could also be defined at the WMU or LEH and National Park. • Bear numbers are extrapolated to the LU using overlapping density and LU area.
Data Sources	**Validation**
• Provincial density estimate (BC MFNRO, 2012)	• Population studies. Density estimates derived from field-based DNA studies.

7 In preparation.

3.1.4 Road Density – Supplemental Indicator

Scientific Context

Studies have found that most known grizzly bear deaths lie within 500 m of a road or other corridor (Wakkinen & Kasworn, 1997; McLellan, 2015; Benn, 1998; Benn & Herrero, 2002; Boulanger & Stenhouse, 2014). Although grizzly bears avoid busy roads (Mace et al., 1996; Northrup et al., 2012), resource roads with fewer vehicles attract some individuals because of food availability (naturally regenerated or seeded vegetation or carrion), for security from dominant bears, and as travel routes (Nagy & Russell, 1978; MacHutchon & Mahon, 2003; Herrero et al., 2005, Roever et al., 2008; Schwarz et al., 2010; Haroldson & Gunther, 2013). Grizzly bears that are active close to roads usually have a higher risk of human-caused mortality (Johnson et al., 2004; Nielsen et al., 2004; Graham et al., 2010; Schwartz et al., 2010; Boulanger & Stenhouse, 2014). Since roads and traffic can alter bear behaviour in complex ways that vary by bear gender and dominance, some demographic groups may experience higher road-related mortality risk than others (Boulanger & Stenhouse, 2014). Grizzly bear mortality is higher close to open roads when people who use the roads are armed (Mattson et al., 1996; McLellan et al., 1999; Johnson et al., 2004; Ciarnello et al., 2007; Schwartz et al., 2010; McLellan, 2015). Most human-bear conflicts are also near access routes. Collisions with vehicles also kill bears (Gunther et al., 1998; Bertch & Gibeau, 2009) though typically only on highways.

As road density increases, grizzly bear mortality risk increases, habitat avoidance increases, and populations decline (Kasworm & Manley, 1990; Mace et al., 1996; Apps et al., 2004; Schwartz et al., 2010; Boulanger & Stenhouse, 2014; MacHutchon & Mahon, 2003), although nearby areas of high quality secure habitat potentially reduce the impact of high road density at a population scale (McLellan, 2015). Female grizzly bears use areas with lower road density than is available over the landscape, suggesting that they select a home range to minimize roads (MacHutchon & Proctor, 2015b). With high road densities, secure grizzly bear habitat can shrink to isolated islands surrounded by a matrix of hazards to the extent that bears do not use areas with high road density (Mace et al., 1996; Gibeau et al., 2001; Schwartz et al., 2010), nor the islands in between the alienated matrix. Climate change is likely to increase natural disturbances events such as forest fire, insect and disease outbreaks which will likely increase plant-based foods for bears. However, as humans respond to these events, through activities such as forest salvage, road densities will increase beyond what would be expected under a stable climate, potentially increasing negative human-bear encounters.

Determining a road density threshold for population maintenance is challenging because of the variety of factors that affect habitat use and mortality, including the distance to human populations, attractiveness of habitat to humans, and human behaviour. Road densities above 0.75 km/km^2 were associated with modeled population decline in an Alberta population (Boulanger & Stenhouse, 2014). This work has been used to establish road density targets of 0.6 km/km^2 in areas managed for conservation (Government of Alberta, 2008), and of 0.75 km/km^2 in areas managed for long-term stability. Consistent with this level, adjacent B.C./US trans-border sub-populations have increased in a region where road density in a female home range averages 0.39 km/km^2 and decreased where density averaged 0.9 km/km^2 (MacHutchon & Proctor, 2015b). Several studies have recommended landscape scale thresholds of 0.6 km/km^2, and planning processes in B.C., Alberta and the US have used these recommendations (Mace et al., 1996; Noss et al., 1996; Government of Alberta, 2008; McLellan & Hovey, 2001; BC MELP, 2000; Antoniuk & Ainslie, 2003).

Management Context
Decisions related to: • Managing human access – road densities, road closures • Managing attractants – right of ways (Hydro lines, pipeline corridors), dumps, camp management, access to salmon, hunter regulation for managing ungulate kills, etc. • Minimizing bear mortality resulting from negative encounters with humans.

Indicator Description	Flags
Primary Indicator • Total length of roads divided by the total LU area (km/km^2) Note: Roaded areas that are coastally disconnect, for example requiring barge, ferry or air access, are given a separate classification, and generally are considered low risk.	Road Density: • Roadless: 0 km/km^2 • Not Roadless and Coastal Disconnected: > 0 and Coastally Disconnected. • Low: >0 – 0.3 km/km^2 • Moderate: 0.31 – 0.6 km/km^2 • High: 0.61 – 0.75 km/km^2 • Very High: > 0.75 km/km^2
	Reporting Strata
	Summarized to Landscape Unit.
Data Sources	**Validation**
Road Density: • B.C. CEF Consolidated Roads layer: representing a composite from DRA, FTEN, OGC, and RESULTS. Restricted (gated, deactivated) or overgrown roads are excluded, where this information is available (See Appendix IV). • In-block roads, transmission, pipelines, rail • Coastally disconnected areas	Compulsory inspection data.

3.1.5 Core Security – Core Indicator

Scientific Context

Human access to grizzly bear habitat, and subsequent human behaviour in grizzly bear habitat, was the main reason for declines in grizzly bear populations throughout North America (McLellan, 1990; Schoen, 1990; Banci et al., 1994; Mattson & Merrel, 2002). In the past decade, all-terrain vehicles, global positioning systems and Google Earth have increased accessibility everywhere. Further, it is anticipated that as humans respond to increases in natural disturbance, it will accelerate incursions into what is currently secure habitat through the construction of roads and fire guards. As well, with climate change, changes in the abundance and distribution of capable habitat will alter the viability of secure habitat. The effects of roads are complex, and the magnitude of the effect of roads on grizzly bear density varies with road density, road location in relation to good quality habitat, road characteristics, traffic patterns, human activities, and grizzly bear age, gender, experience and behaviour.[8] Essentially, where bears and people overlap in space and time, risk of grizzly bear mortality increases, and potentially cause population declines.

Core security areas are defined as areas that have adequate habitat with a minimum of human use (after Gibeau et al. 2001, Morgan 2011). They are large enough to accommodate a female grizzly bear's daily foraging requirements. The integrity of the security area is sensitive to the extent and spatial arrangement of developments including roads, settlements, recreation areas and industrial areas. Science and policy from other jurisdictions recommend that secure habitat constitute 68-84% of an average female home range for long term stability (Gilbert et al., 2004); in addition, the Yellowstone and Northern Continental Divide Ecosystem conservation plans apply the objective of no less than 60% core security in any one bear management unit to support recovery of grizzly bear populations. Appendix IV describes the technical process for identifying secure core areas.

Management Context

Decisions related to:

- Managing human access – road densities, road closures
- Managing attractants – right of ways (Hydro lines, pipeline corridors), dumps, camp management, access to salmon, hunter regulation for managing ungulate kills, etc.
- Minimizing bear mortality resulting from negative encounters with humans.
- Hunter education and regulations

Indicator Description

- Proportion of secure core area (i.e. areas with no road density and >500m from human disturbance in patches ≥10 km^2), within the capable portion of the Landscape Unit.

Note: Roaded areas that are coastally disconnect, for example requiring barge, ferry or air access, are considered secure, as they have limited accessibility.

Flags

- Percent of secure core in LU. Flag is classed as:
  - 1: ≥ 60% Capable Core (lower risk)
  - 2: < 60% Capable Core (higher risk; flagged)

Reporting Strata

Summarized to landscape Unit.

[8] See Table 2 of Appendix 3: MacHutchon & Proctor, 2015b.

Data Sources	Validation
• BEI Capability Ratings • Road Density/ Secure Core Analysis (Appendix IV) • BC CEF Consolidated Human Disturbance – 500m buffers on select human disturbance are excluded from Secure Core: mining & extraction, oil & gas, utility ROWs, agricultural, urban, urban mixed, recreation (see Appendix II tab 'meta Disturbance') or Appendix III) • Coastally disconnected areas	Compulsory inspection data.

3.1.6 Front Country – Core Indicator

Scientific Context

A human-pressure index (see Appendix V) integrates roads, assumed level of road use, human populations, and land type to predict both road density and possible use (Coleman et al., 2013; Cristescu et al., 2013). The index is used to differentiate what would be considered front and backcountry areas. Grizzly bears have different interactions with people depending on whether the interaction occurs in the front or backcountry. In the backcountry, grizzly bears may be attracted to anthropogenic food sources associated with recreational or industrial camps. Destination sites, such as remote fishing lodges, hunting camps, off-road vehicle cabins and camps, equestrian camps, hiking and backpacking, berry picking, bear viewing lodges, and many other activities and sites, draw people into remote areas and increase human density within bear habitat. Heli-fishing and heli-skiing can bring people into otherwise secure – roadless and high quality habitat – areas. Most research on the potential impacts of human presence in grizzly bear habitat has been road-related, but these studies have documented impacts of human use away from roads (Apps et al., 2014). As humans respond to increases in natural disturbance events (forest fire, insect and disease) increased road densities and road use due to forest salvage and the presence of human facilities for housing emergency responders could lead to increasing negative human-bear encounters.

Mortality risk depends on attractant management. Private land is monitored in US conservation strategies, and it is found that mortality risk increases as the proportion of rural private land increases. Uncertainty for this indicator is high, due to variability in attractant management and its application as proactive versus reactive.

The front country is urban and rural landscapes that include both relatively high human density and grizzly bear attractants in the form of livestock, livestock carcasses, livestock feed, fruit trees, human food/garbage and grain. Bears tend to be absent in urban areas, due to historic human-bear conflict, so these areas do not increase mortality risk to the same extent as rural areas unless there are anthropogenic attractants along the urban interface. Rural agricultural landscapes provide good quality habitat with high human access, and hence can act as sink habitat (Northrup et al., 2012). In these areas, human-grizzly bear conflicts can lead to defence-of-life-and-property and management kills (Gunther et al., 2004; Wilson et al., 2006). Grizzly bear density and probability of population persistence decrease as number of livestock increase (Mattson & Merrill, 2002; Mowat et al., 2013). Management strategies, including attractant management (e.g. rapid removal of livestock carcasses, electric fencing) reduces risk of conflict.

Management Context

Front Country decisions related to:

- Managing attractants – right of ways (Hydro lines, pipeline corridors), dumps, camp management, access to salmon, hunter regulation for managing ungulate kills, etc.
- Education for private land owners – fruit trees, garbage, etc.
- Managing human access – road densities, road closures, livestock management on public lands, etc.
- Managing livestock attractants – (e.g. rapid removal of carcasses, electric fencing livestock) reduces risk of conflict
- Managing livestock areas (husbandry practices)
- Minimizing bear mortality resulting from negative encounters with humans.

Back Country decisions related to:

- Managing attractants – access to salmon, hunter regulation for managing ungulate kills, etc.
- Major project permit requirements, best management practices
- Minimizing bear mortality resulting from negative encounters with humans.

Indicator Description	Flags
Front Country/Back Country designation: • Front Country Landscape Units are defined by: – Human pressure index (Appendix V) which is a function of: – Human population size; – Travel time on roads, and – Land cover type 5 classes: – Class 1- Travel time from cities ≤1 hour (Very High Encounter Class) – Class 2- Travel time from cities 1-2 hours (High Encounter Class) – Class 3- Travel time from cities >2 hours, but travel time from high-use road ≤ 1 hour (Moderate Encounter Class) – Class 4- Travel time from cities > 2hours, but travel time from high-use road 1-2 hours (Low Encounter Class) – Class 5- Travel time from cities or high-use roads > 2 hours or coastal remote watersheds (Very Low Encounter Class) Classes 1-3 are considered front country. Classes 4 & 5 (including coastal remote watersheds) are backcountry. • Landscape Units are flagged if >20% of the LU is front country.	Front or backcountry • > 20% Front country (higher risk; flagged) • ≤ 20% Front country (lower risk; not flagged). **Reporting Strata** • 1 hectare raster model output summarized to Landscape Unit.
Data Sources	**Validation**
• B.C. Consolidated Roads layer: representing a composite from DRA, FTEN, OGC, and RESULTS • Human populations – Provincial communities/cities and population • Baseline Thematic Mapping (BTM) (BC MFLNRO, 2011) • Coastally disconnected areas	Compulsory inspection data.

3.1.7 Hunter Day Density – Core Indicator

Scientific Context
Grizzly bear mortality occurs at a disproportionate rate when they are close to active roads travelled by people carrying firearms (Ciarnello et al., 2009; Coleman et al., 2013; Cristescu et al., 2013). Mortality may occur from mistaken identity kill, poaching, be conflict related (self-defense kill, management control kill, landowner defense-of-life and property kill), and vehicle collisions. Data for the density of hunters in the Province are available at the WMU scale and provides a proxy for hunter day density. Hunter day density combined with metrics of human presence identifies areas where there is higher risk of lethal human-bear encounters.

Management Context
Minimize bear mortality resulting from negative encounters with hunters.

Indicator Description	Flags
Average annual hunter day density. Calculated on number of days over 5 year period (2013-2017)/ per year for the occupied portion of the management unit (MU). This density is used to extrapolate to the LU level (ndays/km^2).	• LU average hunter day density is divided into statistical quartiles for the current assessment – quartiles are not static. • Relative ranking of average annual hunter day density by Landscape Unit: – Low: Quartile 1,2 (0-0.65 hunter days/km^2) – Mod: Quartile 3 (0.65 – 1.87 hunter days/km^2) – High: Quartile 4 (flagged) (> 1.87 hunter days/km^2) Note: Quartiles are calculated for each set of assessment results (i.e. they are not static thresholds)
	Reporting Strata
	Wildlife management unit metric summarized to Landscape Unit.
Data Sources	**Validation**
Hunter Questionnaires and Guide Outfitter declarations.	Non-hunt mortality will be examined in relation to front-country/back-country and both hunting and non-hunting mortality will be examined in relation to hunter day density using compulsory inspection data.

3.2 Grizzly Bear Habitat Component

3.2.1 Quality Food – Supplemental Indicator

Scientific Context

Grizzly bears are omnivores, with a diet that varies with location and season (Gyug et al. 2004; Mowat et al., 2013). In B.C., coastal and interior grizzly bears have very different foraging behaviour and ecology driven by the availability of salmon. On the coast, the spring diet includes early green vegetation, often beginning with riparian vegetation at low elevation in spring. Grizzly bears follow receding snow up avalanche chutes and return to lower slopes for summer berries and salmon runs. They focus on spawning salmon until late fall. Grizzly bear density on the coast increases with the availability of salmon and decreases with coniferous tree cover. In the interior, early spring diet includes roots and emerging vegetation. Grizzly bears also prey on ungulates at their calving grounds in spring. They focus on berries through summer and fall, supplemented with small mammals, carrion, insects and roots where available. Grizzly bear densities in the interior increase with terrestrial productivity and are negatively related to tree cover and human presence.

Availability of protein food sources greatly increases habitat quality for grizzly bears and can have a large positive effect on population productivity (Mowat et al., 2013). Grizzly bear density on the coast increases with the proportion of salmon in the diet (Mowat et al., 2013 The relationship between grizzly bear density and the availability of meat, though intuitive, has not been demonstrated unequivocally in the interior.

Climate change is causing increased water temperature and decreased precipitation which have resulted in greatly reduced salmon abundance throughout much of BC's coastal areas. The impact of changed climate may influence ungulate availability and increased drought may decrease berry production in some years, alternatively the reduction in tree cover from continental drying may benefit both ungulates and some berry species.

For the purposes of this assessment, provincially available data for forage was limited to salmon biomass and high capable areas. Information on berry distribution and abundance; and ungulate density is intended to be used in the future, as information becomes available.

Management Context

Minimize bear mortality resulting from negative encounters with hunters.

Indicator Description	Flags
• Quality Food is identified as: – Salmon biomass by Landscape Unit – Sum of 5 species of salmon kg in LU over all available time periods > 10,000 kg; and/or – Total Weighted Area of Broad Ecosystem Inventory (BEI) habitat capability i.e. BEI CAPAB1 & 2 in classes 1 (Very High) and 2 (High) > 50% of LU. – Great Bear Rainforest ecosystem-based management (EBM) grizzly habitat class 1 and class 2 are also used > 50% of LU • Quality Food is defined as: – > 50% of LU is high or very high habitat capability (BEI or EBM); and/or – Any unit with >10,000kg Salmon biomass.	• Yes – high salmon or high capability • No – Not high salmon or high capability **Reporting Strata** Summarized to Landscape Unit.
Data Sources	**Validation**
• Salmon escapement data linked to watershed and summarized (DFO approx. 1950 -2014 as available) • BEI High and Very High capability • Great Bear Rainforest EBM habitat class 1 and 2	• TBD

3.2.2 Poor Forage Potential (BEC Mid-Seral Dense Conifer) – Core Indicator

Scientific Context

Canopy openness is a predictor of berry patches, an important grizzly bear food source, and frequented by bears even outside of berry season (Proctor et al., 2012). Mid-seral conifer dominant forests (BC MF & BC MELP, 1995) can be dense, have closed canopy and be sub-optimal for forage production. Landscapes with > 30% mid-seral dense coniferous forests should be evaluated for a shortage of forage and included in assessments of suitability, particularly in more sensitive ecological zones. Further, mid-seral condition is tracked when projecting future forest structure and limits to long-term grizzly bear forage supply can be noted. Climate change may trigger an increase in natural disturbance which could lead to increases in mid-seral forest.

Management Context

Decisions related to:

- Managing forage supply – e.g. Timber Supply Review, silviculture, etc.
- Meeting specific mid-seral objectives in some timber supply areas (e.g. Kalum TSA).

Indicator Description	Flags
• Mid seral is assigned as per NDT/Biogeoclimatic Ecosystem Classification (BEC) forest age criteria from the Biodiversity Guidebook, and further classified for potential forage suitability. 'Low' forage suitability (dark, dense stands with little understory) are considered as 'mid-seral dense conifer' • BEC Zones have varying capacity to provide forage when in a mid-seral state and are rated as High, Moderate, or Low: – High: CWH, ICH, ESSF, SBS – Moderate: MS, MH, IDF – Low: (all other BEC Zones)	• Mid-Seral Dense Conifer ≤ 30% in High or Moderate BEC zones (or Low sensitivity BEC Zone) in a landscape unit (low risk) • Mid-Seral Dense Conifer > 30% for select BEC Zones in a landscape unit (high risk) (flagged) • Insufficient Data: VRI gap ≥ 10% of BEC Zone in LU **Reporting Strata** • Landscape Unit

Data Sources	Validation
• Vegetation Resources Inventory (VRI) • Mid-seral forest classification calculated from the Biodiversity Guidebook • BEC Zones	• Grizzly bear food studies and habitat occupancy studies.

3.2.3 Habitat Protection – Supplemental Indicator

Scientific Context

At a coarse scale, Broad Ecosystem Inventory (BEI) units can provide an estimate of habitat capability for abundance of seasonal food. At a 1:250,000 scale, BEI has been used to rate grizzly bear habitat capability and suitability across the province into six classes (very high-1, high-2, moderate-3, low-4, very low-5, nil-6) (BC MELP, 1999). At a finer scale (1:20,000 or sometimes 1:50,000), Terrestrial Ecosystem Mapping (TEM) or Predictive Ecosystem Mapping (PEM) can provide more precise information where available. Conservation areas provide some level of habitat protection or restrict some human activity and include provincial parks, national parks, wildlife management areas, visual quality areas, etc. (see Appendix II: 'Meta Protected' Tab for a full list of categories used in this assessment).

Management Context

Decisions related to:

- Conservation management

Indicator Description

- Percent area of very high and high habitat (BEI or EBM) in conservation areas (including parks and protected areas and other designated areas, see Appendix 2) as a proportion of very high and high habitat in the assessment unit.
- Presence/absence of Grizzly Wildlife Habitat Areas (WHA)/Specified Areas or Coastal Ecosystem Based Management (EBM) areas within an LU.

Flags

Indicator 1:

- Low risk >60% protection;
- Moderate risk 30-60%; and
- High risk <30% protected

Indicator 2:

- Yes: LU contains >= 0.05% WHA/EBM areas (present)
- No: WHA/EBM areas absent or < 0.05% (absent)

Reporting Strata

- Landscape Unit

Data Sources

- Consolidated protected and restricted areas dataset
- BEI High and Very High capability
- Provincial Grizzly WHAs, excluding Specified Areas with conditional harvesting
- Coastal EBM Grizzly areas

Validation

- TBD

Habitat Suitability and Capability

Capability is defined as the ability of the habitat, under the optimal natural (seral) conditions for a species to provide its life requisites, irrespective of the current condition of the habitat.

Suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species.

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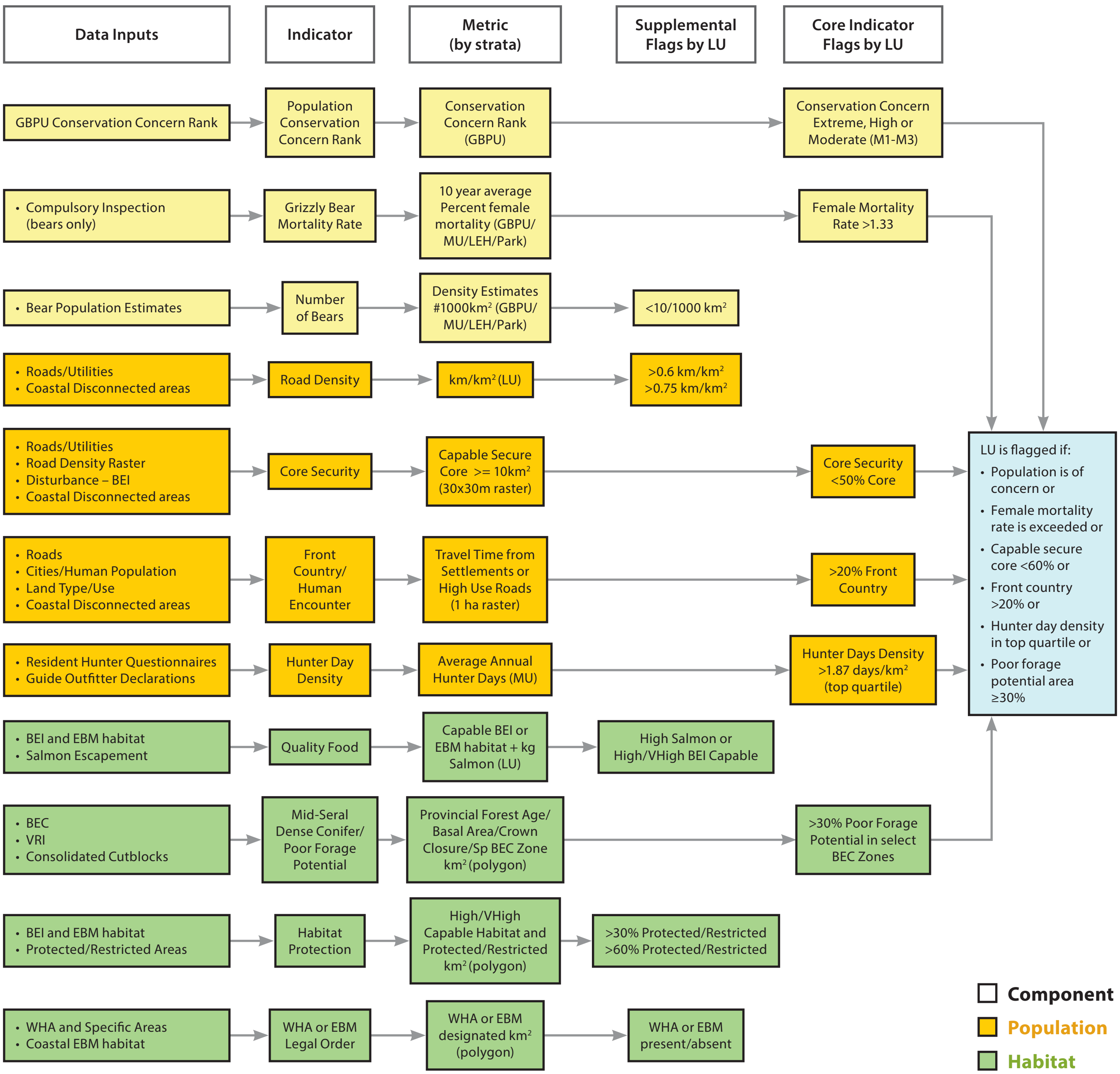
5 Appendices

Appendix I

Analysis Summary Diagram



Overview of the data inputs, indicators, metrics, and flags used in the technical assessment.

Appendix II

Summary GIS Spreadsheet for Indicators, Data Inputs, Assessment Summary Fields, and Metadata for Classification of Protected/Restricted Areas, Land Use/Human Disturbance, and Road Source Information

The summary sheet for the 2018 Grizzly Bear GIS assessment can be found in the following Microsoft Excel spreadsheet, available on the CEF Website:

Grizzly_Protocol_Appendix2_Indicators_Inputs_DataDict_2018_20200325

Appendix III

Derivation of a Consolidated Landbase and Human Disturbance Dataset

Objective

To create a consolidated human disturbance footprint dataset for the province for the purpose of spatial assessment in GIS (Geographic Information Systems). This dataset can be used for a variety of values assessments. For grizzly bear, this dataset was used for front country/back country and secure core analysis.

Method

To avoid double accounting of areas on the landbase, data from a variety of layers were combined in hierarchical order such that more current and permanent disturbance would overwrite layers 'beneath' it. Non-disturbed/natural areas were also included in the dataset in order to provide 100% area coverage. Disturbance was classified as 'current' (within 20 years of 2019) or 'historical' (pre 1999).

The initial land-use layers were drawn from historic (circa 1995) Baseline Thematic Mapping (BTM1) (BC MFLNRO, 2011), then updated with more recent disturbance including urban, recreational, agricultural, mining and extraction, forest harvesting, oil and gas activities, and utility data extracted from various datasets.[9] This revised product was called the 'Consolidated Human Disturbance with BTM' dataset.

The table below outlines the hierarchy of the various layers. The hierarchy is applied such that the layers at the top of the list are the highest ranking and overwrite any overlapping layers 'below' them, where 1 is the highest ranking level. The ranking applies within each group and between groups. For example, with the Mining_and_Extraction Group, 1-1 is higher ranking than 1-2 (and so on). Group 1 is higher ranking than Group 2 Rail_and_Infrastructure, and so on.

Group – SubGroup Rank	Disturbance Group	Disturbance Sub Group	Description	Human Disturbance Class
1-1	Mining_and_Extraction	Custom – North Area 2015	GeoBC – Custom mine footprints digitized for the North Area	Current
1-2	Mining_and_Extraction	Baseline Thematic Mapping	BTM – Mining – mineral extraction or quarry	Current
1-3	Mining_and_Extraction	VRI Mining	VRI – Gravel pits, mines, rubbly mine spoils, mine tailings (>= 20% cover).	Current
1-4	Mining_and_Extraction	TRIM Enhanced Base Map	TRIM – Mines and quarries	Current
2-1	Rail_and_Infrastructure	Railway BC	GeoBase – Rail lines buffered by 7.5m	Current
2-2	Rail_and_Infrastructure	Railway NEBC	GeoBase – Rail lines buffered by 17.5m	Current

9 Cumulative Effects Assessment Provincial Development Layer Documentation, 2019. In-progress/Available upon request.

Group – SubGroup Rank	Disturbance Group	Disturbance Sub Group	Description	Human Disturbance Class
2-3	Rail_and_Infrastructure	VRI Airports	VRI – Airport or associated areas (buildings, parking) (>= 20% cover)	Current
2-4	Rail_and_Infrastructure	TRIM Airfields	TRIM – Runway, airstrip	Current
3-1	OGC_Infrastructure	Surface Land Use – OGC	OGC – Oil and Gas pipelines, well facilities, and ancillary features	Current
4-1	Power	Dams	Water – Linear dams, buffered by 25m	Current
4-2	Power	Transmission	GeoBase – Transmission lines, buffered to 12.5m	Current
5-1	ROW	Surveyed ROW	Tantalis – Surveyed rights-of-way – including private and some crown	Current
5-2	ROW	Crown ROW	Tantalis – Surveyed rights-of-way – crown	Current
6-1	Urban	Baseline Thematic Mapping	BTM – Urban and Residential Agriculture Mixtures	Current
6-2	Urban	VRI Builtup	VRI – Urban and builtup areas (>= 20% cover)	Current
6-3	Urban	TRIM Enhanced Base Map	TRIM – Urban and builtup areas	Current
7-1	Recreation	BTM – Recreation	BTM – Recreation activities e.g. ski resort, golf course	Current
8-1	OGC_Geophysical	Surface Land Use – Geophysical	OGC Geophysical represents seismic survey activity in NE BC from the Oil & Gas industry. The disturbance from this survey type are cutlines in the vegetation cover. Airborne surveys were not considered a disturbance. It is anticipated this survey time will decline in the future for less invasive methods.	Current
9-1	Cutblocks	Current – FAIB	FAIB – Forest harvesting cutblocks since 1999 – excluding select reserves	Current
9-2	Cutblocks	Historic – FAIB	FAIB – Forest harvesting cutblocks pre 1999 – excluding select reserves	Historic (>20 yrs)
9-3	Cutblocks	Historic – BTM	BTM – Historically logged or selectively logged areas – does not consider reserves	Historic (>20 yrs)
10-1	Agriculture_and_Clearing	Baseline Thematic Mapping	BTM – Agricultural areas	Current
10-2	Agriculture_and_Clearing	VRI Clearing	VRI – Clearings and agricultural areas – clearings are undifferentiated as to type (type may vary)	Current
11-1	RESULTS_Reserves	RESULTS Reserves	Select harvest reserves and natural feature from RESULTS. These may have varying age, but are considered as undisturbed/part of the natural landbase. This is a custom dataset with a specific selection criteria.	Natural Landbase
12-1	BTM Natural Landbase – Range Lands	BTM – Range Lands	Unimproved pasture and grasslands, sparse forest	Natural Landbase
12-1	BTM Natural Landbase – Forest Land	BTM – Forest Land	Forested areas or old burns	Natural Landbase

Group – SubGroup Rank	Disturbance Group	Disturbance Sub Group	Description	Human Disturbance Class
12-1	BTM Natural Landbase – Shrubs	BTM – Shrubs	Naturally occurring shrub cover with at least 50% coverage	Natural Landbase
12-1	BTM Natural Landbase – Wetlands Estuaries	BTM – Wetlands Estuaries	Swamps, marshes, bogs or fens; salt water mud flats and inter tidal areas	Natural Landbase
12-1	BTM Natural Landbase – Fresh Water	BTM – Fresh Water	Rivers, Lakes	Natural Landbase
12-1	BTM Natural Landbase – Salt Water	BTM – Salt Water	Salt water, ocean	Natural Landbase
12-1	BTM Natural Landbase – Alpine SubAlpine Barren	BTM – Alpine SubAlpine Barren	Alpine or sub alpine areas virtually devoid of trees; rock barrens, badlands, sand and gravel flats, dunes and beaches where un-vegetated surfaces predominate	Natural Landbase
12-1	BTM Natural Landbase – Glaciers and Snow	BTM – Glaciers and Snow	Glaciers and relatively permanent snow	Natural Landbase

For further description of the disturbance classes used in the grizzly bear assessment, please see the Appendix II spreadsheet, 'meta Disturbance' Tab.[10]

Discussion

- Although portions of the province have revised BTM, full coverage of the province was only available in version 1 (circa 1995). This provided the basis for the natural/non-disturbed and some historical disturbance.
- The order of layers was adjusted compared to the 2015 version of this dataset. For example, harvesting (with the probability of re-growth) was placed lower in the hierarchy, below mining and urban disturbance, which are more permanent.
- Seismic lines are quite extensive in the northeast of B.C. and were included in this version of the dataset. However, in many cases they may be less-permanent on the landscape. A fuller understanding of the permanence and vintage of seismic lines in NE BC will help advise whether they should be included.
- Crown land tenure polygons were excluded, as they represent only a general tenure area where activity may be permitted, but where the actual disturbance 'footprints' are within that tenure is unknown. This includes range tenures, mineral tenures, and agricultural tenures. This layer can be re-run to include crown land tenures by those who wish to include them, as a script exists to automate the process.
- While the inclusion of road buffers in this disturbance layer was considered, it would have added considerable processing time and potential data processing issues. Road buffers were created separately and are available as a separate data product. This allows each value assessment to use roads how they wish (for example, road buffers to represent footprints versus road density to represent road network area).
- Future runs of the compilation may want to re-consider the hierarchy and inclusion or exclusion of certain layers, especially for site specific assessments using local layers that are not available for the entire extent of B.C.

[10] Grizzly Bear Data Dictionary - Available upon request.

Appendix IV

Core Security Area Model

Objective

The objective of this model is to identify areas of secure core habitat capable for grizzly bears (see Grizzly Bear Knowledge Summary Section 3.3.1 vi). For the purpose of this spatial analysis, secure core areas are defined as areas that are roadless (or roaded but coastally remote) and in patches ≥10 km^2. Capable habitat is identified in Broad Ecosystem Inventory (BEI) mapping (BC MOECCS, 2014), and excludes major water, ice and glacial features. The following 500m buffers on select human disturbance (see Appendix II tab 'meta Disturbance') or Appendix III) are also excluded from the secure core: mining and extraction, rail and airport infrastructure, oil and gas infrastructure, power and utility Rights of Way, agricultural, urban and urban-mixed use (e.g. recreational) areas. Harvest cut blocks and seismic lines were not excluded from core, as these areas may offer some habitat and forage opportunities.

Method

The general steps for determining capable secure habitat were as follows. Details are provided below and illustrated in Figure 4.

1. Calculate road density (raster) for 'open' roads and utilities in order to identify the 'roadless' areas (Figures 4a and 4b).
2. Smooth the 'roadless' areas to eliminate long, narrow 'peninsulas' and select only resulting secure core areas ≥10 km^2 (Figures 4c, 4d and 4e).
3. Further refine by removal of non-capable areas and select human disturbance to create final capable secure core polygons (Figure 4f).

1. Roads and Road Density

A consolidated roads dataset for the province (BC CEF 2019) was used as the initial data source. This was built based on inputs from the following sources, and combined in hierarchical order such that source data towards the top of the list would overwrite priority data towards the bottom of the list. Road line features are integrated if they are within 7m of each other.

Priority Order	Description	Source	Note
1	Digital Road Atlas (DRA)	WHSE_BASEMAPPING.DRA_DGTL_ROAD_ATLAS_MPAR_SP	
2	Forest Tenure Roads – Active	WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW	Active road tenures
3	Forest Tenure Roads – Pending or Retired	WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW	Retired' roads may in fact have been built, but are no longer under tenure.
4	RESULTS Forest Roads	WHSE_FOREST_VEGETATION.RSLT_FOREST_COVER_INV_SVW	Road centerlines created from polygons for selected road features
5	As Built Roads (ABR)	WHSE_FOREST_TENURE.ABR_ROAD_SECTION_LINE	May be more accurate than FTEN roads, but only tracked from ~ March 2005-June 2008
6	OGC Petroleum Development Roads Pre-2006	WHSE_MINERAL_TENURE.OG_PETRLM_DEV_RDS_PRE06_PUB_SP	
7	Oil and Gas Commission Road Segment Permits	WHSE_MINERAL_TENURE.OG_ROAD_SEGMENT_PERMIT_SP	
8	Oil and Gas Commission Road Right of Way Permits	WHSE_MINERAL_TENURE.OG_ROAD_AREA_PERMIT_SP	Road centerlines created from polygons

For further description of the roads attributes, please see the Appendix II spreadsheet, 'meta Roads' Tab. Ideally for this assessment, only 'open' roads should be considered, as defined in the Recovery Plan For Grizzly Bears in the North Cascades of British Columbia (North Cascades Grizzly Bear Recovery Team, 2004) "a road without restriction on motorized vehicle use or that receives use by conventional passenger cars or light-duty trucks (note that gated roads that receive use by conventional passenger cars or light-duty trucks are considered "open")".

The provincial roads datasets have limited information tracked as to restrictions and decommissions. The information that is available may not be up-to-date and is inconsistent between datasets. However, to meet the 'open roads' definition as best as possible, roads were excluded where the attributes were shown as restricted or overgrown (see Appendix II, 'meta Roads' Tab for a breakdown of available road attributes (North Cascades Grizzly Bear Recovery Team, 2004).

Major utility lines (transmission, pipeline, and rail) were also included in the input linework. An example of a combined open roads and utilities dataset is shown in Figure 4a. There was a deliberate decision not to use recreation trails, even though there may be additional impact due to motorized off-road vehicles using trail networks. If a finer scale analysis is conducted, then the use of trails data may be recommended.

A roads and utilities density raster was then calculated using ArcGIS 10.6 Spatial Analyst to identify roadless areas beyond 500m of road or utility influence. The Line Density tool was used with a neighbourhood search radius of 500m, 30m cell size, and units in square km. Grid cells where density was zero were considered roadless (Figure 4b).

Road Density Classes were assigned as follows:

Road Density Class	Road Density (km/km^2)
0	0 (Roadless)
1	0 to 0.3 km/km^2
2	>0.3 to 0.6 km/km^2
3	>0.6 to 0.75 km/km^2
4	>0.75 to 1.25 km/km^2
5	>1.25 to 1.75 km/km^2
6	>1.75 to 2.5 km/km^2
7	>2.5 km/km^2
88	> 0 and Coastally Disconnected

2. Removal of Peninsulas and Small Areas

The resulting roadless or roaded but coastally disconnected areas were further ‘smoothed’ by removing long-narrow peninsulas or irregular areas. The raster processing methodology was developed for ArcGIS, based on the initial concepts of Andrew Fall (Gowlland Technologies) for Spatially Explicit Landscape Event Simulator (SELES). It involves running two moving windows to calculate cell neighbourhood statistics (Focal Statistics tool in ArcGIS):

1. Identify secondary road effects within a 1 km circular window (564m radius). Using Focal Statistics, this is the percent of cells within 1 km^2 of each grid cell that are at least 564m from roads. If surrounding cells have more than one percent of secondary road influence, then the cell is insecure. Otherwise, if zero road influence, then the cell is considered fully secure (Figure 4c).

2. Run Focal Statistics to determine the number of fully secure cells within 1 km^2 of insecure cells. If there is at least one fully secure cell adjacent, then the cell is secure. If there are no fully secure neighbours then the cell is still insecure, and is filtered out (Figure 4d). Another way to look at this is that the fully secure areas area ‘ballooned’ out to fill significant adjacent cells. This effectively results in removal of irregular areas.

Finally, these resulting smoothed areas are selected for areas ≥10 km^2. Areas < 10 km^2 are filtered out or ignored, to produce the ‘Secure Core’ layer (Figure 4e).

3. Refine for Capable Habitat

The smoothed secure core is further refined to include capable habitat only and exclude 500m buffers on select human disturbance (mining, oil and gas, utility Rights of Way, agricultural, urban, urban mixed use areas, etc).

This uses the Broad Ecosystem Inventory (BEI) selected for capable habitat ratings 1-5 (Very High to Very Low), with exclusion of major water bodies, ice and glacial features from the Baseline Thematic Mapping (BTM). Area is weighted by BEI capable proportion. Note that removal of non-capable areas may split a contiguous area of ‘secure core’ into smaller portions, and reduce the overall size and contiguity, however fragmented areas are still maintained as overall secure core.

Select disturbances (see Appendix II tab ‘meta Disturbance’) or Appendix III) were buffered by 500m and excluded/erased from the core areas. The final ‘Capable Secure Core’ is capable habitat in secure core areas > =10 km^2 (Figure 4f).

Figure 4 below illustrates the progression from road density to roadless to capable secure core for a sample landscape unit.

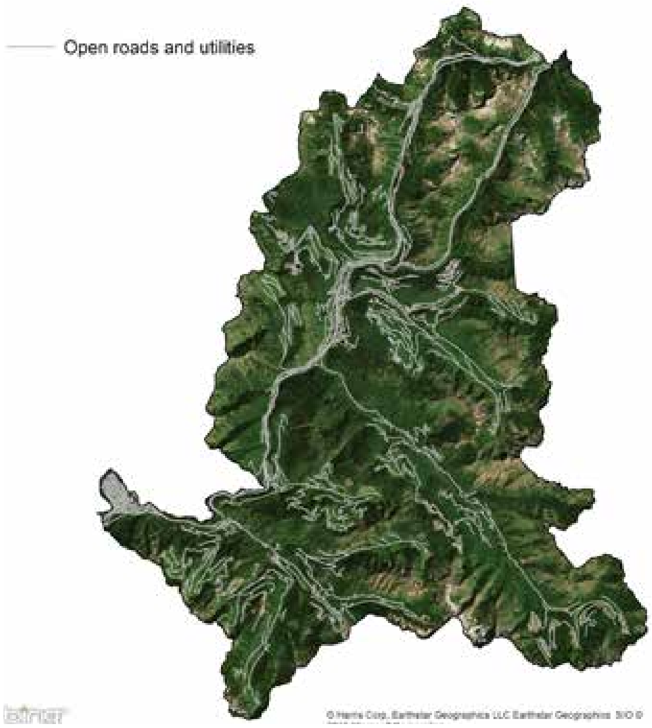


Fig.4a. Open Roads and Utilities in the Coquihalla Landscape Unit

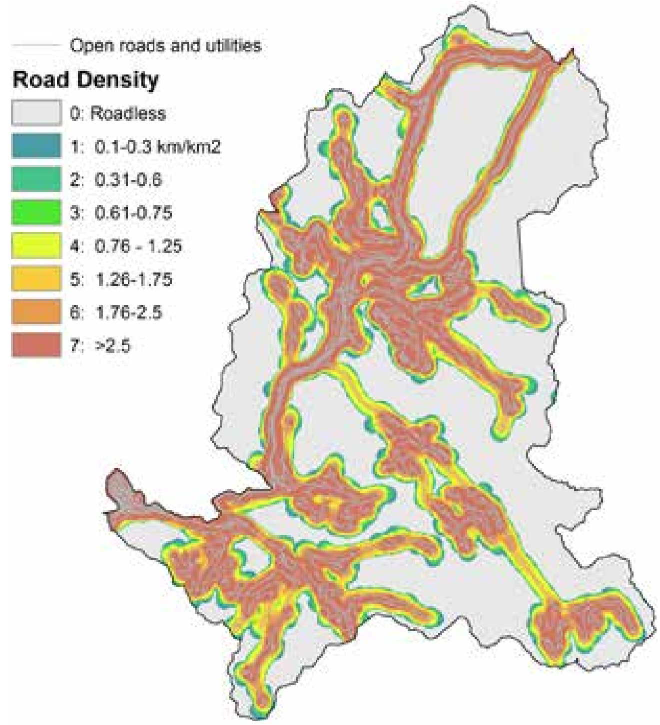


Fig.4b. Road Density and Roadlessness Classification

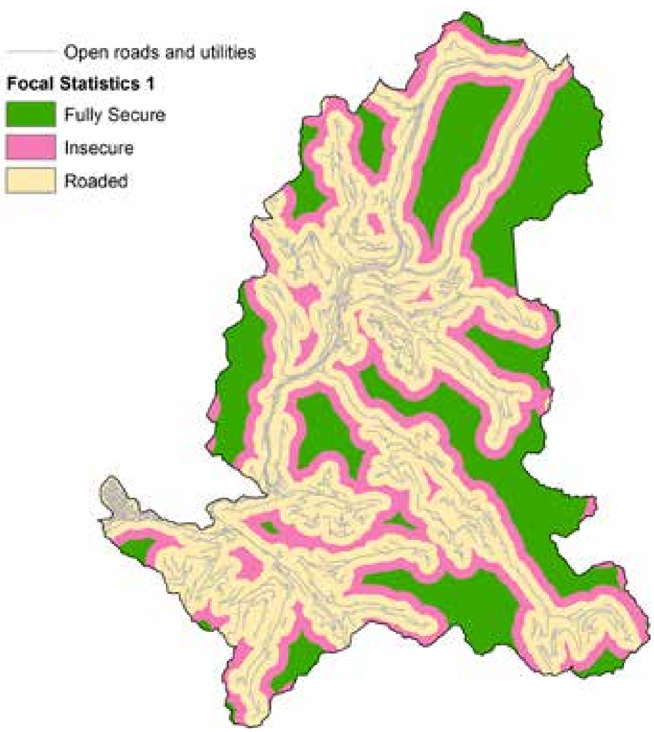


Fig.4c. Focal Statistics 1 to determine 'Fully Secure' areas

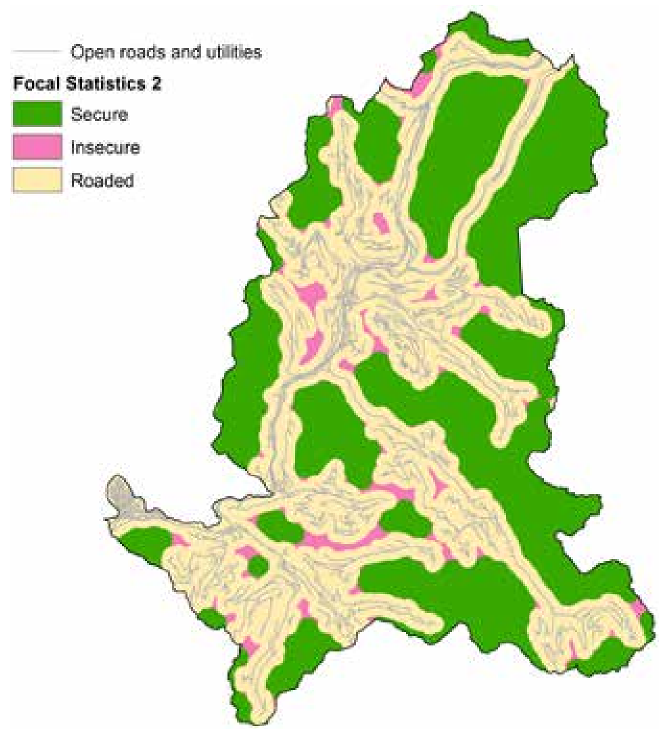


Fig.4d. Focal Statistics 2 'ballooning' to add adjacent Secure areas

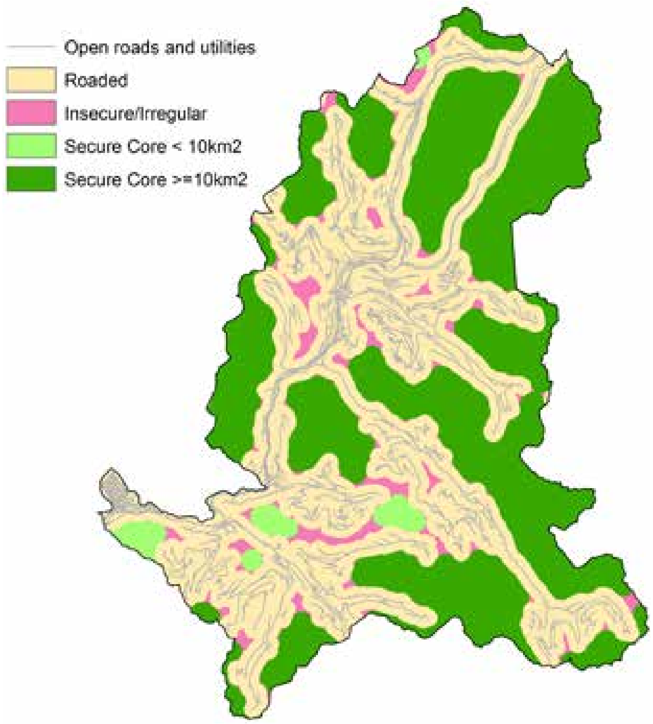


Fig.4e. Classification of Secure Core by size

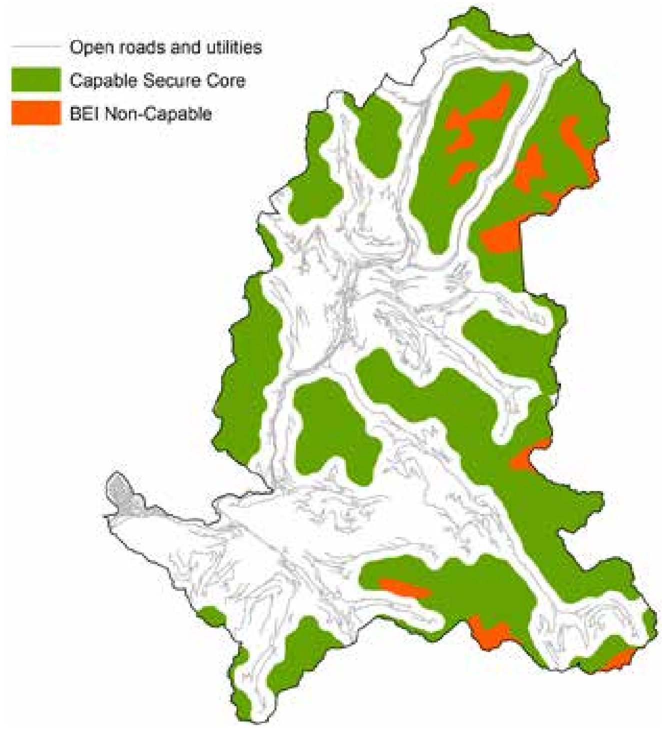


Fig.4f. Final Capable Secure Core, excluding non-secure, non- capable habitat, and select disturbance.

Figure 4. *Progression from Roads to Road Density to Capable Secure Core Habitat using ArcGIS*

Appendix V

Human Pressure Index

Human population pressure corresponds to the likelihood of encountering humans at a particular location on the landscape. This relates to access (e.g. road type, off-road terrain type), assumed travel rates, and proximity to sizeable human populations. The following is based on concepts proposed by Clayton Apps. The analysis (2015) was prepared by Andrew Fall (Gowlland Technologies) using SELES.

The first step of a human pressure index is to determine, for each community, the travel time to every location on the landscape. The landscape is defined by 1 hectare grid cells in a raster environment. Travel time must be computed for (a) every community and (b) for every location in the study area (at least up to some maximum travel time limit).

To compute travel time for every community requires that diffusion is initiated in each community in *sequence* (i.e. one at a time, as opposed to simultaneously). Diffusion spread rate is done as follows:

i. On roads: at the road type speed limit (Table 1)

ii. Off-road: a speed equal to the likely fasted mode of travel for the cover type (often by foot, but perhaps by snowmobile or ATV on land, or by boat or swimming/wading across water). Boat access is assumed only possible when the water body is accessible by road. Once mode of travel is by foot, it cannot revert to motorized travel (Table 2).

Table 1. *Travel speeds applied by 2015 road type (See Appendix II – Meta Roads 2015 tab) for provincial scale analysis. More detailed road speed classification can be applied in study areas with higher precision road information.*

Road Type	Travel speed (motorized)
High use	100 km/h
Moderate use	50 km/h
Low use	25 km/h

Table 2. *Non-motorized (foot and boat) travel speeds applied by cover type for provincial scale analysis. Non-motorized travel speeds are applied when encountering a road from an off-road mode of travel.*

Cover Type	Travel speed (foot)	Travel speed (non-motorized boat)
Roads	5 km/h	n/a
Open terrain (alpine, rock, clearing, urban, meadow, open range)	5 km/h	n/a
Semi-open terrain (sub-alpine forest)	2.5 km/h	n/a
Challenging terrain (ice, gravel, clay, brush, non-productive, burns)	1 km/h	n/a
Water (lakes, rivers, swamps, saltwater)	0.5 km/h	2 km/h

For each community, this creates a complete coverage of the expected time required to travel from the community to each location in the study area, perhaps using multiple modes of travel. For example, travel time to a remote island in an alpine lake may assume a first step by automobile along roads, then by foot into the alpine, then by swimming (or rafting) to the island.

At each location, the travel time to a community can be scaled by the community population size (with a decay rate parameter) to compute an index of the *"expected number of humans"* from that community. The index is a relative value if no quantitative time frame is specified (i.e. relative proportion of expected people encountered per year). To obtain an absolute index (i.e. expected number of people encountered per year) would require information on the number of travellers from communities (including visitors). The sum of all human presence indices, across all communities is used to compute an overall index of the expected number of humans to access that location, creating a relative or absolute *"human pressure index"*.

More specifically, this the relative human pressure index at each 1-ha grid cell in the province is computed as:

$$\sum_{c=1}^{n} pop(c) * d^{t(c,ij)}$$

Where

- *ij* is the grid cell (row *i*, column *j*)
- *n* is the number of communities
- *pop(c)* is the population size of community *c*
- *d* is the decay rate of human pressure with distance
- *t(c, ij)* is the travel time in hours to grid cell location *ij* from community *c*

The current scenarios apply a decay rate parameter *d* of 0.5 (i.e. human pressure decreases at a rate of 50% per hour of travel time).

One limitation of the above approach to human pressure is that it does not consider "attractiveness" of sites. That is, while it can consider the effect of faster travel along trails and open, gentler terrain (i.e. "push factors" from communities towards easier-to-reach locations), it does not consider the "pull factor" of locations that attract humans (e.g. scenic views, remote camp sites, fishing locations) that may draw more human presence compared with other locations of equal travel time.

The travel time from cities and high-use roads was further interpreted into five classes:

1: Travel time from cities <= 1 hour

2: Travel time from cities 1-2 hours

3: Travel time from cities > 2 hours, but travel time from high-use road <= 1 hour

4: Travel time from cities > 2 hours, but travel time from high-use road 1-2 hours

5: Travel time from cities or high-use roads > 2 hours

where classes 1-3 are considered front country, and classes 4 and 5 are considered backcountry. This was used as a main indicator for likelihood of human-bear encounter.

Data Sources:

- B.C. CEF Consolidated Roads 2015 layer: representing a composite from DRA, FTEN, OGC, and RESULTS
- Human populations
  - 1:2M city population (2000)
- BTM (BC MFLNRO, 2014)

BRITISH COLUMBIA

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