Conservation Ranking of Grizzly Bear Population Units - 2019

Ministry of Environment and Climate Change Strategy

Don Morgan, Ministry of Enviornment and Climate Change Strategy, Conservation Sciences,
Michael Proctor, Birchdale Ecological,
Garth Mowat, Ministry of and Forests, Lands Natural Resource Operations and Rural Development, Fish and Wildlife,
Bruce McLellan,
Tony Hamilton, and
Laurence Turney, Ardea Biological Consulting Ltd.

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Introduction

British Columbia (BC)'s 1995 Grizzly Bear Conservation Strategy proposed direction for the management of 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*"[1]. In 2016, the Ministries of Environment and Climate Change Strategy (ENV), and Forests, Lands Natural Resource Operations and Rural Development (FLNRORD) agreed to 3 objectives for Viable Grizzly Bear Population Units:

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.

Defining the conservation ranking of Grizzly Bears in geographically discrete areas of the Province helps direct Grizzly Bear related management activities. In BC, almost all grizzly bears live in one large connected population. For administrative reasons, however, all occupied habitat has been divided into 55 Grizzly Bear Population Units (GBPUs) and these range in size from 2,670 km^2 to 49,578 km^2. They are used to describe population abundance and stability, and for capturing regional and sub-regional variation in population and habitat management. The ranking of GBPUs is used to inform land-use planning, major project impact assessment and quantification of cumulative effects (CE) under the Province's CE policy. GBPUs as well as the Wildlife Management Units (WMUs) and Limited Entry Hunt Zones (LEH Zones) are used to establish and track Annual Allowable Mortality levels of Grizzly Bears. GBPUs are also used to report on the objectives identified in the 1995 Grizzly Bear Conservation Strategy and more recently the objectives endorsed by CE ADM's in 2016. Reporting on the condition of GBPUs is pivotal to government's response to the BC Auditor General's (OAG) October 2017 Grizzly Bear Audit recommendations[2] and as it considers implementing key recommendations from the recent scientific panel[3] review of Grizzly Bear management in BC. The drafting of the Provincial Grizzly bear management plan also requires GBPU ranks, as GBPU-specific management objectives (e.g. for population recovery) are contemplated.

The definition of ***conservation rank*** of BC Grizzly Bear Population Units is distinct but linked to the ***conservation status*** designations resulting formal Federal, Provincial and international species conservation assessment ranking processes (Table 1). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identifies two distinct populations of Grizzly Bears in Canada; the extinct Ungava population, and the Western population[4] which is designated as a

[1] MOELP (Ministry of Environment Lands and Parks). 1995. A future for the grizzly: British Columbia grizzly bear conservation strategy. Accessed Jan 25, 2012: http://www.env.gov.bc.ca/wld/grzz/grst.html
[2] http://www.bcauditor.com/pubs/2017/independent-audit-grizzly-bear-management
[3] http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grizzly-bear-harvest-management-2016.pdf
[4] COSEWIC. 2012. COSEWIC assessment and status report on the Grizzly Bear *Ursus arctos* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 84 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

'Species of Concern' under the Federal government's Species at Risk Act (SARA; 2018)[5]. Special Concern species "may become threatened or endangered because of a combination of biological characteristics and identified threats."[6] Special concern species are particularly sensitive to human activities or natural events but are not endangered or threatened at the species level. The BC Ministry of Environment's Conservation Data Centre, a member of the global NatureServe network, has assessed Grizzly Bears provincially as "S3", which loosely corresponds to "Special Concern" at the 'sub-national' geographic scale. This is the current *conservation status* for Grizzly Bears in British Columbia.

Listing Program	Status	Scope
BC Red and Blue species	Blue-listed	Province
BC Conservation Data Center Status Rank	S3 (Vulnerable Uncertain; 2015)	Province
COSEWIC	Special Concern (2012)	Western Population
SARA	Special Concern (2018)	Western Population
IUCN Redlist	CR-Critically Endangered (Stein-Nahatlatch, North Cascades, Fountain Valley and Hat Creek), EN-Endangered (Yahk-Yaak), VU-Vulnerable (South Selkirks), LC-Least Concern (remaining population)	Sub-populations of the Western Population
Global Redlist	LC (IUCN 2017)	Global

Table 1. Grizzly Bear conservation status under Provincial, Federal and International listing systems.

Grizzly Bear genetic and telemetry monitoring studies have suggested that there are discrete sub-populations within the Western population[7]. However, under COSEWIC assessment methodology, these sub-populations do not qualify for individual listing as designatable units because their isolation results from human disturbance, not natural factors[8]. However, these sub-populations *are* recognized by the International Union of the Conservation of Nature (IUCN). Under a 2017 global status review[9] the IUCN has listed 5 isolated populations of Grizzly Bears in BC as Critically Endangered (Stein-Nahatlatch, North Cascades, Fountain Valley and Hat Creek), Endangered (Yahk-Yaak) or Vulnerable (South Selkirks). The designations were based on the IUCN redlist criteria as modified for Regional Assessment and this included the size and distance of the isolated population to a large healthy population, how permeable the fracture

[5] Species at Risk Public Registry. Accessed Feb 7, 2019: https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=1195

[6] https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/wildlife-species-status-categories-definition.html

[7] McLellan, B.N., Proctor, M.F., Huber, D. and Michel, S. (IUCN SSC Bear Specialist Group). 2016. Brown Bear (*Ursus arctos*) Isolated Populations (Supplementary Material to *Ursus arctos Redlisting* account). The IUCN Red List of Threatened Species 2016.

[8] https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/guidelines-recognizing-designatable-units.html

[9] McLellan, B.N., Proctor, M.F., Huber, D. & Michel, S. 2017. *Ursus arctos*. (amended version published in 2016) The IUCN Red List of Threatened Species 2017: e.T41688A114261661. http://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T41688A114261661.en. Downloaded on **26 October 2017**.

zone is to the movement of female bears and whether there are management actions in place that are resulting in improved conditions for female bears to traverse the fracture zone or genetic evidence that females have moved into the sub-population area and successfully produced offspring[7] (Figure 1).

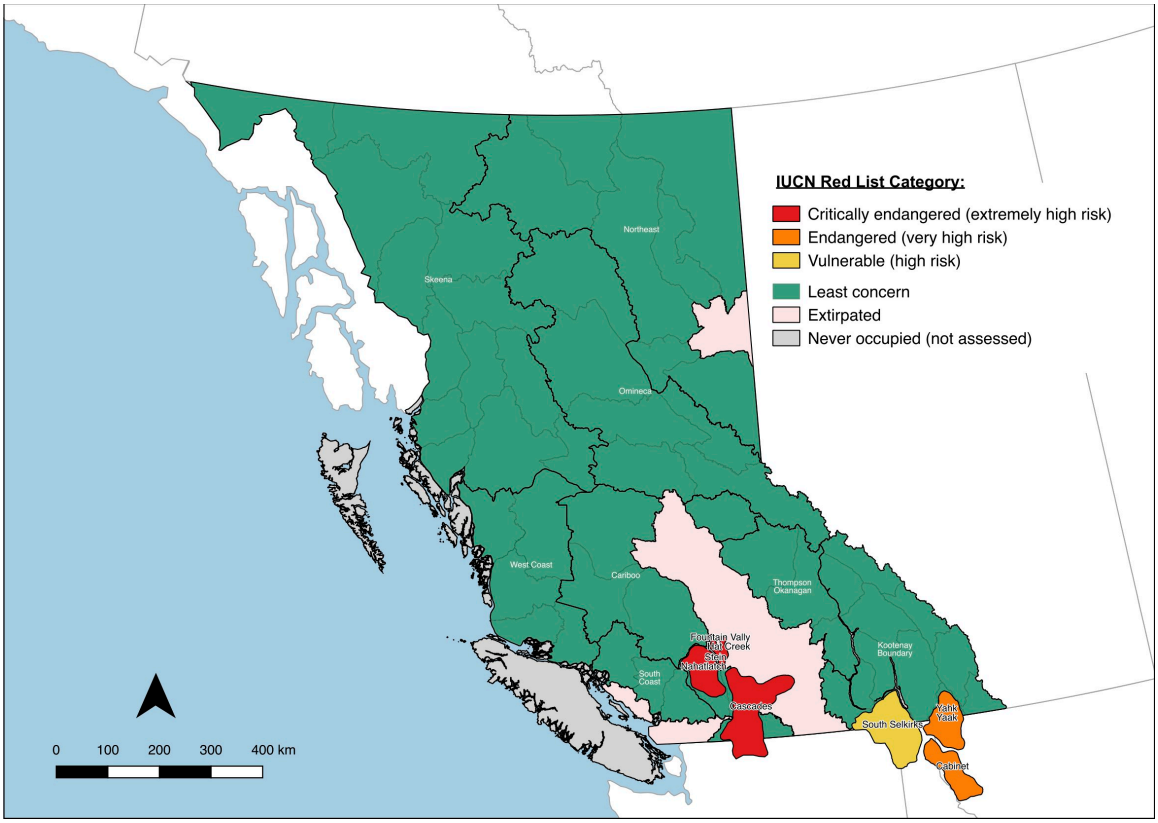

Figure 1. IUCN status of the Western Grizzly Bear Population in British Columbia. The published BC range of grizzly bear's is coloured green, however it may not reflect actual occupancy.

The IUCN assessment estimates the risk of extirpation of each isolated grizzly bear population in B.C., however, it does not determine localized conservation concerns for populations that are not isolated because connectivity ensures little risk of extinction. As a result, a biologically relevant and provincially consistent system for ranking ***localised conservation concern*** is required for discrete geographic areas with a focus on delivering provincial conservation management.

The current Grizzly Bear Population Unit (GBPU) conservation ranking is based on a 2012 assessment[10], where the Province used a three class system for assigning the conservation ranking of GBPUs; Extirpated, Threatened or Viable (Figure 2). Threatened units include; Blackwater West Chilcotin, South Chilcotin Ranges, Squamish Lillooet, Stein Nahatlatch, Garabaldi Pitt, North Cascades, Kettle Granby, South Selkirk and Yahk. A unit's designation as threatened or viable was determined by evaluating the difference between the size of the current population and an estimate of the carrying capacity for the landscape to support Grizzly Bears in the absence of significant human presence. If the current population was considered to be less

[10] http://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html

than half of what the GBPU could support the unit was designated as 'Threatened'. Historically, hunting in some Viable and in all Threatened units was not permitted[11]. This methodology is now considered out of date, no longer reflecting high-level Grizzly Bear conservation initiatives, and based on difficult to determine land capability estimates.

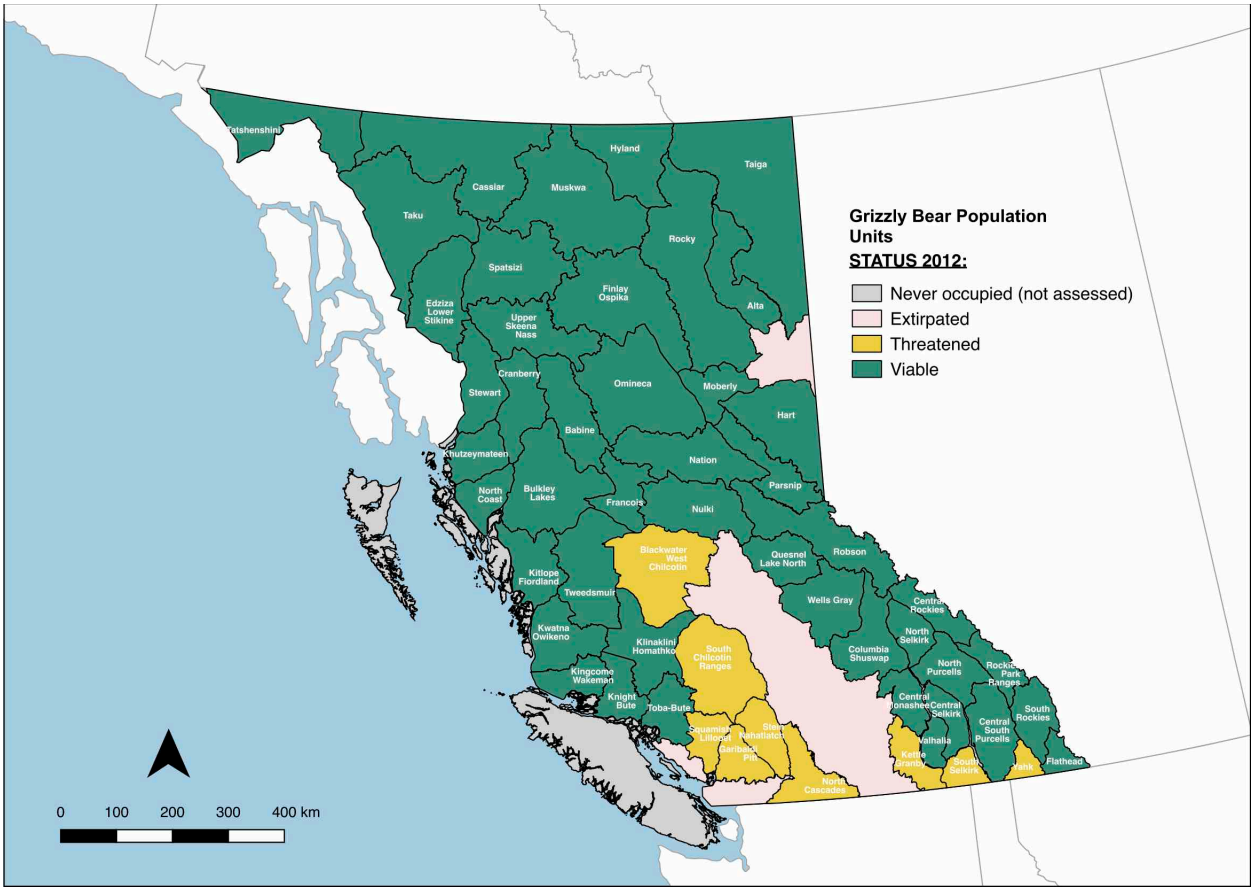

Figure 2. 2012 conservation rank of grizzly bears within Province's Grizzly Bear Population Units (GBPU).

Although BC uses the term Grizzly Bear ***Population*** Unit, almost all of these units simply divide one large, connected population into smaller units for administrative purposes. They were partitioned into areas of similar ecology, with occasional natural and anthropogenic boundaries. GBPUs are used to assess conservation concern, because even within one large population, there can be local areas with elevated conservation concern and these are important to determine and manage.

This report presents the results of a ranking exercise using internationally recognized methodologies for management categorization within a species. Here, we propose an update to the conservation ranking of the 55 GBPUs in British Columbia using a modification of the NatureServe approach: The Element Occurrence Viability Calculator. We did not assess GBPUs for their risk of extinction as the IUCN did, neither are we assessing GBPUs for their "evolutionary significance", as COSEWIC did. We are using this system to assess localized conservation concern across BC to help government meet its stated conservation objectives.

[11] http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grizzly_bear_faq.pdf

Methods

Overview

BC is part of NatureServe's western hemisphere-wide network of non-profit 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[12] including threats. The threats are based on the IUCN-CMP (Conservation Measures Partnership) classifications of direct threats[13]. To document the steps for ranking *species* or ecosystems NatureServe uses an 'Element Rank Calculator'[14]. The calculator includes a summary of the IUCN threats to species[13], as well as, population size, trend and other criteria based on standardized ranking methods[12]. The Ministry of Environment and Climate Change Strategy's (ENV) Conservation Science Section undertook the revised ranking project in collaboration with Forest Lands Natural Resource Operations and Rural Development (FLNRORD) Grizzly Bear specialists. Each GBPU is assigned a local conservation ranking that reflects the GBPU's population size and trend, genetic and demographic isolation, as well as threats to bears and their habitats (M1, the highest conservation concern to M5, the lowest concern)[15].

NatureServe Calculator Logic Overview

We used the NatureServe methodology to determine the conservation ranking of British Columbia's Grizzly Bears[16,17]. Typically, the NatureServe method integrates rarity (e.g., range extent, population size), trend, and threats information to produce a conservation status rank for discrete geographical scales; global (G), national (N) or sub-national (S). For sub-national rankings these are S1 = Critically Imperilled; S2 = Imperilled; S3 = Vulnerable (status of grizzly bears in BC, see Table 1); S4 = Apparently Secure; S5 = Secure. "At Risk of Extripation" species are considered to be in the S1-S3 range, whereas species ranked S4–S5 are categorized as "More Secure". In the NatureServe system, at-risk status is independent from the Canadian Species at Risk Act (SARA), but it is roughly equivalent to the IUCN Red List terms "Near Threatened" and "Threatened" where Threatened encompasses the Critically Endangered, Endangered, and Vulnerable, categories[18].

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[12] http://www.natureserve.org/conservation-tools/conservation-rank-calculator and http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusfactors_apr12_1.pdf

[13] http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme

[14] http://www.natureserve.org/conservation-tools/conservation-rank-calculator

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

[16] Faber-Langendoen, D., J. Nichols, L. Master, K. Snow, A. Tomaino, R. Bitman, G. Hammerson, B. Heidel, L. Ramsay, A. Teucher, and B. Young. 2012. NatureServe Conservaton Status Assessments: Methodology for Assigning Ranks. NatureServe, Arlington, VA.

[17] Master, L. L., D. Faber-Langendoen, R. Bitman, G. A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, VA.

[18] Mace, G. M., Collar, N. J., Gaston, K. J., Hilton-Taylor, C., Akcakaya, H. R., Leader-Williams, N., Milner-Gulland, E. J. & Stuart, S. N. 2008 Quantification of extinction risk: IUCN's system for classifying threatened species. Conserv. Biol. 22, 1424–1442. (doi:10.1111/j.1523-1739. 2008.01044.x)

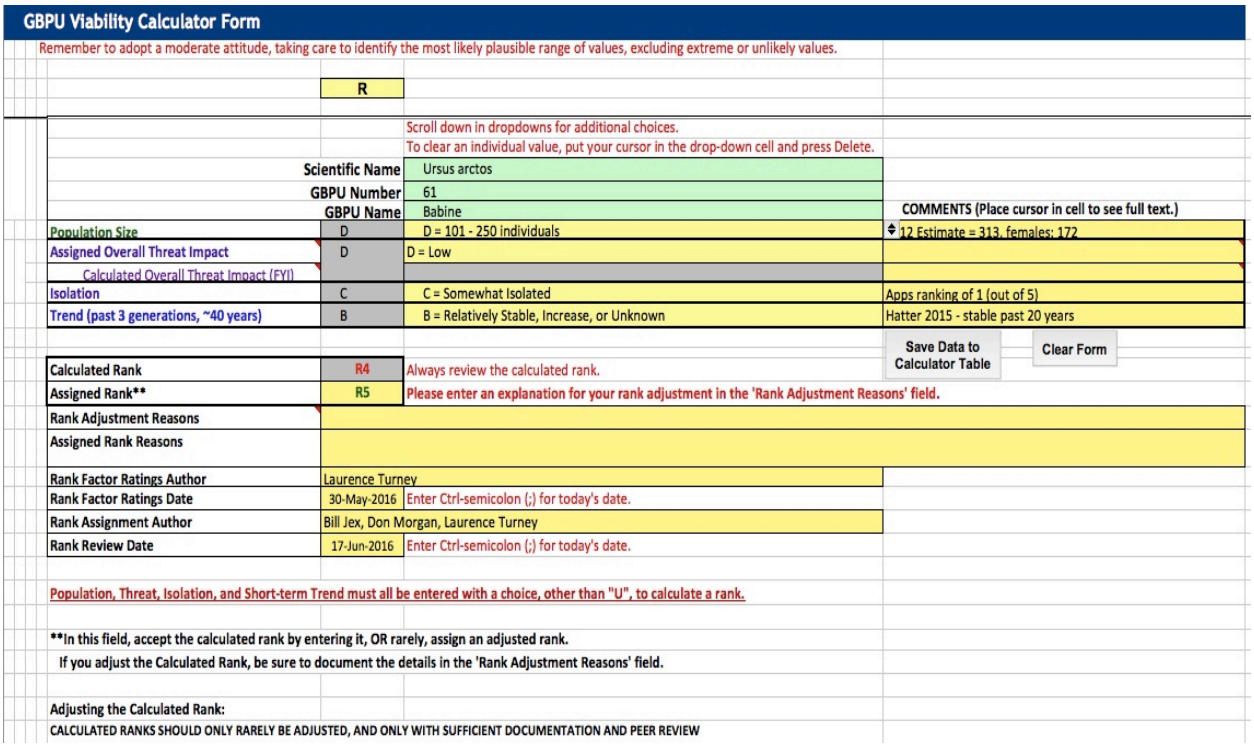
To calculate population trend and the severity of threats the NatureServe method follows the IUCN and uses generation time - mean age of the breeding cohort. This is estimated over the longer of either 3 generations or 10 years. The IUCN uses a 10 year generation time for all 8 species of bears including the brown/grizzly bear so a 30 year period for decline is used.

The Nature Serve calculator uses the 11 IUCN threat categories[19] to determine impacts to species (residential and commercial development, agriculture and aqua- culture, energy production and mining, transportation and service corridors, biological resource use, human intrusions and disturbance, natural system modifications, invasives and other problematic species and genes, pollution, geological events, climate change and severe weather). Threat categories are based on threat scope and severity. The NatureServe calculator then combines the individual threats to determine an overall threat category. Appendix 5 in British Columbia's Guide to Recovery Planning for Species and Ecosystems presents a full description of NatureServe threat assignment using threat scope, severity, and timing[20].

The NatureServe calculator provides a framework for combining population size, isolation, trend and threats, an example of the main calculator form used by NatureServe is shown in Figure 3. Typically, an assessor would record the scope, severity of each of the threats. Threats could be in the past ("historical, unlikely to return" or "historical, likely to return"), "ongoing", and/or likely to occur in the "future". A time frame of 30 years was used as context for assessing the severity of threat. An example threat form is presented in Figure 4.

[19] Salafsky, Nick & Salzer, Dan & J Stattersfield, Alison & Hilton-Taylor, Craig & Neugarten, Rachel & H M Butchart, Stuart & Collen, Ben & Cox, Neil & L Master, Lawrence & O'Connor, Sheila & Wilkie, David. (2008). A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. Conservation biology : the journal of the Society for Conservation Biology. 22. 897-911. 10.1111/j.1523-1739.2008.00937.x.

[20] British Columbia Guide to Recovery Planning for Species and Ecosystems: Appendix 5. Guidance for Threats Assessments. http://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/species-ecosystems-at-risk/recovery-planning/appendix_5_threat_guidance_v2_5may2015.pdf



GBPU Viability Calculator Form

Remember to adopt a moderate attitude, taking care to identify the most likely plausible range of values, excluding extreme or unlikely values.

	R		
		Scroll down in dropdowns for additional choices.	
		To clear an individual value, put your cursor in the drop-down cell and press Delete.	
Scientific Name		Ursus arctos	
GBPU Number		61	
GBPU Name		Babine	COMMENTS (Place cursor in cell to see full text.)
Population Size	D	D = 101 - 250 individuals	12 Estimate = 313, females: 172
Assigned Overall Threat Impact	D	D = Low	
Calculated Overall Threat Impact (FYI)			
Isolation	C	C = Somewhat Isolated	Apps ranking of 1 (out of 5)
Trend (past 3 generations, ~40 years)	B	B = Relatively Stable, Increase, or Unknown	Hatter 2015 - stable past 20 years

Save Data to Calculator Table | Clear Form

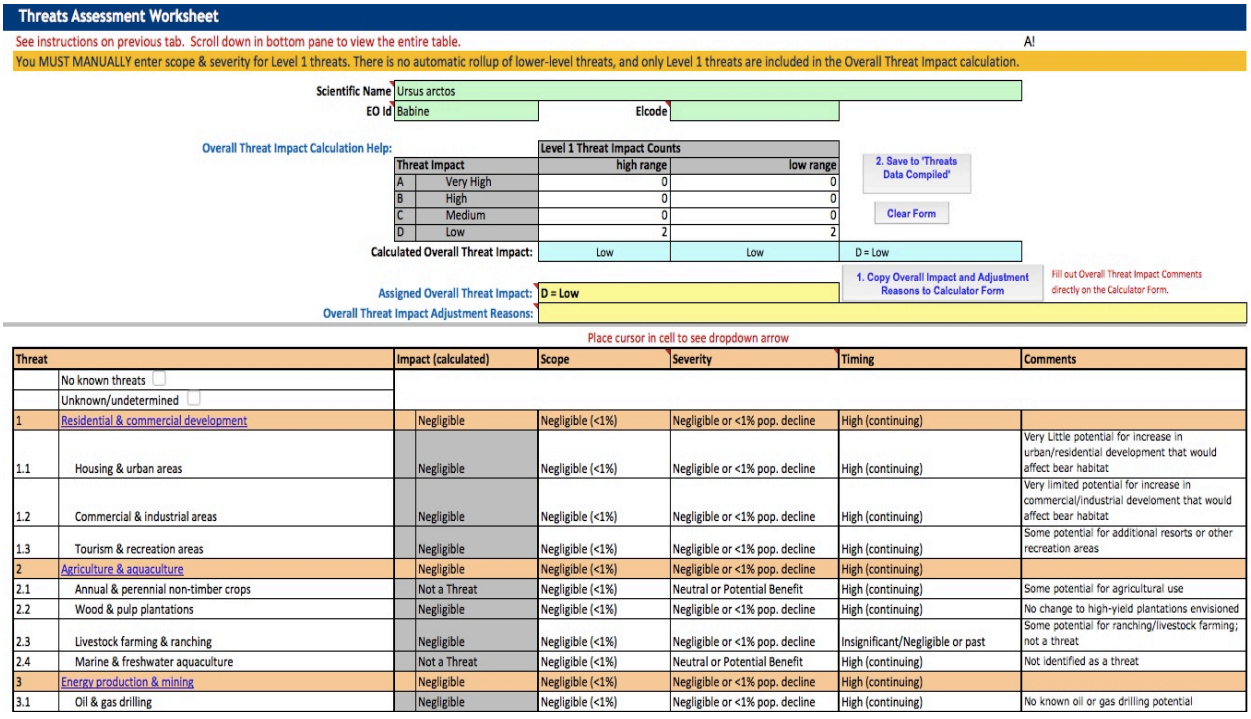
Calculated Rank	R4	Always review the calculated rank.
Assigned Rank**	R5	Please enter an explanation for your rank adjustment in the 'Rank Adjustment Reasons' field.
Rank Adjustment Reasons		
Assigned Rank Reasons		
Rank Factor Ratings Author	Laurence Turney	
Rank Factor Ratings Date	30-May-2016	Enter Ctrl-semicolon (;) for today's date.
Rank Assignment Author	Bill Jex, Don Morgan, Laurence Turney	
Rank Review Date	17-Jun-2016	Enter Ctrl-semicolon (;) for today's date.

Population, Threat, Isolation, and Short-term Trend must all be entered with a choice, other than "U", to calculate a rank.

**In this field, accept the calculated rank by entering it, OR rarely, assign an adjusted rank.
If you adjust the Calculated Rank, be sure to document the details in the 'Rank Adjustment Reasons' field.

Adjusting the Calculated Rank:
CALCULATED RANKS SHOULD ONLY RARELY BE ADJUSTED, AND ONLY WITH SUFFICIENT DOCUMENTATION AND PEER REVIEW

Figure 3. Example of the NatureServe calculator main form.



Threats Assessment Worksheet

See instructions on previous tab. Scroll down in bottom pane to view the entire table. A!

You MUST MANUALLY enter scope & severity for Level 1 threats. There is no automatic rollup of lower-level threats, and only Level 1 threats are included in the Overall Threat Impact calculation.

Scientific Name: Ursus arctos
EO Id: Babine | Elcode:

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	2	2
Calculated Overall Threat Impact:		Low	Low

2. Save to 'Threats Data Compiled' | Clear Form | D = Low

Assigned Overall Threat Impact: D = Low | 1. Copy Overall Impact and Adjustment Reasons to Calculator Form | Fill out Overall Threat Impact Comments directly on the Calculator Form.

Overall Threat Impact Adjustment Reasons:

Place cursor in cell to see dropdown arrow

Threat			Impact (calculated)	Scope	Severity	Timing	Comments
	No known threats						
	Unknown/undetermined						
1	Residential & commercial development		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Very Little potential for increase in urban/residential development that would affect bear habitat
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Very limited potential for increase in commercial/industrial develoment that would affect bear habitat
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	Some potential for additional resorts or other recreation areas
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	
2.1	Annual & perennial non-timber crops		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (continuing)	Some potential for agricultural use
2.2	Wood & pulp plantations		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	No change to high-yield plantations envisioned
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	Insignificant/Negligible or past	Some potential for ranching/livestock farming; not a threat
2.4	Marine & freshwater aquaculture		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (continuing)	Not identified as a threat
3	Energy production & mining		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	High (continuing)	No known oil or gas drilling potential

Figure 4. Example NatureServe Threat form in the calculator.

NatureServe Element Rank Calculator Modifications for Grizzly Bears

NatureServe modified their Element Rank Calculator in 2015 to adapt to the GBPU level[21] by request of BC ENV. The calculator was fine-tuned after input and testing by Drs. M. Proctor and B. McLellan. The modified methodology is consistent with ENV's 2015 Guidance for Threats Assessments for Species and Ecosystems at Risk[20], 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 approach was modified as follows:

- Added a new ranking factor (isolation; Appendix A) to reflect a factor that is important to the viability of GBPUs[22, 23, 24].
- Combined female population size and degree of isolation as a ranking factor modifier to better reflect the reality that GBPUs are often jurisdictional units of varying physical and numerical size (not real biological populations) whose conservation risk depends on their degree of isolation[21].
- Retained the existing threats assessment protocol with no alterations. It was concluded that this standardized treatment of threats and the resulting overall threat impact scores can be used at multiple geographic scales ranging from global to national or sub-national populations (such as GBPUs). However, we recommend that threats be quantified and documented where possible, as we have done here (see below).
- Developed a table that generates an initial GBPU localized conservation risk rank (ranging from 1 [low viability] to 5 [high viability]) from a combination of the GBPU population size, degree of isolation, and the overall threat impact score.
- Retained the short-term trend ranking factor, but changed (simplified) the categories to reflect the limited relevant information available for GBPUs. This factor serves as a modifier to the rank generated from the combined population size/degree of isolation combination and threat impact factors.
- Eliminated all other ranking factors as not appropriate or useful for estimating the viability of GBPUs.

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

[22] Proctor, M. F., B. N. McLellan, C. Strobeck, and R.M.R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of The Royal Society B. Published online. 8 pp.

[23] Proctor, M. F., Paetkau, D., Mclellan, B. N., Stenhouse, G. B., Kendall, K. C., Mace, R. D., Kasworm, W. F., Servheen, C., Lausen, C. L., Gibeau, M. L., Wakkinen, W. L., Haroldson, M. A., Mowat, G., Apps, C. D., Ciarniello, L. M., Barclay, R. M. R., Boyce, M. S., Schwartz, C. C. and Strobeck, C. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs 180: 1–46.

[24] Proctor, M. F., S. E. Nielsen, W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. MacHutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada-United States trans-border region. Journal of Wildlife Management. DOI: 10.1002/jwmg.862.

The NatureServe calculator – an MS-Excel spreadsheet - produces a GBPU rank based on: population size/degree of isolation combination, trend, and threats (see Table 2). To facilitate the ranking analysis, the spreadsheet calculator logic was replicated in a series of automated scripts written using the R[25] statistical package[26].

Calculator Requirement	Description	Data Source
Population Size	Size of female population (55% of total adult) at last census with some updated estimates based on recent field studies.	Garibaldi-Pitt, South Chilcotin Ranges, Squamish-Llilooet, Stein-Nahatlatch, Toba-Bute [27] ; Flathead, South Rockies [28]; and Kettle-Granby [29]; all others 2012 BC Population Estimates[30].
Population Trend	Estimate population trend over last 3 generations.	Hatter 2015[31], published works**Error! Bookmark not defined.** ,32, [33], expert interviews[34]
Population Isolation	Degree of isolation based primarily on human use, with secondary consideration given to natural barriers, such as water, ice fields.	Expert interview**Error! Bookmark not defined.**, expert provincial assessment[35], genetic evidence[23] published works[23, 36], spatial model[37]

[25] R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
[26] https://github.com/bcgov/grizzly-bear-IUCN-threats
[27] Apps, C., D. Paetkau, S. Rochetta, B. McLellan, A. Hamilton, and B. Bateman. 2014. Grizzly bear population abundance, distribution, and connectivity across British Columbia's southern Coast Ranges. Version 2.3. Aspen Wildlife Research and Ministry of Environment, Victoria, British Columbia.
[28] Mowat, G., and C. Lamb. 2016. Population status of the South Rockies and Flathead grizzly bear populations in British Columbia, 2006-2014. BC Ministry of Forests, Lands, and Natural Resource Operations, Nelson BC. http://wild49.biology.ualberta.ca/ files/2016/05/Recent-status-of-the-South-Rockies_final.pdf
[29] Mowat, G., C.T. Lamb, L. Smit, and A. Reid. 2017. The relationships among road density, habitat quality, and grizzly bear population density in the Kettle-Granby area of British Columbia. Prov. B.C., Victoria, B.C. Exten. Note 120. www.for.gov.bc.ca/hfd/pubs/Docs/En/En120.htm
[30] http://www.env.gov.bc.ca/fw/wildlife/docs/Grizzly_Bear_Pop_Est_Report_Final_2012.pdf
[31] HatlerHatter, I. 2015. Statistical Population Reconstruction of Grizzly Bears in British Columbia: Version 1.0. Report to FLNRO Fish and Wildlife.
[32] Mowat G, Heard DC, Schwarz CJ. 2013. Predicting Grizzly Bear Density in Western North America. PLoS ONE 8(12): e82757. doi:10.1371/ journal.pone.0082757
[33] Apps, C. D., B. N. McLellan, M. F. Proctor, G. B. Stenhouse, and C. Servheen. 2016. Predicting spatial variation in grizzly bear abundance to inform conservation. Journal of Wildlife Management 80:396-413.
[34] Bill Jex - Skeena, Shelley Marshal - Ominica, Audrey Gagne-Delorme - Peace, Tony Hamilton - Coast and Cariboo, Michael Proctor - South-east.
[35] Apps, C. 2015. Rating The Potential For Demographic And/Or Genetic Fracturing Within And Among Grizzly Bear Population Units Of British Columbia, Aspen Wildlife Research, June, 2015
[36] Apps, C., D. Paetkau, S. Rochetta, B. McLellan, A. Hamilton, and B. Bateman. 2014. Grizzly bear population abundance, distribution, and connectivity across British Columbia's southern Coast Ranges. Version 2.2. Aspen Wildlife Research and Ministry of Environment, Victoria, British Columbia.
[37] Fall, A. and D. Morgan. 2016. Methods for Grizzly Bear Connectivity Analysis using Spatial Graph Theory. Unpublished report to Ministry of Environment (ver. 1.1; March 29, 2016). 14 pp.

Threats	Extent of residential and commercial development, energy production and mining, transportation networks and service corridors, biological resource use (legal and illegal mortality) and climate change.	Variety of sources please see threats section below for full list

Table 2. Information requirements and sources used for NatureServe Element Rank Calculator.

Each GBPU starts with a rank of 5 – M5 no conservation concern – this value is reduced based on 1) negative population trend, 2) small and/or isolated population, and 3) overall threat (negligible, low, medium, high & very high) . Each of these factors are presented below.

Population Trend

Population trend (A generation time of ~10 years was used for Grizzly Bears, 3 generations being ~30 years[12]) modifies the rank, such that if the population decrease is >25% then the population/risk rank value gets downgraded from the starting value of 5 by 1 to 4. If the population is stable, increasing or there is no empirical evidence of a decline then there is no adjustment to rank.

Population Size-Isolation

The female adult population size /degree of isolation combination follows rank adjustment values as shown in the matrix presented in Table 3. Population size considers the number of female adults, as well isolation is generally considered for females[22,23] . For example, populations with < 10 female adults or small populations < 100 female adults that are totally isolated (>90% isolated) are further downgraded from the trend adjusted rank by 4, shown as an adjustment value of '-4' in Table 3. Various combinations of population size and degree of isolation have various downgrade values as per the matrix below. Isolation categories that are < 25% isolated populations are considered totally connected, between 25-66% isolation are moderately isolated, between 66-90% isolated are highly isolated and > 90% isolated are considered totally isolated. Each population category and isolation have a letter assigned; these letters are combined into a 2 character population-isolation attribute.

Population Size		**Isolation %**			
	Female Adult Population Size	<25 (D)	25-66 (C)	66-90 (B)	>90 (A)
Small (A)	<10	-3	-4	-4	-4
Small (B)	10-50	-0.5	-1	-1.5	-4
Small (C)	50-100	0	-1	-1.5	-4
Medium (D)	100-250	0	-0.5	-1	-3
Large (E)	>250	0	-0.5	-1	-2

Table 3. Rank adjustment values for female population size/degree of isolation, the smaller and more isolated a population the more the unit's rank is reduced. Each GBPU is assigned a combined letter code based on the letter combinations, e.g. small (A) isolated (A) populations are assigned a code of 'AA'.

Threats

Not all NatureServe Threats were considered; natural system modification, invasive species, pollution, and geological events were considered negligible in all cases. Avalanches as a geological event was considered but due to it being a natural and commonly advantageous was not included. This resulted in a subset of Threats assessed, 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. The rank resulting from the trend and population-isolation adjustment are further reduced based on the number and type of sub-threats.

Data used for quantifying threats included; Baseline Thematic Mapping (BTM)[38], Statistics Canada census data for human and livestock (cows and sheep) density[39], energy and mining data[40], recent linear corridor information from the Province's Digital Road Atlas (DRA) and related road data[41]. Provincial cumulative effects (CE) assessment data sets[42], FLNRORD Fish and Wildlife Grizzly Bear mortality data[43], and Federal Department of Fisheries and Oceans (DFO) NuSEDS (New Salmon Escapement Database System) data[44]. Table 4 presents each of the Threat categories, the spatial data and the source for the data.

No.	NatureServe Threat Category	Spatial Data	Data Source
1	**Residential & commercial development**		
1.1a	Housing & urban areas	Urban & Industrial Footprint	DataBC - BTM
1.1b	Housing & urban areas	Human Density	Stats Canada
1.2	Commercial & industrial areas	NA	NA
1.3	Tourism & recreation areas	NA	NA
2	**Agriculture & aquaculture**		

[38] https://catalogue.data.gov.bc.ca/dataset/baseline-thematic-mapping-present-land-use-version-1-spatial-layer
[39] Human-https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/comprehensive.cfm, Cows-https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210042401 and Sheep-https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210042501
[40] https://catalogue.data.gov.bc.ca
[41] WHSE_BASEMAPPING.DRA_DGTL_ROAD_ATLAS_MPAR_SP, WHSE_FOREST_TENURE.ABR_ROAD_SECTION_LINE, WHSE_FOREST_VEGETATION.RSLT_FOREST_COVER_INV_SVW where STOCKING_STATUS_CODE = 'NP' AND STOCKING_TYPE_CODE IN ('RD' , 'UNN') AND SILV_POLYGON_NUMBER NOT IN ('Landing', 'LND') and polygons converted to center lines, WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW(active), WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW(retired), WHSE_MINERAL_TENURE.OG_PETRLM_DEV_RDS_PRE06_PUB_SP, WHSE_MINERAL_TENURE.OG_PETRLM_DEV_ROADS_PUB_SP, and WHSE_MINERAL_TENURE.OG_PETRLM_ACCESS_ROADS_PUB_SP.
[42] Provincial Grizzly Bear Technical Working Group. 2016. Assessment Methods for Grizzly Bears in BC (Tier 1 Provincial Scale Grizzly Bear Assessment Protocol) Standards for British Columbia's Values Foundation (ver. 2.2; March 24, 2016). 42 pp.
[43] Available by request FLNRORD Fish and Wildlife Branch.
[44] https://open.canada.ca/data/en/dataset/c48669a3-045b-400d-b730-48aafe8c5ee6

No.	NatureServe Threat Category	Spatial Data	Data Source
2.1	Annual & perennial non-timber crops	Agriculture, Residential Agriculture Mixtures Footprint	DataBC - BTM
2.2	Wood & pulp plantations	NA	NA
2.3	Livestock farming & ranching	Livestock Density (Sheep and Cows)	Stats Canada
3	**Energy production & mining**		
3.1	Oil & gas drilling	Projects designated as 'Completed', 'Proposed', 'Construction started'	DataBC - energy & mine points
3.2	Mining & quarrying	Projects designated as 'Completed', 'Proposed', 'Construction started'	DataBC - energy & mine points
3.3	Renewable energy	Projects designated as 'Completed', 'Proposed', 'Construction started'	DataBC - energy & mine points
4	**Transportation & service corridors**		
4.1	Roads & railroads - density	Roads and Railway area density	DRA + DataBC (Railway)
4.2	Utility & service lines - density	Transmission lines+Oil and Gas pipelines+Seismic Lines area density	CE data set fromDataBC
5	**Biological resource use**		
5.1a	Hunting & collecting terrestrial animals	average %female mortality for past 10 years	Provincial Mortality Data
5.1b	Hunting & collecting terrestrial animals	All Species Hunting Day Density	Fish & Wildlife hunter data
5.3	Logging & wood harvesting	Area of Mid-Seral Forest	CE data set - Forest Cover
6	**Human intrusions & disturbance**		
6.1	Recreational activities	Front Country	CE data set – modeled Front Country
7	**Natural system modifications**		
8	**Invasive & other problematic species & genes**		
9	**Pollution**		
10	**Geological events**		
11	**Climate change & severe weather**		
11.1	Habitat shifting & alteration	Salmon % Difference between average annual recent (2005-2014) and annual average for all years	CE data set - based on DFO NuSEDS data
11.2	Droughts	NA	NA
11.3	Temperature extremes	NA	NA

Table 4. NatureServe Threat categories, spatial data used to characterize each Threat and the data source, including Baseline Thematic Mapping, DataBC Statistics Canada, CE (Cumulative Effects) data[42]. Threat categories 7, 8, 9 and 10 and some Threat sub-categories were not considered.

Threat Metrics

Specific threat metrics (Table 5) were generated from the spatial data for each Threat:

- Area summaries were used for threats 1.1a (Housing & urban areas), 2.1 (Annual & perennial non-timber crops), where the percentage of the GBPU's flat area in each category was calculated from the spatial layer. Based on a landform[45] analysis (D. Morgan unpublished data), the occurrence of residential, commercial and agriculture land conversions tended to be restricted to flatter areas. In addition, a large portion of some GBPU's area can be non-habitat skewing the area analysis of urban and agricultural land conversions.
- Density of people (1.1b Housing & urban areas) and livestock (2.3 Livestock farming & ranching) were calculated based on assigning the number of people or cows and sheep to the finest spatial resolution that the census data were collected at and converting the layer to a raster and assigning an average density for each GBPU[46].
- Threat 3 (Energy production and mining) used counts of facilities in each GBPU.
- Threat 4.1 (Transportation & service corridors) densities were calculated based on total length of roads in a 1 hectare polygon converted to a raster coverage[47]. A one kilometer moving window was used to calculate the road density for each 1 ha cell in the Province in kilometers/kilometers^2. The average road density/area was assigned to each GBPU with non-habitat removed (large water, ice and rock).
- Threat 5.1a (Hunting & collecting terrestrial animals) was based on the number of female bears recorded and estimated un-reported mortality averaged over 2008 to 2017 (For more detail please see: Appendix B. Grizzly Bear Unreported Mortality Estimate & Mortality Reporting Methodology). The percent female mortality of the estimated total GBPU grizzly bear population was compared against mortality reference points – see Table 5.
- Threat 5.1b hunter-day density was estimated based on 1976-2017 Big Game Harvest Statistics (FLRNORD Fish and Wildlife). To reflect current hunter densities the 5 year period of 2013-2017 was used. The data base provides hunter days per year and the analysis combined resident and non-resident hunters for each year for each wildlife management unit (WMU). A hunter day density was created by assuming even hunter effort across each WMU and dividing the hunter days by the size (km^2) of each WMU. A raster of annual hunter day density was generated and averaged for each GBPU[48].
- Threat 5.3 (Logging & wood harvesting) used an estimate of the amount of forest in a mid-seral state under the assumption that greater than 30% mid-seral forest would limit the availability of Grizzly Bear forage. The estimate is assigned per NDT/Biogeoclimatic Ecosystem Classification (BEC) forest age criteria from the Biodiversity Guidebook[49], and further classified for potential forage suitability. 'Low' forage suitability (dark, dense stands with little understory) are considered as 'mid-seral dense conifer' and BEC Zones are distinguished as either High or Moderate sensitivity[42].

[45] https://adaptwest.databasin.org/pages/adaptwest-landfacets
[46] https://github.com/bcgov/HumanLivestockDensity
[47] https://github.com/bcgov/bc-raster-roads
[48] https://github.com/bcgov/HunterDensity
[49] https://www.for.gov.bc.ca/hfd/library/documents/bib19715.pdf

- Threat 6 (Human Intrusion) uses an index of human-pressure that combines roads, assumed level of road use, human populations, and land type. The index is used to differentiate what would be considered front and backcountry areas. Front Country is considered areas that are within 2 hours of cities or ≤ 1 hour travel time from high-use roads[42].
- Threat 11 (Climate change & severe weather) evaluated the decline of salmon, resulting from climate change (changes in thermal conditions and shifts in predator assemblages impacting at sea, spawning and rearing survival[50]). An estimate of Salmon biomass by 1:50,0000 Watershed Atlas units[44] were aggregated into British Columbia's Landscape Units (LU) [42] based on the average weight of each salmon species and the annual escapement recorded in the NuSEDS database for the stream reaches associated with a Watershed Atlas watershed. Recent escapement (2005 to 2014) was compared to the complete historic record[44].

No.	NatureServe Threat Category	Strata	Reference Point Low	Reference Point Med	Reference Point Rationale
1	**Residential & commercial development**				
1.1a	Housing & urban areas	% of flat areas*	>0.1462%	NA	> 1st quartile
1.1b	Housing & urban areas	Humans/km^2 flat areas	>0.5 humans/km^2	>7 people/km^2	Mattson and Merrill, 2002[51]
2	**Agriculture & aquaculture**				
2.1	Annual & perennial non-timber crops	% of flat areas	>0.8091%	NA	> 1st quartile
2.3	Livestock farming & ranching	livestock/km^2 flat areas	>0.5261 cows/km^2	NA	> 1st quartile
3	**Energy production & mining**				
3.1	Oil & gas drilling	# oil and gas in GBPU	>=1	NA	any is a threat
3.2	Mining & quarrying	# of mines in GBPU	>=1	NA	any is a threat
3.3	Renewable energy	# of renewable sites - wind, run of river in GBPU	>=1	NA	any is a threat
4	**Transportation & service corridors**				
4.1	Roads & railroads - density	km/km^2 of GBPU - remove non-habitat % of unit	0.6 km/km^2	0.75 km/km^2	CE benchmark & Proctor et al. 2018[52]

[50] https://www.nwfsc.noaa.gov/assets/4/9042_02102017_105951_Crozier.2016-BIOP-Lit-Rev-Salmon-Climate-Effects-2015.pdf

[51] Mattson, D. J., and T. Merrill. 2002. Extirpations of grizzly bears in the contiguous United States, 1850–2000. Conservation Biology 16:1125–1136.

[52] Proctor, M. F., B. N. McLellan, G. B. Stenhouse, G. Mowat, C. T. Lamb, and M. Boyce. 2018. Resource Roads and Grizzly Bears in British Columbia, and Alberta. Canadian Grizzly Bear Management Series, Resource Road Management. Trans-border Grizzly Bear Project. Kaslo, BC. Canada http://transbordergrizzlybearproject.ca/research/publications.html.

No.	NatureServe Threat Category	Strata	Reference Point Low	Reference Point Med	Reference Point Rationale
4.2	Utility & service lines - density	km of lines in GBPU-remove non-habitat	0.001 km/km^2	NA	> 1st quartile
5	**Biological resource use**				
5.1a	Hunting & collecting terrestrial animals	by GBPU	>1.33% in GBPU	>2.0% in GBPU	1.33%-2% female based on McLellan et al. 2016.[53]
5.1b	Hunting & collecting terrestrial animals	density days/km^2 GBPU-remove non-habitat	1.5 days/km2	NA	CE benchmark
5.3	Logging & wood harvesting	% of forested portion of GBPU in mid-seral	>30% of strata	NA	CE benchmark
6	**Human intrusions & disturbance**				
6.1	Recreational activities	% of GBPU in front country-remove non-habitat	0.2	NA	CE benchmark
7	**Natural system modifications**				
8	**Invasive & other problematic species & genes**				
9	**Pollution**				
10	**Geological events**				
11	**Climate change & severe weather**				
11	Habitat shifting & alteration	GBPU	>25% average salmon decline	NA	0

Table 5. Threat metric, threshold for low and medium assignment and rationale.

Overall Threat

The final modification to the GBPU rank score is by overall threat. Each of the individual threats were combined to yield an overall threat category – Negilibile, Low, Medium, High or Very High depending on the number and type of individual threats. In general, threats are considered in the context of habitat loss, except in the case of the threat category 'Biological Resource Use' which has a direct impact to the population. The method for combining threats into an overall GBPU specific overall threat score are shown in Table 6.

[53] McLellan BN, Mowat G, Hamilton T, Hatter I. 2017. Sustainability of the grizzly bear hunt in British Columbia, Canada. Journal of Wildlife Management 81(2):218–229
DOI 10.1002/jwmg.21189

Rules for Calculating Overall Threat Class	Threat Class	Ranking Reduction
≥1 Very High, or ≥2 High, or 1 High + ≥2 Medium	Very High	-2.0
1 High, or ≥3 Medium, or 2 Medium + 2 Low, or 1 Medium + ≥3 Low	High	-1.5
1 Medium, or ≥4 Low	Medium	-1.0
1-3 Low	Low	0
0	Negligible	0

Table 6. Number of instances of each threat and assignment to overall threat[16] and amount ranking is reduced.

Rank Assignment

A GBPU rank was assigned based on a starting value of 5 –no conservation concern – this value was then reduced based on 1) negative population trend (0 or -1), 2) small and/or isolated population (0 to -4), and 3) overall threat (Negligible, Low, Medium, High & Very High; 0 to -2) as presented above. Possible scores range from 5 to -2, all scores 0 or below are assigned a 1, highest conservation concern. This results in a final value between 1 and 5, least to most conservation concern. Typically, NatureServe ranking uses a five category approach for species at risk; critically imperilled, imperilled, vulnerable, apparently secure, and secure. When the NatureServe method cannot clearly establish a rank, such as "Vulnerable" (S3) or "Apparently Secure" (S4) it produces a compound rank S3S4. In most cases, to be precautionary and for simplicity, the more conservative part of the rank is used, such that S3S4 would be presented as S3[12].

In the context of grizzly bears in BC, the majority of the GBPUs are part of one large connected population and therefore have a very low extirpation risk over 30 years, in our application we are assessing *localized conservation concern* to guide management. As a result, these categories have been reframed as a range of conservation management concerns (Table 7) from high (M1 and M2) to moderate (M3) to low conservation management concern (M4 and M5). As well, consistent with the NatureServe methodology, compound management ranks were generated for cases where a single rank could not be determined. Those GBPUs in the top 3 management categories (Very High to Moderate) are deemed to have issues that require management actions to improve their condition.

NatureServe Species at Risk Status	GBPU Conservation Ranking
R1-Critically Imperilled	M1-Extreme Concern
R2-Imperilled	M2-High Concern
R3-Vulnerable	M3-Moderate Concern
R4-Apparently Secure	M4-Low Concern
R5-Secure	M5-Very Low Concern

Table 7. NatureServe Conservation Status and GBPU conservation ranking.

Rank Adjustment Criteria

To provide realistic and necessary flexibility into a complex system, other ranking systems (e.g. IUCN Red Lsit assessments) incorporate the ability to adjust a calculated rank based on documentation of pre-determined criteria. Here we suggest that final calculated rankings may be manually modified if they meet the following criteria:

1. The unit is within a female's dispersal distance to a large healthy population;
2. The existence of a written 'recovery/management" plan; and
3. The plan is being implemented.

Results

All of British Columbia's 55 GBPUs were assessed (please see Appendix C for detailed summary of results). Table 8 presents the GBPU population size, population trend, population-isolation code, the 2012 rank, overall threat, and final compound and single rank. Only 5 units had published empirical trend data (Garibaldi-Pitt, North Cascades and Stein-Nahatlatch, declining, and Flathead and South-Rockies, stable).

GBPU	Female Pop 2018	Trend	Popn Iso	2012 Status	Overall Threat	Compound Rank	Single Rank
Garibaldi-Pitt	2	-1	AB	Threatened	Medium	M1	M1
North Cascades	3	-1	AA	Threatened	High	M1	M1
Stein-Nahatlatch	12	-1	BA	Threatened	Medium	M1	M1
Central Monashee	81	0	CB	Viable	High	M2	M2
Central-South Purcells	97	0	CB	Viable	High	M2	M2
Kettle-Granby	48	0	BB	Threatened	High	M2	M2
Moberly	39	0	BB	Viable	High	M2	M2
South Rockies	94	0	CB	Viable	High	M2	M2
South Selkirk	32	0	BA	Threatened	High	M2	M2
Valhalla	48	0	BB	Viable	High	M2	M2
Yahk	11	0	BA	Threatened	VHigh	M2	M2
Columbia-Shuswap	175	0	DB	Viable	High	M2M3	M2
Flathead	77	0	CC	Viable	High	M2M3	M2
Francois	32	0	BC	Viable	High	M2M3	M2
Nulki	24	0	BC	Viable	High	M2M3	M2
Rockies Park Ranges	64	0	CC	Viable	High	M2M3	M2
Squamish-Lillooet	25	0	BB	Threatened	Medium	M2M3	M2
Alta	73	0	CC	Viable	Medium	M3	M3
Blackwater-West Chilcotin	29	0	BC	Threatened	Medium	M3	M3
Central Selkirk	103	0	DB	Viable	Medium	M3	M3
Hart	134	0	DC	Viable	High	M3	M3
Nation	94	0	CC	Viable	Medium	M3	M3
North Coast	105	0	DB	Viable	Medium	M3	M3
Babine	172	0	DC	Viable	Medium	M3M4	M3
Bulkley-Lakes	241	0	DC	Viable	Medium	M3M4	M3
North Purcells	183	0	DC	Viable	Medium	M3M4	M3
North Selkirk	146	0	DC	Viable	Medium	M3M4	M3
Quesnel Lake North	103	0	DD	Viable	High	M3M4	M3

GBPU	Female Pop 2018	Trend	Popn Iso	2012 Status	Overall Threat	Compound Rank	Single Rank
Robson	294	0	EC	Viable	Medium	M3M4	M3
Rocky	296	0	EC	Viable	Medium	M3M4	M3
South Chilcotin Ranges	122	0	DC	Threatened	Medium	M3M4	M3
Central Rockies	93	0	CC	Viable	Low	M4	M4
Cranberry	194	0	DD	Viable	Medium	M4	M4
Taiga	52	0	CC	Viable	Low	M4	M4
Toba-Bute	72	0	CC	Viable	Low	M4	M4
Khutzeymateen	152	0	DC	Viable	Low	M4M5	M4
Kingcome-Wakeman	109	0	DC	Viable	Low	M4M5	M4
Kitlope-Fiordland	118	0	DC	Viable	Low	M4M5	M4
Klinaklini-Homathko	138	0	DC	Viable	Low	M4M5	M4
Knight-Bute	138	0	DC	Viable	Low	M4M5	M4
Kwatna-Owikeno	126	0	DC	Viable	Low	M4M5	M4
Tatshenshini	224	0	DC	Viable	Negligible	M4M5	M4
Wells Gray	190	0	DC	Viable	Low	M4M5	M4
Cassiar	336	0	ED	Viable	Low	M5	M5
Edziza-Lower Stikine	219	0	DD	Viable	Low	M5	M5
Finlay-Ospika	534	0	ED	Viable	Low	M5	M5
Hyland	127	0	DD	Viable	Negligible	M5	M5
Muskwa	462	0	ED	Viable	Low	M5	M5
Omineca	221	0	DD	Viable	Low	M5	M5
Parsnip	250	0	ED	Viable	Low	M5	M5
Spatsizi	366	0	ED	Viable	Low	M5	M5
Stewart	197	0	DD	Viable	Low	M5	M5
Taku	317	0	ED	Viable	Low	M5	M5
Tweedsmuir	202	0	DD	Viable	Negligible	M5	M5
Upper Skeena-Nass	415	0	ED	Viable	Negligible	M5	M5

Table 8. GBPU, female population (55% of total adult), population trend, isolation population code, 2012 rank, overall threat, and compound and single rank. GBPUs with * have had their ranks adjusted from M1 to M2 due to meeting adjustment criteria.

Estimates of threat impact suggest that approximately half (23 GBPUs) are in a Low or Negligible overall threat category. Sixteen have a Medium level of overall threat, fifteen are in a High threat category and one in Very-High for the time frame assessed (Figure 5. Overall threat impacts (combination of all threat categories) to GBPUs (left), Estimated impact of major threat categories (right).). Units with Medium overall threat can still have M1 rankings due to small isolated populations (please see Appendix C). The largest number of threats was due to Human Intrusion (Human Pressure Index), followed by transportation (road and rail density), energy production and mining (number of facilities), agriculture (livestock density), residential (human density), biological resource use (mortality), and climate-change (salmon decline; Figure 5).

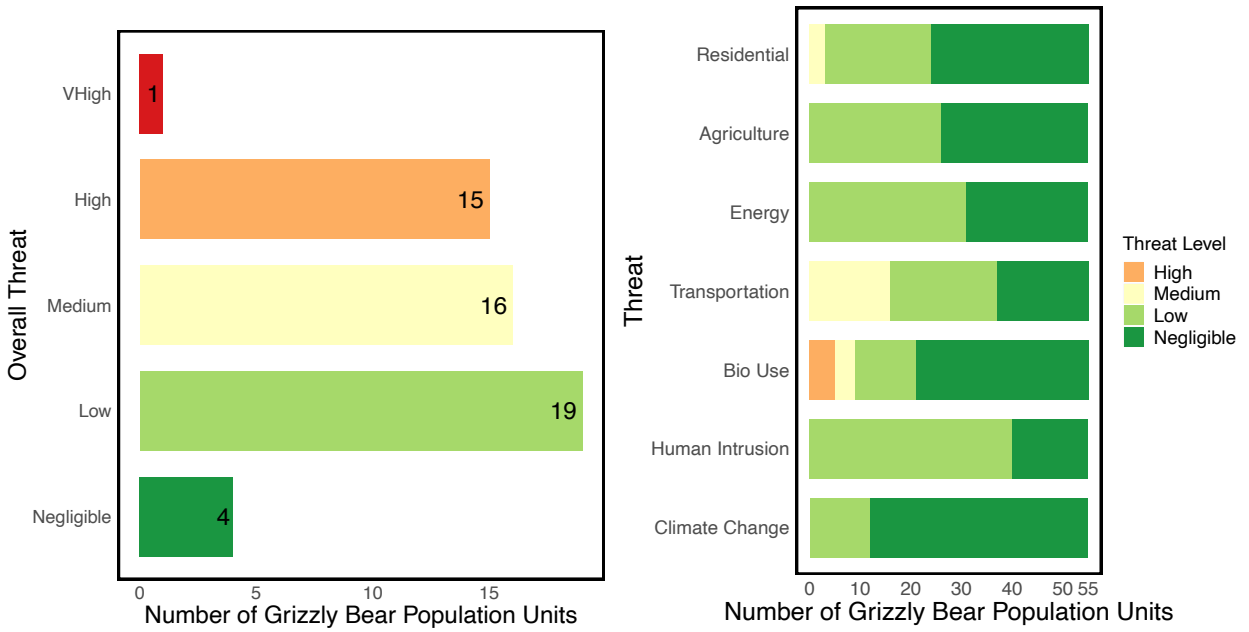

Figure 5. Overall threat impacts (combination of all threat categories) to GBPUs (left), Estimated impact of major threat categories (right).

Units that were assigned a compound rank were also allocated to a single rank based on the highest concern component of their compound rank. The South Selkirk and Yahk GBPUs met all of the adjustment criteria moving them from a M1 to M2 designations[54, 55]. No other units were modified.

Three units were identified as Extreme management concern M1 or M1M2. Fourteen units were identified as High M2, or M2M3. Fourteen are M3 and M3M4 and are of Moderate management concern. Twenty-four are of Low management concern – M4, M4M5 and M5. Table 9 presents a summary of the number and names of each of the GBPUs in each of the NatureServe ranking categories.

Rank	# GBPUs	GBPU Name
M1	3	Garibaldi-Pitt, North Cascades, Stein-Nahatlatch
M1M2	0	
# Extreme Concern	**3**	
M2	7	Central Monashee, Central-South Purcells, Kettle-Granby, Moberly, South Selkirk, Valhalla, Yahk

[54] Proctor, M. F., W. F. Kasworm, K. M. Annis, A. G. MacHutchon, J. E. Teisberg, T. G. Radandt, C. Servheen. 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human Wildlife Interactions 12:248-272.

[55] MacHutchon, A.G. and M.F. Proctor. 2016. Management Plan for the Yahk and South Selkirk Grizzly Bear (*Ursus arctos*) Sub-Populations, British Columbia. Trans-Border Grizzly Bear Project, Kaslo, B.C. 84 pp.

Rank	# GBPUs	GBPU Name
M2M3	7	Columbia-Shuswap, Flathead, Francois, Nulki, Rockies Park Ranges, South Rockies, Squamish-Lillooet
# Higher Concern	**14**	
M3	6	Alta, Blackwater-West Chilcotin, Central Selkirk, Hart, Nation, North Coast
M3M4	8	Babine, Bulkley-Lakes, North Purcells, North Selkirk, Quesnel Lake North, Robson, Rocky, South Chilcotin Ranges
# Moderate Concern	**14**	
M4	4	Central Rockies, Cranberry, Taiga, Toba-Bute
M4M5	8	Khutzeymateen, Kingcome-Wakeman, Kitlope-Fiordland, Klinaklini-Homathko, Knight-Bute, Kwatna-Owikeno, Tatshenshini, Wells Gray
M5	12	Cassiar, Edziza-Lower Stikine, Finlay-Ospika, Hyland, Muskwa, Omineca, Parsnip, Spatsizi, Stewart, Taku, Tweedsmuir, Upper Skeena-Nass
# Lower Concern	**24**	
Total	**55**	

Table 9. GBPUs management rank and name in each of the NatureServe categories, units in pink are of higher concern than those shown in green, with moderates in yellow.

The map shown in Figure 6 shows the geographic distribution of the conservation management ranking with the compound ranks, Figure 7 shows the single rank map of GBPUs. Units of higher management concern are clustered in the central, southern and north-east portions of the Province where there is more extensive human presence and industrial activity. The north-central and north-west GBPUs are generally of lower concern and have lower concentrations of people and activities.

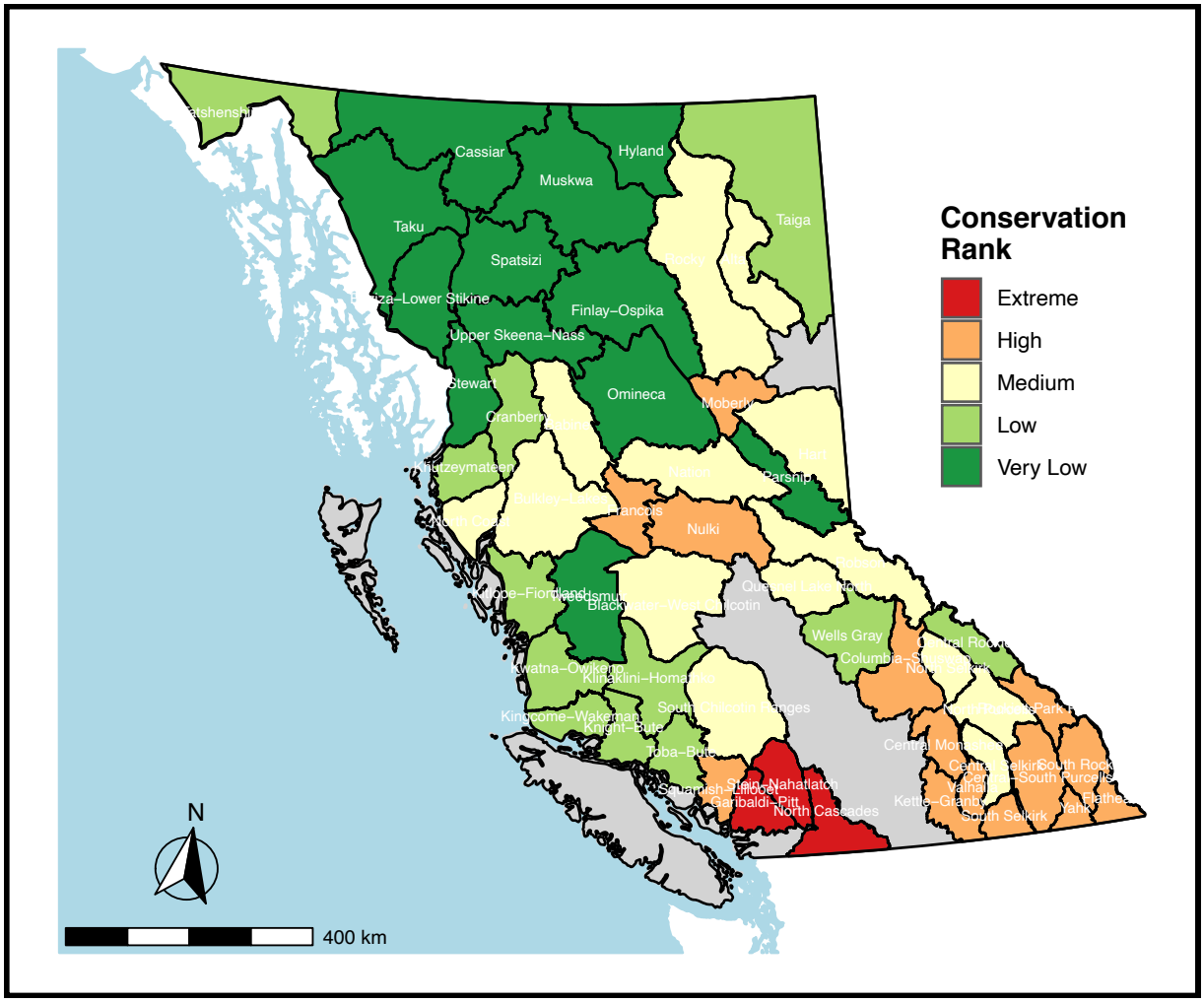

Figure 6. 2019 GBPU Conservation rank with compound ranks, Extreme are the units with the highest conservation rank and Very Low the lowest.

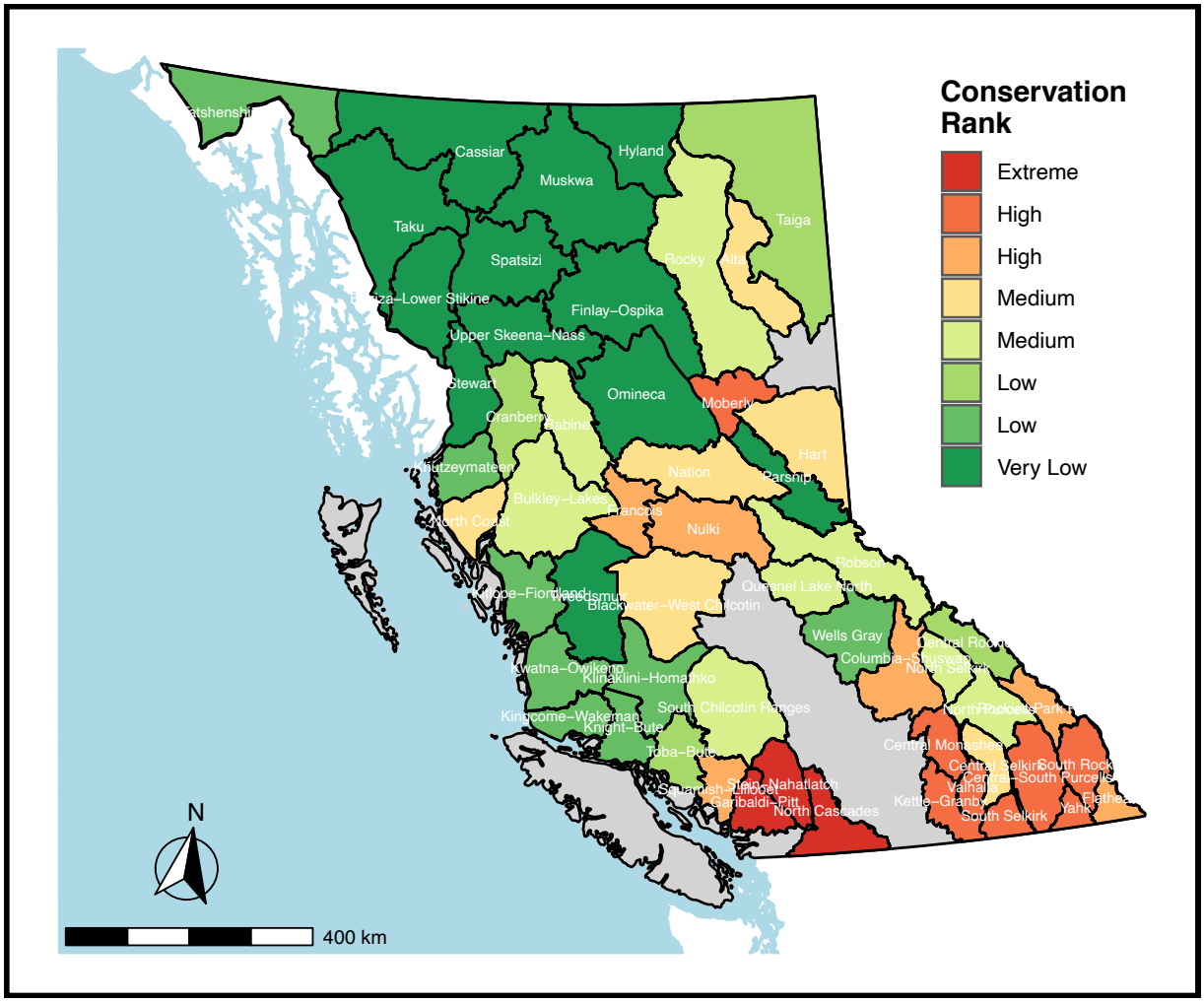

Figure 7. GBPU Conservation rank with simplified ranks, Extreme are the units with the highest conservation rank and Very Low the lowest.

Discussion

Using the NatureServe calculated approach provides an objective, transparent and science-based approach to assigning ranks to BC's GBPUs. The specific management activities associated with a designation of Extreme, High, Moderate or Low conservation concern can be established through Provincial grizzly bear management planning. The specific actions that a wildlife manager or land use decision maker would undertake for Low, Moderate, High or Extreme conservation concern is beyond the scope of this assessment. Further, the approach presented uses a cautionary interpretation of combined ranks, such that an M3M4 is assigned a Moderate (M3) concern and not a Low (M4). However, applying more or less management action for a M3M4 would, again, be at the discretion of Provincial managers.

There are significantly more GBPUs that could be considered of management concern than the nine identified in the 2012 assessment. A direct comparison between this assessment and that

conducted in 2012 is difficult due to the differences in methodologies for assigning ranks. However, there are some factors that have informed this assessment that are leading to lower ranks for some GBPUs, including changes in some threats, such as increases in the amount of active roads and declining salmon stocks, and documented population declines. It is recommended that the rank of GBPUs be re-assessed as new information becomes available, such as population inventory, trend or improved threat mapping.

As with other NatureServe assessments, (and other conservation ranking systems e.g. IUCN Red List Assessments) calculated ranks can be modified based on other information including where assessors can technically justify that threats are less of a concern than the data would indicate. Further, as shown here for the South Selkirk and Yahk GBPUs, those areas that have been documented to fit the predetermined Rank Adjustment Criteria, e.g. active grizzly bear management, which is guided by recovery or conservation management plans, ongoing research and monitoring and elevated education about living with bears, the rankings can be modified.

Work continues to support Grizzly Bear ranking through alignment with provincial and regional spatial assessment to more explicitly quantify threats and isolation. Further, the Province's Cumulative Effects Framework value assessment uses a roll up approach that expresses the state of a value with a single mapped product. The results of the NatureServe GBPU ranking provides a more rigorous and transparent approach and presentation of the condition of British Columbia's GBPUs to inform cumulative effects decision-making.

For a specific GBPU, managers could use the information in the appendices to identify the specific threats that were flagged. Management plans could then outline actions that could be implemented to mitigate those threats. Further, the Province's CE policy, and its Grizzly Bear protocol, provide a framework for identifying indicators of threats that can be explicitly linked to management activities. For example, road density is a threat to bears and road deactivation could be used to reduce densities from 0.75 km/km^2 resulting in shifting the Transportation threat from Medium to Low or to below 0.6 km/km^2 where the threat would become Negligible. In some cases, this could result in reducing a GBPU's conservation rank category. Also see several recent examples of how conservation-related management has improved conservation rank in several GBPUs (Lamb et al 2017[56], Proctor et al. 2018[54]).

A scientific panel was convened to evaluate BC's Grizzly Bear harvest management system. The panel had several recommendations that can be, at least partially, addressed by this work, including linking human caused mortality to habitat condition, organizing current geographic information system layers that can be used to assist in estimating population sizes, establishing population trend procedures, and improved assessment of ecological parameters, such as key foods and habitat quality possibly through resource selection function modeling where feasible.

The use of NatureServe status methods improves the reliability and transparency of GBPU conservation ranking and will result in a more consistent and defensible Provincial approach to GBPU conservation rank assignment. The revised ranking is a key building block in the

[56] Lamb, C. T., G. Mowat, A. Reid, L. Smit, M. Proctor, B. N. McLellan, S. E. Nielsen, and S. Boutin. 2018. Effects of habitat quality and access management on the density of a recovering grizzly bear population. Journal of Applied Ecology 55:1406-1417.

Province's response to the recommendations in the Auditor General's report and can lead to the setting of explicit and defensible conservation and management objectives for each GBPU in British Columbia, including facilitating the development of an inventory and monitoring plan.

Appendix A. Desciption of Grizzly Bear Population Isolation Categories[15]

Isolated (A): extensive glaciers, ice fields, or settled transportation corridors occur along >90% of the population unit border; or genetic or movement data indicate a very high degree of isolation from (or very low degree of demographic interaction with) other population units (e.g., essentially no immigration of males and females into the population unit from other areas), regardless of the presence of glaciers, ice fields, or settled transportation corridors.

Moderately Isolated (B): extensive glaciers, ice fields, or settled transportation corridors occur along 66-90% of the population unit border; or genetic or movement data indicate a moderate to high degree of isolation from (or much reduced—but not complete absence of—demographic interaction with) other population units (e.g., little or no immigration of females into the population unit, but with some immigration of males).

Somewhat Isolated (C): extensive glaciers, ice fields, or settled transportation corridors occur along 25-66% of the population unit border; or genetic or movement data indicate a small but not insignificant reduction in demographic interaction with other population units.

Not Isolated (D): extensive glaciers, ice fields, or settled transportation corridors exist along <25% of the population unit border; or genetic or movement data indicate that the population unit appears to be integrated demographically with adjacent population units (e.g., immigration of females into the population unit appears to be essentially unimpaired). Due to good connectivity and the "rescue effect," these units are likely to have a higher probability of long-term persistence than do more isolated units with the same population size and threat impact.

Appendix B. Grizzly Bear Unreported Mortality Estimate & Mortality Reporting Methodology

Background

The current approach to estimating grizzly bear mortality is described in the Province's Grizzly Bear Harvest Management Procedure (2012). Estimates of mortality are calculated for each Grizzly Bear Population Unit (GBPU) and are reported as recorded mortality plus an estimate of unreported mortality. The specific methods for calculating unreported mortality is described in the 2004 Grizzly Bear Harvest Management in British Columbia[57]. Females are critical in maintaining the long-term viability of grizzly bear populations. BC's Grizzly Bear Management policy identifies a maximum known human caused mortality of 30%[57] female of the total maximum mortality. As a result, tracking female mortality is central to reporting on risk associated with grizzly bear populations.

A new rank assessment is being done for Grizzly Bears in B.C. The assessment uses IUCN/NatureServe methods[58] to estimate risk to bears in each GBPU. For Threat 5, 'Biological Resource Use', the assessment uses the average annual per cent mortality based on a 10 year period. Where Biological Resource Use threat level is based on the percent female mortality with higher percentage mortality being a greater threat to the GBPU's population. The BC grizzly bear hunt was canceled starting in 2018, as a result and for consistency, the 10 year period used - 2008-2017- included reported hunt mortality.

In summary, updates are required to the 2004 methods of unreported mortality due to:

- Changes in human use of landscapes since 2004 which will alter potential for unreported mortalities;
- Recent research provides updates into rates of unreported Grizzly Bear mortality[59];
- An update to the conservation rank of Grizzly Bears requires up to date estimates; and
- Province has committed to implementing recommendations from the Auditor General[60] and is considering implementing key recommendations from the recent scientific panel[61] review of Grizzly Bear management in BC.

Current Approach to Estimating Unreported Mortality (from 2004)

- Appendix 2 of the 2004 report presents a table of GBPUs and the 4 metrics used to evaluate the extent of unreported mortality:
  - Percentage of Capable Habitat in Areas with >5,000 People within 50km;
  - Hunter Day Density (days/1000 sq km);

[57] Austin, M.A., D.C. Heard, and A.N. Hamilton. 2004. Grizzly Bear (*Ursus arctos*) Harvest Management in British Columbia. B.C. Ministry of Water, Land and Air Protection, Victoria, BC. 9pp.
[58] http://www.natureserve.org/conservation-tools/conservation-rank-calculator and http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusfactors_apr12_1.pdf
[59] McLellan et al. (2018), Estimating unrecorded human-caused mortalities of grizzly bears in the Flathead Valley, British Columbia, Canada. PeerJ 6:e5781; DOI 10.7717/peerj.5781
[60] http://www.bcauditor.com/pubs/2017/independent-audit-grizzly-bear-management
[61] http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grizzly-bear-harvest-management-2016.pdf

    - Large Ungulate Harvest Density (Animals/year/1000 sq km); and
    - Percentage of Capable Habitat in >0 km/km2 Road Density Class.
- To estimate unreported mortality for each GBPU, the Flathead GBPU is used as a benchmark and the scores for each metric are normalized to the Flathead, such that the Flathead would score a total of 4, 1 for each metric which equates to the field-based estimate of 2% unreported mortality per year.
- To calculate a final percent unreported mortality for a GBPU, each final score is converted to a proportion of the field-based estimate of the Flathead unreported mortality. Lastly, this estimate is bounded where any scores greater than 3 are set to 3 and scores below 0.3 are reported as 0.3. These are reported as 'Unreported Mortality Rate (Bounded between 0.3 and 3.0%)'.

<u>Updated Approach to Estimating Unreported Mortality</u>

- The 2004 approach uses 2 sets of correlated variables:
    - Areas with >5000 people within 50km of capable habitat and capable habitat in >0 km/km2 road density are both road dependent variables and have a 0.67 correlation; and
    - Hunter day density and large ungulate harvest density are both hunting related with a correlation of 0.73.
- Further, there is no evidence provided that would indicate the power of these factors to predict increases or decreases in unreported mortality.
- We propose a simpler, more transparent method. It uses 3 metrics:
    - Road density: A recent literature review[62] summarizes that landscapes with high road densities have higher bear mortality rates, reflecting the risk that roads travelled by people present to grizzly bear survival. Using only this metric instead of derived ones, including those used in 2004 or others, such as amount of female natal security area (i.e. areas far from human development including roads), provides a more direct metric with fewer associated assumptions;
    - Hunter day density: This metric was used in 2004 and should be retained. During the review of the Provincial Cumulative Effects protocol[63] roads and hunters were identified as two of the most significant factors impacting bears survival by Provincial experts; and
    - Bear density: This metric accounts for probability of encountering a bear, i.e. if there are fewer bears there is a lower probability of encountering a bear and thus lower risk of bear mortality.

[62] Proctor, M. F., B. N. McLellan, G. B. Stenhouse, G. Mowat, C. T. Lamb, and M. Boyce. 2018. Resource Roads and Grizzly Bears in British Columbia, and Alberta. Canadian Grizzly Bear Management Series, Resource Road Management. Trans-border Grizzly Bear Project. Kaslo, BC. Canada http://transbordergrizzlybearproject.ca/research/publications.html.

[63] https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/cumulative-effects/cef_assessment_protocol_grizzly_interim_v11_2018feb6.pdf

Methods: Updated Approach to Estimating Unreported Mortality

- All analyses were performed in R[64] and code stored on the Province's GitHub site (https://github.com/bcgov/). Data is either publicly available or supplied by FLNRORD Fish and Wildlife.
- Data:
  - Roads:
    - The Provincial Cumulative Effects group has generated a 2017 consolidated road file using Digital Road Atlas (DRA), Forest Tenure roads (FTEN), RESULTS constructed for harvest operations, and Oil and Gas Commission roads.
    - The consolidated roads were converted to a 1 hectare raster registering the length of roads in each hectare.
    - A 1 kilometer diameter moving window was applied to the raster roads to generate a **road density** metric of km/km2 roads for each 1 hectare.
    - The R code is posted here: https://github.com/bcgov/bc-raster-roads/tree/bc-ce-roads. The code is a 'branch' of Environmental Reporting BC's provincial road indicator[65].
  - Hunter Day Density:
    - The Hunter Day Density is calculated from data included in the 1976-2017 Big Game Harvest Statistics provided by FLRNORD Fish and Wildlife. Only the previous 5 years were used, 2013-2017 to reflect current hunter densities.
    - The data base provides hunter days per year and the analysis combined resident and non-resident hunters for each year for each wildlife management unit (WMU). Density was created by assuming even hunter effort across each WMU and dividing the hunter days by the size (km2) of each WMU
    - A raster of annual **hunter day density** averaged over the 5 years of the hunter statistics (2012-2017) was generated for the Province based on the density of hunter days in each WMU.
  - Grizzly Bear density
    - WMU/LEH units population estimates have been updated to 2018 based on 2012 estimates[66,67] and recent population estimates based on recent field studies for some GBPUs, (Garibaldi-Pitt, South Chilcotin

[64] R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
[65] http://www.env.gov.bc.ca/soe/indicators/land/roads.html
[66] BC Ministry of Forests, Lands, and Natural Resource Operations. 2012. 2012 Grizzly bear population estimate for British Columbia
[67] Mowat G, Heard DC, Schwarz CJ (2013) Predicting Grizzly Bear Density in Western North America. PLoS ONE 8(12): e82757. doi:10.1371/ journal.pone.0082757

Ranges, Squamish-Llilooet, Stein-Nahatlatch, Toba-Bute [68] ; Flathead, South Rockies [69]; Kettle-Granby [70]).
    - Density is estimated based on bear population and WMU/LEH area corrected for area of non-habitat.
    - The R code is posted here: https://github.com/bcgov/GB_Data.
- Analysis:
    - For each WMU/LEH combination in the Province the Grizzly Bear density, hunter day density and road density were calculated.
    - McLellan et al (2018) summarized historic reported mortality information for collared and uncollared Grizzly Bears in the Flathead drainage (WMU 4-01), see table 2. For all collared bears the ratio of legal hunting to non-hunting mortality is at most 1:1.2, assuming the three suspected cases are nonhunting mortality and that all legally hunted bears are reported. The uncollared data have a 7.1:1 ratio of legal hunting to non-hunting. This would indicate that it is possible that many uncollared non-hunted bear mortalities are unreported. If the ratios were the same approximately 75.2 bears could have been killed and not reported in WMU 4-01over the 37 years of the study. Therefore, as noted by McLellan et al (2018) if the uncollared mirrored the collard then we would assume 88% of the non-hunt mortalities are un-reported, such that: Collared hunt (10)/collared non-hunt(12)=uncollared hunt (71)/x, where x= uncollared non-hunt (85.2), non-hunt mortality should be 85.2 but only 10 uncollared non-hunt are reported leaving 75.2 unreported. As a percent of the total 75.2/85.2 =88.26% of the non-hunt mortalities are un-reported.
    - If we consider non-hunted bears the ratio of reported to not-reported is 10 reported to 75.2 missing giving 75.2/10 = 7.5. The reported non-hunt mortality would be multiplied by 7.5 to give the estimated total non-hunt mortality. This was the ratio used in the analysis.
    - Ideally we would use female collared vs uncollared however the sample size is only 10 bears and so too small to draw reliable sex specific mortality ratios so all sexes were pooled for this analysis.

Table 10. The number of radio collared and uncollared grizzly bears that were known to have died (suspected in parentheses) in the Flathead Valley of British Columbia, 1979–2016[59]

Sex	Cause of death	Collared	Uncollared
Male	Natural	1	0
	Legal Hunting	6	45

[68] Apps, C., D. Paetkau, S. Rochetta, B. McLellan, A. Hamilton, and B. Bateman. 2014. Grizzly bear population abundance, distribution, and connectivity across British Columbia's southern Coast Ranges. Version 2.3. Aspen Wildlife Research and Ministry of Environment, Victoria, British Columbia.
[69] Mowat, G., and C. Lamb. 2016. Population status of the South Rockies and Flathead grizzly bear populations in British Columbia, 2006-2014. BC Ministry of Forests, Lands, and Natural Resource Operations, Nelson BC. http://wild49.biology.ualberta.ca/ files/2016/05/Recent-status-of-the-South-Rockies_final.pdf
[70] Mowat, G., C.T. Lamb, L. Smit, and A. Reid. 2017. The relationships among road density, habitat quality, and grizzly bear population density in the Kettle-Granby area of British Columbia. Prov. B.C., Victoria, B.C. Exten. Note 120. www.for.gov.bc.ca/hfd/pubs/Docs/En/En120.htm

	Nonhunting	4(2)	8
Female	Natural	4	0
	Legal Hunting	4	26
	Nonhunting	5(1)	2
Both	Natural	5	0
	Legal Hunting	10	71
	Nonhunting	9(3)	10

- The Road Density and Hunter Day Density metrics were each normalized to 1 for the WMU 4-01. The two normalized metrics were added and divided by 2 for a WMU 4-01 score of 1.
- The other GBPUs were ranked based on the normalized value of Road Density and Hunter Day Density relative to WMU 4-01.
- The GBPU Road and Hunter Density scores were then multiplied by GBPU bear density, normalized to the Flathead (WMU 4-01), to give a final reported:unreported ratio for the GBPU, such that the Flathead scores a 7.5 consistent with the findings of McLellan et al (2018).
- The R code is here: https://github.com/bcgov/GB_Unreported

Methods: Updated Approach to Generating an Indicator of Grizzly Bear Mortality

- Data:
  - Estimating mortality requires; 1) current bear population estimates, 2) average reported non-hunt mortality over previous 10 years; 3) average reported hunt mortality over previous 10 years 2008-2017[71]; and 4) an estimate of unreported non-hunt mortality.
  - Ratio of reported to unreported mortality as generated above.
  - Average 5 year and 10 year reported mortality data was provided by FLNRORD Fish and Wildlife[72].
  - Population size – as above.
- The Province tracks location and information on grizzly bears that have died in the Province. The previous 10 years of mortality data was combined with WMU/LEH areas to calculate female and unknown sex bear mortality by WMU/LEH. Mortality from hunt and other causes are reported separately.
- Unknown female mortality for the 10 year period was calculated by multiplying the reported female non-hunt mortality by a factor of 7.5. The female unreported non-hunt mortality for the WMU/LEH was then averaged for the 10 year period.
- The overall percent female mortality for a GBPU was then calculated based on the number of reported and unreported non-hunted females + hunted females for all WMU/LEHs in a GBPU. The total female mortality was then calculated as a per cent of the total GBPU population.
- BC uses 4-6% as the range of mortality**Error! Bookmark not defined.**,[53] for interpreting population risk (1.33 to 2% female), with the higher values associated with units

[71] Consistent time frame, given that BC had a hunt for this time period.
[72] Steve MacIver pers. Comm.

verified to have higher recruitment rates. Research[59] indicates that mortality can be as high as 10% (3.33 % female) and still be sustainable.

- For the risk assessment we assume the following for female mortality:
  - 0 to 1.33% is negligible risk - below 4% total;
  - 1.33 to 2% is low risk - below the 6% total;
  - 2 to 3.33% is moderate risk - above 6% but below possible maximum ; and
  - Above 3.33% is high risk – above absolute maximum of 10% total.
- The R code is posted here: https://github.com/bcgov/GB_Mortality

Results: Updated Approach to Estimating Unreported Mortality

Presented in Table 11 is the Grizzly Bear density, road density, hunter day density, and unreported ratio by GBPU.

	GBPU	GB Density	Road Density	Hunter Density	Unreported Ratio
8	Alta	10	1.20	766	0.89
16	Babine	23	0.76	913	1.44
27	Blackwater-West Chilcotin	2	1.12	689	0.17
19	Bulkley-Lakes	20	0.81	891	1.33
2	Cassiar	17	0.09	310	0.16
39	Central Monashee	24	1.33	4144	3.40
31	Central Rockies	28	0.50	592	1.13
42	Central Selkirk	34	0.94	2302	3.08
55	Central-South Purcells	16	1.19	6624	2.61
30	Columbia-Shuswap	25	1.20	1849	2.61
15	Cranberry	31	0.68	308	1.55
10	Edziza-Lower Stikine	29	0.05	87	0.16
11	Finlay-Ospika	33	0.14	125	0.36
49	Flathead	40	1.36	7773	7.50
22	Francois	7	1.50	1356	0.81
48	Garibaldi-Pitt	1	0.71	345	0.05
53	Hart	13	1.04	2542	1.35
4	Hyland	13	0.18	221	0.22
46	Kettle-Granby	13	1.65	6971	2.60
20	Khutzeymateen	38	0.24	142	0.71
38	Kingcome-Wakeman	41	0.45	32	1.23
26	Kitlope-Fiordland	23	0.08	32	0.13
32	Klinaklini-Homathko	20	0.44	181	0.63
52	Knight-Bute	47	0.62	224	2.18
33	Kwatna-Owikeno	25	0.25	12	0.42
17	Moberly	9	0.82	1136	0.62
5	Muskwa	24	0.06	354	0.17
21	Nation	10	1.57	2104	1.32
47	North Cascades	1	1.22	2816	0.12
23	North Coast	30	0.38	188	0.83
37	North Purcells	39	0.71	1307	2.51
34	North Selkirk	49	0.50	496	1.90
54	Nulki	3	2.29	6014	0.67
14	Omineca	14	0.70	445	0.76
18	Parsnip	42	0.50	956	1.93
28	Quesnel Lake North	22	1.18	861	2.00
24	Robson	28	0.87	1357	2.10
36	Rockies Park Ranges	20	0.94	2588	1.90
7	Rocky	14	0.54	1405	0.78
35	South Chilcotin Ranges	12	0.84	1078	0.84
41	South Rockies	21	1.38	10615	4.70
51	South Selkirk	14	1.42	6027	2.41
9	Spatsizi	32	0.03	267	0.17
44	Squamish-Lillooet	9	0.59	619	0.42
43	Stein-Nahatlatch	3	0.61	527	0.14
13	Stewart	40	0.20	41	0.52
3	Taiga	2	0.80	84	0.11
6	Taku	21	0.02	124	0.08
1	Tatshenshini	28	0.02	127	0.10
40	Toba-Bute	21	0.31	172	0.47
25	Tweedsmuir	22	0.18	135	0.33
12	Upper Skeena-Nass	47	0.08	115	0.34
45	Valhalla	25	1.12	3826	3.08
29	Wells Gray	25	0.96	1551	2.11
50	Yahk	7	2.73	14305	2.47

Table 11. Grizzly Bear density, road density, hunter density and unreported ratio for each WMU/LEH. The coloured bars represent the magnitude of the indicator, unreported ratios greater than 2.00 are coloured red, all others green.

Results: Proposed Updated Approach to Generating an Indicator of Grizzly Bear Mortality

Presented in Table 12 is the Grizzly 2018 population estimate, hunt and non-hunt reported and unreported female mortality, total mortality, per cent mortality by GBPU, Threat (converted to number where 0 is Negligible, 1 Low, 2 Medium and 3 High).

GBPU	Pop 2018	10yr Avg Reported Female Non-Hunt Mortality	Unreported Non-Hunt Mortality Ratio	Unreported Non-Hunt Female Mortality	Total Non-Hunt Female Mortality	10yr Avg Total Hunt Female Mortality	Total Female Mortality	per cent Mortality	Threat
Alta	132	0.0	NA	0.00	0.00	1.2	1.20	0.91	0
Babine	313	1.3	NA	2.42	3.72	1.5	5.22	1.67	1
Blackwater-West Chilcotin	53	0.3	NA	0.04	0.34	0.0	0.34	0.64	0
Bulkley-Lakes	439	2.2	NA	3.77	5.97	2.4	8.37	1.91	1
Cassiar	611	1.0	NA	0.22	1.22	5.2	6.42	1.05	0
Central Monashee	147	0.4	NA	1.97	2.37	1.1	3.47	2.36	2
Central Rockies	169	0.0	NA	0.00	0.00	1.6	1.60	0.95	0
Central Selkirk	188	0.2	NA	0.65	0.85	1.2	2.05	1.09	0
Central-South Purcells	176	1.2	NA	4.72	5.92	0.6	6.52	3.70	3
Columbia-Shuswap	318	0.2	NA	1.02	1.22	1.8	3.02	0.95	0
Cranberry	352	0.6	NA	1.17	1.77	2.0	3.77	1.07	0
Edziza-Lower Stikine	398	0.5	NA	0.06	0.56	1.7	2.26	0.57	0
Finlay-Ospika	971	0.1	NA	0.05	0.15	6.1	6.25	0.64	0
Flathead	140	0.6	NA	9.21	9.81	1.0	10.81	7.72	3
Francois	58	0.1	NA	0.11	0.21	0.0	0.21	0.36	0
Garibaldi-Pitt	3	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
Hart	244	0.8	NA	1.33	2.13	3.0	5.13	2.10	2
Hyland	231	0.2	NA	0.05	0.25	1.5	1.75	0.76	0
Kettle-Granby	87	0.2	NA	1.02	1.22	0.0	1.22	1.40	1
Khutzeymateen	277	0.0	NA	0.00	0.00	0.1	0.10	0.04	0
Kingcome-Wakeman	199	0.0	NA	0.00	0.00	0.4	0.40	0.20	0
Kitlope-Fiordland	214	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
Klinaklini-Homathko	251	0.4	NA	0.23	0.63	0.0	0.63	0.25	0
Knight-Bute	250	0.0	NA	0.00	0.00	0.9	0.90	0.36	0
Kwatna-Owikeno	229	0.3	NA	0.11	0.41	0.8	1.21	0.53	0
Moberly	71	0.5	NA	0.28	0.78	0.8	1.58	2.23	2
Muskwa	840	1.0	NA	0.35	1.35	5.1	6.45	0.77	0
Nation	170	0.1	NA	0.24	0.34	0.8	1.14	0.67	0

GBPU	Pop 2018	10yr Avg Reported Female Non-Hunt Mortality	Unreported Non-Hunt Mortality Ratio	Unreported Non-Hunt Female Mortality	Total Non-Hunt Female Mortality	10yr Avg Total Hunt Female Mortality	Total Female Mortality	per cent Mortality	Threat
North Cascades	6	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
North Coast	190	0.8	NA	0.90	1.70	1.2	2.90	1.53	1
North Purcells	332	0.3	NA	1.02	1.32	3.2	4.52	1.36	1
North Selkirk	265	0.0	NA	0.00	0.00	2.0	2.00	0.75	0
Nulki	44	0.8	NA	0.70	1.50	0.1	1.60	3.64	3
Omineca	402	0.1	NA	0.04	0.14	4.7	4.84	1.20	0
Parsnip	455	0.1	NA	0.24	0.34	2.7	3.04	0.67	0
Quesnel Lake North	187	0.1	NA	0.25	0.35	2.8	3.15	1.68	1
Robson	534	0.5	NA	1.03	1.53	4.6	6.13	1.15	0
Rockies Park Ranges	116	0.6	NA	2.12	2.72	1.0	3.72	3.21	2
Rocky	538	2.0	NA	2.72	4.72	3.8	8.52	1.58	1
South Chilcotin Ranges	222	0.5	NA	0.50	1.00	0.0	1.00	0.45	0
South Rockies	170	3.3	NA	28.75	32.05	1.3	33.35	19.62	3
South Selkirk	58	0.1	NA	0.49	0.59	0.0	0.59	1.02	0
Spatsizi	666	0.2	NA	0.03	0.23	3.9	4.13	0.62	0
Squamish-Lillooet	46	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
Stein-Nahatlatch	22	0.1	NA	0.02	0.12	0.0	0.12	0.55	0
Stewart	358	0.8	NA	0.14	0.94	1.8	2.74	0.77	0
Taiga	94	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
Taku	576	0.5	NA	0.06	0.56	3.3	3.86	0.67	0
Tatshenshini	407	0.1	NA	0.01	0.11	2.8	2.91	0.71	0
Toba-Bute	130	0.0	NA	0.00	0.00	0.0	0.00	0.00	0
Tweedsmuir	368	1.6	NA	1.32	2.92	0.7	3.62	0.98	0
Upper Skeena-Nass	755	0.1	NA	0.06	0.16	2.5	2.66	0.35	0
Valhalla	88	0.0	NA	0.00	0.00	0.1	0.10	0.11	0
Wells Gray	345	0.2	NA	0.42	0.62	0.8	1.42	0.41	0
Yahk	20	0.3	NA	1.14	1.44	0.0	1.44	7.20	3

Table 12. Grizzly Bear 2018 population estimate, 10 year average reported female non-hunt mortality, estimated unreported non-hunt female mortality, total non-hunt female mortality, female hunt mortality, total female mortality (including hunt) and per cent female mortality for each GBPU. The coloured bars represent the magnitude of the indicator, per cent female mortality greater than 1.33 are coloured red, all others green. Threat 0 is Negligible, 1 Low, 2 Medium, 3 High based on per cent mortality.

Appendix C. Table of NatureServe GBPU Ranks and Threats by Region.

GBPU	Calculated Rank	Overall Threat	Residential	Residential1a	Residential 1b	Agriculture	Agriculture2 .1	Agriculture 2.3b	Energy	Energy 3all	Transportation	Transport 4.1	Bio Use	BioUse 5.1a	BioUse 5.1b	BioUse 5.3	Human Intrusion	HumanIntrusion 6	Climate Change	Climate Change 11
Cariboo																				
Blackwater-West Chilcotin	M3	Medium	Negligible	0.0633	0.0287	Low	1.0496	0.222	Low	1	Medium	1.2855	Negligible	0.66	0.687	20.5391	Low	34.4922	Negligible	18.1058
Klinaklini-Homathko	M4M5	Low	Negligible	0.076	0.0318	Negligible	0.4855	0.1246	Negligible	0	Negligible	0.5661	Negligible	0.27	0.1884	17.5575	Low	33.0555	Negligible	2.89
Quesnel Lake North	M3M4	High	Negligible	0.1313	0.1545	Low	0.0891	0.3183	Low	2	Medium	1.3958	Low	1.7	0.8809	6.0052	Low	58.0202	Low	35.0169
South Chilcotin Ranges	M3M4	Medium	Negligible	0.0512	0.2792	Low	0.4651	0.4512	Low	1	Low	1.006	Negligible	0.45	1.0959	13.1596	Low	52.6889	Low	33.2237
Kootenay-Boundary																				
Central Rockies	M4	Low	Negligible	0.2662	0.451	Negligible	0.8003	0	Negligible	0	Low	0.6379	Negligible	0.95	0.6138	13.18	Low	49.0914	Negligible	0
Central Selkirk	M3	Medium	Low	1.8854	3.2111	Negligible	0.9571	0.0751	Low	1	Low	1.0393	Low	1.11	2.2524	14.23	Low	99.3987	Negligible	0
Central-South Purcells	M2	High	Low	0.942	4.2275	Low	3.7465	0.2179	Negligible	0	Medium	1.3049	High	3.77	6.6127	25.5572	Low	88.2708	Negligible	0
Flathead	M2M3	High	Low	0.5323	3.0734	Low	1.3481	0.2137	Low	2	Medium	1.4954	High	7.78	7.7414	22.1199	Low	95.7735	Negligible	0
Kettle-Granby	M2	High	Low	0.6523	4.1151	Low	1.3681	0.5199	Negligible	0	Medium	1.8209	Low	1.38	6.8895	22.7418	Low	94.3451	Negligible	-4.7384
North Purcells	M3M4	Medium	Low	0.173	0.5586	Negligible	0.5234	0.0026	Negligible	0	Low	0.88	Low	1.38	1.3358	15.464	Low	79.4182	Negligible	0
North Selkirk	M3M4	Medium	Low	0.2252	1.6909	Negligible	0.0004	0	Low	2	Low	0.6198	Negligible	0.75	0.5008	9.1923	Low	67.6008	Negligible	0
Rockies Park Ranges	M2M3	High	Low	0.84	2.1819	Low	2.0945	0	Low	2	Low	1.0064	Medium	3.2	2.5779	18.1326	Low	89.7403	Negligible	0
South Rockies	M2	High	Low	0.5182	1.5157	Low	2.6187	0.2525	Low	3	Medium	1.4884	High	19.76	10.6028	20.567	Low	93.4215	Negligible	0
South Selkirk*	M2	High	Medium	2.3392	11.9332	Low	4.5605	0.417	Negligible	0	Medium	1.5344	Low	1	5.9629	28.9031	Low	98.7421	Negligible	0
Valhalla	M2	High	Low	0.8067	2.6965	Low	2.6131	0.1179	Negligible	0	Medium	1.2126	Low	0.11	3.69	14.7226	Low	98.9144	Negligible	0
Yahk*	M2	VHigh	Medium	1.4952	11.0521	Low	3.1949	0.6581	Negligible	0	Medium	2.8979	High	7.6	14.0159	38.9822	Low	99.8564	Negligible	0
Northeast																				
Alta	M3	Medium	Negligible	0.0443	0.1168	Low	5.1014	0.2228	Negligible	0	Medium	1.3306	Negligible	0.91	0.7679	21.6512	Low	58.5676	Negligible	0
Hart	M3	High	Low	0.1793	0.8643	Low	4.5478	1.1812	Low	9	Low	1.1425	Medium	2.11	2.543	15.0125	Low	76.1462	Negligible	0.0113
Hyland	M5	Negligible	Negligible	0.0384	0	Negligible	0.0177	0	Negligible	0	Negligible	0.2089	Negligible	0.76	0.2201	8.9348	Negligible	13.0867	Negligible	0
Moberly	M2	High	Low	0.4654	0.9052	Low	0.2118	0.4415	Low	3	Low	0.9443	Medium	2.25	1.1264	8.7978	Low	66.8111	Negligible	0
Muskwa	M5	Low	Negligible	0.0191	0	Negligible	0.0087	0.0004	Low	1	Negligible	0.0634	Negligible	0.77	0.3534	5.1591	Negligible	7.2665	Negligible	0
Rocky	M3M4	Medium	Negligible	0.1216	0.1607	Low	1.2223	0.1753	Negligible	0	Low	0.6122	Low	1.59	1.4117	13.9519	Low	37.7434	Negligible	0
Taiga	M4	Low	Negligible	0.0342	0.0255	Negligible	0.5042	0.0795	Low	1	Low	0.8729	Negligible	0	0.0844	24.7449	Low	24.1257	Negligible	0
Skeena																				
Finlay-Ospika	M5	Low	Negligible	0.0455	0.0322	Low	0.0116	0.3023	Low	1	Negligible	0.1677	Negligible	0.64	0.1248	12.1442	Negligible	0	Negligible	0.0448
Nation	M3	Medium	Negligible	0.1474	0.2742	Negligible	0.5686	0.0356	Low	1	Medium	1.8847	Low	0.67	2.122	10.8597	Low	79.0733	Negligible	20.2247
Nulki	M2M3	High	Low	1.3558	6.6138	Low	8.8049	1.1978	Low	3	Medium	2.5322	High	3.77	6.0142	15.852	Low	97.7714	Negligible	-7.8298
Omineca	M5	Low	Negligible	0.0353	0.014	Negligible	0.0115	0.0806	Low	1	Low	0.8221	Negligible	1.2	0.4391	11.9384	Low	27.9503	Negligible	7.3922
Parsnip	M5	Low	Negligible	0.0555	0.009	Negligible	0.1386	0.049	Negligible	0	Negligible	0.586	Negligible	0.67	0.9663	4.0185	Low	25.6527	Negligible	9.5182
Robson	M3M4	Medium	Negligible	0.1924	0.2239	Low	1.589	0.1395	Low	3	Low	1.0073	Negligible	1.17	1.3736	7.2395	Low	75.3527	Negligible	16.1786
Skeena																				
Babine	M3M4	Medium	Negligible	0.1554	0.4817	Low	2.2572	0.2153	Negligible	0	Low	0.9006	Low	1.71	0.9132	8.3947	Low	56.2252	Negligible	15.2137
Bulkley-Lakes	M3M4	Medium	Low	0.4653	1.4652	Low	1.3395	0.2683	Low	4	Low	0.9696	Low	1.96	0.8823	5.2297	Low	61.8786	Negligible	-28.2837
Cassiar	M5	Low	Negligible	0.0465	0.0244	Negligible	0	0.0011	Low	1	Negligible	0.1019	Negligible	1.05	0.311	2.6552	Negligible	19.0198	Negligible	8.3705
Cranberry	M4	Medium	Low	0.4351	1.6622	Negligible	0.5044	0.0141	Negligible	0	Low	0.7736	Negligible	1.08	0.302	2.583	Low	59.4565	Low	28.1363

GBPU	Calculated Rank	Overall Threat	Residential	Residential1a	Residential 1b	Agriculture	Agriculture2 .1	Agriculture 2.3b	Energy	Energy 3all	Transportation	Transport 4.1	Bio Use	BioUse 5.1a	BioUse 5.1b	BioUse 5.3	Human Intrusion	HumanIntrusion 6	Climate Change	Climate Change 11
Edziza-Lower Stikine	M5	Low	Negligible	0.0275	0.0333	Negligible	0.0069	0.0078	Low	5	Negligible	0.0731	Negligible	0.57	0.0873	2.2832	Negligible	12.4652	Negligible	-30.5342
Francois	M2M3	High	Low	0.4896	0.6459	Low	3.0261	0.2639	Low	2	Medium	1.8464	Negligible	0.38	1.3684	17.6647	Low	81.555	Negligible	15.7889
Khutzeymateen	M4M5	Low	Negligible	0.0548	0.2779	Negligible	0.0054	0.0024	Low	2	Negligible	0.3121	Negligible	0.04	0.1436	3.7118	Low	41.3041	Negligible	3.8141
North Coast	M3	Medium	Low	0.7389	2.8329	Negligible	0.0377	0	Low	2	Negligible	0.4238	Low	1.61	0.1582	3.3993	Low	22.3546	Negligible	19.7391
Spatsizi	M5	Low	Negligible	0.0343	0.0033	Negligible	0.0015	0.0032	Low	1	Negligible	0.0344	Negligible	0.62	0.2678	1.0411	Negligible	9.4682	Negligible	0
Stewart	M5	Low	Negligible	0.1286	0.1341	Negligible	0	0.0078	Low	2	Negligible	0.2966	Negligible	0.78	0.0391	1.8903	Low	31.1	Low	31.0105
Taku	M5	Low	Negligible	0.0291	0.0096	Negligible	0.0073	0.0024	Low	1	Negligible	0.0284	Negligible	0.67	0.1227	1.5118	Negligible	6.9817	Negligible	21.1315
Tatshenshini	M4M5	Negligible	Negligible	0.0026	0	Negligible	0	0	Negligible	0	Negligible	0.0342	Negligible	0.71	0.132	0.5483	Negligible	5.4104	Negligible	0.0157
Upper Skeena-Nass	M5	Negligible	Negligible	0.0333	0	Negligible	0.0737	0.0068	Negligible	0	Negligible	0.0939	Negligible	0.35	0.1166	2.5444	Negligible	5.345	Negligible	-0.4734
South Coast																				
Garibaldi-Pitt	M1	Medium	Medium	0.9065	9.1421	Negligible	0	0.0672	Negligible	0	Low	0.8457	Negligible	0	0.3398	14.3074	Low	83.0074	Low	51.237
North Cascades	M1	High	Low	0.4446	1.9348	Low	0.4918	2.0266	Low	3	Medium	1.3314	Low	0	2.8142	16.0789	Low	97.1017	Low	25.798
Squamish-Lillooet	M2M3	Medium	Low	0.2263	2.9007	Low	1.2596	0.0117	Low	4	Low	0.7579	Negligible	0	0.6096	8.521	Low	59.868	Negligible	24.8341
Toba-Bute	M4	Low	Negligible	0.0103	0.0823	Negligible	0	0.0221	Low	1	Negligible	0.4324	Negligible	0	0.1696	5.5546	Negligible	0	Low	59.8615
Thompson-Okanagan																				
Central Monashee	M2	High	Low	0.2681	1.0852	Low	0.8473	0.5255	Negligible	0	Medium	1.5061	Medium	2.36	4.0244	11.25	Low	90.085	Negligible	-53.7931
Columbia-Shuswap	M2M3	High	Low	0.3115	0.9326	Low	1.5651	0.2481	Low	1	Medium	1.4154	Negligible	0.96	1.8826	15.95	Low	79.9368	Negligible	-58.5283
Stein-Nahatlatch	M1	Medium	Low	0.145	0.6642	Negligible	0.4593	0	Low	4	Low	0.7069	Negligible	0.55	0.5218	8.097	Low	74.8499	Low	48.4406
Wells Gray	M4M5	Low	Negligible	0.2144	0.362	Low	0.6481	0.2718	Negligible	0	Low	1.126	Negligible	0.42	1.5843	12.7347	Low	58.1172	Negligible	9.877
West Coast																				
Kingcome-Wakeman	M4M5	Low	Negligible	0	0.0228	Negligible	0	0	Negligible	0	Low	0.6065	Negligible	0.2	0.032	7.2613	Negligible	0	Low	56.1345
Kitlope-Fiordland	M4M5	Low	Negligible	0.0062	0	Negligible	0	0.0012	Negligible	0	Negligible	0.0902	Negligible	0	0.0242	2.1364	Negligible	0	Low	48.4015
Knight-Bute	M4M5	Low	Negligible	0	0	Negligible	0	0.0046	Negligible	0	Low	0.8638	Negligible	0.36	0.2032	9.0381	Negligible	0	Low	31.3844
Kwatna-Owikeno	M4M5	Low	Negligible	0.0077	0.0172	Negligible	0	0.0041	Negligible	0	Negligible	0.314	Negligible	0.55	0.0095	3.8873	Negligible	0	Low	37.773
Tweedsmuir	M5	Negligible	Negligible	0.0301	0.125	Negligible	0.045	0.1388	Negligible	0	Negligible	0.2284	Negligible	1.02	0.1383	9.2121	Negligible	12.336	Negligible	22.3749

Table 1. GBPU by FLNRO Region with Compound Rank, Overall Threat assignment, and specific NatureServe threat category - followed by the indicator value. Reference points for assigning threat to a Negligible, Low, Medium or High category are presented in the body of the report's Table 5.