

Appendix D

Marten Habitat and Territory Analyses Summary Report

Telkwa Coal Project Marten (*Martes americana*): Habitat and Territory Analyses Summary Report

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Marten (*Martes americana*), photo courtesy of B. Steventon.

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Summary

An analysis of current and potential marten habitat condition, and resultant estimated number of potential breeding-female territories, was conducted for the 194,656 ha regional study area (RSA , includes the LSA) and 35,724 ha local study area (LSA). Assessments were done for 1) current condition ('Suitability') and, 2) assuming all forested sites were in optimal habitat condition ('Capability'). Both these scenarios were conducted assuming no mine infrastructure, and again assuming mine infrastructure with no habitat value.

For current Suitability with no mine infrastructure, I estimated 270 (262-277) potential female territories for the RSA. This could equate to a marten population of up to 1108. For Capability with no mine, I estimated 380 (359-394) territories and a potential marten population of 1576.

Assuming future mine infrastructure had no habitat value, Suitability estimates of RSA female territories were 268 (255-276) and for Capability 370 (341-385).

Caution is advised, however, in interpreting the absolute number of estimated territories or population size as the results can be sensitive to model assumptions such as minimum acceptable territory size and fluctuations in population dynamics.

Along with this report, I have available upon request the analysis model (SELES) coding, raw output files, and input and output maps, and documents cited.

Introduction and Purpose

The purpose of this exercise was to assess the habitat value for marten (*Martes americana*) of the Telkwa Coal Project study area defined by Ardea Biological Consulting. Marten are often a species of interest due to their importance as a fur bearer, especially in relation to aboriginal trapping rights, and as a forest management sustainability indicator species.

Methods

Simulations were conducted using the Spatially Explicit Landscape Event Simulator engine and language (SELES 3.4, Fall & Fall 2001). A summary of model steps and key assumptions is provided here, while details are in the references and model files provided separately.

Primary output map products are: 1-ha raster raw Habitat Score; Smoothed Foraging Habitat Score; Denning Score; Territory ID; Territory Score, and a Combined Foraging Score/Territory Score (the average of Foraging Score and Territory Score). A text file of the characteristics of each potential territory is also provided for potential further analyses.

Landscape Attributes

There have been several marten habitat modelling approaches applied in British Columbia based directly on Vegetation Resources Inventory (VRI)¹ attributes, or interpretations of ecosystem mapping (TEM and/or PEM)² combined with VRI. The simplest version of the latter being a combination of ecosystem (usually BEC variant and site-series) and Seral Stage interpreted from VRI age³. These two attributes are roughly predictive of forest attributes more directly relevant to marten (stand density (basal area), tree sizes (qDBH), snags and coarse woody debris, and potential prey accessibility/productivity). It was my assessment (Steventon 2015), that it is preferable to use those attributes directly from the VRI where available (coarse woody debris an exception, see below).

Other issues with the ecosystem mapping based approach is that consistent mapping is often lacking (size of polygons and use of complexes of ecosystems not spatially defined), and unlike VRI the mapping is not regularly updated. Ecosystem boundaries are an awkward basis for defining habitat units when overlain with VRI age or other shifting attributes of the landscape. Ecosystem mapping may, however, have additional value beyond VRI alone in terms of representing prey productivity (Steventon 2015, page 8). Lofroth (1993), for example, found that site units had some descriptive power of marten use (namely less use of xeric sites) however this was also correlated with more predictive site-level forest structure attributes. VRI site-index, is an alternate indicator of productivity.

For this exercise, I adopted the VRI approach per Steventon (2015).

Maps for the VRI attributes (*Forest Age, Live Basal Area, Site Index, % Dead, Species Layers 1-3 codes and %*) were provided as 1-ha raster maps from Ardea Biological Consultants, and Biogeoclimatic subzone/variant from HectaresBC⁴.

There is no Coarse Woody Debris (*cwd_vol*) mapping available. CWD volumes (m³/ha) were estimated from VRI site-index assuming the generally accepted U-shaped relationship with age, and a linear relationship to productivity represented by Site Index (Feller, 2003). CWD volumes were elevated for up to 50 years in new natural disturbance, returning to background levels after. These are hypothetical estimates, however values are comparable to field studies. Since these are hypothetical and correlated with other attributes, the *cwd* volumes were limited to 5% of the habitat suitability score (see marten model below).

Step 1: $cwd_vol = CLAMP(-150.7 + 14.7 * (Site_Index), 50, 300)$

Step 2: $cwd_vol = CLAMP(cwd_vol * ((87.52 - 1.1 * OverstoryAge + 0.014 * OverstoryAge^2 - 0.00002 * OverstoryAge^3) / 100), 0, 300)$

Step 3: $cwd_vol = cwd_vol * 2$ for natural disturbance <50 years old

¹ <https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory>

² TEM, Terrestrial Ecosystem Mapping; PEM predictive ecosystem mapping.

³ e.g., BC Wildlife Habitat Ratings, <https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-habitats/wildlife-habitat-mapping>

⁴ www.hectaresbc.org

For estimating Snag Basal Area, the maximum of 15% of Live Basal Area or the VRI attribute of Percent Dead was applied (many sites showed no % dead in the VRI).

For the Capability assessment, all forested sites were set to 200 years of Age, and the Basal Area and qBDH were estimated from TIPSYS⁵ estimates using the 200 year Age, Site Index, and current leading species. A starting density of 1600 stems/ha was applied in TIPSYS with a 'natural' stem spatial distribution (uneven spacing). Snag (dead) Basal Area was assumed to be ≈15% of live Basal Area (based on Coates et al., 1997).

Suitability and Capability scenarios were conducted assuming no mine infrastructure, and again assuming mine infrastructure had a habitat score of zero.

Marten Model

The marten assessment procedure and biological rationale follows Steventon (2015) and Steventon & Daust (2009), predicting potential female territories. The winter season, especially for breeding age females, is considered limiting to populations and thus the focus. For this project, we take VRI attributes at face-value, as Mountain Pine Beetle effects and any partial cutting should now be adequately accounted for in the inventory. The landscape connectivity component of those earlier projects was not applied as the project area is well above territory densities where movement effects are no longer relevant.

Marten productivity is closely correlated with prey abundance and accessibility as affected by forest structure (e.g., Andruskiw et al., 2008). Overall, based on prey abundance and the interior climate (cold snowy winters), marten abundance and habitat use are expected to be similar to other interior areas. The closest marten field study to inform the analysis was in the SBS Biogeoclimatic zone between Smithers and Houston (Lofroth, 1993).

In summary, at the site level marten life requisites are access to prey, provision of winter and kit-rearing den sites, and protection from other predators. The key site level forest characteristics include forest density or over-head cover (represented as m²/ha Basal Area), tree sizes (represented as quadratic mean diameter at breast height, qDBH, in cm), and coarse woody debris abundance (represented as volume m³/ha). All these are strongly affected by forest age and productivity.

Habitat scoring is applied to each 1-ha raster cell as follows (Steventon 2015):

$$BA_score = 1 - e(-10 \times (m^2/ha \div 40)^4)$$

$$Snag_BA_score = (1 - e(-7.5 \times (m^2/ha \div 20)^4))$$

$$qDBH_score = 1 - e(-7.5 \times (qDBH \div 30)^{2.5})$$

⁵ Table Interpolation Program for Stand Yields (TIPSYS),
<https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/growth-and-yield-modelling/table-interpolation-program-for-stand-yields-tipsy>

$$CWD_score = 1 - e(-7.5 \times (m3/ha \div 300)^2)$$

$$\%SF_score = (1 + e(-10 \times (\% \div 75)^{2.5}))^{-1}$$

These attribute scores were then combined into a Habitat Suitability Index (HSI) score:

$$HSI = 0.75 \times (\text{Live_BA_score} \times \text{qDBH_score} \times \%SF_score) + (0.2 \times \text{CWD_score} \times \text{qDiamCWD_score}) + (0.05 \times \text{Snag_Score} \times \text{qDBH_score})$$

To account for edge effects and potential raster-scale mapping anomalies, a smoothed HSI layer was then created using a moving window averaging procedure (map *ForageScore*).

To be a successful reproducing female, enough suitable habitat must be integrated into a territory to provide for energetic requirements. Female territories are mostly non-overlapping with other females, resulting in a density limitation. Further, female territories are typically centred on sizeable patches of mature forest, possibly resulting from limited mobility while kits are being weaned in early spring. Thus, the model considers not only the foraging value of each hectare but also the potential for kit rearing (concentrations of high value habitat) and winter denning opportunities (map *DenningScore*).

The territory drawing procedure then probabilistically starts in the higher value landscape locations, with each territory spreading in a roughly circular pattern until either sufficient habitat is found or the maximum allowed territory size is exceeded, 1125 ha in this exercise. The model strives to fit in as many territories as possible on the landscape. Other territory restrictions included having not more than 60% of the territory in low quality (HSI Score < 20), and an x/y shape ratio less than 1.5 (to prevent sinuous shaped territories).

Since there is a stochastic element to the territory drawing procedure (starting locations are probabilistic), small differences in results will occur between simulation runs. To assess the magnitude of this, 10 iterations were conducted for each scenario (Suitability and Capability).

Since the study area is relatively small, to avoid study area edge effects on the territory drawing procedure, habitat scoring and territory spread was applied to a 7 ha buffer around the RSA. All maps, and territory tallies, however, were limited to the RSA and LSA. Any territory partially overlapping the RSA was included.

Results and Discussion

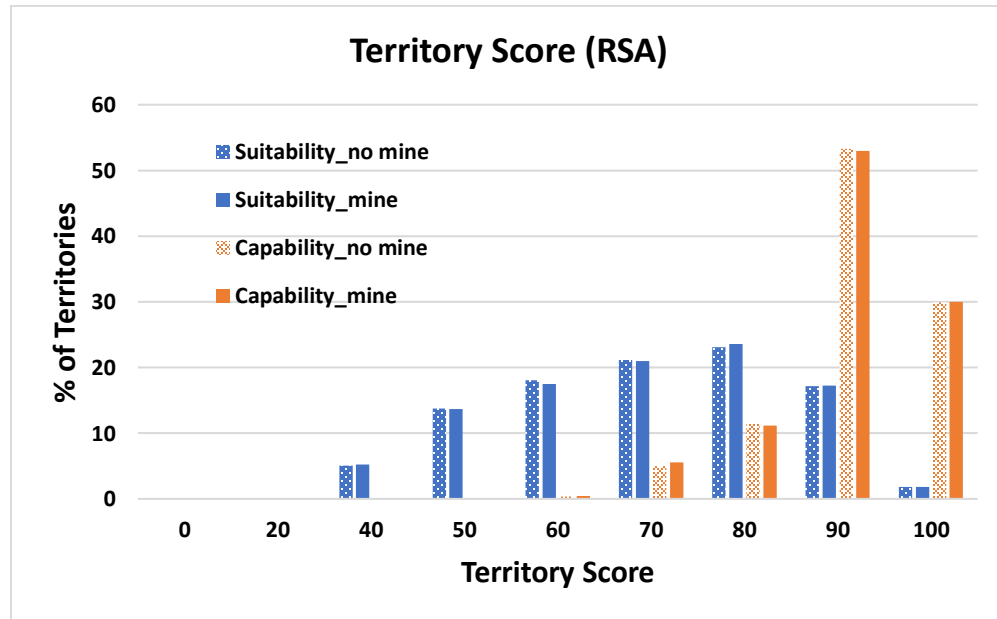
The results for mean number of potential territories (range across 10 iterations) was:

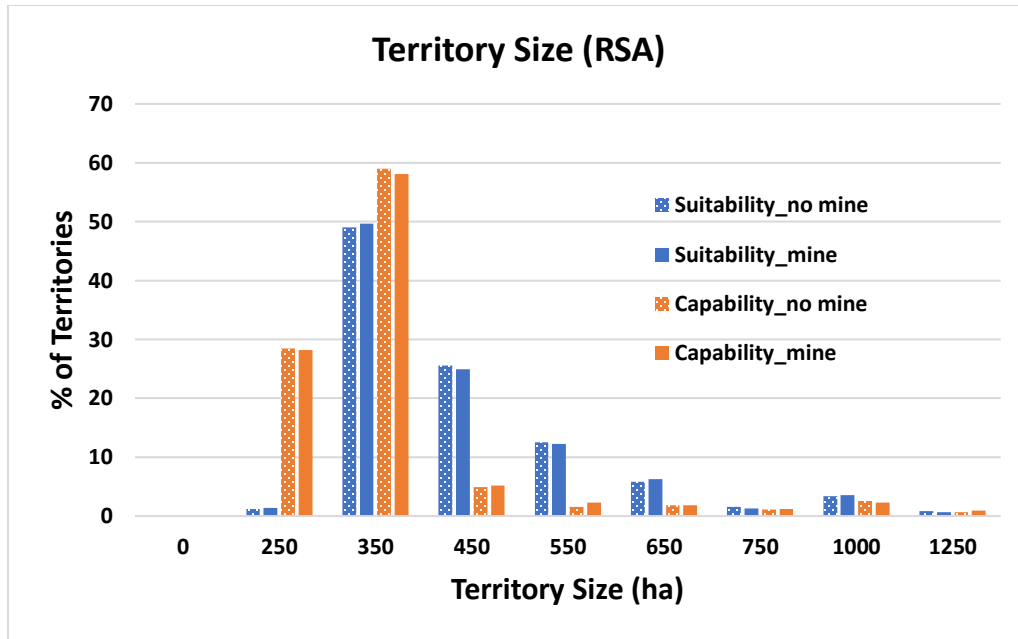
Mean Number of Simulated Territories (range in brackets)

	Without Mine		With Mine	
	Suitability	Capability	Suitability	Capability
RSA¹	270 (262-277)	380 (359 – 394)	268 (255 – 276)	370 (341 – 385)
LSA	43 (37-48)	69 (62-74)	40 (36 – 46)	60 (55 – 73)

¹ includes LSA

Current Suitability is about 70% of Capability for the RSA, 62% for LSA. The distribution of territories within the RSA (no mine) by score and size were as illustrated below:

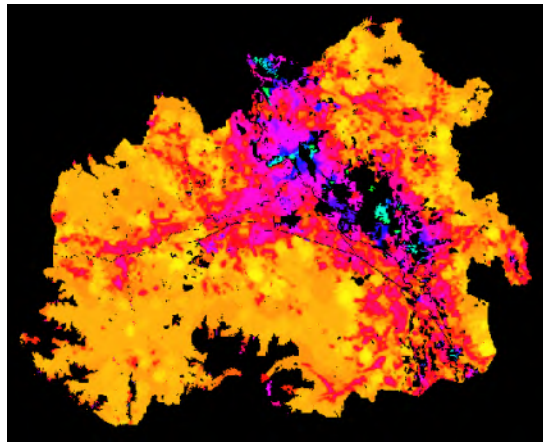
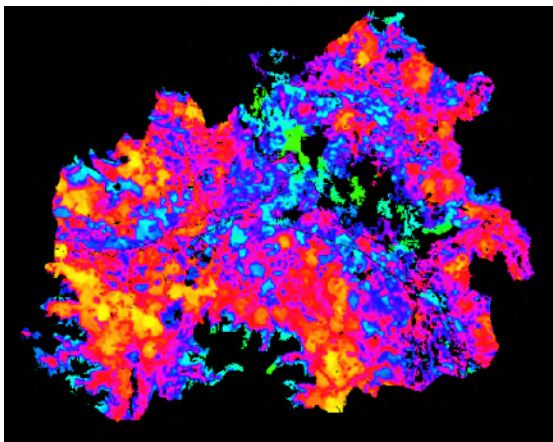


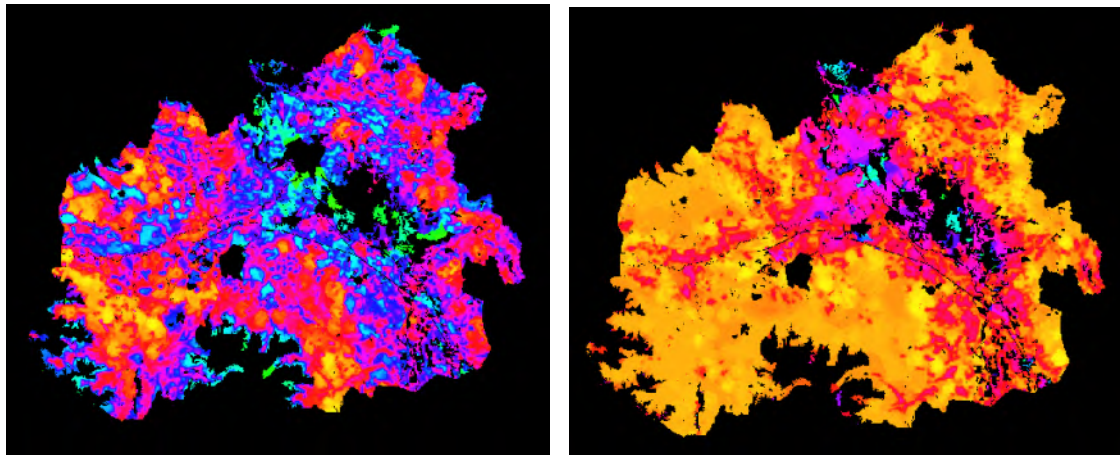


As with all simulation models, the results should not be taken literally but rather as an approximation of the distribution of potential territories. Field studies show that actual marten territories are constantly shifting in response to deaths of neighbours or abandonment of territories.

For a single map of habitat quality, I would suggest the *ComboScore* (below) which is the average of the *ForageScore* and the *ScoreMap_F* (territory score). This captured both the site-level habitat value and the spatial context of the territory. Highest score would be a high value site within a high value ter

ComboScore rating for RSA Suitability (left) and Capability (right), averaged across the 10 iterations. Yellows are highest value, through reds, blues and green. Black is Nil. Top pair is with no mine, bottom pair with the mine.





Marten populations can fluctuate substantively from year to year, largely due to fluctuations in prey abundance affecting survival and reproduction (Flynn & Schumacher, 2009; Fryxel et al., 1999; Schults 2001). Including males, juveniles, and non-territorial adult ‘floaters’ the early winter population could be 2-4x the number of predicted female territories. These simulations suggested a current population of about 524-1108 for the RSA, or 0.27-0.57/km². The LSA (18% of RSA area) represents 14-16% of the RSA territories.

Marten densities are difficult to compare among studies due to varying methodologies and definitions of a landscape. This estimate, however, is within values reported in the literature. It is somewhat higher, for example, than the genetic mark-recapture derived density estimate of 0.30/km² (0.21 – 0.42) for the forested area in a mountainous region of south-east BC (Mowat & Paetkau, 2002). Whereas, Siren et al. (2016) in northern New Hampshire using camera-based mark-recapture reported a density of 0.60/km² (0.35 – 1.01) and Shults (2001) reported mark-recapture densities of 0.69, 0.41, and 0.45/km² over three years in interior Alaska.

Lofroth (1993) could not calculate a density estimate from his data but did suggest the SBSmc BEC variant (and I would suggest the ESSFmc) are higher density than the valley bottom SBSdk, consistent with my results. The Telkwa Coal Project area is thus expected to be in generally high capability habitat.

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Appendix 1: SELES event modules in order of execution each time step

Kispiox MartenTerritories_loop2.scn: Scenario control file

territories.sel: Model definitions file

Landscape

StudyArea.lse : Define study area, prepares input maps, increments forest attributes (succession)

Habitat and Territories

CalcHabitat.lse : calculates habitat score for each raster cell

marten_nesting.lse : uses a 50ha moving window to average habitat score for prioritizing landscape as potential for kit rearing (creates map “DenningScore”

marten_foraging.lse : uses averaging within 100m buffer to smooth score map for estimating foraging habitat score

Territories_marten_v2.lse : draws potential territories

TerritoryMap.lse : creates map of potential territories by quality score (Score_Map_F)

Appendix 2: Maps

All maps are in GRASS compressed raster format, BC Albers 1-ha resolution

Within folder:

Cell: map rasters

Cellhd: geo-spatial criteria

Cat: legend

Colr: vaklue colour coding

Input Maps (/gisData_new)

BEC = BEC_revised: Biogeoclimatic subzones

ITG_Overstory = % Spruce/Fir from the VRI species layers 1-3

SI = siteindex: SiteIndex VRI (estimated for stands less than 50 years)

StudyArea = RSA and LSA from Ardea Biological Consultants

Mine = mine infrastructure from Ardea Biological Consultants

Basal_Area = basalarea: Live Basal Area (m²/ha) from VRI

OverstoryAge = Stand Age from VRI

qDBH = qDBH125: Quadratic Mean Diameter of stems $\geq$ 12.5cm qDBH at breast height VRI

Output Maps (/output/cell)

(X=Scenario, y=iteration)

Score_x_y: initial raster score

ForageScore_x_y: Foraging Score (smoothed initial score from moving window)

DenningScore_x_y: Denning Score (used for territory starting probability)

ScoreMap_F_x_y: Territory Score

TerId_F_x_y; Individual Territory ID

ComboScore_x_y: Average of Foraging Score and Territory Score

ComboScoreAverage_x: ComboScore averaged across 10 iterations

Appendix 3: Input and Output Data Files

Input Files in folder SELES/inputFiles:

tipsy_BA_7.5.txt : Tipsy Basal Area predictions by 5-Year interval and Analysis Unit

tipsy_qDBH_12.5.txt : Tipsy quadratic mean diameter at breast height for stems ≥ 12.5 cm, predictions by 5-Year interval and Analysis Unit.

Output Files in folder /output:

Territories.txt: Raw database of individual territories

LandScene: 1 = Suitability, 2 = Capability

Rep: Repeat iteration of scenario

Sex: 1=female

TerId: Territory sequential ID number

min_Size: Minimum allowed territory size

Ter_Size: actual Territory size

TerScore_raw: Sum of foraging score (scaled 0-1) for territory

TerScore: $\text{TerScore_raw} / \text{Ter_Size}$

xCentre: x coordinate of territory centroid

yCentre: y coordinate of territory centroid

ratio: length to width ratio of territory

Appendix E Grizzly Bear Species Account and Habitat Model Report

Tenas Project

Grizzly Bear Species Account and Habitat Model Report

March 2020

VERSION 4.2

Submitted to: Telkwa Coal Limited
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Tenas Project

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Appendix A	Grizzly Bear Habitat Suitability Mapping
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1. INTRODUCTION

This report describes the grizzly bear (*Ursus arctos*) habitat suitability model developed as baseline information for assessment of the Tenas Project (the Project). The Project Footprint encompasses the area where the proposed mine activities will be conducted. The Local Study Area (LSA) is the area that is expected to contain all direct effects of the Project. The Wide-Ranging Wildlife Regional Study Area (RSA) for wildlife is the area that will be used to assess the context of the direct and indirect effects of the Project on grizzly bear and is the extent of the habitat model for grizzly bear (also referred to as the study area).

Suitability ratings were completed for grizzly bear in the RSA in order to assess potential effects of the Project on current grizzly bear habitat. The species' ecology was reviewed and is summarized here in context of the factors that are required to be taken into consideration in developing the model. This includes the known threats to the species and its known habitat requirements based on the most current available data in the region. Identification of site-specific features such as potential dens will be addressed through pre-clearing surveys and incidental detections.

2. DISTRIBUTION AND STATUS

2.1 Distribution

Grizzly bears are found throughout British Columbia (BC) except for several coastal islands, including Haida Gwaii and Vancouver Island (Stevens 1995). Grizzly bears are wide-ranging in the types of ecosystems that they utilize, occurring in most ecosystem units and across a large gradient of elevations, from sea level to alpine tundra (British Columbia Ministry of Water, Land and Air Protection [MWLAP] 2004, Hamilton et al. 2018). They have been extirpated through much of the Southern Interior, Georgia Depression, and Boreal Plains ecoprovinces in BC. They are found in all biogeoclimatic zones except BG (Bunchgrass), CDF (Coastal Douglas-fir) and Ponderosa Pine (PP).

In 2012, the BC grizzly bear population was estimated to be 15,000 (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development [MFLNRO] 2012). The estimate is based on predictive population densities, by Grizzly Bear Population Unit (GBPU), using all available inventory data supplemented by expert-based knowledge where inventory data is lacking. The grizzly bear range is divided into 56 GBPUs in the Province of BC. BC assigns a status of Threatened or Viable to the GBPUs for the purpose of setting management objectives. Nine GBPUs currently have the status Threatened and 47 are classified as Viable.

The RSA overlaps with the Bulkley-Lakes and Babine GBPUs. Grizzly bear populations are classified as Viable in these two GBPUs and the objectives for these units include maintaining current population abundance and distribution and providing sustainable harvest and viewing opportunities where appropriate (BC MFLNRO 2012). The population within the Bulkley-Lakes GBPU is currently estimated at 439 with an estimated density of 19 grizzly bears/1000 square kilometres (km²). The Bulkley-Lakes GBPU is an estimated 23,884 km² in size with 22,554 km² of useable grizzly bear habitat. The grizzly bear population within the Babine GBPU is estimated at 313 with an estimated population density of 23 grizzly bears/1000 km². The Babine GBPU measures approximately 14,323 km² and encompasses an estimated 13,805 km² of useable grizzly bear habitat (BC MFLNRO 2012).

Grizzly bears are known to occur in each of the ecosystem units in the study area for the Project (Table 1).

Table 1: Study Area of Grizzly Bear Habitat Mapping

Study Area:	Wide-Ranging Wildlife Regional Study Area
Ecoprovince:	Central Interior
Ecoregion:	Eastern Hazelton Mountains (EHM) and Fraser Plateau (FAP)
Ecosections:	Bulkley Basin (BUB) and Bulkley Ranges (BUR)
Biogeoclimatic Zones:	Alpine Tundra (AT) Boreal Altai Fescue Alpine undifferentiated (BAFAun), Coastal Western Hemlock wet sub maritime Montane variant (CWHws2), Engelmann Spruce – Subalpine Fir moist-cold (ESSFmc), Engelmann Spruce – Subalpine Fir moist-cold Parkland (ESSFmcp), Engelmann Spruce – Subalpine Fir moist-cold Woodland (ESSFmcw), Engelmann Spruce – Subalpine Fir moist-cool (ESSFmk), Engelmann Spruce – Subalpine Fir moist-cool Parkland (ESSFmkp), Engelmann Spruce – Subalpine Fir moist-cool Woodland (ESSFmkw), Engelmann Spruce – Subalpine Fir wet-very cold (ESSFwv), Engelmann Spruce – Subalpine Fir wet-very cold Parkland (ESSFwvp), Engelmann Spruce – Subalpine Fir wet-very cold Woodland (ESSFwvw), Interior Cedar – Hemlock moist-cold – Nass variant (ICHmc1), Sub-Boreal Spruce dry-cool (SBSdk), Sub-Boreal Spruce moist-cold Babine variant (SBSmc2)

2.2 Threats and Status

Grizzly bears appear to be limited primarily by human-caused mortality from a variety of factors, and secondarily by habitat loss, alienation (the displacement from otherwise suitable habitat) and fragmentation (Ciarniello et al. 2004; Committee on the Status on Endangered Wildlife in Canada [COSEWIC] 2002). Most grizzly bear mortalities result from human activities, including legal harvesting, Indigenous subsistence hunting, control killing for threatening human habitation or property, self-defence, poaching and railway/road kills (McLellan et al. 2000; COSEWIC 2002). In BC, sport grizzly bear hunting is currently closed. In the Babine GBPU, between 1975 and 2010, annually between 2 and 12 bears were killed, mostly through hunting, followed by animal control and defence kills. Some illegal kills were reported but most remained unknown (BC MFLNRO 2012). In the Bulkley Lakes GBPU, the annual mortality between 1975 and 2010 was between 5 and 18 bears. Most of the mortality was due to hunting, followed by animal control and defence kills as well as illegal kills and railway/road kills (BC MFLNRO 2012).

Human-caused mortality and displacement are exacerbated by access (McLellan 1990; Mace et al. 1996). Literature reports that roads negatively affect grizzly bear populations through increased direct and indirect mortality and that their use of habitat is constrained by roads. Studies have identified that the majority of grizzly deaths were caused by humans and occurred within 500 metres (m) of a road (Ciarniello et al. 2004; Summerfield et al. 2004). Mortality was reported to be either direct (through collisions) or indirect (through hunting and illegal kills). The specific effect of roads on grizzly bears is variably reported in the literature. McLellan and Shackleton (1988) found that grizzly bears avoided even lightly used roads, utilizing habitats within 100 m of roads less than expected. Studies suggest a threshold of 0.6 km/km² of linear access can result in reduced grizzly bear density (Proctor et al. 2018). Some studies show grizzly bears will not cross highways at all resulting in genetic isolation of bears. Conversely, other research has found that grizzly bears will utilize habitats with roads, although avoidance will increase in relation to ease of public access (e.g., open, restricted or closed, Wielgus et al. 2002) and amount of traffic (Mace et al. 1996).

Habitat loss, alienation and fragmentation also threaten grizzly bear populations in BC. Human development often causes direct loss of preferred valley-bottom habitat (BC MWLAP 2004) as well as habitat fragmentation of preferred habitat (Proctor et al. 2002). The fragmentation of habitat has been noted as a threat to grizzly populations, by limiting movement of grizzly bears across the broader landscape.

COSEWIC lists the western population of grizzly bear as a Species of Special Concern and they are also listed as Special Concern under Schedule 1 of the federal Species at Risk Act (Table 1). In BC, grizzly bears are on the provincial blue list as being a species that is of special concern (BC Conservation Data Centre [CDC] 2019, Table 2).

Table 2: Status of Grizzly Bear (*Ursus arctos*)

Species Code	M-URAR
Provincial Status	S3 – Special concern, vulnerable to extirpation or extinction
B.C. List	Blue
Identified Wildlife (Yes / No)	Yes
COSEWIC Status	Special Concern
Species at Risk Act (SARA) Status	Special Concern (Schedule 1, SARA)

3. HABITAT REQUIREMENTS

3.1 Life Requisites

Hibernating habitat is not expected to be abundant in the RSA; therefore, habitat modelling will only rate for Living during spring, summer and fall seasons. The life requisites Forage and Security/Thermal are important to describe habitat suitability for the Living life requisite and are described below. Identification of site-specific features, such as dens, will be addressed through pre-construction surveys and incidental detection protocols due to the limited potential for grizzly bear denning in the RSA.

3.1.1 Forage

The availability, abundance, and distribution of important grizzly bear forage species directly influence grizzly bear reproductive success, movements, human-caused mortality risk, and cub survivorship. In BC, berry species such as huckleberry and blueberry (*Vaccinium* spp.), salmonid species, and whitebark pine (*Pinus albicaulis*) cone seeds are considered important grizzly bear food (Hamilton et al 2018). It has been documented that grizzly bear diets differ among regions due to variation in food availability across different climatic areas and other environmental factors (Coogan et al. 2014, Bojarska and Selva 2011, McLellan 2011). Individual grizzly bear diets are also considered highly variable and dependent on seasonal availability of food items within their home ranges. Variability in food selection occurs year-to-year due to availability, but also individual bears may feed in the same area as others but key in to different food types indicating a certain level of individual preference (Simpson 1990 and 1992, Hatler 1995, MacHutchon et al. 1993, Zager and Jonkel 1983, Hamilton et al. 1986). Individual bears learn about high value feeding areas while they are cubs with their mothers and continue to reinforce this pattern through years of experience using these sites. Grizzly bear seasonal movements are generally attributed to the distribution, abundance and phenology of the major plant food species (e.g., *vaccinium* species in late summer and fall) , as well as

the presence and activity levels of animal food sources such as fish, marmots, caribou and moose (Hamer and Herrero 1984, Lloyd 1979, Hamer and Herrero 1987, Hamilton 1987). Table 3 provides an overview of forage plants important to grizzly bears in the study area.

Table 3: Important Forage Plants within the Study Area (Ash 1985, McCrory et al 1985, Zager et al. 1980, as summarized in Ardea Biological Consulting 2004)

Food Type	Plant Species		
Fruits / Berries	<i>Arctostaphylos uva-ursi</i>	<i>Oplopanax horridum</i>	<i>Sorbus</i> spp.
	<i>Cornus stolonifera</i>	<i>Ribes</i> spp.	<i>Streptopus roseus</i>
	<i>Disporum</i> sp.	<i>Rosa</i> spp.	<i>Vaccinium</i> spp.
	<i>Fragaria</i> sp.	<i>Rubus</i> spp.	<i>Viburnum edule</i>
	<i>Lonicera</i> sp.	<i>Shepherdia canadensis</i>	
Stems and leaves	<i>Angelica</i> spp.	<i>Erigeron</i> spp.	<i>Ranunculus</i> spp.
	<i>Aralia nudicaulis</i>	<i>Fritillaria</i> spp.	<i>Smilacina</i> spp.
	<i>Arnica</i> spp.	<i>Gramineae</i> spp.	<i>Taraxacum</i> spp.
	<i>Athyrium felix-femina</i>	<i>Gymnocarpium dryopteris</i>	<i>Trifolium</i> spp.
	<i>Carex</i> spp.	<i>Heracleum spondylium</i>	<i>Urtica dioica</i>
	<i>Cirsium</i> spp.	<i>Osmorhiza</i> spp.	<i>Valeriana sitchensis</i>
	<i>Epilobium angustifolium</i>	<i>Polygonium</i> spp.	<i>Veratrum veride</i>
	<i>Equisetum</i> spp.	<i>Potentilla</i> spp.	<i>Viola</i> spp.
Roots and tubers	<i>Clintonia uniflora</i>	<i>Erythronium</i> spp.	<i>Lonicera</i> spp.
	<i>Claytonia</i> spp.	<i>Lomatium</i> spp.	<i>Sambucus racemosa</i>
Catkins	<i>Salix</i> spp.	<i>Alnus</i> spp.	<i>Populus</i> spp.
Cones	<i>Pinus albicaulis</i>		

3.1.2 Security/Thermal

Grizzly bears require thermal cover and security habitats. Thermal cover habitat mostly refers to areas providing relief from the elements, usually heat of the sun in the summer but also from other types of extreme weather such as heavy rains. Security habitat is comprised of areas that provide visual screening from other bears and humans.

Security habitat are areas of dense vegetation (e.g., shrubbery, coniferous forest) provide hiding cover (Craighead et al. 1982 in Mace and Waller 1997). Dense coniferous stands provide the highest value security habitat when compared to mixed or deciduous stands (Simpson 1992). During the late spring and summer areas of tall shrub cover can provide security cover. Open, highly suitable feeding habitat where cover is limited can be used during the night. In these cases, darkness provides the security cover to bears using these habitats (Mattson et al. 1987, Gibeau et al. 2002). Security cover is extremely important for sub-adults and sows with cubs, which will often use lower quality foraging habitat in order to ensure the security values are sufficient (McClellan and Shackleton 1988). Sows with cubs often forage in rugged, isolated terrain within forested habitats that are older than pole/sapling and that have dense understory development, or in alpine areas in early summer with a good line of sight, to avoid aggressive male bears (Pearson 1975).

Thermal cover, to avoid the stresses of solar heat, is provided by a variety of habitats such as open water (e.g., rivers, streams, lakes,), permanent snow patches, steep north aspect slopes, and mature forest patches with high canopy closure (Pearson 1975). This requirement is thought to play a small part in forage habitat selection. Often, day beds are found in dense coniferous forest adjacent to high value foraging habitat such as alder-fern patches or wetlands and are utilized during the period of peak daytime

temperatures. Pearson (1975) also found that grizzly bears utilize mature coniferous stands with high canopy closure (>70%) for day bedding to seek shelter from heavy rains.

3.2 Home Range

Grizzly bears are mostly solitary omnivores that have large seasonal and annual home ranges. Home range size varies with food availability, with home ranges in productive coastal habitats are typically smaller than in interior mountains (Hamilton et al. 2018). In addition, the size of individual home ranges can vary from year to year in response to variation in quality and abundance of food (Picton et al. 1985). Home range sizes have not been studied for the GBPUs in the RSA; however, the average BC home range size is 200 to 300 km² for males and 100 km² for females with young. Home ranges in areas with abundant salmon access can be significantly smaller and overlap (Hamilton et al. 2018).

3.3 Seasonal Habitat Attributes

It is assumed that seasonal habitat use will follow the following general trends (McLellan and Hovey 2001, Ciarniello et al. 2003):

- ▶ Winter – hibernation dens in alpine and subalpine areas and along edges of established avalanche tracks.
- ▶ Spring – snow-free areas found in lower elevation valleys, south facing aspects and avalanche chutes, riparian forests and wetlands to feed on emergent vegetation and carrion, areas near goat winter range or marmot colonies and early summer calving areas for moose and caribou.
- ▶ Summer – late-melting slopes (mid-elevation herbaceous habitats and north slopes) to take advantage of emergent vegetation, young seral-stage openings (e.g., burns) and riparian areas for berries, subalpine and alpine meadows for marmots and huckleberry site series often associated with cutblocks and recent burns.
- ▶ Fall – young seral-stage openings (e.g., burns) for late berries and ants in burned stumps, open alpine herbaceous slopes for roots, late berries, marmots and carrion, and riparian areas (including rivers) for roots, late berries, rodents, carrion, and salmon.

Grizzly bears must consume enough food through the spring, summer and fall seasons to deposit sufficient fat to sustain them while hibernating in the winter and for females to produce cubs. Grizzly bears hibernate from November to April, when food is scarce or unavailable; however, the exact timing may vary slightly with latitude and altitude. Adult male bears hibernate later, emerge in the spring earlier, and spend less time near the den site before dispersing than other age and sex classes (Pearson 1975). Mating occurs in May and June, and females give birth in late January through early February in their den (Zager and Jonkel 1983). Litters range from one to three (rarely four) cubs with an average of two cubs (LeFranc et al. 1987). Female grizzly bears usually have their first litter when they are five to seven years old (McLellan 1989, Craighead et al. 1974, Eberhardt et al. 1994, Hovey and McLellan 1996) and remain fertile throughout their lives. They typically only successfully breed every three to four years (Craighead et al. 1995, in McLellan and Hovey 2001). This is in part due to the long rearing period. Young typically remain with their mothers for 26 to 28 months during which the female will pass on necessary skills for survival and habitat selection.

Table 4 provides a summary of seasonal ecosystem attributes for each of the life requisites (Sazena and Bilyk 2000).

Table 4: Seasonal Attributes for Suitable Grizzly Bear Habitat in the Study Area

Season	Life Requisite	Ecosystem Attributes
Winter	HI*	• alpine and subalpine areas with steep slopes, deep soils, some vegetation for roof stability • edges of avalanche tracks
Spring	LI	• south-facing slopes with well-developed soil • lower elevation valley bottoms with open forest canopies • south-facing herbaceous avalanche tracks cleared of snow • mature conifer dominated cover forest
Summer	LI	• subalpine meadows and alpine tundra excluding rock, ice and snow, predominantly alpine meadows, herb fields and grasslands • krummholz subalpine fir/slide alder/rhododendron communities • early seral stage openings (e.g., riparian areas, burns, cutblocks) with high berry production • herbaceous and shrubby avalanche tracks, especially north-facing • salmonid bearing streams / lakes
Fall	LI	• alpine tundra excluding rock and ice, meadow, herb fields and grasslands predominantly • young-seral stage openings (i.e., burns and cutblocks) with high berry production • rivers for spawning salmonids

* Hibernation is not considered for the study area as described in Section 4.1.

3.3.1 Spring Living Habitat Attributes

In early spring, the grizzly bear diet usually consists of new emergent vegetation, roots and winter-weakened or winter-killed ungulates. Plants typically selected during this period include grasses (*Poaceae* family), horsetails (*Equisetum* spp.) and sedges (*Carex* spp.) (Lloyd and Fleck 1977; Hamer et al. 1977; Simpson 1990). As spring progresses, bears will often travel to seepage and avalanche areas where some of their preferred foods are more abundant (Simpson 1990). Mid-spring to late spring, grizzly bear diets start to include plant species such as dandelion (*Taraxacum* spp.), false hellebore (*Veratrum viride*), cow-parsnip (*Heracleum maximum*), hedsarum (*Hedysarum* spp.), and stinging nettle (*Urtica dioica*) (Hamer et al. 1977, Zager and Jonkel 1983, Simpson 1990). In more coastal areas, grizzly bears are also known to feed on the roots of skunk cabbage (*Lysichiton americanus*) and on ferns especially spiny wood fern (*Dryopteris expansa*) and ladyfern (*Athyrium filix-femina*) (Lloyd 1979).

It is assumed that early spring feeding habitat is associated with areas of early green-up such as riparian areas, low elevation wetlands, low elevation south- and west-facing slopes and areas within winter ungulate ranges. Simpson (1990) recorded that a mix of regenerating and mature forests and wetlands provided an abundance of spring forage and, in addition, security cover for grizzly bears ranging in the Babine River drainage of interior BC.

In the study area during spring, grizzly bears are expected to predominantly be focusing on low elevation alder-fern sites, riparian forest ecosystems, wet and rich forested stands such as spruce – horsetail and spruce – devil's club sites, various wetland complexes, and road-side vegetation. They are also expected to move through the area to alpine areas for mating in early summer (alpine mating areas are not present in the study area).

3.3.2 Summer Living Habitat Attributes

Important early summer foods are horsetails, grasses, willow catkins (*Salix* spp.) and lush forbs such as cow parsnip, peavine (*Lathyrus* spp.), clover (*Trifolium* spp.), colts foot (*Petasites* spp.) and angelica (*Angelica lucida*) (Mace and Bissell 1986, Wielgus 1986, McLellan and Hovey 1995, and McCann 1997). Grizzly bears also eat the current years growth of fruiting shrubs as the season progresses into early summer. Lloyd (1979) described coastal grizzly bears feeding on the shoots of salmonberry (*Rubus spectabilis*), the leaves of devil's club (*Oplopanx horridus*) and huckleberry (*Vaccinium* spp.) which are species that are present in the study area.

In the summer, grizzly bears tend to utilize all available habitats within their range such as low elevation habitats like riparian and wetlands, rivers with early salmon runs, mid-elevation habitats like herbaceous meadows, open forests and recently disturbed areas with high berry producing plants or herb dominated avalanche tracks, and some forage in alpine and subalpine habitats feeding on herbaceous and grassy vegetation, marmots and occasionally ungulates like caribou, mountain goats, and moose (LeFranc et al. 1987). Ash (1985) estimated that in forested habitats, canopy closures of 20-50% are optimal for berry production. In late summer, grizzly bears tend to favour berries and a variety of other foods such as huckleberries, soopolallie (*Shepherdia canadensis*), saskatoon (*Amelanchier alnifolia*), kinnikinnick (*Arctostaphylos urva-ursi*), crowberry (*Empetrum nigrum*), cranberry (*Viburnum* spp.), and rose hips (*Rosa* spp.) (Mace and Bissell 1986, McLellan and Hovey 1995, MacHutchon 1996, and McCann 1997).

In the study area, summer berry species include devil's club, red elderberry (*Sambucus racemose*), high-bush cranberry (*Viburnum edule*), red raspberry (*Rubus idaeus*), black twinberry (*Lonicera involucrata*), and soopolallie among others.

3.3.3 Fall Living Habitat Attributes

Fall feeding is a crucial time for grizzly bears since they must put on fat rapidly in preparation for winter denning. Berries make up the majority of the fall food source and the timing and use of different berries corresponds with the dates of ripening. Typically, berries are more abundant at higher elevations in the fall, however, some low elevation habitats also supply some berries and a variety of other food sources. Huckleberries, soopolallie, and saskatoon become the most important food sources while kinnikinnick, crowberry, cranberry, buckthorn (*Rhamnus* spp.) and rose hips continue to be consumed where available (Mace and Bissell 1986, McLellan and Hovey 1995, MacHutchon 1996, and McCann 1997).

Berries tend to be most abundant in natural openings as well as those areas that have been recently disturbed through fire or clear-cut logging. As a result, structural stage can be an important variable when correlated with the availability of berries. Regenerating burns and 10 to 20-year-old clear-cuts typically provide abundant berries and receive relatively high late summer and fall use (Nielson et al. 2004a, b; Ciarnello et al. 2007).

In late summer and fall, salmon start moving up into the interior rivers and, at this time, the diet of many grizzly bears will shift focus to include this food source. Rivers and creeks in the study area used and potentially used by salmonids were identified in Environmental Resource Management's (ERM's) baseline report (2019) and included Goathorn Creek, Tenas Creek, Telkwa River and Bulkley River. Species in the study area include chinook, coho, pink, sockeye and chum salmon (*Oncorhynchus tshawytscha*, *kisutch*, *gorbuscha*, *nerka*, and *keta*, respectively) as well as rainbow and steelhead trout (*Oncorhynchus mykiss*). In addition, Hamer et al. (1977) suggested that ungulates, such as post-rut bull moose may provide an opportunistic fall food source, in particular for male bears.

4. MODEL DEVELOPMENT

4.1 Life Requisites and Seasons

The RSA provides the requirements for spring, summer and fall living functions. Winter denning habitat is typically limited to alpine and subalpine areas, which are limited within the RSA. Table 5 summarizes the seasonal life requisite requirements for grizzly bear based on the seasons outlined by the Resources Inventory Committee (1999).

Table 5: Grizzly Bear Living Seasons for the Biogeoclimatic Subzones in the Study Area*

BEC Subzone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SBSmc2												
SBSdk												
ESSFmc												

Not Used



Spring



Summer



Fall



* The majority of the study area is located within SBS and ESSF habitats; therefore, the description of living seasons focuses on these habitats. Site-specific denning habitat will be addressed through pre-construction surveys and chance find protocols.

4.2 Data Acquisition and Preparation

The spatial datasets, with their sources, used to develop grizzly bear model are described in Table 6. The ecosystem attributes were from an updated dataset developed by combining provincial Predictive Ecosystem Mapping (PEM) and Vegetation Resource Index (VRI) datasets and clipping the extend of the combined dataset to the RSA.

Table 6: Datasets Used in the Development of the Grizzly Bear Model

Dataset Name	Description	Source
Digital Elevation Model	Raster file of elevation data	https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/terrain
Vegetation Resource Index	Polygons representing vegetated and non-vegetated land classifications	https://catalogue.data.gov.bc.ca/dataset/vri-forest-vegetation-composite-polygons-and-rank-1-layer
Predictive Ecosystem Mapping	Large scale classification and mapping of ecosystem units across BC	https://catalogue.data.gov.bc.ca/dataset/predictive-ecosystem-mapping-pem-detailed-polygons-with-short-attribute-table-20-000-spatial-view
Digital Road Atlas	Road dataset for BC	https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads
GeoBase 250K Land Cover, Circa 2000	Polygons identifying land classifications (e.g., annual cropland, snow/ice, developed)	https://catalogue.data.gov.bc.ca/dataset/other-land-cover-1-250-000-geobase-land-cover#edc-pow
Recreation Tenure Alpine Ski Areas	Polygon and point features for ski areas	https://catalogue.data.gov.bc.ca/dataset/recreation-tenure-alpine-ski-areas

Dataset Name	Description	Source
Municipalities – Legally Defined Administrative Areas of BC	Polygons outlining legally defined municipalities in BC	https://catalogue.data.gov.bc.ca/dataset/municipalities-legally-defined-administrative-areas-of-bc#edc-pow
CanVec	Point sources for anthropogenic features (e.g., dam, dike/levee, sewage pipeline)	https://open.canada.ca/data/en/dataset/fd4369a4-21fe-4070-914a-067474da0fd6
Mineral Titles Online Tenure	Data for minder, placer claims and leases, and coal licence applications/licences/leases	https://catalogue.data.gov.bc.ca/dataset/mta-mineral-placer-and-coal-tenure-spatial-view
Forest Tenure Road Section Lines	Roads under the BC Forest and Range Act Tenures	https://catalogue.data.gov.bc.ca/dataset/forest-tenure-road-section-lines
GeoBase National Railway Network	Contains railway track classification, use type, and operator data.	https://catalogue.data.gov.bc.ca/dataset/railway-track-line#edc-pow
Oil and Gas Commission Pipeline Right-of-Way Permits	Polygon data for approved and post-construction pipeline right-of-ways	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-right-of-way-permits
Oil and Gas Associated Ancillary Permit	Polygons of associated oil and gas activities (e.g., campsites, staging areas, work spaces)	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-associated-and-ancillary-permits
Oil and Gas Pipeline Segment Permit	Polygons representing segments of non-continuous pipeline	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-segment-permits
BC Transmission Lines	High voltage electrical transmission lines for power distribution	https://catalogue.data.gov.bc.ca/dataset/bc-transmission-lines
Telkwa Motor Vehicle Closure	Road closures due to caribou habitat protections	ftp://ftp.geobc.gov.bc.ca/publish/Regional/Smit%20hers/Telkwa%20motor%20vehicle%20closure/
Recreation Polygons	Polygons of a recreation feature (e.g., recreation reserve, recreation site, interpretive forest)	https://catalogue.data.gov.bc.ca/dataset/recreation-polygons
Recreation Line	Linear spatial representation for recreation features (e.g., recreation trails)	https://catalogue.data.gov.bc.ca/dataset/recreation-line

All analyses were completed using NAD83 BC Albers projected coordinate reference system (EPSG: 3005). Analyses and management of spatial data was completed using ArcGIS Desktop 10.3 with the Spatial Analyst extension (ESRI 2013).

4.3 Model Rating Scheme

There is a detailed level of knowledge of the habitat requirements of grizzly bear in BC to use a six-class rating scheme (Table 7). Habitat suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species (Resources Inventory Committee 1999). When a suitability rating for grizzly bear was assigned to a particular habitat, that habitat was assessed for its potential to support the

species for a specified season and life requisite compared with the best habitat in the province (i.e., the provincial benchmark) for the same season and life requisite. Each biogeoclimatic zone, site series, and structural stage (stages 1 to 7) was evaluated and assigned a suitability rating class based on its ability to provide the life requisites for grizzly bear for spring feeding, summer feeding and fall feeding. Availability of feeding habitat is believed to be the main driver for the bears' habitat use and was used in the habitat rating.

Table 7: Habitat Suitability Rating Scheme used for Grizzly Bear (Resources Inventory Committee 1999)

Percent of Provincial Benchmark	Rating	Suitability Class
76 – 100%	High	1
51 – 75%	Moderately High	2
26 – 50%	Moderate	3
6 – 25%	Low	4
1 – 5%	Very Low	5
0	Nil	6

The following ecosystem attributes were used from the Vegetation Resource Inventory (VRI) as base data for the study area.

- ▶ site: ecosystem type, aspect, elevation, slope, structural stage, site disturbance
- ▶ vegetation: % cover by layer, species list by layer, % cover by species

For seasonal forage, ratings were driven primarily by the abundance of known grizzly bear food plants based on information from other regional studies and ecosystem unit descriptions.

Provincial benchmark ecosystems are reference units against which other habitats can be compared for their ability to produce major grizzly bear forage species. The following benchmarks are presented by Hamilton et al. (2018) to facilitate habitat comparisons within three dominant climatic regimes (interior, coastal and northern).

Interior Benchmark

Ecosection:	Flathead Valley (FLV)
Biogeoclimatic Zone:	Engelmann Spruce – Subalpine Fir (ESSF)
Biogeoclimatic Subzone(s)/Variant:	ESSF dry cool (dk1)
Habitats (BEUs):	Engelmann Spruce – Sub-alpine Fir Dry Forested (EF)
Site Modifier:	None
Stand Structure:	Seral Stage 1

This is designated as the Interior Benchmark because of the amount of research demonstrating the importance of the ESSFdk1 to the Flathead Grizzly Bear population – older burns that produced extensive berry fields of black huckleberry (*Vaccinium membranaceum*). The group of site series that form the EF Broad Ecosystem Unit includes the most productive black huckleberry producers in BC (Hamilton et al. 2018).

Coastal Benchmark

Ecosection:	Kimsquit Mountains (KIM)
Biogeoclimatic Zone:	Coastal Western Hemlock (CWH)
Biogeoclimatic Subzone(s)/Variant:	Central moist sub-maritime (ms2)
Habitats (BEUs):	Sitka spruce – Black cottonwood Riparian (SR)
Site Modifier:	None
Stand Structure:	Seral Stage 6

This is designated as the Coastal Benchmark because the Kimsquit study highlighted the importance of the CWHms2 including its extensive floodplains, estuaries, avalanche chute run-outs and fans, skunk cabbage swamps, and forested and non-forested wetlands. The Floodplain SR Broad Ecosystem Unit includes the 3 floodplain high, mid and low “benches” commonly found along major rivers in the CWH and the blue-listed Sitka Spruce Devil’s Club site series. The SR offers grizzly feeding opportunities in multiple seasons across structural stages from herb/shrub units to old-growth forests (Hamilton et al. 2018).

Northern Benchmark

Ecosection:	Muskwa Foothills (MUF)
Biogeoclimatic Zone:	Boreal White and Black Spruce (BWBS)
Biogeoclimatic Subzone(s)/Variant:	Fort Nelson moist warm (mw2)
Habitats (BEUs):	Boreal White Spruce – Trembling Aspen (BA)
Site Modifier:	None
Stand Structure:	Seral Stage 1

South-facing slopes in the Muskwa Foothills Ecosection, BWBSmw2, Boreal White Spruce – Trembling Aspen (BA) Broad Ecosystem Unit, seral stage 1, are designated as the Northern Benchmark because they offer several seasonally-preferred grizzly bear foods. Grizzly bears can graze on a variety of grasses and herbs in the spring; and soopolallie (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*), and highbush-cranberry (*Viburnum edule*) in the fall (Hamilton et al. 2018).

4.4 Habitat Requirements Summary

The following summary of grizzly bear habitat use for the RSA (Table 8) has been developed based on the assumption that habitat use is similar other areas of BC.

Table 8: Summary of Habitat Requirements in the Study Area

Season	Specific Attributes Required	Preferred Structural Stages
Spring	warm aspect slopes and south-facing forested habitats at low elevations that provide early green-up of emergent vegetation	2, 3, 6, 7
	low elevation herbaceous meadows	2, 3
	low elevation alder-fern sites	3
	low elevation wetland complexes	2, 3
	riparian forest ecosystem	2, 3, 6, 7
	road-side vegetation	2
Summer	mid-elevation sites similar to spring attributes for emergent vegetation	2, 3, 6, 7
	wet, rich forest stands with high herbaceous plant growth	5, 6, 7
	open forests and recently disturbed areas with high berry producing plants	2,3, 4-7
	alder-fern / alder-willow sites	3
	avalanche chutes with well-developed herb layers	2, 3
	late summer - rivers/creeks for early spawning salmon and trout	-
	late summer – high elevation wetland complexes for tender vegetation	2, 3
	late summer – alpine areas for berries and marmots	2, 3
Fall	open-canopy forests that support berry production	4- 7
	old burned stands and early seral stage forests with high berry production and riparian areas with berries	2- 4
	subalpine and alpine areas for berries or marmots	2, 3
	rivers/creeks for spawning salmon and trout	-

4.5 Ratings Assumptions

The habitat used by grizzly bears is primarily driven by the amount of preferred foods in those habitats. Key assumptions of this model are that preferred forage corresponds to site series and structural stage used in the ecological mapping.

The preliminary ecosystem ratings assume that the PEM and VRI used in the rating are of equal accuracy and adequately describe the attributes of ecosystems preferred by grizzly bear.

The following assumptions were made in the development and application of ecosystem ratings:

1. Ratings are based on vegetation descriptions for the ecosystems.
2. Ratings for spring feeding are based on early spring forage availability.
3. Ratings assume the following broad pattern of forb and shrub abundance across structural stages:

Structural Stage	Herbs	Shrubs
1 - Sparse	Very Low	Very Low
2 – Forb	High	Very Low
3 – Shrub	High – Moderate	High

Structural Stage	Herbs	Shrubs
4 – Pole / Sapling	Low	Low
5 – Young Forest	Low	Low
6 – Mature Forest	Low – Moderate	Low – Moderate
7 – Old Growth	Moderate	Moderate – Moderately High

Ratings driven by herbs and shrubs as forage plants, generally reflect these patterns of abundance with Pole / Sapling and Young Forest stages typically having the lowest ratings.

- Each combination of site series and structural stage was rated for presence and abundance of preferred forage species for grizzly bear (based on a literature review).
- Ratings considered Hamilton et al. (2018) who rated habitat quality for the ability to produce known forage plants. Ratings in that study were however not delineated by season but reflected all foraging seasons.
- Ratings are based on aspects being neutral or for the aspect that the ecosystem is typically found on. Adjustments may be required for north or south facing aspects for some ecosystems and seasons.
- It was assumed that higher elevation subzones have a shorter growing season and are under snow cover longer in the spring and earlier in the fall.
- Rivers and creeks used by salmon and trout were assumed to significantly increase grizzly bear forage suitability within a 100 m buffer of these watercourses during late summer and fall due to feeding opportunities on salmonids. Rivers and creeks in the study area used and potentially used by salmonids were determined based on ERM's baseline report (2019) and included Goathorn Creek, Tenas Creek, Telkwa River and Bulkley River.
- While it is acknowledged that areas below goat winter range in spring, moose and caribou calving in early summer and marmot colonies all have increased habitat values, ecosystem ratings in this report are based on vegetation during all seasons and salmonid spawning in later summer and fall.

Using these assumptions and the information provided in the previous sections of this report, Table 9 provides general habitat ratings for grizzly bear in the study area.

Note that the side series codes in each ecosystem unit are based on the PEM / Terrestrial Ecosystem Mapping (TEM) mapping for the study area and are specific to each biogeoclimatic zone and subzone.

Table 9: General Grizzly Bear Habitat Ratings for Ecosystem Units in the Study Area

General Habitat Types	Elevation	Ecosystem Units	General Rating
Forested parkland habitats	High	AT, BAFAun, ESSFmcp, ESSFmcp, ESSFwvp: PF AT: PF Kr	- low to nil value for spring feeding due to high snow levels at high elevation - moderate value for summer feeding due to high herbaceous growth - moderate to low value for fall feeding
Berry producing forested habitats	All	ESSFmc: FB, FC, HH, FT ESSFmk, ESSFwv: FL ESSFmc, ESSFmk, ESSFwv: FD CWHws2: AB, LK, AD, SS, CD ICHmc1: HD	- low to nil values for spring feeding due to high snow levels at high elevations - moderate to low values for spring feeding at low elevations - moderate to moderately high value as late summer and fall feeding habitat in early and late structural stages due to berry production
Avalanche tracks	High	ESSFmc: AV ESSFmc, ESSFmcp ESSFmk, ESSFmcp ESSFwv, ESSFwvp: SA	- moderately high to high spring feeding values at lower elevations with south or west aspect - moderate to moderately high values for summer and fall feeding due to high herbaceous and shrub growth
Dry forested habitats	High	ESSFmc, ESSFwv: LC ESSFmk: WC, MC	- low to nil values for spring feeding due to high snow levels - low values for summer and fall feeding due to lack of forage vegetation; WC has moderate to moderately high feeding value in fall due to cone seeds during seed / mast production years
	Low	SBSdk: SF, SP, LC, LJ	- low values for spring, summer and fall feeding due to lack of forage vegetation
Circum-mesic forested habitats	High	ESSFwv: FA, MH CWHws2: LS, AO ESSFmk: MT	- low to nil values for spring feeding due to high snow levels at higher elevations - low value for late spring and early summer feeding due to low forage production - low to moderate values for late summer and fall feeding due to moderate berry production
	Low	ICHmc1: HM, SBSdk: SF, SP SBSmc2: BM	- low to moderate values for spring, summer and fall feeding due to low to moderate forage vegetation

General Habitat Types	Elevation	Ecosystem Units	General Rating
Moist, rich forested habitats	High	ESSFmc, ESSFwv: FD, FO, FV ESSFmk: FD, FO ESSFwv: FF CWHws2: HQ ICHmc1: HC, HO, HM	- low to nil values for spring feeding due to high snow levels - moderate to moderately high values for summer and fall feeding due to high herbaceous and shrub growth in early and late structural stages
	Low	SBSdk: CS, SH, ST SBSmc2: SH, TC, TC SO	- moderate to moderately high values for spring, summer and fall feeding due to high herbaceous and shrub growth
Equisetum producing forested habitats	High	ESSFmcw, ESSFmk ESSFmkw, ESSFwv, ESSFwvw: FL ESSFwv, ESSFmk: FH	- low to nil values for spring feeding due to high snow levels - moderate to moderately high values for summer feeding due to abundant horsetails and other herbs - low fall values due to lack of forage
	Low	ESSFmc: FH, HG SBSdk: SH SBSmc2: SH, SG	- moderate to high values for spring and summer feeding due to high growth of horsetails and other herbs - low fall values due to lack of forage
Forested bog and swamp habitats	All	ESSFmc: OF SBSdk, SBSmc2: BS, SS	- low values for spring, summer and fall feeding due to lack of forage vegetation
Productive wetland or wet meadow habitats	High	AT, BAFAun, ESSFmcp, ESSFmkp, ESSFwvp: WM BAFAun, ESSFmc, ESSFmcp, ESSFmk, ESSFmkp, ESSFwvp: WL ESSFmc: ME	- low to nil values for spring feeding due to high snow levels at high elevations - moderate to high values for summer feeding due to abundant horsetails and other herbs - moderate to low values for fall feeding due to limited forage availability
	Low	ICHmc1: MW SBSdk: ML, MS, ME SBSmc2: ME, WL	- moderate to high values for spring and summer feeding due to high growth of horsetails and other herbs - moderate to low values for fall feeding due to limited forage vegetation

General Habitat Types	Elevation	Ecosystem Units	General Rating
Riparian / wetland shrub habitats	All	CWHws2: RS, CW, RC, WE, AW ESSFmc: BW, LU, ESSFmc, ESSFmcw, ESSFwv, ESSFwvp, ESSFwww: RS ESSFmc, ESSFmcp, ESSFmk, ESSFmkw, ESSFwv, ESSFwvp, ESSFwww: AW ESSFmc, ESSFmcp, ESSFmcw, ESSFmkw, ESSFwv, ESSFwww: WE SBSdk, SBSmc2: BW, WE, CU SBSmc2: RS, LU, AW	- low to nil values for spring feeding at high elevations due to high snow levels - low to moderate values at high elevations for summer and fall feeding due to low to moderate herbaceous growth - low to moderate values for spring, summer and fall feeding at low elevations due to low to moderate herbaceous growth; RC has moderate value for late spring feeding;
Herbaceous meadow / grassland / scrub habitats or cultivated fields	All	AT, ESSFmcp, ESSFmkp: DL AT, BAFAun, ESSFmcp, ESSFmkp, ESSFwvp: HG AT, BAFAun, ESSFmc, ESSFmcp, ESSFmcw, ESSFmkp, ESSFmkw, ESSFwv, ESSFwvp, ESSFwww: HM, ESSFmc, ESSFmcw, ESSFmkw, ESSFwww,: SW ESSFmc, SBSdk, SBSmc2: BW SBSmc2, SBSdk: HM, SW, CF	- low to nil values for spring feeding at high elevations due to high snow levels; HG will have moderate value when south facing and/or at bottom of avalanche shoots - low to moderate summer and fall values at high elevations due to low to moderate herbaceous growth - moderate to moderately high values for spring, summer and fall feeding at low elevations due to herbaceous forage

General Habitat Types	Elevation	Ecosystem Units	General Rating
Rivers	Low	RI	- low value as spring feeding habitat due to lack of forage - moderate to high late summer and fall habitat due to spawning salmonids and associated riparian cover used as movement corridors
Unvegetated or sparsely vegetated sites	All	AT, BAFAun, ESSFmcp, ESSFwvp: GL CWHws2, ESSFmc, ESSFmcw, ESSFmk, ESSFmcp, ESSFmkw, ESSFwv, ESSFwvp, ESSFwww: TA ESSFmc, ESSFwv: ES SBSmc2: GB SBSdk, SBSmc2: CB, ES, TA	- low to nil values due to lack of forage vegetation
Ponds and lakes, open water	All	PD, LA, OW	- low to nil values due to lack of forage vegetation
Rocky or cliff habitats	All	RO	- low value as feeding habitat due to lack of forage vegetation
Permanent snow and ice, glacier	High	AT, BAFAun, ESSFmcp, ESSFwvp: GL ESSFmcp, ESSFmcw, ESSFwvp, ESSFwww: PN	- low to nil spring, summer and fall feeding values due to lack of forage vegetation; snow patches have some thermal value in summer
Human development, urban / suburban sites, rural sites, roads	All	DV, UR, RU, RZ, GP	- very low to nil values of human development sites due to high mortality or displacement - some roads may have moderate to moderately high value due to roadside vegetation in spring

4.6 Ratings Adjustments

Many different factors affect the habitat use by grizzly bears (e.g., slope, aspect, and proximity to human development) and, where necessary, modifications were applied to account for these variables, as described in the following paragraphs.

Grizzly bears are known to avoid using high quality habitat near human disturbance. Proximity to human activities was determined through mapping anthropogenic features in the RSA with the following attributes: urban (includes sub-urban and rural polygons), agricultural (areas with a low population density and with landscapes that are continually modified for agriculture purposes), buildings (outside of urban and agricultural areas, mostly for residential, recreation and commercial purposes), oil and gas pipelines, power lines, railroads (and rail spurs, rail yards), and several categories of roads (highway, haul roads, primary roads, secondary roads, tertiary roads (and tertiary seasonal roads), quaternary roads) and trails. Traffic on roads has been shown to deter bears from using areas adjacent to roads and studies have identified that the majority of grizzly bear deaths occurred within 500 m of a road (Ciarniello et al. 2004; Summerfield et al. 2004) through direct mortality (collisions) and indirect mortality (hunting and poaching). McLellan and Shackleton (1988) found that grizzly bears avoided even lightly used roads, resulting in habitat alienation. Major roads are also causing habitat fragmentation which may affect the bears on a population level. On the other hand, research has found that grizzly bears will utilize habitats with roads (e.g., for feeding on roadside vegetation during spring), although avoidance will increase with the amount of traffic (Mace et al. 1996). Grizzly bears may continue to use feeding habitats that are close to roads with sufficient vegetation cover and they may also use these roads as travel corridors (McClellan and Shackleton 1988). Traffic volumes were available for Highway 16, assumed to have the highest amount of traffic on roads in the study area. Observed mean daily average traffic increased from 646 vehicles in 2007, to 1,721 vehicles in 2014 and 2,662 vehicles in 2017 (BC Traffic Data Program 2019). Appropriate rating adjustments for roads were required as outlined below.

A polygon layer of the cumulative severity data from multiple years of mountain pine beetle (*Dendroctonus ponderosae*) attacks on forests in the RSA was created using a provincial dataset (BC Data Catalogue, Pest Infestation Polygons 2017). Seeds from cones of whitebark pine form an important food source for grizzly bears in fall and in other seasons when they dig up squirrel (*Tamiasciurus hudsonicus*) middens (Hamilton and Austin 2004). Rating adjustments are included in the below list.

The following adjustments were applied to the ratings:

1. Slopes greater than 50 degrees were adjusted to be of very low to nil value during spring, summer and fall.
2. Heath-Grassland (HG) habitats in ESSFmcp, mcp and wvp zones with warm (southerly and westerly) aspects were assumed to experience spring green-up sooner, therefore, the value for those sites was upgraded by 2 classes for spring feeding. Similarly, HG habitats in AT and BAFAun with southerly and westerly aspects were upgraded by 2 classes for summer feeding.
3. Based on grizzly bear avoidance of humans and human activity, anthropogenic (human activity) polygons were assumed to have lower feeding values than similar habitat types without human disturbances. In addition to the disturbance, availability of suitable feeding habitat in areas of human activity is reduced. To account for these factors, the feeding value was downgraded by 2 classes for all habitat within 500 m of human activity during all seasons.
4. No downward adjustments were made to the fall feeding value within 100 m of salmonid spawning streams regardless of human activity.

5. Due to increased grizzly bear mortality in proximity of roads and grizzly bear avoidance of some road types, habitat suitability ratings during all seasons in proximity to highways, haul roads, primary, secondary and tertiary roads (i.e., roads assumed to have the highest amount of traffic) were downgraded by 2 classes within a 500 m buffer around the width of the feature (to a minimum rating of Class 5 – very low). All other road types were not downgraded. It should be noted that this buffer method was chosen over the “moving window” method (which used a road density threshold of 0.6 roads / km² based on the same road classes) because approximately 7% more area in the LSA and 13% more area in the RSA were downgraded with this buffer approach.
6. Rivers and creeks in the study area without known or predicted salmonid presence (based on ERM 2019), were downgraded by 2 classes for fall feeding.
7. Areas that were attacked severely and very severely by mountain pine beetle (as classified in BC Data Catalogue, Pest Infestation Polygons 2017) and have stands of whitebark pine were downgraded by 2 classes due to the negative effects of the beetle attacks on cone production and the high feeding value of cone seeds for grizzly bears.

4.7 Model Evaluation

Baseline surveys (e.g., wildlife camera studies, incidental observations) detected an insufficient number of grizzly bears to validate the model performance, as a result a desktop model evaluation was conducted. This consisted of iterative reviews of model outputs and adjustment of parameter ratings during model development. Information used during evaluation and calibration exercises included a review of satellite imagery, field conditions observed by biologists conducting wildlife surveys, and knowledge from local biologists of habitat present within the LSA and RSA. The calibration exercises were conducted to determine model parameters that would include all, or almost all, areas with potential habitat (i.e., to minimize errors of omission) while avoiding ratings that were too liberal, which would result in overestimating the amount of habitat present.

5. LIMITATIONS/CONFIDENCE

The spring, summer, and fall grizzly bear habitat suitability models are knowledge-based and may include author bias. The number of detections of grizzly bears from baseline surveys (e.g., wildlife camera, incidental observations) and a desktop review was insufficient to assist in conducting a quantitative validation of the model or guide the model development. Model development used spatial ecosystem data (e.g., PEM and VRI datasets) that were not field verified prior to use and inconsistencies between datasets and real-world conditions may exist. Habitat requirements incorporated into the model were obtained from a literature review that relied on data, where possible, from the same region or similar ecosystems, relative to resource development or other anthropogenic disturbance, and for the same seasons and life requisites. Therefore, while overall confidence in the grizzly bear model was limited by the nature of the model development approach and lack of validation, the overall confidence in the model is moderate because of the relatively well-known habitat requirements and relative confidence in the ecosystem spatial data.

6. SUMMARY OF MAPPING RESULTS

The output from the spring and summer grizzly bear suitability models indicated that relatively more high, moderately high, and moderate rated habitat was present in the Wildlife RSA than the LSA, whereas the opposite was true in the fall habitat model (Table 10, Appendix 1). No moderate to high rated suitable spring habitat was found within the LSA and little was found in the RSA (<3%), most of which was in the western part of the RSA in the Telkwa River valley, although a small amount was found in the upper elevations in the centre of the RSA. The summer habitat model indicated that most moderate to high rated habitat was located at mid to upper elevations, with concentrations in the centre and western portions of the RSA. Some moderate and moderately high habitat was also present at lower elevations, although impressions from field visits and satellite imagery suggest that less habitat may be present than indicated in the model. Some of the overestimation may be due to the difficulty in mapping all anthropogenic disturbances within the RSA. Mapping of suitable fall habitat indicated that most moderate to moderately high suitable habitat was located in the western RSA in the Telkwa River valley and along other known salmon-bearing rivers and creeks. A few other patches of moderate rated habitat were located throughout the lower elevations of the RSA, and less was located at upper elevations compared to the other seasons.

Table 10: Amount of Suitable Habitat for Grizzly Bear by Season and Study Area

Season	Habitat Suitability Rating	Wildlife LSA (ha)	Wildlife LSA (%)	Wide-ranging RSA (ha)	Wide-ranging RSA (%)
Spring	High	0.00	0.00	536.99	0.15
	Moderately High	0.00	0.00	387.37	0.11
	Moderate	54.25	0.15	8,096.35	2.26
	Low	4,254.78	11.91	76,833.48	21.49
	Very Low	25,024.71	70.05	230,000.01	64.32
	Nil	6,392.14	17.89	41,732.84	11.67
	Total	35,725.88	100.00	357,587.03	100.00
Summer	High	5.21	0.01	4,024.23	1.13
	Moderately High	355.65	1.00	8,861.62	2.48
	Moderate	4,317.14	12.08	65,196.06	18.23
	Low	10,246.92	28.68	113,475.22	31.73
	Very Low	14,724.47	41.22	130,851.01	36.59
	Nil	6,076.49	17.01	35,178.90	9.84
	Total	35,725.88	100.00	357,587.03	100.00
Fall	High	0.00	0.0	0.00	0.00
	Moderately High	606.63	1.70	3,104.10	0.87
	Moderate	2,411.31	6.75	19,343.32	5.41
	Low	8,205.92	22.97	138,717.73	38.79
	Very Low	18,114.45	50.70	154,807.31	43.29
	Nil	6,387.58	17.88	41,614.58	11.64
	Total	35,725.88	100.00	357,587.88	100.00

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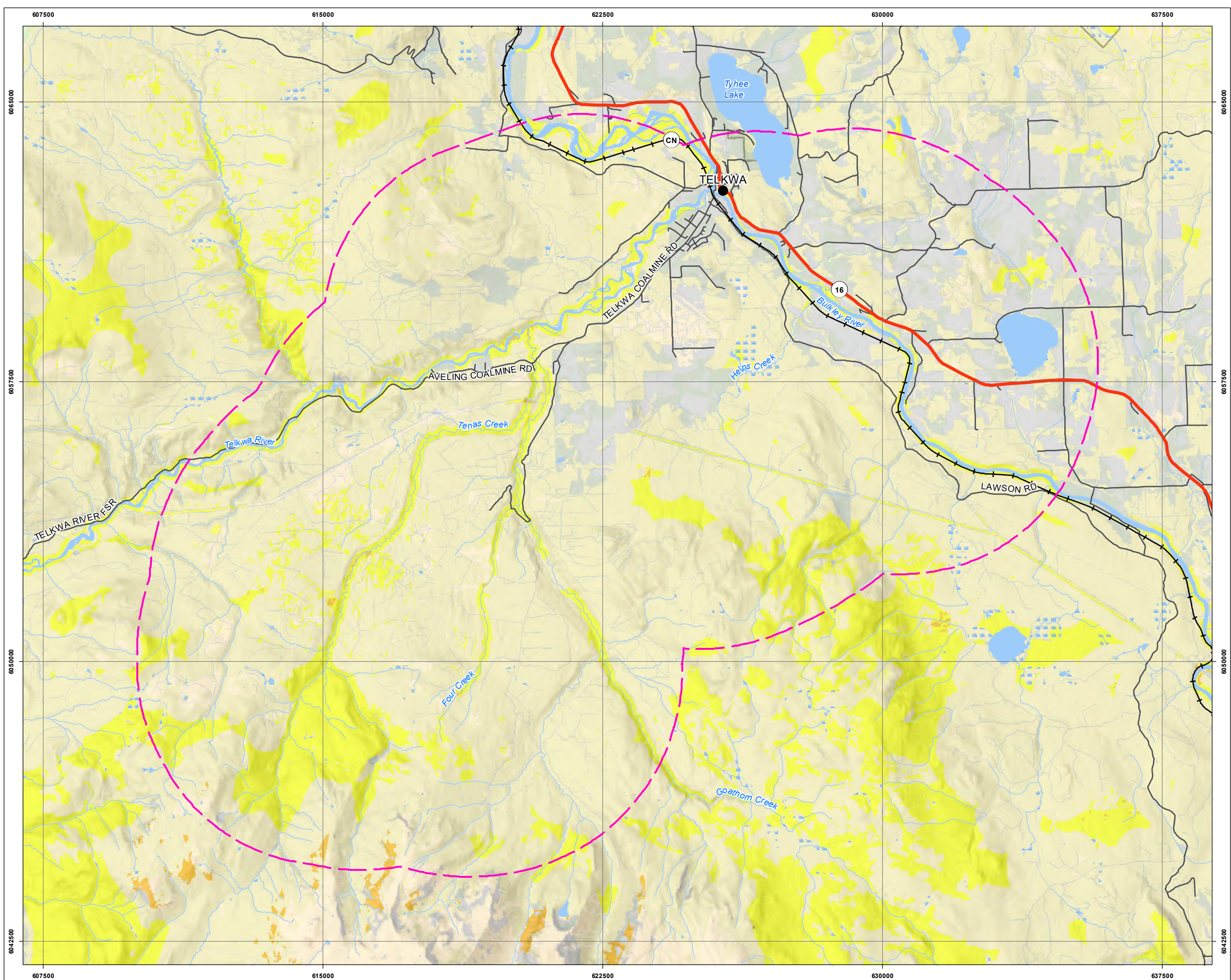
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Appendix A Grizzly Bear Habitat Suitability Mapping

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Tenas Project

Habitat suitability model ratings for grizzly bear Living in the spring within the Wildlife Local Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area

Habitat Rating

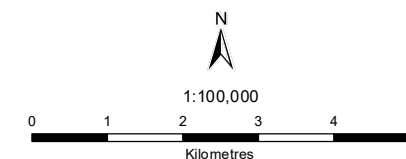
- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of British Columbia
- Basemap: World Topographic Map. ESRI.

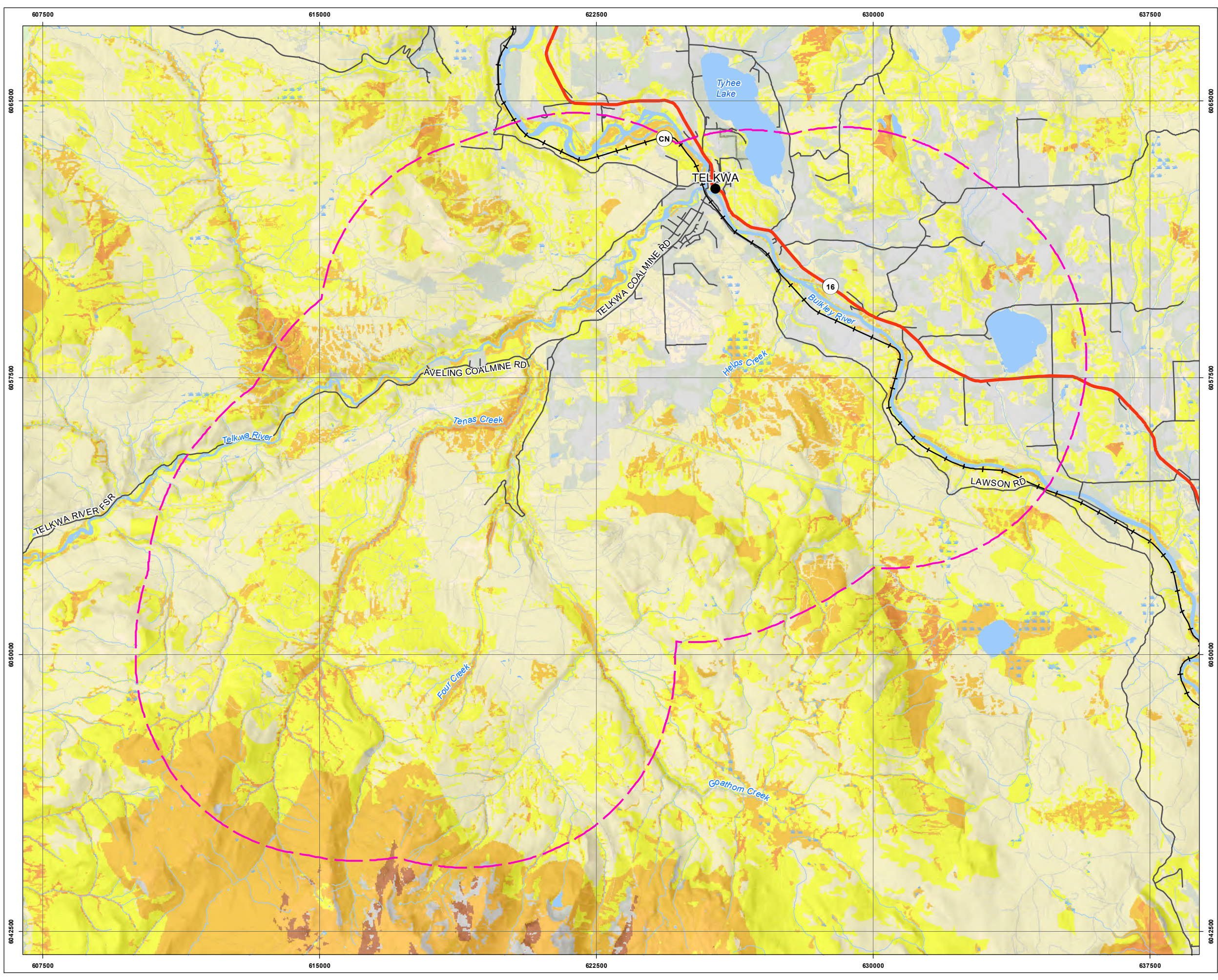


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Tenas Project

Habitat suitability model ratings for grizzly bear Living in the summer within the Wildlife Local Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area

Habitat Rating

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Notes

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2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

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- Basemap: World Topographic Map. ESRI.

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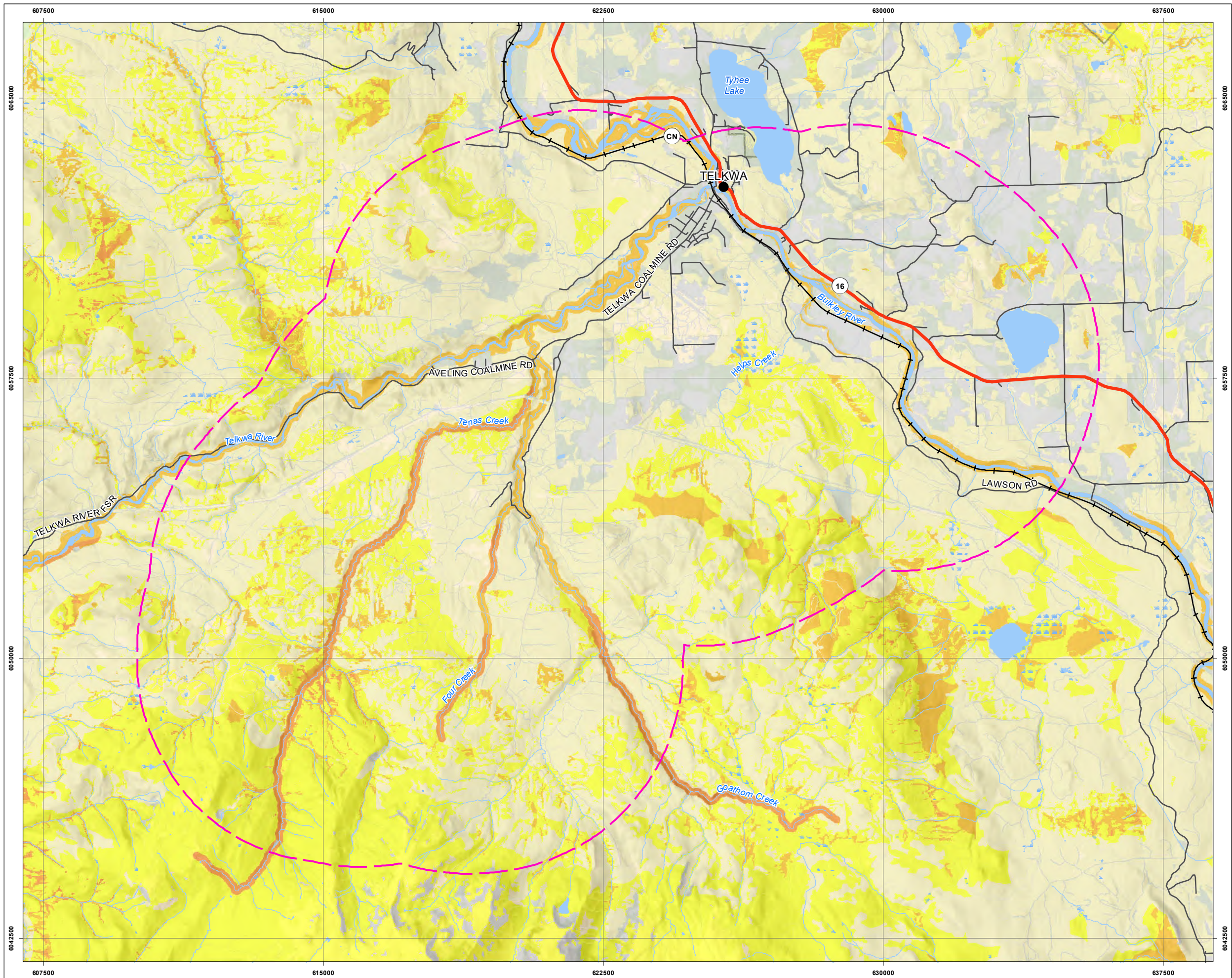
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Tenas Project

Habitat suitability model ratings for grizzly bear Living in the fall within the Wildlife Local Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area

Habitat Rating

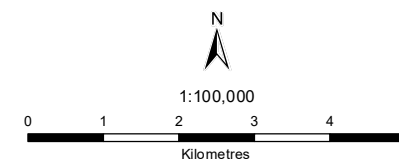
- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

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- Basemap: World Topographic Map. ESRI.

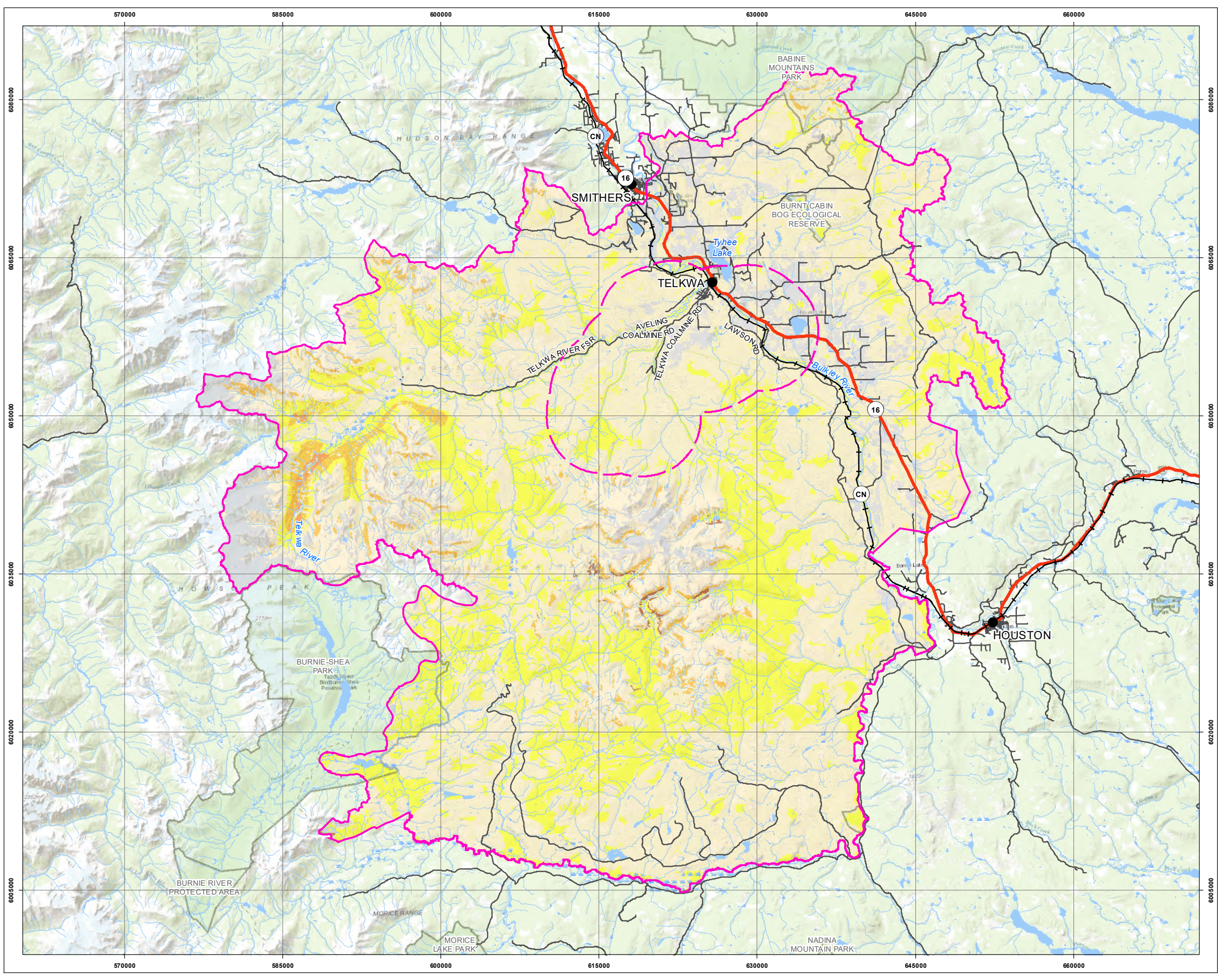


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Tenas Project

Habitat suitability model ratings for grizzly bear Living in the spring within the Wide-ranging Wildlife Regional Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area
- Wilde-Ranging Wildlife Regional Study Area

Habitat Rating

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of British Columbia
- Basemap: World Topographic Map. ESRI.

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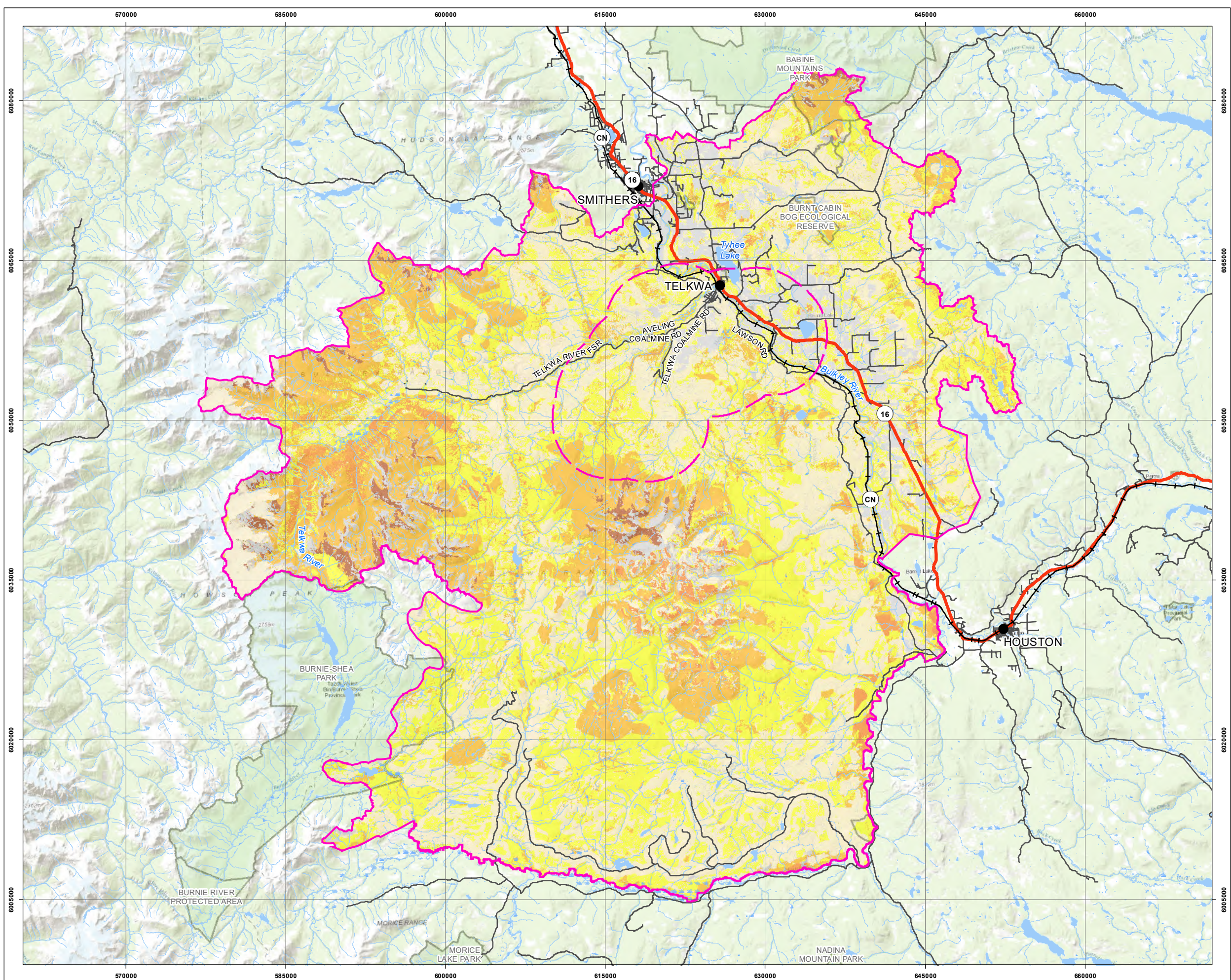
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Tenas Project

Habitat suitability model ratings for grizzly bear Living in the summer within the Wide-ranging Wildlife Regional Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area
- Wilde-Ranging Wildlife Regional Study Area

Habitat Rating

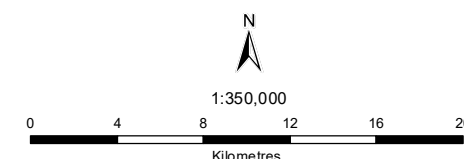
- High
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- Moderate
- Low
- Very Low
- Nil

Notes

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Sources

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- Basemap: World Topographic Map. ESRI.



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Appendix F

Assessment of Disturbance in the Telkwa Caribou Herd Range

Tenas Project

Assessment of Disturbances in the Telkwa Caribou Herd Range

October 2020

VERSION 1

Submitted to: Telkwa Coal Limited
Suite 1410 – 409 Granville Street
Vancouver, BC V6C 1T2

Submitted by: EDI Environmental Dynamics Inc.
301 George Street
Prince George, BC V2L 1R6

EXECUTIVE SUMMARY

The Tenas Project (the Project) is a proposed surface coal mine near the current range of the Telkwa Caribou Herd (TCH). At the federal level, the TCH is designated as part of the Northern Mountain population of woodland caribou but currently is listed on the *Species at Risk Act* (SARA) as part of the Southern Mountain population. As it remains listed on SARA under the Southern Mountain population, the TCH is subject to management and recovery objectives outlined in the *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* (Environment Canada 2014). The Recovery Strategy proposes a disturbance threshold for caribou (35% total disturbance), based on meta-analyses that showed that most caribou subpopulations with disturbance levels above 35% in their ranges were declining. The Recovery Strategy defines disturbance as the sum of anthropogenic footprints plus 500 m buffers, as well as natural disturbance footprints from fires.

The current annual range of the TCH consists primarily of the alpine and subalpine Biogeoclimatic Ecosystem Classification (BEC) variant groups in the Telkwa and Howson Mountains. Human disturbances within the alpine and subalpine variant groups consist of moderate recreational activities, including limited all-terrain vehicle (ATV) trails and a snowmobile recreation area. However, the lower elevation areas surrounding the Telkwa Mountains include numerous disturbances and land use activities, including forestry, mining, transportation and utility corridors, agriculture, urban and rural residential areas, recreational activities, and tourism.

The objective of this report was to provide a comprehensive assessment of existing human disturbances within the TCH range and within an area adjacent to the herd's range that could affect the herd via regional predator-prey relationships. Based on input from the Caribou Sub-working Group, four study areas were delineated for this assessment.

- ▶ Wildlife Local Study Area (LSA) – a 5 km buffer around the Project Area.
- ▶ TCH-Regional Study Area (RSA)1 – The herd's annual range plus a limited buffer into surrounding forested BEC zones, bounded by valley bottom rivers; this extent has been the primary management area for the TCH to date.
- ▶ TCH-RSA2-Core – The 'Core' portion of the latest Critical Habitat area proposed by the Province of British Columbia, which approximates the current annual range of the herd.
- ▶ TCH-RSA2-Matrix – The 'Matrix' portion of the latest Critical Habitat area proposed by the Province of British Columbia, which consists of a 20 km buffer around the Core.

As part of the Project, a comprehensive set of geospatial data for anthropogenic features and fires was compiled. For this analysis the data were summarized to determine (1) the total disturbed area for each study area, (2) the extent of each anthropogenic disturbance type within each study area, and (3) the extent of disturbances type within BEC variant groups. A supplemental analysis investigated the effects of specific disturbances related to two ecological mechanisms that can affect caribou populations — apparent competition and facilitated predation.

Within the TCH RSA2 Core (which best approximates the annual range of the herd), the total disturbance was 23%, and disturbances were mostly associated with recreational activities and forestry in the forested Engelmann Spruce-Subalpine Fir BEC variant group. For study areas that included extents beyond the TCH annual range, total disturbance varied from 48.3% in TCH-RSA1, to 58.5% in TCH-RSA2-Matrix, to 90.1% in the Wildlife LSA. Disturbance levels showed a strong correspondence to BEC variant groups,

increasing from 16.5% in alpine to 95.0% in the lowest elevation Sub-boreal Spruce dry cool variant. Within the Sub-boreal Spruce and the lower portions of the forested Engelmann Spruce-Subalpine Fir variants, forestry (cutblocks and associated roads) was the dominant disturbance type and resulted in habitat changes that may support apparent competition and facilitated predation, which increase predation risk to caribou. Extensive disturbances within the Bulkley Valley include urban and rural residential developments, transportation and utility corridors, agriculture, and recreational activities and tourism.

Patterns of anthropogenic disturbance in the TCH study areas essentially create an island of low-moderate disturbance in alpine and subalpine mountain plateaus, surrounded by high levels of disturbance in forested BEC variants to the north, east, and south, and inhospitable high mountains to the west. The broad distribution of the Telkwa caribou over the last 20 years mirrors that pattern with 87% of telemetry locations occurring in the alpine and subalpine BEC variants. Caribou that venture into the forested BEC variants, especially the Sub-boreal Spruce, experience greatly elevated mortality rates, consistent with predicted effects of apparent competition and facilitated predation associated with the dominant types and amounts of anthropogenic disturbances that occur there.

ACKNOWLEDGEMENTS

Kerman Bajina was the primary author. Todd Mahon was an author and senior reviewer. Christina Tennant provided GIS analysis and mapping support.

Tenas Project

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Appendix A	Disturbances Within Biogeoclimatic Variant Groups
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GLOSSARY AND ABBREVIATIONS

Abbreviation	Long form of abbreviation
BAFA	Boreal Altai Fescue Alpine
BEC	Biogeoclimatic Ecosystem Classification
CMA	Coastal Mountain-heather Alpine
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWH	Coastal Western Hemlock
ECCC	Environment and Climate Change Canada
ESSF	Engelmann Spruce-Subalpine Fir
GIS	Geographic Information System
ICH	Interior Cedar Hemlock
IUCN	International Union for the Conservation of Nature
LPU	Local Population Unit
LRMP	Land and Resource Management Planning
LSA	Local Study Area
MH	Mountain Hemlock
RSA	Regional Study Area
SARA	<i>Species at Risk Act</i>
SBS	Sub-boreal Spruce
TCH	Telkwa Caribou Herd
the Project	the Tenas Project (Telkwa Coal Ltd.)

1. INTRODUCTION

The Tenas Project (hereafter referred to as the 'Project') is a proposed open pit coal mine located 25 kilometres (km) south of Smithers and 7 km southwest of the village of Telkwa in northwestern British Columbia (Map 1). The Telkwa Caribou Herd (TCH) occupies the Telkwa and Howson mountains southwest of the Project and have been identified as a subcomponent of the Wildlife Valued Component for evaluation in the environmental assessment of the Project. This report is a supplement to the caribou section of the Wildlife Baseline Report (2020) for the Project and summarizes the amount of disturbed habitat following criteria outlined in *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* (Environment Canada 2014).

The TCH was designated and assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as part of the Northern Mountain population of woodland caribou (*Rangifer tarandus caribou*) and assigned a conservation status of 'special concern' in May 2014 (COSEWIC 2011, 2014). The Northern Mountain population is under consideration for listing on the *Species at Risk Act* (SARA; Government of Canada 2019). Previously, the subpopulation was listed as 'threatened' under Schedule 1 of SARA as part of the Southern Mountain population (Government of Canada 2019). Until there is a relisting of the Northern Mountain population, the TCH is still considered part of the Southern Mountain population. At the provincial level, the herd is considered part of the Northern Mountain population and is Blue listed ('special concern') on the British Columbia Conservation Data Centre (B.C. Conservation Data Centre 2020). The herd has been surveyed intermittently since 1949 and population size counts have varied from 271 animals to a low 6 animals with no calves recorded in 1997 (Ministry of Environment, Lands and Parks 1998, Cichowski 2014). To recover the population, 30 animals were translocated from the Chase-Sustut herd to the TCH range. This effort initially led to an increase in the population size to 110 animals in 2005, but a steep decline began in 2007 and by 2013 the population had fallen below 15 animals (Thiessen 2014). The most recent (minimum) count of the TCH was of 25 animals in 2019 (Hoffman and Grant 2019).

Threats directly affecting the TCH and other northern groups of Southern Mountain caribou have been assessed by ECCC using the International Union for the Conservation of Nature (IUCN) Threat Calculator (Environment Canada 2014). Predation poses the greatest threat ('Very High') to the TCH given its potential to frequently affect a large proportion of the herd and, ultimately, leading to population decline (Environment Canada 2014). Other potential threats to the herd include mining activities ('Medium'), logging and wood harvesting ('Medium Low'), and roads and railroads ('Low'). Though identified as independent effects, these threats to caribou occur in parallel through the interaction between biotic processes and anthropogenic disturbances. Forestry activity, such as creating cutblocks, enables interspecific competition and the presence of alternative prey (e.g., moose and deer) that consequently increases predator densities (e.g., wolves). Predation may also be further facilitated by linear features that yield routes of efficient travel for predators, which increases the risk of mortality and the decline of TCH numbers (Tenas Project Wildlife Baseline Report 2020).

In this report, the basis for a caribou habitat assessment for the Project is an evaluation of disturbed areas following criteria outlined the 2014 Recovery Strategy (Environment Canada 2014). The criteria for disturbed areas under the Recovery Strategy includes the footprint of any anthropogenic disturbance plus a 500 metre (m) buffer, and the footprint of natural fires aged <40 years (Environment Canada 2014). For forestry cutblocks, only cutblocks <40 years were used, similar to the criteria for fires. The rationale for the approach to use an evaluation of disturbed areas to assess caribou habitat is based on a meta-analysis of caribou population trends for herds across Canada, relative to disturbed areas, which showed that most caribou subpopulations whose ranges were >35% disturbed were declining (Environment Canada 2012). As such, this approach is different from a traditional habitat model, such as a Resource Selection Function

model, which aims to quantify the amount and location of suitable habitat based on environmental conditions that caribou select for. Also, this approach is not associated with any one disturbance effect, such as sensory disturbance or habitat loss. The disturbed area approach is assumed to capture a combination of effects associated with human disturbance including habitat loss, reduced habitat effectiveness, facilitated predation, apparent competition, and sensory disturbance; although Environment Canada (2012) identifies 'habitat-mediated apparent competition', which elevates predation risk to caribou, as a primary factor potentially associated with caribou population declines.

Initially, a traditional habitat model was also considered to quantify habitat quality across the study areas, in addition to the disturbed area analysis; however, the Caribou Sub-working Group concluded that would be uninformative because (1) the Project and most of the Zone of Influence (i.e., the area of the receiving environment potentially changed or altered as a result of the Project) occur in forested areas, which are outside the TCH's regular annual range, and (2) the small proportion of caribou telemetry locations that occur in forested areas appear to be primarily forays or dispersal events (i.e., versus use of those areas for regular life requisites, such as foraging; Tenas Project Wildlife Baseline Report 2020).

The objective of this report was to provide a comprehensive assessment of existing disturbances within the TCH range and within areas adjacent to the herd's range that could affect the herd via regional predator-prey relationships. Data were summarized to determine (1) the total disturbed area for each study area, (2) the extent of each anthropogenic disturbance class within each study area, and (3) the extent of anthropogenic disturbance class by habitats. A supplemental analysis investigated the effects of specific disturbance related to two ecological mechanisms that can affect caribou populations — apparent competition and facilitated predation (Tenas Project Wildlife Baseline Report 2020).

Map 1. Telkwa Caribou Herd study areas.

 Project Area
 LSA
 TCH-RSA1
 TCH-RSA2 Core
 TCH-RSA2 Matrix
 City/Town
 Rail Line
 Highway
 Watercourse
 Wetland
 Waterbody
 Park or Protected Area

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

- Project Area: Allegiance Coal, 2020
- Basedata: Government of British Columbia
- Basemap: World Topo Base



Map 1



2. METHODS

2.1 Study Area

The current annual range of the TCH consists primarily of alpine and subalpine habitat in the Telkwa Mountains and Howson Range (Map 1). The results of twenty years of telemetry data indicate that the herd used primarily the alpine and subalpine during all seasons (87% of all telemetry locations; Tenas Project Wildlife Baseline Report 2020), and consistently avoided forested areas (especially the Sub-Boreal Spruce; Roberts et al. 2003, Thiessen 2013). Although several subpopulations of Southern Mountain Caribou utilize lower elevation forested habitat in winter (Environment Canada 2014), there is no evidence that the TCH currently does so. The majority of collar locations in forested areas appear to be dispersal events or forays (Cichowski 2014), mostly by transplanted animals. This assumption is supported by mortality data, which indicate that mortality risk is orders of magnitude higher in forested areas compared to the alpine and subalpine (Tenas Project Wildlife Baseline Report 2020). The herd has not made regular use of discrete seasonal ranges over the last 20 years and regular movement areas are also not evident from the data. Although the herd does make concentrated use of certain areas in some seasons and in some years, those locations vary within and across years.

Four study areas have been defined for the TCH (Map 1) based on input from and discussion among members of the Caribou Sub-working Group. These study areas include a Wildlife Local Study Area (LSA) and two Regional Study Areas (RSAs), one of which includes two areas: Core habitat and Matrix habitat.

The Wildlife LSA consists of a five (5) km buffer around the project and covers 35,382 ha.

TCH-RSA1 corresponds to the primary area used for recent conservation and management initiatives. The exact boundary is the Critical Habitat area delineated for the TCH in the *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* (Environment Canada 2014). This boundary closely matches the extent of the provincial Wildlife Habitat Area (Ministry of Environment 2016) that has been established for the herd and also closely matches the area defined in the *Telkwa Caribou Herd Recovery Plan* (Ministry of Environment, Lands and Parks 1998). From an ecological perspective, this area corresponds to the herd's annual range (primarily occurring within the alpine and subalpine) plus a buffer of surrounding forested landscape to account to the potential for winter use there and the influence of adjacent predator-prey systems. The total area covered by TCH-RSA1 is 260,611 ha and is bounded by valley bottom rivers to the north, east, and south, and by the coast mountain divide to the west.

TCH-RSA2 is the latest Critical Habitat recommendation by the Province of British Columbia for the TCH and is divided into Core and Matrix habitats (Dodd and Carswell 2019). The Core habitat is defined as “the area that encompasses the annual range for a subpopulation” and the Matrix habitat is defined as “the area adjacent to Core habitat that has periodic or low use by caribou but supports primary prey and associated predators that have the potential to affect the caribou subpopulation” (Dodd and Carswell 2019). The Matrix for the TCH consists of a 20 km buffer around the Core, based on average wolf pack home range sizes (Dodd and Carswell 2019). The TCH RSA2 Core and Matrix habitats cover 160,272 ha and 531,706 ha, respectively, for a combined total of 691,978 ha. In this assessment, the Core and Matrix habitats were used as separate study areas (i.e., TCH-RSA2-Core and TCH-RSA2-Matrix).

Emphasis was placed on TCH-RSA1 for this analysis because that is the extent that existing management plans are focused on, and it is anticipated to be the study area of primary focus for the Project's effects assessment. However, the results of most analyses are provided across all four study areas.

In addition to the study areas, analyses also examined patterns of anthropogenic disturbance relative to the Biogeoclimatic Ecosystem Classification (BEC) variants grouped into similar habitat types (see section 2.2 for BEC variant group descriptions). BEC variants are broad ecological zones that offer varied conditions for caribou life requisites (e.g., food, cover, climate [notably snow depths]) and that caribou show clear distribution patterns across. Though high-level and not habitat-specific at a site level, these zones provide a mechanistic link between caribou distribution and biologically relevant attributes in their range.

There is substantial anthropogenic land use in the TCH study areas consisting of forest harvesting, mining, transportation and utility corridors, agriculture, residential areas, and areas of recreational activity and tourism (BC Ministry of Agriculture and Lands 2005, Cichowski 2014). There are two major land and resource management planning (LRMP) areas overlapping the TCH range. The Bulkley LRMP is a policy document that was initially completed in 1998 (and updated in 2005; Government of British Columbia 2005) and provides management direction for the following units within the “Telkwa Caribou Recovery Area”: three high elevation special management zone planning units (Hankin Plateau, Howson Range, Mooseskin Johnny Lake), one low elevation special management zone planning unit (Telkwa River), and one low elevation integrated resource management zone planning unit (Goathorn Creek) (Cichowski 2014). The Morice LRMP was completed in 2007 and provides management direction to maintain high value seasonal habitats for caribou and limit the amount of anthropogenic disturbance to those habitats (Government of British Columbia 2007, Cichowski 2014). Management directions from both of these LRMP areas support the objectives of the *Telkwa Mountains Caribou Herd Recovery Plan*, which aims to reverse declines in the TCH population size, increase understanding of factors influencing the TCH’s population growth rates, and protect TCH habitat (Ministry of Environment, Lands and Parks 1998). Protected areas within the TCH range include Burnie River Protected Area, Atna River, Morice Lake, and Burnie-Shea provincial parks.

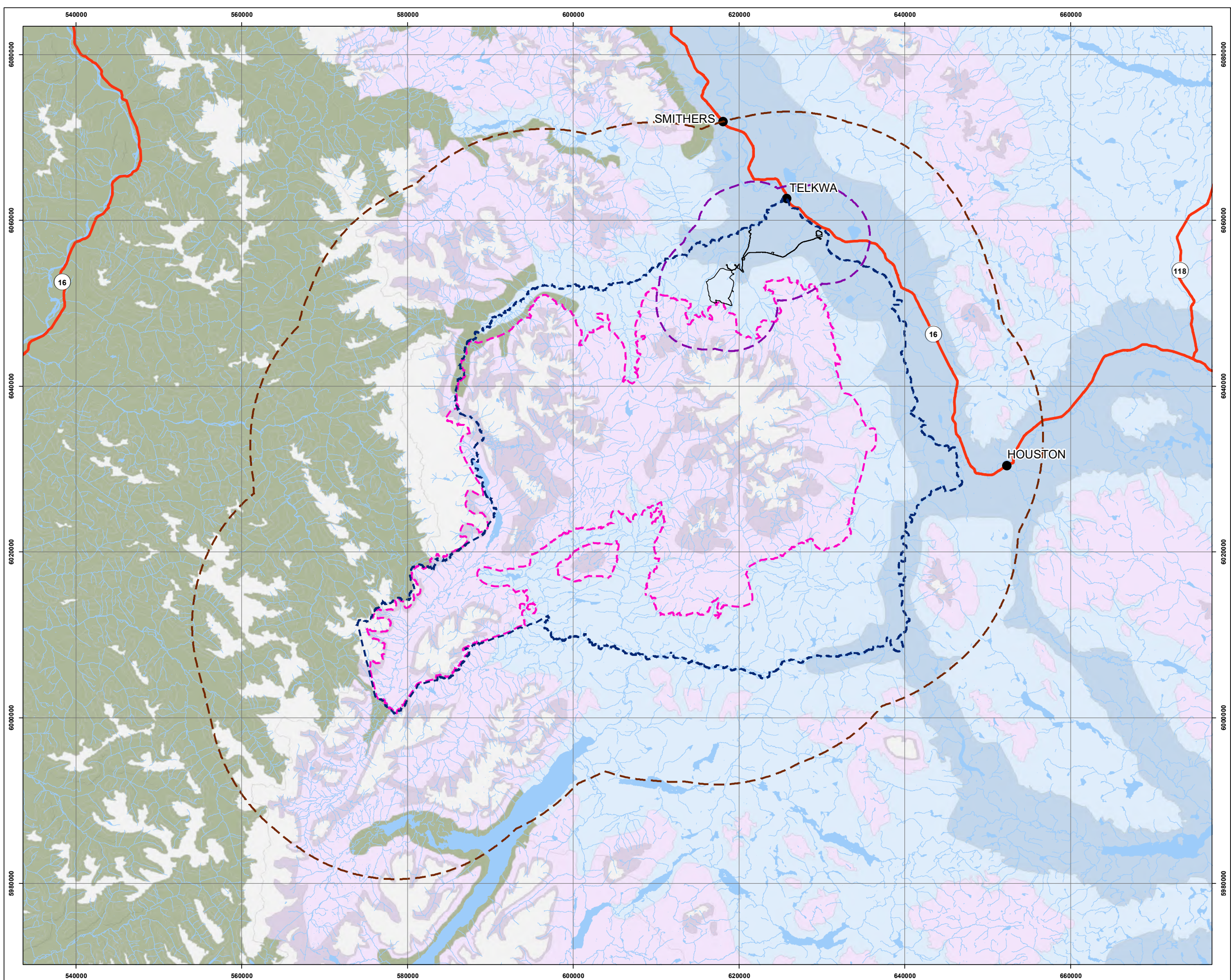
2.2 Biogeoclimatic Ecosystem Classification Variants

The BEC system was used to examine the distribution of disturbance classes across broad ecological zones with different climate and vegetation to inform how those patterns may affect caribou. When evaluating the distribution of BEC variants in each study area, the coastal (CWH and MH) and coastal transition (ICH) BEC variants were excluded because they receive very little use by the TCH and constitute a minor proportion of the TCH RSA2 (<1% combined total). Remaining BEC variants were combined into five groups (Table 1, Map 2) based on ecological similarities and differences relevant to caribou ecology (e.g., forage potential, cover, and snow depths). The BEC variant groups included: alpine consisting of the undifferentiated Boreal Altai Fescue Alpine (BAFAun) and Coastal Mountain-heather Alpine (CMAun) variants, subalpine consisting of the Engelmann Spruce - Subalpine Fir parkland variants (ESSFmcp, ESSFmkp, ESSFwvp), the forested Engelmann Spruce - Subalpine Fir forest variants (ESSFmc, ESSFmk, ESSFwv), the forested Sub-boreal Spruce moist cold - Babine variant (SBSmc2), and the forested Sub-boreal Spruce dry cool variant (SBSdk).

Table 1: Biogeoclimatic Ecosystem Classification groups and variants that overlap the Telkwa Caribou Herd study areas.

BEC Group	BEC Variants	Description
Alpine	BAFAun, CMAun	High elevation, mountainous areas dominated by dwarf shrubs, heaths, herb and grassland tundra, mosses, and lichen. May contain a mosaic of krummholz tree patches at lower elevations. The climate is severe with a short frost-free period and low growing season temperatures. Snowpack exists from October-May, generally >1 m; however, wind scouring can greatly reduce depth on some sites. Human activity in the area is limited to moderate levels of recreation that occurs year-round, including a designated snowmobile area and limited ATV access in summer.
Engelmann Spruce – Subalpine Fir parkland	ESSFmcp, ESSFmkp, ESSFwvp	High elevation, subalpine parkland with clumps of stunted Engelmann spruce and subalpine fir that are separated by areas of heath, meadow, and grassland. The climate is slightly milder than alpine but cold still limits tree growth. Snowpack is generally >1 m and lacks local scouring that occurs in the alpine. Human development is similar to alpine.
Engelmann Spruce – Subalpine Fir forest	ESSFmc, ESSFmk, ESSFwv	Mid-high elevation, forest dominated by subalpine fir and Engelmann spruce. The climate in summer is moderated enough to support productive tree growth. Winter snowpack generally exceeds 70 cm. Forestry roads and cutblocks are developed though most of the zone.
Sub-Boreal Spruce – moist cold – Babine	SBSmc2	Productive, mid elevation forest zone dominated by interior spruce, subalpine fir, and lodgepole pine. Cooler and moister summers than the SBSdk and longer winters with deeper snowpack, generally >50 cm. Forestry development is extensive, with limited rural and recreational development.
Sub-Boreal Spruce – dry cool	SBSdk	The most productive and lowest elevation interior BEC variant. Occurs in the Bulkley Valley and lower portions of the Telkwa and Morice River valleys. The climate has relatively dry and warm summers and dry cold winters with generally <50 cm snow. Mature forests are dominated by lodgepole pine and spruce, but the zone also contains a significant component of seral deciduous and mixed forests with trembling aspen, black cottonwood, and paper birch. Human development is extensive, including forestry, agriculture, urban and rural development, and a major transportation corridor.

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Tenas Project

Map 2. Biogeoclimatic Ecosystem Classification variants across the Telkwa Caribou Herd study areas.

Legend

BEC Group

- Alpine (BAFA, CMA)
- Subalpine (ESSF Parkland variants)
- ESSF Forested (ESSFmc, ESSFmk, ESSKwv)
- SBSmc2
- SBSdk
- Coastal (CWH, ICH, MH variants)

Other Features

- Project Area
- LSA
- TCH-RSA1
- TCH-RSA2 Core
- TCH-RSA2 Matrix
- City/Town
- Rail Line
- Highway
- Watercourse
- Wetland
- Waterbody

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Project Area: Allegiance Coal, 2020
- Basedata: Government of British Columbia
- Basemap: World Topo Base

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Production Date: Oct 16, 2020

Map 2

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2.3 Data Acquisition

2.3.1 Anthropogenic Features

As part of the Project, a comprehensive set of geospatial data for anthropogenic features and fires was compiled for the study areas. Anthropogenic features that occur in the study areas include urban areas, buildings, agriculture, roads, trails, recreational areas and trails, railroads, powerlines and pipelines, forestry cutblocks, and forest fires (Table 2). Several of these features were initially divided into sub-features based on their differing characteristics and potential effects, e.g., roads were split into highways, primary, and secondary categories. Some sub-features were subsequently grouped. Features and sub-features were assigned one of five disturbance categories (high, moderately high, moderate, moderately low, and low) based on a qualitative rating of the relative level of human activity associated with the anthropogenic feature. For example, highways were classified as high disturbance, trails were classified as moderate disturbance, and forestry cutblocks were classified as low disturbance. Disturbance ratings were based primarily on the frequency and duration of human activities, the type and magnitude of disturbance, and the persistence/recovery of the disturbance effect.

Spatial layers for the disturbance assessment were acquired from a suite of data available in British Columbia's Data Catalogue:

- ▶ Urban areas, agriculture, cutblock, and fire polygons from the Vegetation Resources Inventory (VRI) spatial layer;
- ▶ GeoBC's National Topographic System (NTS) 'Other Land Cover' 250k Land Cover, Circa 2000 (published December 11, 2014);
- ▶ Building polygons from Sentinel-2 Satellite Images (September 29, 2019) and Terrain Resource Information Management (TRIM) – Enhanced Base Map (EBM) (published December 15, 2014);
- ▶ Agricultural Land Commission (ALC) – Agricultural Land Reserve (ALR) Polygons (published December 11, 2014);
- ▶ Master Partially-Attributed Roads from GeoBC's Digital Road Atlas (DRA) (published February 27, 2013);
- ▶ Forest Tenures (FTEN) Road Section Lines (published December 11, 2014);
- ▶ GeoBase's National Railway Network (NRWN) Railway Track Line (published May 28, 2015);
- ▶ GeoBC's Telkwa Motor Vehicle Closure (TMVC) spatial files (published May 7, 2018);
- ▶ Recreation Polygons and Lines (both published March 9, 2011) by Recreation Sites and Trails (RST) British Columbia;
- ▶ Recreation Tenure Alpine Ski Areas (published December 11, 2014) by Mountain Resorts Branch (MRB) British Columbia;
- ▶ British Columbia Oil and Gas Commission (OGC) Pipeline Right of Way Permits (on or after October 20, 2006; published December 19, 2016), Associated and Ancillary Permits (published December 19, 2016), and Pipeline Segment Permits (on or after July 11, 2016; published January 20, 2017) spatial files; and
- ▶ GeoBC's British Columbia Transmission Lines (compiled from several sources, published November 3, 2017).

Where duplicate features occurred, such as for the three road layers, duplicates were removed. As a final Quality Assurance step, the draft map of the compiled anthropogenic features was compared to recent satellite imagery to assess spatial and thematic accuracy, and features were digitized or corrected to address a small set of systematic errors. In addition to the 'Relative Disturbance Level', a 'Disturbance Hierarchy' was developed to establish the dominance of features where overlap occurred (Table 3). For example, where a road and cutblock overlapped, the road was given precedence. For the purpose of this assessment, the 22 anthropogenic features in Table 2 were grouped into a hierarchy of 12 disturbance classes, based on their similarity of potential effects on caribou (Table 3, Map 3).

Table 2: Anthropogenic features considered for quantifying disturbance effects on the Telkwa Caribou Herd.

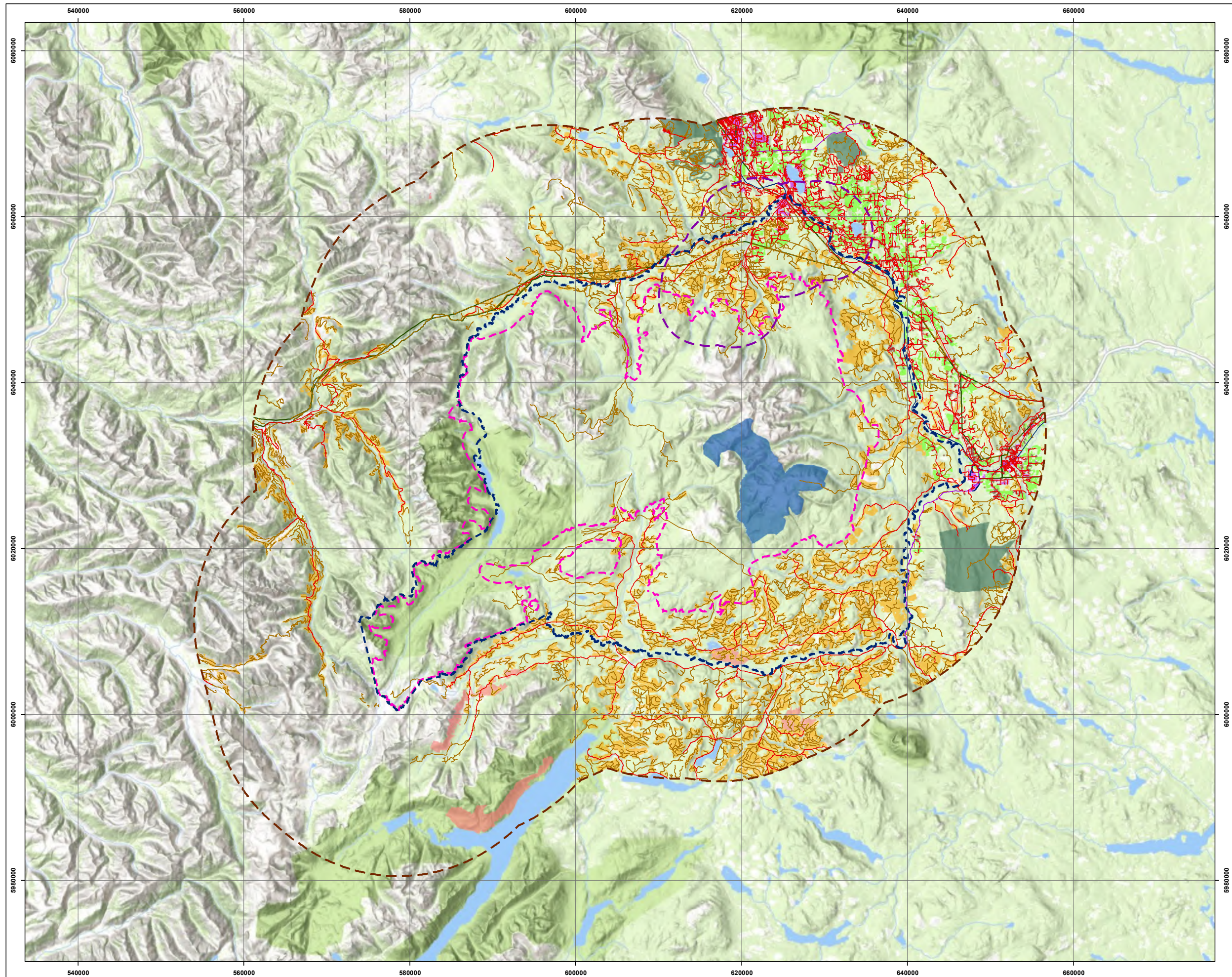
Anthropogenic Feature	Relative Disturbance Level	Buffer Width (m)	Source	Description
Roads – Highway and Haul	High	500	DRA, FTEN	Highway and haul roads (i.e., Highway 16 and main haul roads, Babine Lake Road, and Mortice River Road).
Roads – Primary	High	500	DRA, FTEN	Primary urban and rural roads.
Roads – Secondary	High	500	DRA, FTEN	Secondary urban and rural roads, as well as main forest service/resource roads.
Recreation – Snowmobile	High	500	TMVC	Recreational snowmobiling areas and trails.
Recreation – Ski/Bike	High	500	RST, MRB	Recreational ski and bike trails.
Rail – Yard	High	500	NRWN	All rail yards, mains, and spurs.
Rail – Main	High			
Rail – Spurs	High			
Buildings – Commercial	High	500	TRIM–EBM	Buildings not classified as urban.
Buildings – Residential	High			
Buildings – Recreation	High			
Urban Area	High	500	VRI, NTS 250k	Urbanized regions (e.g., complexes, buildings etc.).
Roads – Tertiary	Mod-High	500	DRA, FTEN	Tertiary roads and secondary resource roads.
Roads – Quaternary – Closure	Mod-High	500	DRA, FTEN	Quaternary roads including 2018 caribou road closures.
Trails	Mod	500	DRA, GeoBC, RST	All recreational trails, reserves, and sites.
Agriculture	Low-Mod	500	VRI, ALC–ALR, NTS 250k	Herb-graminoid cover and annual/perennial croplands.
Roads – Tertiary – Seasonal	Low-Mod	500	DRA and FTEN	Winter snowmobile access routes.

Anthropogenic Feature	Relative Disturbance Level	Buffer Width (m)	Source	Description
Roads – Quaternary	Low	500	DRA, FTEN	Retired forest service roads and overgrown roads.
OilGasPower – Powerline	Low	500	GeoBC	All current powerlines.
OilGasPower – Pipeline	Low	500	OGC	All current pipelines.
Forestry – Cutblock	Low	500	VRI	Forestry cutblocks ≤ 40 years old.
Natural – Fire	Low	N/A	VRI	Forest fires ≤ 40 years old.

Table 3: Classification of anthropogenic features into classes with disturbance hierarchy.

Disturbance Class	Disturbance Hierarchy
Urban	1
Industrial	2
Building-Residential	3
Recreation-Snowmobile	3
Road-Primary/Secondary	4
Recreation-Ski/Bike	4
Road-Haul	5
Rail	6
Buildings-Recreation	7
Road-Tertiary/Trail	8
Agriculture	9
Powerline/Pipeline	10
Cutblock	11
Fire	12

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Tenas Project

Map 3. Distribution of anthropogenic disturbances across the Telkwa Caribou Herd study areas.

Legend

Disturbance Class

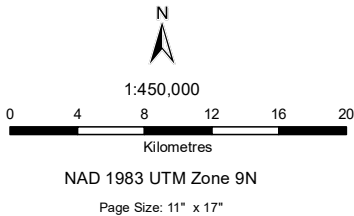
- Road-Primary/Secondary
- Road-Haul
- Rail
- Road-Tertiary/Trail
- Powerline/Pipeline
- Urban
- Industrial
- Building-Residential
- Recreation-Snowmobile
- Recreation-Ski/Bike
- Building-Recreation
- Agriculture
- Cutblock
- Fire
- LSA
- TCH-RSA1
- TCH-RSA2 Core
- TCH-RSA2 Matrix
- Watercourse
- Waterbody

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Project Area: Allegiance Coal, 2020
- Basedata: Government of British Columbia
- Basemap: World Topo Base



20P0172 Production Date: Oct 16, 2020 Map 3



2.4 Disturbance Calculations

2.4.1 Baseline Anthropogenic Disturbance

Existing disturbed areas were calculated following the approach outlined in the *Recovery Strategy for the Woodland Caribou, Southern Mountain Population* (Environment Canada 2014), which consists of calculating the extent of anthropogenic features, plus a 500 m buffer, and the extent of fires ≤ 40 years old. To assess patterns of disturbance across the study areas, disturbance class was retained in the analysis. All spatial data preparation and analyses were conducted in a geographic information system (GIS) program, ArcGIS v10.7 (ESRI 2019). The disturbed area extent was calculated by buffering each disturbance type and then overlaying the buffers and footprints so that the dominant feature and feature buffer took precedent in the final consolidated layer. Where a feature footprint overlapped with a buffer, the footprint took precedent, regardless of hierarchy. The disturbed area layer was then intersected with the four study areas and five BEC variant groups to facilitate data summaries across those areas.

The following data summaries were computed:

- ▶ Total disturbed area for each study area;
- ▶ Extent of each disturbance class for each study area; and
- ▶ Relative disturbance by BEC variant group for each study area.

For ease of interpretation, results are presented as a percentage (%) of the total area for each study area and BEC variant group. Percentages are standardized to the study area or BEC variant group to provide the contribution of each disturbance class within the areas; for example, the percentage of anthropogenic disturbance from rail within the LSA is area of rail disturbance divided by the total area of the LSA. The relative disturbance by BEC variant group is summarized for the TCH-RSA1, but additional summary tables for the LSA, TCH-RSA2 Core, and TCH-RSA2 Matrix study areas are provided in Appendix A.

2.4.2 Analyses Specific to Apparent Competition and Facilitated Predation

To supplement the overall disturbed area analyses, a subset of disturbances associated with two specific effects pathways on caribou were also summarized — apparent competition and facilitated predation.

In the case of the TCH, apparent competition refers to the situation where moose and/or deer populations increase, which results in higher densities of wolves, and that, in turn, leads to higher predation on caribou (Anderson et al. 2018). Within the TCH study areas, anthropogenic disturbances associated with apparent competition are primarily forestry cutblocks and fires, which provide abundant forage for moose and, to a lesser degree, deer. Cutblocks provide an abundance of browse species 5 to 40 years post-disturbance (Keystone Wildlife Research Ltd. 2006, Environment Canada 2014). The presence of large, young cutblocks leads to an increased presence and density of moose (Serrouya and D'Eon 2002). High densities of moose support higher densities of wolves in the area. Wolves then opportunistically prey on caribou which, ultimately, leads to the decline of caribou populations (Wittmer et al. 2007, Apps et al. 2013, Serrouya et al. 2019).

Facilitated predation is the mechanism by which linear features like low use roads, seismic lines, and power- and pipelines can enhance predation rates by increasing predator abundance through travel corridors into caribou range, and with that hunting efficiency (see Dickie et al. 2017b and DeMars and Boutin 2018 for the relevant literature). Disturbances associated with facilitated predation are linear features associated with low human use during growing seasons and those where human use during winter results in packed snow. These linear features increase the efficiency with which wolves search and capture prey (James and

Stuart-Smith 2000, Dickie et al. 2017a, 2017b). Linear features can also increase wolf access to caribou range that is spatially removed from other ungulate ranges by creating an open linear feature (i.e., an easy travel route), through terrain or vegetation wolves may otherwise not travel, or travel through less frequently. During winter, the compaction of snow on linear features also plays an important role. Snow compaction has been shown to significantly increase use of linear features (Keim et al. 2019).

To provide an example of the composition of cutblocks and linear features in the study areas, cutblock areas and linear feature lengths were summarized for TCH RSA1. For this summary, cutblock ages were divided into different age-classes based on five-year intervals, then each age class's total combined area was calculated based on its aggregate footprint. Total lengths of linear features (i.e., all roads, rails, trails, powerlines and pipelines) were calculated by dividing their footprint areas by their average ROW ("right-of-way") widths.

3. RESULTS

3.1 Baseline Anthropogenic Disturbance

Anthropogenic disturbance (comprised of the disturbance footprint and a 500 m buffer, and unbuffered fire footprints) is extensive in parts of the TCH study areas. The proportion of disturbed area varied widely among study areas, from 90% in the Wildlife LSA to 23% in the TCH-RSA2-Core (Table 4).

Table 4: Total anthropogenic disturbance within the Wildlife LSA, the TCH-RSA1, and the Core and Matrix habitats of TCH-RSA2.

	Wildlife LSA	TCH-RSA1	TCH-RSA2-Core	TCH-RSA2-Matrix
Total Area (ha)	35,382.07	260,610.56	160,272.39	531,706.25
Disturbed Area (%)	90.11	48.34	22.89	58.46
Footprint (%)	32.28	17.29	7.82	20.24
Buffer (%)	57.83	31.05	15.07	38.22

While the type and extent of disturbances varied across study areas, tertiary roads and trails (resulting mostly from forestry) consistently contributed the majority of total disturbance (>30% of total disturbed area; Table 5). In total, more than 50% of total disturbances were associated with linear features. Cutblocks were also extensive within all study areas relative to other features and, overall, fire contributed the least disturbance. The TCH RSA1 and the TCH-RSA2-Core were the only study areas in which recreational snowmobiling created a disturbance, the relative extent being greater in the TCH-RSA2-Core.

Overall, the extent of disturbance buffers was approximately twice as large as the extent of disturbance footprints (Table 4). For example, in the TCH-RSA1, the total extent of disturbance buffers was 31.05% of the total study area, whereas the total extent of disturbance footprints was only 17.29% (Table 6). However, disturbance buffers were not equivalent in magnitude among the disturbance classes. Disturbance buffers of tertiary roads and trails, and primary and secondary roads, were an order of magnitude greater than their associated disturbance footprints (Table 6). In contrast, the disturbance buffer for cutblocks was four times less than its associated disturbance footprint. These disparities in footprint-to-buffer ratios are a result of the type of feature (i.e., linear feature widths are much narrower than the 500 m buffer added to it) and the rank associated with each disturbance class. In many cases, tertiary roads and trails are access routes to forestry cutblocks and their disturbance buffer rank took precedence when overlapping the disturbance buffers from cutblocks.

Table 5: Percentage of each disturbance class contribution to total disturbance within the Wildlife LSA, the TCH-RSA1, and the Core and Matrix habitats of TCH-RSA2.

Baseline Conditions		Total Standardized Disturbance (%) in Study Areas ¹			
Disturbance Class	Disturbance Hierarchy	Wildlife LSA 31,882.78 ha ²	TCH-RSA1 125,979.14 ha ²	TCH-RSA2-Core 36,686.35 ha ²	TCH-RSA2-Matrix 310,835.47 ha ²
% of Study Area Disturbed		90.11	48.34	22.89	58.46
Urban	1	5.94	0.59	–	2.78
Industrial	2	–	–	–	0.07
Building-Residential	3	10.80	1.75	<0.01	5.84
Recreation-Snowmobile	3	–	9.77	33.56	-
Road-Primary/Secondary	4	19.96	13.60	1.88	19.20
Recreation-Ski/Bike	4	–	–	–	4.18
Road-Haul	5	–	0.16	–	0.47
Rail	6	0.19	0.27	–	0.24
Buildings-Recreation	7	–	0.12	0.39	0.22
Road-Tertiary/Trail	8	32.38	43.44	51.32	35.13
Agriculture	9	10.33	1.37	–	4.62
Powerline/Pipeline	10	0.49	0.15	–	0.40
Cutblock	11	19.91	28.42	12.84	25.38
Fire	12	<0.01	0.34	0.02	1.48

¹ Percentage calculated as the area of disturbance within the disturbance class divided by the size of study area.

² Total area of disturbance in the study area. Total study area sizes are provided in Table 4.

NOTE: top five disturbance classes in each study area are highlighted.

Table 6: Extent of disturbance classes and their associated footprints, buffers, and total disturbances within the TCH-RSA1 (relative to the total study area size).

Baseline Conditions		TCH-RSA1 (260,610.56 ha) ¹		
Disturbance Class	Rank	Footprint (%)	Buffer (%)	Total Disturbance (%)
Urban	1	0.08	0.20	0.28
Industrial	2	–	–	–
Building-Residential	3	0.02	0.83	0.85
Recreation-Snowmobile	3	3.57	1.15	4.72
Road-Primary/Secondary	4	0.34	6.24	6.57
Recreation-Ski/Bike	4	–	–	–
Road-Haul	5	–	0.08	0.08
Rail	6	0.02	0.11	0.13
Buildings-Recreation	7	<0.01	0.06	0.06
Road-Tertiary/Trail	8	1.24	19.76	21.00
Agriculture	9	0.61	0.05	0.66
Powerline/Pipeline	10	0.07	0.01	0.07
Cutblock	11	11.17	2.57	13.74
Fire	12	0.17	–	0.17
Totals		17.29	31.05	48.34

¹ Total area of the study area.

NOTE: top five disturbance classes for footprints, buffers, and totals are highlighted.

Differences in the proportion of disturbances within study areas corresponded to the amount of the different BEC variant groups that occurred within a study area. For example, alpine BEC variant group was the least disturbed, so study areas that include more alpine contained less disturbed area. The TCH RSA2 Core had the greatest proportion of alpine habitat (15%) whereas the Wildlife LSA had the least (0.2%). This was consistent with the total amount of disturbance in each of these study areas, 23% in the TCH RSA2 Core and 90% in the Wildlife LSA. The same patterns emerged for the subalpine BEC variant group (i.e., ESSF parkland). The disturbance regimes in alpine and subalpine BEC variant groups of the TCH RSA1 were like those of the TCH RSA2-Core. In the TCH RSA1, human activity in alpine and subalpine BEC variant group is moderate but occurs year-round, with some ATV access occurring only in summers. Alpine and subalpine BEC variant groups are relatively open and have substantial snowpack, which is why they were associated with the greatest amount of recreational snowmobiling activity (Table 7). Snowmobiling contributed the most disturbance in these two habitats, followed by tertiary roads and trails. Less than a quarter of the available alpine and subalpine BEC variant groups were disturbed (Table 7) and, overall, only modest amounts of disturbance occurred in these areas, accounting for less than 5% of the total disturbance in TCH RSA1.

The proportion of disturbance in a study area increased with the proportion of forested BEC variant groups. This was somewhat true of the ESSF-Forest BEC variant groups, but was most evident of SBS BEC variants (e.g., Table 7 and Appendix A). In the ESSF-Forest BEC variant groups, forestry roads and cutblocks are developed in across much of the lower elevation portions of this zone. Transitioning into SBS BEC variants, first SBSmc2 (moist, cold Babine) and then SBSdk (dry, cool) at lowest elevations, forestry

development becomes more extensive and agriculture, urban and rural development, and major transportation corridors increase in total area and density. This is why study areas that are predominantly within SBS BEC variants (e.g., 82% of the Wildlife LSA and 50% of the TCH RSA2 Matrix) also had the greatest proportion of total disturbance. In these study areas, the proportion of disturbance within SBS BEC groups were, for the most part, >95% of each BEC group's total area (see Appendix A). The TCH RSA1 has 40% of its area within SBS BEC groups, which is why it had a greater total disturbance area than TCH RSA2 Core.

Table 7: Percentage of each disturbance class contribution to total disturbance by Biogeoclimatic Ecosystem Classification variant groups in the TCH-RSA1 (% standardized to the total study area).

Baseline Conditions		Standardized Disturbance (%) in TCH-RSA1 260,610.56 ha ¹				
Disturbance Class	Disturbance Hierarchy	Alpine 25,340.67 ha ¹ (9.7%)	Engelmann Spruce – Subalpine Fir – Parkland 34,938.79 ha ¹ (13.4%)	Engelmann Spruce – Subalpine Fir 93,354.84 ha ¹ (35.8%)	Sub-Boreal Spruce – moist cold – Babine 79,215.95 ha ¹ (30.4%)	Sub-Boreal Spruce – dry cool 25,595.34 ha ¹ (9.8%)
Urban	1	–	–	–	–	0.29
Industrial	2	–	–	–	–	–
Building-Residential	3	–	–	<0.01	0.02	0.82
Recreation-Snowmobile	3	1.28	2.23	1.21	0.01	–
Road-Primary/Secondary	4	–	–	0.26	4.12	2.19
Recreation-Ski/Bike	4	–	–	–	–	–
Road-Haul	5	–	–	–	–	0.08
Rail	6	–	–	–	–	0.13
Buildings-Recreation	7	<0.01	0.03	0.02	–	<0.01
Road-Tertiary/Trail	8	0.32	0.92	5.48	11.51	2.77
Agriculture	9	–	–	–	–	0.66
Powerline/Pipeline	10	–	–	–	0.02	0.05
Cutblock	11	–	<0.01	1.61	9.74	2.34
Fire	12	–	–	–	0.17	–
Total Disturbance in Study Area		1.60	3.18	8.60	25.58	9.34
Total Disturbance in BEC Area²		16.49	23.70	24.00	84.14	95.10

¹ Total area.

² Percentage calculated as the total disturbance within the BEC group divided by the BEC group's total area.

NOTE: Top five disturbance classes in each BEC group are highlighted.

3.2 Analyses Specific to Apparent Competition and Facilitated Predation

Habitat mediated apparent competition is driven by the footprints of specific disturbance features, namely fires and cutblocks. In general, fires contributed very little disturbance to all study areas (Table 5), and the primary source of early seral stage vegetation in the study areas was from cutblocks. Cutblocks contributed considerable portions of footprint disturbances in all study areas. In TCH RSA1, cutblocks contributed 11% to the total 17% disturbance extent in the study area (Table 6). These disturbances occurred in the SBS and ESSF-Forest BEC variant groups that surround the alpine and subalpine (i.e., ESSF parkland) BEC variant groups along their northern, eastern, and southern extents. The two forested SBS variant groups were most associated with the patches of early seral stage vegetation but least associated with TCH collar locations (Tenas Project Wildlife Baseline Report 2020). In the TCH RSA1, cutblocks occurred at a density of 0.11 km²/km². Cutblock densities were similar for other study areas with substantial SBS forested BECs, such as the TCH RSA2 Matrix (0.11 km² of cutblocks/km²). The density of cutblocks is equivalent to the proportions used to calculate percentages reported in Table 5; for example, a density of 0.11 km²/km² is equal to 11% disturbance.

The area of cutblocks in the TCH RSA1 were relatively uniform across age classes (Figure 1). This pattern was consistent with cutblock ages in the TCH RSA2 Matrix. However, the Wildlife LSA had a greater area of cutblocks aged 30–40 years old, and the TCH RSA2 Core had a greater area of cutblocks aged 20–30 years old (Appendix Figure 1). The age distribution of cutblocks is important in the context of how the effects of apparent competition will persist into the future. For example, a distribution of cutblocks skewed towards younger ages would demonstrate greater potential for effects to persist longer, than if the distribution was skewed towards older cutblocks. Most of these early seral regenerating forest patches occurred in the TCH RSA2 Matrix; their extents in the TCH RSA2-Core were almost negligible (Appendix Figure 1).

Facilitated predation is driven by footprints of linear features, which can provide enhanced travel routes for wolves. The features that are most conducive to facilitated predation in the study areas are tertiary roads and trails as well as powerlines and pipelines. Based on review completed for the Project, other linear features such as primary and secondary roads received frequent enough human use that wolves are unlikely to use them. In the TCH RSA1, tertiary roads and trails were the most prevalent type of linear feature (Figure 2), extending a total length of 1,683 km, corresponding to a density of 0.65 km/km² in the study area. In an area more relevant to the movements and occurrence of the TCH (i.e., TCH RSA2-Core), tertiary roads and trails extended a total length of 299 km, equivalent to a density of 0.19 km/km² (Appendix Figure 2). The densities and lengths of forestry associated roads were negligible in alpine and subalpine.

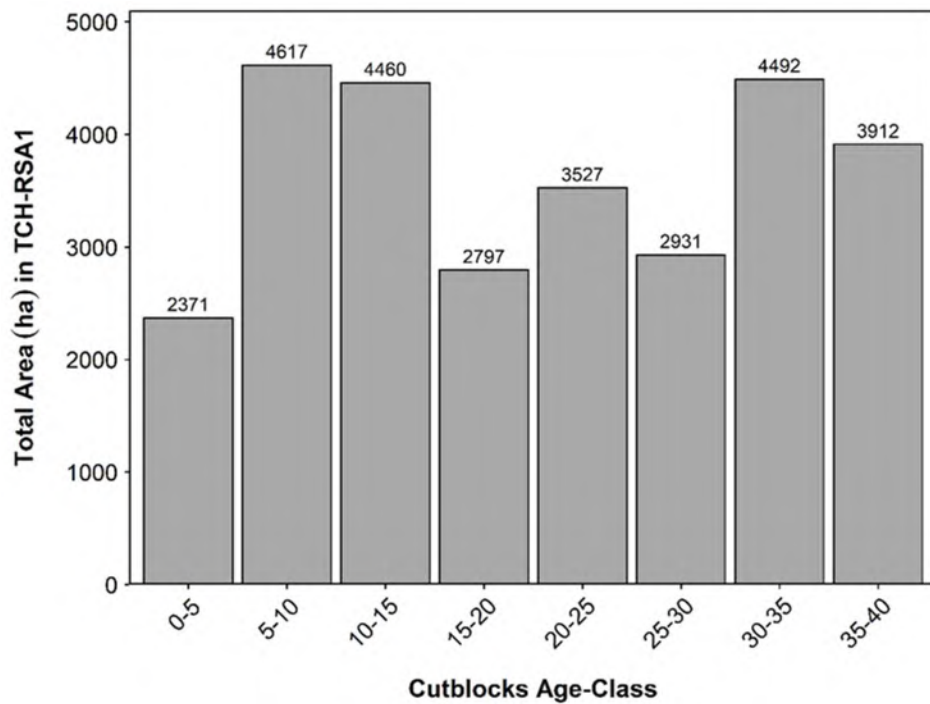


Figure 1: Disturbance area (ha) of cutblocks (sorted by age class) in the TCH-RSA1.

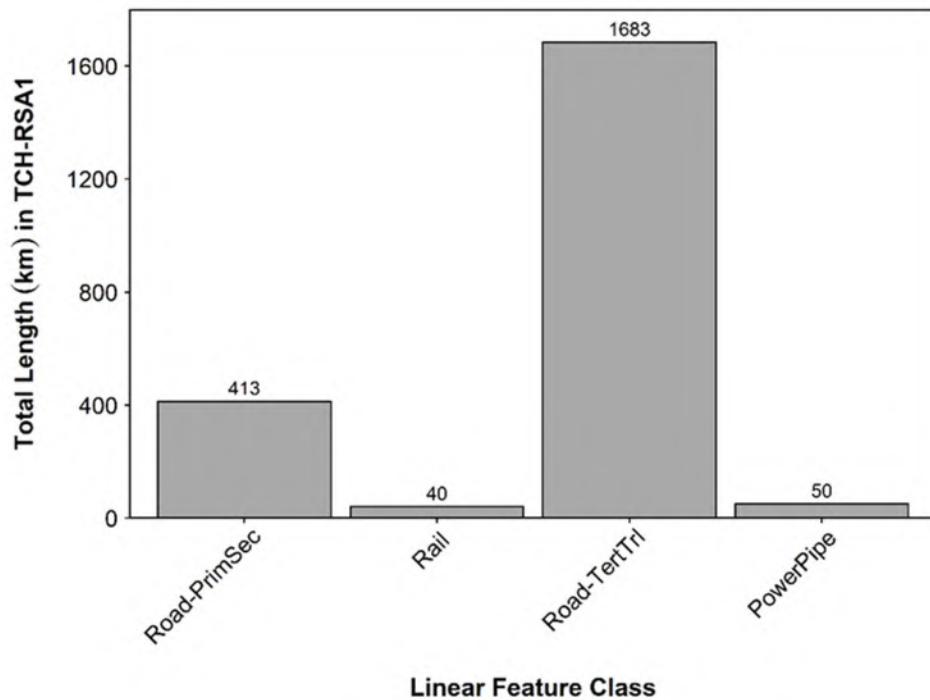


Figure 2: Disturbance length (km) of linear feature classes in the TCH-RSA1.

4. DISCUSSION

Patterns of anthropogenic disturbance in the TCH study areas essentially create an island of moderately disturbed alpine and subalpine BEC variants surrounded by higher levels of disturbance in forested BEC variants to the north, east, and south, and inhospitable high mountains to the west. The broad distribution of the TCH over the last 20 years mirrors that pattern with 87% of telemetry locations occurring in the alpine and subalpine BEC variants (Tenas Project Wildlife Baseline Report 2020). Caribou that venture into the forested BEC variants and, especially, the SBS BEC variants, experience greatly elevated mortality rates (Tenas Project Wildlife Baseline Report 2020), suggesting that apparent competition and facilitated predation may be occurring. Unlike some Southern Mountain caribou herds, the TCH does not include winter use of lower elevation forested BEC zones as part of their seasonal range use strategy. Whether they did so in the past is unknown, but the currently observed high level of disturbance in those areas may at least partly account for the lack of current use.

All but one study area exceeded the ECCC proposed 35% total disturbance threshold. The TCH RSA2 Core, which is the study area that best approximates the herd's annual range, has much less disturbed area, at 23%, than the other study areas. Approximately 65% of the total disturbance in the TCH RSA2 Core is attributable to tertiary roads and trails and cutblocks in the lower elevation portions of the forested ESSF variant groups, and the remainder of the disturbance is associated with recreational snowmobiling. Overall, $\leq 5\%$ of disturbance occurs in alpine and subalpine BEC variant groups, where the TCH is most frequently present. In addition, the disturbances that do occur are mostly recreational activities, which primarily result in intermittent sensory disturbance, rather than altering habitat which can affect forage availability and predator-prey dynamics.

Our estimate of total disturbance in TCH-RSA1 (48%) was similar to one in a recent report by the Wilderness Committee (though with slightly different methodology and study area), which calculated a total disturbance area of 43% in the TCH Local Population Unit (LPU) (Wilderness Committee 2020). This amount of disturbance and prevalence of forestry is common in other herd ranges of Southern Mountain caribou, including those of northern (e.g., Chilcotin and Tweedsmuir), central (e.g., Narraway and Quintette), and southern (e.g., Kinbasket and Southwest Kootenay) LPUs of this population (Wilderness Committee 2020). For the Barkerville caribou subpopulation, disturbance estimates as part of the Bonanza Ledge Project in British Columbia, identified 53.9% of the caribou assessment area to be disturbed, primarily by forestry cutblocks and roads and trails (Golder Associates Ltd. 2017).

The 35% disturbance level in the Recovery Strategy is presented as a threshold-type management target but the critical value of disturbance for caribou is more likely a range than a specific critical value. The actual amount of disturbance a subpopulation can tolerate will likely vary due to several factors, such as the types of disturbance, local predator-prey dynamics, forage supply, and climate. The way these conditions affect caribou will likely vary among subpopulations based on the spatial overlap between disturbances and seasonal ranges and movement patterns. Another source of uncertainty is that the 35% threshold comes from a meta-analysis of boreal or woodland caribou LPUs (Environment Canada 2012). The life history strategies of mountain caribou differ in several ways from boreal caribou, which could result in differences in population responses to disturbance.

Regardless of the precision of the 35% value, the patterns of disturbance and the distribution of the TCH are consistent with the assumption that disturbance results in habitat-mediated apparent competition, which elevates predation risk to caribou and threatens declines in caribou populations (Environment Canada 2012). For the TCH, forestry is the primary disturbance type that has potential to contribute to apparent competition and facilitated predation. Harvesting of mature forest stands creates early seral stage vegetation, that increase moose densities, which in turn could elevate wolf densities (Wittmer et al. 2007,

Environment Canada 2014). The extensive network of forestry roads provides linear features that enhances the travel speed and access, resulting in increased hunting efficiency of wolves (McCutchen 2007).

Predation by wolves is the main proximate cause limiting Southern Mountain Caribou population growth (Wittmer et al. 2005) and is believed to be the main factor limiting the TCH (Ministry of Environment, Lands and Parks 1998, Roberts et al. 2003, Cichowski 2014). Small subpopulations are especially vulnerable to predation-related declines (Bergerud 1980). Local wolf densities in the TCH range are not known; although, estimates for the overall Skeena region range from 5 to 10 wolves/1000km² (MFLNRO 2014). Based on moderately high densities of moose in the Game Management Zone 6C (Kuzyk et al. 2018), which encompasses the TCH, local wolf densities are likely in the mid to upper portion of the regional range estimate. Bergerud and Elliot (1986) estimated that densities of greater than 6 wolves/1000 km², resulted in declines of caribou subpopulations. However, the Recovery Strategy suggests that densities of <3 wolves/1000km² are required in Matrix habitat to maintain caribou subpopulations (Environment Canada 2014).

Similar to other caribou subpopulations, the TCH exhibits distribution patterns that limits their spatial overlap with alternative prey that wolves focus on. Specifically, the herd avoids the forested BEC variants that have higher moose densities, which are potentially elevated due to forestry disturbances (Tenas Project Wildlife Baseline Report 2020). However, this spatial segregation is incomplete and there are cases of both caribou moving into lower elevation forested areas, and wolves moving into the alpine and subalpine BEC variant groups, which result in caribou mortalities. Although human access routes into the alpine and subalpine BEC variant groups are limited to a small number of historic roads and trails, the snowmobile recreational area, packing snow on those features in winter, could facilitate travel by wolves (Keim et al. 2019) into these areas.

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Appendix A Disturbances Within Biogeoclimatic Variant Groups

The following are tables identifying the total standardized disturbance (%) contributed by each disturbance class within Biogeoclimatic Ecosystem Classification (BEC) variant groups found in the Wildlife LSA, and the Core and Matrix habitats of TCH-RSA2.

Appendix Table 1: Percentage of each disturbance class contribution to total disturbance within Biogeoclimatic Ecosystem Classification variant groups in the Wildlife LSA (% , standardized to total disturbance area).

Baseline Conditions		Standardized Disturbance (%) in Wildlife LSA 35,382.07 ha ¹				
Disturbance Class	Disturbance Hierarchy	Alpine 60.13 ha ¹	Engelmann Spruce –Subalpine Fir – Parkland 447.57 ha	Engelmann Spruce – Subalpine Fir 5,685.40 ha ¹	Sub-Boreal Spruce – moist cold – Babine 18,423.64 ha ¹	Sub-Boreal Spruce – dry cool 10,765.34 ha ¹
Urban	1	–	–	–	–	5.35
Industrial	2	–	–	–	–	–
Building-Residential	3	–	–	–	0.32	9.42
Recreation-Snowmobile	3	–	–	–	–	–
Road-Primary/Secondary	4	–	–	0.43	5.34	12.22
Recreation-Ski/Bike	4	–	–	–	–	–
Road-Haul	5	–	–	–	–	–
Rail	6	–	–	–	–	0.17
Buildings-Recreation	7	–	–	–	–	–
Road-Tertiary/Trail	8	0.04	0.05	5.32	13.62	10.15
Agriculture	9	–	–	–	0.08	9.23
Powerline/Pipeline	10	–	–	–	0.12	0.32
Cutblock	11	–	–	3.30	9.74	4.91
Fire	12	–	–	–	13.62	<0.01
Total Disturbance in Study Area		0.04	0.05	9.04	29.21	51.77
Total Disturbance in BEC Area²		22.68	3.80	56.28	99.42	96.02

¹ Total area (disturbed and undisturbed).

² Percentage calculated as the total disturbance within the BEC group divided by the BEC group's total area.

NOTE: total disturbance for Wildlife LSA used in standardized calculations equals: 31,883.31 ha / 35,382.07 ha = 90.11% of the study area. Top five disturbance classes in each BEC group are highlighted.

Appendix Table 2: Percentage of each disturbance class contribution to total disturbance within Biogeoclimatic Ecosystem Classification variant groups in the TCH-RSA2-Core.

Baseline Conditions		Standardized Disturbance (%) in TCH-RSA2 Core 160,272.39 ha ¹				
Disturbance Class	Disturbance Hierarchy	Alpine 24,228.97 ha ¹	Engelmann Spruce –Subalpine Fir – Parkland 36,508.81 ha ¹	Engelmann Spruce – Subalpine Fir 94,759.94 ha ¹	Sub-Boreal Spruce – moist cold – Babine 3,779.12 ha ¹	Sub-Boreal Spruce – dry cool 0 ha ¹
Urban	1	–	–	–	–	–
Industrial	2	–	–	–	–	–
Building-Residential	3	–	–	<0.01	–	–
Recreation-Snowmobile	3	2.08	3.62	1.97	<0.01	–
Road-Primary/Secondary	4	–	–	0.43	<0.01	–
Recreation-Ski/Bike	4	–	–	–	–	–
Road-Haul	5	–	–	–	–	–
Rail	6	–	–	–	–	–
Buildings-Recreation	7	0.01	0.05	0.03	–	–
Road-Tertiary/Trail	8	0.51	1.49	8.92	0.83	–
Agriculture	9	–	–	–	–	–
Powerline/Pipeline	10	–	–	–	–	–
Cutblock	11	–	0.01	2.62	0.31	–
Fire	12	–	–	–	<0.01	–
Total Disturbance in Study Area		2.61	5.17	13.97	1.14	–
Total Disturbance in BEC Area²		17.24	22.68	23.64	48.45	–

¹ Total area (disturbed and undisturbed).

² Percentage calculated as the total disturbance within the BEC group divided by the BEC group's total area.

NOTE: total disturbance for TCH-RSA2-Core used in standardized calculations equals: 36,686.96 ha / 160,272.39 ha = 22.89% of the study area. Top five disturbance classes in each BEC group are highlighted.

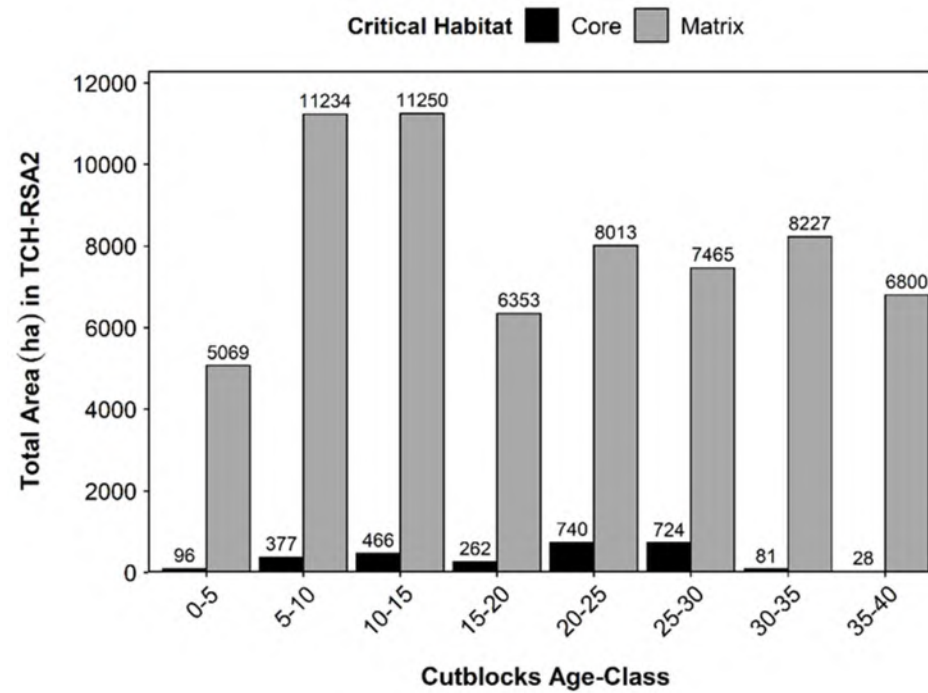
Appendix Table 3: Percentage of each disturbance class contribution to total disturbance within Biogeoclimatic Ecosystem Classification variant groups in the TCH-RSA2-Matrix.

Baseline Conditions		Standardized Disturbance (%) in TCH-RSA2 Matrix				
		531,706.25 ha ¹				
Disturbance Class	Disturbance Hierarchy	Alpine 67,745.82 ha ¹	Engelmann Spruce –Subalpine Fir – Parkland 24,953.83 ha ¹	Engelmann Spruce – Subalpine Fir 74,015.82 ha ¹	Sub-Boreal Spruce – moist cold – Babine 179,586.97 ha ¹	Sub-Boreal Spruce – dry cool 85,299.87 ha ¹
Urban	1	–	<0.01	0.03	0.05	1.55
Industrial	2	–	–	0.01	0.01	0.01
Building-Residential	3	–	0.05	0.07	0.42	2.86
Recreation-Snowmobile	3	–	–	–	–	–
Road-Primary/Secondary	4	–	–	0.44	5.56	3.61
Recreation-Ski/Bike	4	0.04	0.09	0.53	1.48	0.13
Road-Haul	5	–	–	–	0.01	0.26
Rail	6	–	–	–	–	0.14
Buildings-Recreation	7	–	0.06	0.03	0.04	<0.01
Road-Tertiary/Trail	8	0.19	0.26	2.14	11.93	2.53
Agriculture	9	–	–	–	0.23	2.47
Powerline/Pipeline	10	<0.01	–	<0.01	0.05	0.06
Cutblock	11	–	<0.01	0.97	10.02	2.04
Fire	12	<0.01	0.02	0.51	0.21	<0.01
Total Disturbance in Study Area		0.23	0.49	4.73	30.02	15.67
Total Disturbance in BEC Area²		1.80	10.52	34.01	88.87	97.65

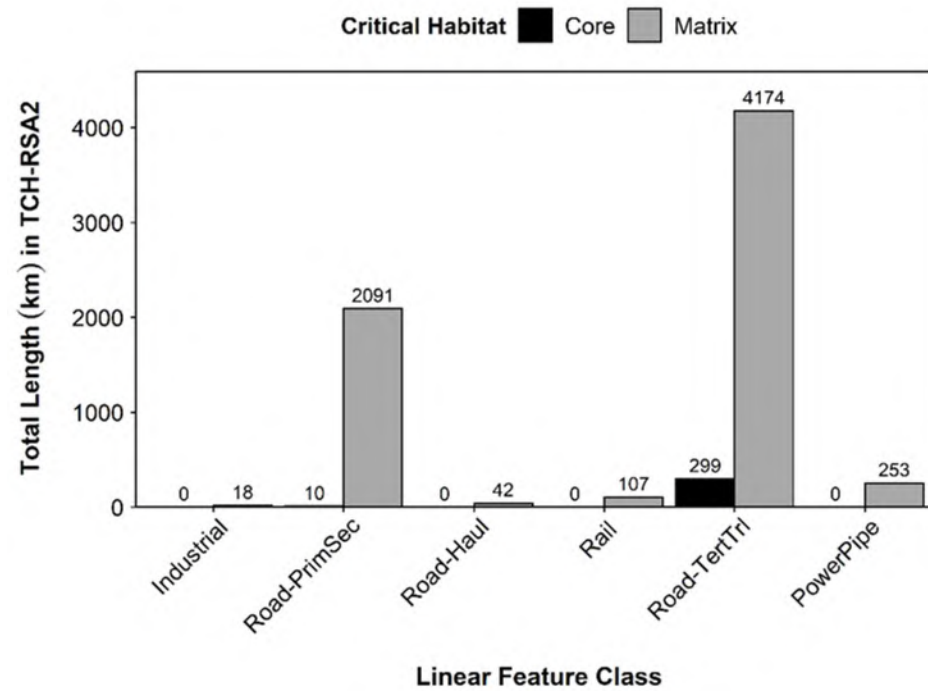
¹ Total area (disturbed and undisturbed).

² Percentage calculated as the total disturbance within the BEC group divided by the BEC group's total area.

NOTE: total disturbance for TCH-RSA2-Matrix used in standardized calculations equals: 271,907.39 ha / 531,706.25 ha = 51.14% of the study area. Top five disturbance classes in each BEC group are highlighted.



Appendix Figure 1: Disturbance area (ha) of cutblocks (sorted by age class) in the TCH-RSA2 Core and TCH-RSA2 Matrix.



Appendix Figure 2: Disturbance length (km) of linear feature classes in the TCH-RSA2 Core and TCH-RSA2 Matrix.

Appendix G Moose Species Account and Habitat Model Report

Tenas Project

Moose Species Account and Habitat Model Report

December 2020

VERSION 2.1

Submitted to: Telkwa Coal Limited
Suite 1410 – 409 Granville Street
Vancouver, BC V6C 1T2

Submitted by: EDI Environmental Dynamics Inc.
301 George Street
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Tenas Project

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Appendix A	Moose Winter Habitat Suitability Mapping
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1. INTRODUCTION

This report describes the moose (*Alces americanus*) habitat suitability model developed as baseline information for assessment of the Tenas Project (the Project). The extent of the habitat model for moose (also referred to as the study area) is the Wide-Ranging Wildlife Regional Study Area (RSA; 357,587 ha or 3,576 km²). The RSA will be used to assess the context of the direct and indirect effects of the Project on moose and encompasses both the Project Area and the Local Study Area (LSA). The Project Area includes the area where the proposed mine activities will be conducted, and the Local Study Area is the area that is expected to contain all direct effects of the Project.

Habitat suitability modelling was completed for moose in the RSA in preparation for assessing potential effects of the Project on current moose habitat. The ecology of the species was reviewed and summarized (see Sections 2 and 3). Attributes considered in model development are summarized herein (see Section 4), including known threats to the species and known habitat requirements in context with the most current available data in the region.

In December 2020, after receiving historical moose observation and GPS location data, the habitat suitability ratings were further evaluated using these data and the ratings were adjusted. The model development, habitat variables, and ratings assumptions are presented in Section 4.1 to Section **Error! Reference source not found.** The final model evaluation and adjustments to the ratings are summarized in Section 4.5.

2. DISTRIBUTION AND STATUS

2.1 Distribution

Moose are found in most habitats throughout British Columbia (BC), inhabiting forested regions ranging from sea level to the sub-alpine, and may use alpine areas in the summer (Cowan and Guiget 1978, Stevens 1995). They have been observed at elevations up to 1,500 m in northwestern BC (Demarchi and Bunnell 1995). Moose are generally not located in non-forested or very open forest types (e.g., Alpine Tundra, Bunchgrass and Ponderosa Pine biogeoclimatic subzones) (Stevens 1995) and on Vancouver Island, Haida Gwaii, and along the west coast of BC (Cowan and Guiget 1978, Stevens 1995, Eder and Pattie 2001).

In 2018, the moose population density within the Bulkley Valley and Lakes District survey area was estimated at 0.59 moose/km² (Schindler et al. 2019). During the last survey in 2012, the estimated density was 0.96 moose/km² and the two estimates are not distinguishable given the variances associated with each estimate (2018: 7,619 ± 1,074; 2012: 8,804 ± 1,409 moose). The 2018 and 2012 estimates showed a decline compared with the 2004 estimate of 11,456 ± 1,076 moose (Schindler et al. 2019). The survey area is 12,872 km² and includes Management Units 6-4, 6-5, 6-6, 6-8, and 6-9. The RSA includes part of this moose survey unit and overlaps with Management Units 6-8 and 6-9.

The Bulkley Basin (BUB) Ecoregion SBSdk biogeoclimatic subzone contains habitat¹ that is considered a provincial benchmark for moose in winter according to the Wildlife Habitat Ratings Standards (Resources

¹ Central Interior Ecoprovince, Bulkley Basin Ecoregion (BUB), SBSdk BA/1 - Boreal White Spruce-Trembling Aspen is a provincial benchmark rated 1 on the 6-class habitat ratings standard.

Inventory Committee 1999). The lowest elevation portion of the RSA is within the BUB SBSdk and contains habitats that are known to provide high quality habitat for moose in the winter. The habitat has been fragmented by forestry and urban development and this is a factor in determining the current suitability of the habitat.

2.2 Threats and Status

In BC, the moose is on the provincial yellow-list (i.e., apparently secure and not at risk of extinction) (BC CDC 2020) and is managed for hunting by the Ministry of Forests, Lands, and Natural Resource Operations and Rural Development. Moose are not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under Schedule 1 of the federal *Species at Risk Act* (Table 1).

Predation by grizzly bears and wolves is commonly the leading cause of moose mortality, followed by human harvest (Hauge and Keith 1981, Bangs et al. 1989, Larsen et al. 1989, Bertram and Vivion 2002), vehicle collisions, old age, and natural accidents (Bangs et al. 1989). Hunting allocation has been altered to limit the general open season from 7 days to 3 days in response to the observed decline in moose density between 2004 and 2018 (Schindler et al. 2019).

Climate is an important limiting factor to moose distribution, with weather extremes in both the summer and winter playing a role (Kelsall and Telfer 1974, Schwab 1985, Renecker and Hudson 1986, Demarchi and Bunnell 1993, 1995). Adult moose are highly tolerant of cold, but sensitive to heat in all seasons (Renecker and Hudson 1986). During high summer temperatures, moose seek cool areas under closed canopy forests and aquatic environments such as lakes, rivers and ponds to mitigate heat stress (Kelsall and Telfer 1974, Schwab 1985, Renecker and Hudson 1986, Demarchi and Bunnell 1993, 1995). They make their way into mid-elevation and subalpine ecosystems in late summer and during the rut (September–October), with a peak in elevation in November (McCulley et al. 2017). Both sexes use lower elevations in winter (December–March) and the calving season (May–June) (McCulley et al. 2017).

Table 1: Status of Moose (*Alces alces*).

Species Code	M-ALAM
Provincial Status	S5
B.C. List	Yellow
Identified Wildlife (Province of British Columbia 2019)	Yes
COSEWIC Status	-
Species at Risk Act (SARA) Status	-

3. HABITAT REQUIREMENTS

Habitat modelling was conducted for the winter season, as this is considered the most limiting season for moose and the location of winter habitat would have the highest interaction with the Project due to the location of the Project. During the winter, three criteria drive selection of habitat by moose: food availability (i.e., forage), predator avoidance (i.e., security), and snow depth (i.e., referred to as “thermal” habitats due to having reduced snow depth). Habitat use is largely dependent on the foraging opportunities and is thought to be influenced by proximity to security/thermal habitat.

3.1 Foraging Habitat - Winter

In the winter, moose inhabit a variety of habitats with abundant browse such as valley floors, riparian habitats, willow flats, cut blocks, and post-fire communities located in proximity to mature forest cover (Peek et al. 1976, Timmermann and McNicol 1988, Westworth et al. 1989, Baker 1990, Forbes and Theberge 1993, Collins and Helm 1997, J.G. MacCracken et al. 1997, Proulx and Kariz 2005a, b, Poole and Stuart-Smith 2005). In average winter conditions, moose often favor young and over-mature forest stands where the abundance of browse is higher than within mid-succession forest (Stelfox et al. 1995). Moose also use old forest types, large openings, and open water as escape terrain from wolves in winter, who flounder in deep snow or water (Stotyn et al. 2005).

During winter, moose primarily rely on shrubs and trees for their winter diet. Moose generally sample a wide variety of plant species but usually consume large quantities of only a few species (Renecker and Schwartz 2007). Browse selection and the composition of their diet varies annually and regionally based on the site productivity, forage availability, palatability, and nutritional value of available trees and shrubs relative to one another (Porter 1990, Renecker and Schwartz 2007). During winter, moose feed primarily on the twigs of deciduous trees and shrubs including willows (*Salix* sp.), red osier dogwood (*Cornus stolonifera*), highbush cranberry (*Viburnum trilobum*), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*), which form the majority of their diet; they also feed on low quantities of numerous other deciduous shrubs such as hazelnut (*Corylus cornuta*), elderberry (*Sambucus racemosa*), mountain ash (*Sorbus* spp.), alder (*Alnus* sp.), serviceberry (*Amelanchier alnifolia*), and raspberry (*Rubus* sp.) (Westworth et al. 1989, Haeussler et al. 1990, Collins and Helm 1997, Poole and Stuart-Smith 2005, Renecker and Schwartz 2007, Baigas et al. 2010). Moose will strip the bark from deciduous trees, particularly young aspen and some willow species, when snow conditions impede movement and limit browse availability in late winter (Miquelle and Van Ballenberghe 1989, James G. MacCracken et al. 1997). Some studies have also found their winter diet to contain a low but significant amount of lichen (Hodder et al. 2013, Rea 2014). The proportion of lichen in the winter diet of moose is likely underestimated in most studies because of the techniques used in fecal pellet analysis and the high digestibility of lichen relative to woody browse (Hodder et al. 2013).

In several regions of western North America, willows are considered the most important winter browse for moose (Peek et al. 1976, Roberts 1986, Risenhoover 1989, Haeussler et al. 1990, Porter 1990, Collins and Helm 1997, Poole and Stuart-Smith 2005). A study of willow and moose browse in logged areas in the central interior of British Columbia showed that most (88% to 91%) of the willow biomass consumed by moose in the winter was comprised of five of the fourteen willow species present in the study area (Porter 1990). Willows were generally browsed in proportion to their abundance, but the author suggests that some of the abundant species appeared to be browsed preferentially over the others when present within the same study plots. Roberts (1986) found similar results in her study of willows of the Lower Skeena Valley, but also that preferential selection of one species, Bebb's willow (*S. bebbiana*), often kept plants hedged at 2 m and was sometimes severe enough to kill plants. Risenhoover (1989) found that willows accounted for more than 94% of the winter diet of moose in Denali National Park and Preserve. Some willows are well adapted to wetter soils and are commonly found in wetland and riparian habitats, while others are adapted to upland sites and open forests where they benefit from natural disturbances (Roberts 1986, Porter 1990). Willows are also an early successional species and relatively shade-intolerant, and, as such, are often abundant in early seral habitats favored by moose such as those resulting from anthropogenic disturbance (e.g., cut blocks, seismic lines) and wildfires (Porter 1990). Red-osier dogwood, highbush cranberry, and serviceberry are also known to be selected preferentially in some areas (Poole and Stuart-Smith 2005).

Conifers can also form an important part of the winter diet of some moose populations (Eastman 1977, Rea 2014). An assessment of moose winter diet in northcentral British Columbia showed that, while moose diet consisted primarily of deciduous trees and shrubs (51%) including willows (21%) and paper birch (13%), subalpine fir (*Abies lasiocarpa*) also comprised a large proportion of their diet (43%) (Rea 2014). A similar study of diet in a deep snow winter in northcentral British Columbia by Hodder et al. (2013) showed that the

diet of moose that year consisted primarily of conifers (64%) including subalpine fir (45%) and Douglas fir (*Pseudotsuga menziesii*; 17%) while deciduous trees and shrubs comprised 36% of moose diet of which only 13% was willows.

3.2 Security/Thermal Habitat - Winter

Winter thermal habitat is provided by closed-canopy coniferous forests, which intercept snow and allow for greater ease of movement (Coady 1974, Eastman 1974, Peek et al. 1976, McNicol and Gilbert 1980, Thompson and Vukelich 1981, Schwab 1985, Hundertmark et al. 1990). Mature closed canopy forests also provide shelter from wind, with even residual stands of trees providing important wind shelter (McNicol and Gilbert 1978). Snow depth and duration are the highest natural mortality factors for moose (McNicol and Gilbert 1978). Thus, snow interception is a critical component of thermal habitat. Allen et al. (1987) suggest that the best thermal protection and snow interception are provided by dense stands at least 10 m in height and composed of a least 60% conifers.

Winter security cover is habitat that provides visual screening and safety from predators and hunters (Timmermann and McNicol 1988, Ministry of Environment 2010). The Ministry of the Environment (2010) has defined moose security habitat in the Skeena region as habitats with stem densities that obscure 90% of a moose at 60 m, diverse understories that obscure moose at close range, or gullied terrain. Security habitat may occur in structural stages 3 – 7; however, best security cover occurs in structural stages 3 – 5 (Ministry of Environment 2010). Retained forest patches in harvested landscape also can provide security habitat, and reducing cutblock size and leaving more uncut forest has been suggested to increase security cover (Eason 1985).

Moose winter habitat use is highly dependent on snow characteristics (Kelsall and Prescott 1971, Coady 1974, Peek et al. 1976, McNicol and Gilbert 1980, Thompson and Vukelich 1981, Hundertmark et al. 1990, James G. MacCracken et al. 1997). Although moose have long legs and low foot loads, which allow them to frequent high snowfall areas, they typically prefer to forage in areas with snow depth less than 60 cm (LeResche 1974, Eastman 1974, Peek et al. 1976, Schwab 1985, Hundertmark et al. 1990, Poole and Stuart-Smith 2005). When snow levels are low (<60 cm) moose are able to forage in open habitat types such as shrublands, burns and cutblocks with relatively low energetic expenditure (LeResche 1974, Eastman 1974, Peek et al. 1976, Schwab 1985, Hundertmark et al. 1990, Poole and Stuart-Smith 2005). As snow levels increase beyond 60 cm, energy expenditure increases, and foraging in open and edge habitat beyond 80 m from forested edges decreases (Eastman 1974, Hamilton and Drysdale 1975, Peek et al. 1976, Hamilton et al. 1980, McNicol and Gilbert 1980, Thompson and Vukelich 1981, Schwab 1985, Hundertmark et al. 1990) in favour of closed canopy forests, edge habitats (Eastman 1974, Peek et al. 1976, Schwab 1985, Hundertmark et al. 1990), and open areas within 60 to 100 m of forested edges (Hamilton and Drysdale 1975, Hamilton et al. 1980, Thompson and Vukelich 1981, Tomm et al. 1981, Baker 1990). When snow levels exceed 90 cm, moose are severely restricted in their movements (Coady 1974, Schwab 1985). However, snow density and crusting also influences the depth of snow that a moose can occupy; higher density snow allows for deeper snow use (Kelsall and Prescott 1971, Coady 1974).

Table 2 shows examples of evidence that moose preferentially used habitat within 100 m from security/thermal habitat. The moose location data available for this project showed that a distance of 100 m or 500 m from security/thermal did not make a difference to selection of habitat; however, forage habitat was used less often when it was greater than 500 m from security/thermal habitat (see Section 4.5).

Moose often exhibit seasonal migrations as a strategy to use different environments to reduce facing detrimental conditions (Edwards and Ritcey 1956). The typical pattern is to inhabit higher elevations during the summer and relocate to lower elevations during the winter. This has been observed in several areas of the province including the Nass Wildlife Area (Demarchi 2003) and Clearwater Valley (Edwards and Ritcey 1956), and in Idaho (Pierce and Peek 1984). As winter progresses, increasing snow depth encourages downward migration; in the spring, melting snow coincides with rapid upward migration (Edwards and

Ritcey 1956). Moose habitat use in winter is also inversely related to slope (Matchett 1985 and Langley 1993 In Halko and Hebert 1997) and road density. Moose typically prefer lower gradient slopes and flat areas and decrease use with increasing frequency on steeper slopes (Gillingham and Parker 2008, Baigas et al. 2012). Resource selection functions (RSF) for winter habitat use in Wyoming found a decline in suitability values to zero with slopes around 40°, while all locations of slopes under 25° had a RSF greater than 0.5 (Baigas et al. 2012).

Road density also influences winter habitat use. Road density in excess of 0.6 km/km² is an apparent threshold value of habitat degradation above which moose populations start to decline (Beazley et al. 2004). Although road avoidance is generally limited to within the first 250 m from roads, road density as low as 0.16 km/km² has been shown to influence moose habitat selection and distribution (Laurian et al. 2012). Studies examining the effects of disturbance on the distribution and behaviour of moose along access corridors found that these effects were limited to within 1000 m of roads, with most effects occurring within 250 to 300 m of roads (Colescott and Gillingham 1998, Yost and Wright 2001, Laurian et al. 2008, 2012, Shanley and Pyare 2011). Differences between study results were likely related to traffic volume, moose habituation to disturbance, and habitat suitability specific to their study areas. Road traffic and density can also increase mortality risk to moose and make developed or urban areas with a higher density of roads and traffic an area of higher risk for moose (Rea 2012, Welch et al. 2015, Mumma and Gillingham 2019).

Table 2: Distance Between Moose Security/Thermal Cover and Foraging Habitats

Distance (m)	Season	Details	Study Area Location	Source
60	Winter	Cow/calf groups ranged 3–60 m (mean = 27 m) from partially or uncut semi-mature to mature conifer stands in early winter and 0–30 m (mean = 12 m) in late winter; distance decreased with increasing snow depth	Ontario	Thompson and Vukelich (1981)
80	All	Moose used edges extensively to provide forage and cover in residual forest, and seldom moved more than 80 m from the edges into open areas when adjacent to areas of vehicle disturbance	Alberta	Tomm et al. (1981)
80	Winter	95% of browse activity within 80 m of cover (residual forest)	Ontario	Hamilton et al. (1980)
100	Winter	Beyond 40 m from cover (residual forest), frequency of use decreased and became zero at approximately 100 m from cover	Ontario	Hamilton and Drysdale (1975)
100	Winter	Typically within 100 m of forest/wetland edge, almost never used areas greater than 200 m from the edge.	British Columbia	Baker (1990)

4. MODEL DEVELOPMENT

4.1 Data Acquisition and Preparation

The spatial datasets used to develop the moose habitat model are described in Table 3. A digital elevation model (DEM) was used to generate the elevation and slope thresholds. Provincial Vegetation Resource Index (VRI) datasets were merged and updated with fire, cutblock, and forest reserve layers to better represent current conditions.

Analyses were completed using NAD83 BC Albers projected coordinate reference system (EPSG: 3005). Analyses and management of spatial data were completed using ArcGIS Desktop 10.3 with the Spatial Analyst extension.

Table 3: Datasets Used in the Development of the Moose Model

Dataset Name	Description	Source
Digital Elevation Model	Raster	https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/terrain
Vegetation Resource Index	Polygons representing vegetated and non-vegetated land classifications combined with VRI, wildfire, harvested area, and forest reserve layers	https://catalogue.data.gov.bc.ca/dataset/vri-forest-vegetation-composite-polygons-and-rank-1-layer https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical https://catalogue.data.gov.bc.ca/dataset/harvested-areas-of-bc-consolidated-cutblocks https://catalogue.data.gov.bc.ca/dataset/recreation-sites-reserves-and-interpretive-forests-details-and-closures-fully-attributed
Digital Road Atlas	Road dataset for BC	https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads
GeoBase 250K Land Cover, Circa 2000	Polygons identifying land classifications (e.g., annual cropland, snow/ice, developed)	https://catalogue.data.gov.bc.ca/dataset/other-land-cover-1-250-000-geobase-land-cover#edc-pow
Recreation Tenure Alpine Ski Areas	Polygon and point features for ski areas	https://catalogue.data.gov.bc.ca/dataset/recreation-tenure-alpine-ski-areas
Municipalities – Legally Defined Administrative Areas of BC	Polygons outlining legally defined municipalities in BC	https://catalogue.data.gov.bc.ca/dataset/municipalities-legally-defined-administrative-areas-of-bc#edc-pow
CanVec	Point sources for anthropogenic features (e.g., dam, dike/levee, sewage pipeline)	https://open.canada.ca/data/en/dataset/fd4369a4-21fe-4070-914a-067474da0fd6
OpenStreetMap	Point sources for buildings to represent building corners.	https://osmbuildings.org/data/
TRIM Enhanced Base Map	Polygons representing building footprints	https://catalogue.data.gov.bc.ca/dataset/buildings-trim-enhanced-base-map-ebm
Mineral Titles Online Tenure	Data for mineral, placer claims and leases, and coal licence applications/licences/leases	https://catalogue.data.gov.bc.ca/dataset/mta-mineral-placer-and-coal-tenure-spatial-view
Forest Tenure Road Section Lines	Roads under the BC Forest and Range Practices Act Tenures	https://catalogue.data.gov.bc.ca/dataset/forest-tenure-road-section-lines
GeoBase National Railway Network	Contains railway track classification, use type, and operator data	https://catalogue.data.gov.bc.ca/dataset/railway-track-line#edc-pow
Oil and Gas Commission Pipeline Right-of-Way Permits	Polygon data for approved and post-construction pipeline rights-of-way	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-right-of-way-permits

Dataset Name	Description	Source
Oil and Gas Associated Ancillary Permit	Polygons of associated oil and gas activities (e.g., campsites, staging areas, workspaces)	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-associated-and-ancillary-permits
Oil and Gas Pipeline Segment Permit	Polygons representing segments of non-continuous pipeline	https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-segment-permits
Transmission Lines	High voltage electrical transmission lines for power distribution	https://catalogue.data.gov.bc.ca/dataset/bc-transmission-lines
Telkwa Motor Vehicle Closure	Road closures due to caribou habitat protections	ftp://ftp.geobc.gov.bc.ca/publish/Regional/Smit hers/Telkwa%20motor%20vehicle%20closure/
Recreation Polygons	Polygons of a recreation feature (e.g., recreation reserve, recreation site, interpretive forest)	https://catalogue.data.gov.bc.ca/dataset/recreation-polygons
Recreation Line	Linear spatial representation for recreation features (e.g., recreation trails)	https://catalogue.data.gov.bc.ca/dataset/recreation-line

4.2 Model Rating Scheme

A high level of knowledge of habitat use is available for moose in BC; therefore, a 6-class rating scheme was applied to the ecosystems (Table 4). Habitat suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species (Resources Inventory Committee 1999). When a suitability rating for moose was assigned to a habitat, that habitat was assessed for its potential to support the species for the living-winter life requisite compared with the best habitat in the province (i.e., the provincial benchmark) for the same life requisite and season.

Table 4: Habitat Suitability Modelling Scheme used for Moose

Percent of Provincial Benchmark	Rating	Suitability Class
76 – 100%	High	1
51 – 75%	Moderately High	2
26 – 50%	Moderate	3
6 – 25%	Low	4
1 – 5%	Very Low	5
0	Nil	6

Provincial benchmark ecosystems are reference units against which other habitats can be compared for their ability to produce major moose forage species. The provincial benchmarks for moose are based on the expert opinion of wildlife biologists and population data (Resources Inventory Committee 1999). The provincial benchmark for moose winter Living is the SBSdk (Resources Inventory Committee 1999).

Winter Season Benchmark

Ecosection: Bulkley Basin (BUB)

Biogeoclimatic Zone: SBSdk

Habitats: Boreal White Spruce - Trembling Aspen - Dense, broad-leaved, mixed or coniferous mixed forest, with shrub and herb dominated understories, that include plant communities that succeed through trembling aspen seral forests to a white spruce climax.

4.3 Habitat Variables and Assumptions

Information used to develop the moose model is primarily from literature about habitat use and selection by moose. The habitat attributes required to satisfy the life requisites of the moose are based on the assumption that moose use habitats in the Project area similarly to those used by moose in comparable habitats in other areas of BC (as summarized in Section 3).

Moose are present in the study area in all seasons; however, the life requisite that will be evaluated for moose will be “Living” for the winter season, as this is the limiting season for moose (Timmermann and McNicol 1988, Keystone Wildlife Research Ltd. 2006, Mumma and Gillingham 2019) and the habitat area with the most concentrated interaction with the Project compared with summer habitat. Habitat use by moose is largely driven by foraging opportunities within a certain proximity to security/thermal habitat; therefore, the Living life requisite combines forage and security/thermal life requisites. Table 5 summarizes winter habitat attributes for moose in the Project area.

Table 5: Summary of General Habitat Attributes for Moose

Season	Life Requisite	Specific Attributes Required	Structural Stages
Winter	Forage	Seral, shrub-stage cutblocks and burns	3a, 3b
		Disclimax shrub-stage ecosystems (wetlands, shrub-carrs, alder swales)	3a, 3b
		Cottonwood and spruce floodplains along the Bulkley, Morice, and Telkwa rivers	3–7
		Seral deciduous and mixed forest stands	3–7
		Valley bottom riparian shrub ecosystems with willow and other shrubs for winter browse	3–7
Winter	Security/ Thermal	Closed canopy mature conifer forests with diverse understory for visual cover and snow interception	5–7

4.3.1 Preliminary Habitat Suitability Ranking

For each ecosystem unit that occurs in the RSA, seasons of use were determined based on habitat requirements and the location of the Project (Table 6). As availability of winter forage habitat is believed to be the main driver for moose winter habitat use, preliminary habitat suitability was ranked using ecosystem units associated with winter forage species as the first priority.

Ecosystem units were stratified by forest type (Table 7) and structural stage. Structural stage was assigned to each ecosystem unit based on stand age (Table 8) (Resources Inventory Committee 1998). Preliminary habitat suitability rankings were assigned to each forest type and structural stage combination based on predicted winter forage (Table 9).

Habitats with high shrub density (structural stages 3a and 3b; wetlands, cutblocks and regenerating burns with high shrub) were rated up to class 1 winter living habitat, depending on forest type (coniferous, deciduous, mixed, or floodplain). Productive floodplains and their associated glaciofluvial benches and riparian habitat were rated up to class 1 moose winter living habitat depending on their structural stage.

4.3.2 Preliminary Habitat Suitability Ranking Modifiers

Security/Thermal Cover

Security cover is assumed to be primarily driven by avoidance of linear features that result in human and wolf predation and sensory disturbance from human activity. Security/thermal cover is assumed to be provided by forested stands of structural stage 5 or greater with canopy closure 30% or greater as these would provide snow interception for thermal cover and diverse understory for security cover. Polygons more than 100 m from security/thermal cover were originally downgraded by one class. This was subsequently widened to proximity of 500 m based on the data analysis presented in Section 4.5.

Anthropogenic Features

Habitats within 250 m of linear features (e.g., highways, resource roads, trails, transmission lines) were downgraded by one class. Moose habitats that fall within urban settings were assumed to have lower values than similar ecotypes outside these areas due to a decrease in the availability of suitable habitat and increase in anthropogenic disturbance, and habitats within 500 m of urban areas (e.g., Smithers, Telkwa) were reduced by one class.

Elevation

On a landscape scale, it was assumed that moose select zones of lower snow depth by moving to lower elevations where snow does not limit winter range movement. Habitat with high elevation ecosystem units (BAFAun, CMAun) were assigned a class 6 and habitats greater than 1,200 m elevation were assigned a class 5 rating due to deep (>60 cm) and persistent (for more than two weeks) snow levels. Snow depth on the landscape was assumed to be adequately estimated using BGC variant modified by elevation.

Slope

Habitat ratings were downgraded by one class for slopes between 25 and 37° and reduced by two classes on slopes greater than or equal to 38°.

Site Productivity

Site index, estimated site index, and soil nutrient regime were considered for site productivity indicators. Site index was selected as measure of site productivity because it was highly attributed and less biased than soil nutrient regime. Site index is an estimate of the height that a tree could reach at the end of 50 years of growth, beyond the time that the tree reaches breast height, or 1.3 m (Thrower et al. 1994).

Productive sites, with site index by ecosystem unit in the 90th percentile, were upgraded by one class for coniferous, deciduous, and mixed forest types while non-productive sites, with site index by ecosystem unit in the 10th percentile were downgraded by one class (Table 10). High productivity is inherent in floodplain-type sites. To avoid biasing the data, productivity upgrades were not applied to floodplain-type sites.

Although the pattern of site index on the landscape did not always correspond to expected mesoslope position or distance from streams, it was included in the model because it can have a major effect on moose forage species. However, the inconsistency in pattern raised the degree of uncertainty.

Table 6: Ecosystem Units and Moose Living Season in the Wide-Ranging Wildlife RSA

Ecoregion Classification	BGC Subzone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eco-province: Central Interior	Boreal Altai Fescue Alpine (BAFAun)												
Eco-regions: Eastern Hazelton Mountains (EHM)	Coastal Mountain-heather Alpine (CMAun)												
and Fraser Plateau (FAP)	Engelmann Spruce – Subalpine Fir moist-cold Parkland (ESSFmcp)												
Eco-sections:	Engelmann Spruce – Subalpine Fir moist-cool Parkland (ESSFmkp)												
Bulkley Basin (BUB)	Engelmann Spruce – Subalpine Fir wet-very cold Parkland (ESSFwvp)												
and Bulkley Ranges (BUR)	Coastal Western Hemlock wet sub maritime Montane variant (CWHws2)												
	Engelmann Spruce – Subalpine Fir moist-cold (ESSFmc)												
	Engelmann Spruce – Subalpine Fir moist-cool (ESSFmk)												
	Engelmann Spruce – Subalpine Fir wet-very cold (ESSFwv)												
	Interior Cedar – Hemlock moist-cold – Nass variant (ICHmc1)												
	Sub-Boreal Spruce dry-cool (SBSdk)												
	Sub-Boreal Spruce moist-cold Babine variant (SBSmc2)												

Not Used or Limited Use



Growing (Spring–Fall)



Winter



Table 7: Forest Type Classification

Forest Type	Criteria
Coniferous	Polygon vegetated with over 75% conifer tree species (i.e. Tree codes = B, BA, BL, CW, H, HM, HW, PA, PL, PLI, PLC, S, SB, SE, SW, SS, SX, SXS, YC)
Broadleaf	Polygon vegetated with over 75% deciduous tree species (AC, ACT, AT, DR, EP)
Mixed	Neither coniferous nor deciduous species make up over 75% of tree species
Floodplain	AC and ACT make up more than 30% of tree species and the polygon is within 450 m of the Bulkley River or within 300 m of the Telkwa River.

Table 8: Ecosystem Units and Age Categories Used to Define Structural Stage

Ecosystem Unit	Structural Stage							
	1	2	3a	3b	4	5	6	7
SBS	0	1-5	6-10	11-35	36-60	61-90	91-150	≥ 151
ESSF	0	1-5	6-12	13-40	41-65	66-100	101-170	≥ 171
MH	0	1-5	6-12	13-40	41-65	66-100	101-170	≥ 171
CWH	0	1-3	4-6	7-30	31-55	56-90	91-150	≥ 151
ICH	0	1-3	4-8	9-35	36-60	61-90	91-150	≥ 151
BAFA	0	>0	-	-	-	-	-	-
CMA	0	>0	-	-	-	-	-	-

Table 9: Forest Types and Structural Stages Used to Define Preliminary Moose Habitat Suitability Rankings

Forest Type	Structural Stage							
	1	2	3a	3b	4	5	6	7
Coniferous	6	5	3	3	4	4	4	4
Broadleaf	6	5	3	2	3	4	3	3
Mixed	6	5	3	2	4	4	3	3
Floodplain	6	5	2	1	3	3	2	1

Table 10: 90th percentile and 10th Percentile Site Productivity Thresholds by Ecosystem Variant

Ecosystem Unit	Percentile	
	90	10
BAFAun	6.6	2.3
CWHws2	14.8	5.0
ESSFmc	12.0	4.7
ESSFmcp	8.4	2.4
ESSFmk	11.0	3.1
ESSFmcp	8.8	2.6
ESSFwv	12.0	3.1
ESSFwvp	6.8	2.3
ICHmc1	12.6	8.8
SBSdk	22.7	12.7
SBSmc2	18.0	7.0

4.4 Ratings Assumptions

The following assumptions were applied to the moose habitat suitability modelling:

1. Food, and access to it, are the primary driving factors in moose use of winter habitat. Moose prefer heterogeneous winter habitats that provide a high diversity of stand types at various stages of seral succession, which maximize browse availability, minimize movement required to access food within and between browse patches, and provides thermal and security cover (LeResche et al. 1973, Peek et al. 1976, Maier et al. 2005, Poole and Stuart-Smith 2005). The size of habitat patches is not as important as the diversity of habitat patches and amount of edge habitats found within the landscape. Furthermore, cover is assumed to be useful only when associated with food.
2. Structural stages by ecosystem variant can be defined by age since disturbance.
3. Forage potential can be linked to structural stage and productivity.
4. Elevation and slope can be used to predict snow accumulation, which affects availability of browse.
5. Ratings are based on aspects being neutral or for the aspect where the ecosystem is typically found.

4.5 Model Evaluation

4.5.1 Wildlife Habitat Ratings Plots

Ratings were initially compared with 186 field wildlife habitat plots that were collected in 2018 within the Project Area and LSA. The field habitat surveys rated habitat suitability based on vegetation characteristics at a plot level. The ratings were the same as field ratings in 27% of plots and were within one rank of the field rating in 42% of plots. The model was assessed to determine what adjustments could be made to improve the fit. However, there was not a clear pattern in the field ratings and several tests adjusting forage classification did not distinctly improve the fit.

4.5.2 Moose Collar and Survey Data

On November 25, 2020, EDI received moose observation and GPS location data for the RSA compiled by Ardea Biological Consulting (L. Turney) obtained from the Province of BC. The data were collected during nine aerial moose surveys conducted between 1992 and 2017 where the locations of all observed groups of moose were recorded. The locations were recorded as the helicopter passed over the observation point. These data are estimates of moose locations and cannot be relied on for stand-level accuracy; therefore, caution was used in drawing inferences to the vegetation mapping attributes. There were 1,303 moose survey locations.

The GPS location data were collected remotely from GPS radio collars attached to 12 adult female moose. These collars collected approximately three to five locations of each moose per day throughout the year resulting in a total of 21,372 locations between 1998 and 2004. For use in this model evaluation, the data were filtered for locations that occurred in the RSA during winter (October through April), which involved 12,312 locations. A series of 5,000 points were randomly distributed within the area where the moose points occurred (with an added 5 km radius) for use in the analysis.

The survey observations and/or GPS location points were used to test the model as follows:

1. Do moose locations occur most often in rating class 1 and decrease with each class, relative to the number of random points that occur? This index is referred to as the selection factor:

$$\text{Selection Factor} = \frac{\% \text{ of Actual Moose Locations that occur in } x \text{ [Class]}}{\% \text{ of Random Moose Locations that occur in } x \text{ [Class]}}$$

2. If this is not the pattern, assess the model parameters considering selection factor of the available variables. Adjust the model and re-test the overall fit.

Figure 1 shows the selection factor by class. A value of greater than one means the moose locations occurred in that class more often than the random points (i.e., a selection); a value of two means there were twice as many moose location points as random points in that class. Classes 1 to 4 had selection factors that were greater than one, with the selection factor for class 1 being calculated at almost five. In terms of selection factor, little differentiation occurred between class 2 and class 3, which had selection factors greater than 3. Class 4 was used twice as often as random points occurred, and class 5 was used similarly to the random points. Class 6 had a selection factor less than one. Classes 4 and 5 should have a selection factor lower than one because the habitat has limited suitability and should therefore be used less often than would occur by random (i.e. selected against). These data indicated that the model could be improved.

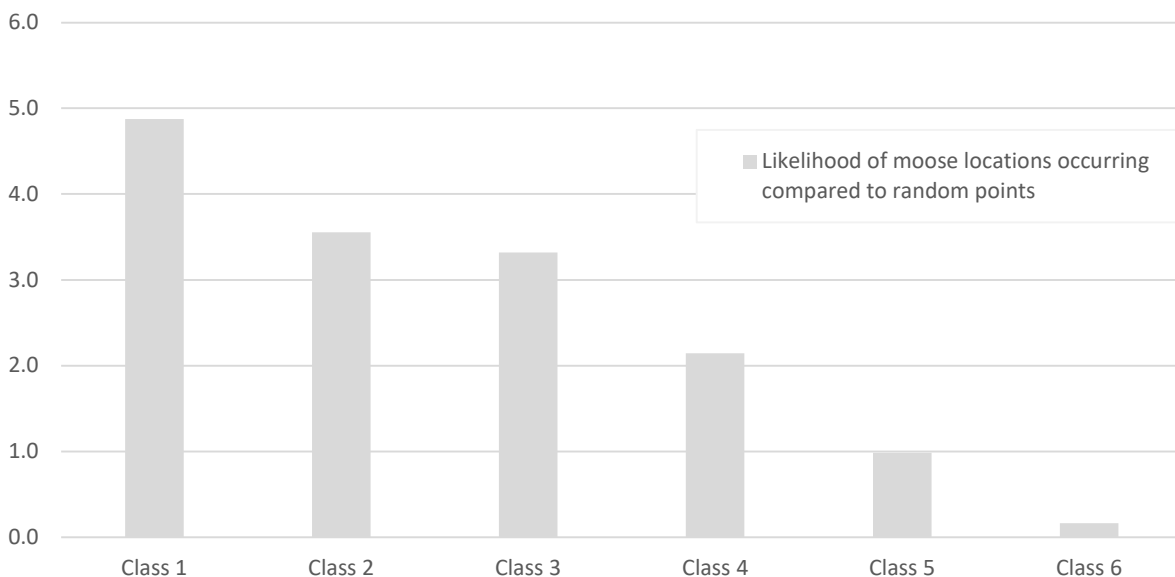


Figure 1: Occurrence of moose locations by habitat rating class relative to occurrence of randomly distributed locations, before model adjustment.

4.5.3 Adjustments to the Model

Assessment of the moose locations points and the previous model parameters showed the following factors that warranted adjustment in the model.

- ▶ Class 6 should be reserved for habitats that have zero suitability as winter/living habitat for moose such as alpine, steep rocky outcrops, and non-vegetated areas (i.e., definition of “nil” habitat as per RIC 1999). Previously the model included some mid-elevation (800–1,200 m) habitats as class 6; this was adjusted so that only alpine was assigned class 6.
- ▶ Previously, an elevation greater than 800 m was assigned class 5. This allowed some mid-elevation (800–1,200 m) habitat to be rated too poorly as class 5 (1–5% as good as the provincial benchmark), or rated as class 6 if downgraded due to security/thermal. This was adjusted so that all habitat above 1,200 m was rated class 5 (except for alpine as class 6). In the moose location data, 98% of the observation points were below 1,200 m.
- ▶ Static forage (e.g., forage in a perennial stage of early succession such as wetlands) was being downgraded readily in the previous ratings due to being more than 100 m from security/thermal habitat, and was not necessarily being captured as a primary factor in forage suitability. The

Omineca Environmental Stewardship Initiative documentation for a moose winter model to select ungulate winter range (Tripp 2018) was used as a reference. Adjustments to the model were made as follows:

- Proximity to security/thermal requirement was widened from 100 m to 500 m.
 - In comparing moose locations in forage classes 1 and 2 (Table 9) with random locations, there was a positive selection factor (2.3). Points in these forage classes that were 100 m, 100–500 m, and greater than 500 m distance from security/thermal had a selection factor 2.6, 2.8, and 1.5, respectively. A similar pattern was observed for moose locations in static forage. There was not a marked difference between the selection factor whether forage was 100 m or 500 m from security/thermal. A proximity of 500 m from forage appeared to be a positive selection factor.
- Floodplain was revised by adding riparian areas (query involves line_5_Vegetation_Cover = sl, ri, by, he, st, hg) to widen the capture of high-rated forage.
- A query was added (as used in the Omineca ESI winter moose model) for Static Winter Forage and Persistent Deciduous and Brush. Rating 1 was assigned to these areas.
 - The query includes Shrub (low and tall), Wetland Herb, Upland, Willow, and Black Spruce Bog, primarily using the BCLCS_LEVEL in the VRI data with some species and age restrictions (Tripp 2018).
- ▶ The forage class ratings (Table 9) were tested for relative occurrence of moose locations compared with randomly generated locations using the selection factor equation. Only GPS locations were used for this analysis. In class 1 and 2, moose locations occurred more than twice as likely compared with randomly generated locations. Forage class 3 had slightly more points than would occur randomly, whereas forage classes 4, 5, 6 were “selected” against. The Forage Class ratings appeared to be performing satisfactorily.
- ▶ Distance to roads was tested. Considering all GPS locations, the selection factor for static forage (1.9) and forage class 1 and 2 (2.3) decreased within 200 m of road (0.9 and 1.2), was similar within 200–500 m from roads (2.1 and 2.3) and increased greater than 500 m from roads (4.4 and 4.1). Therefore, the way the model applied roads (downgrade if within 250m of roads) was appropriate.

The model was tested again once the above adjustments were made. Figure 2 shows the relative occurrence of moose locations within each rating category. The model was improved by these adjustments.

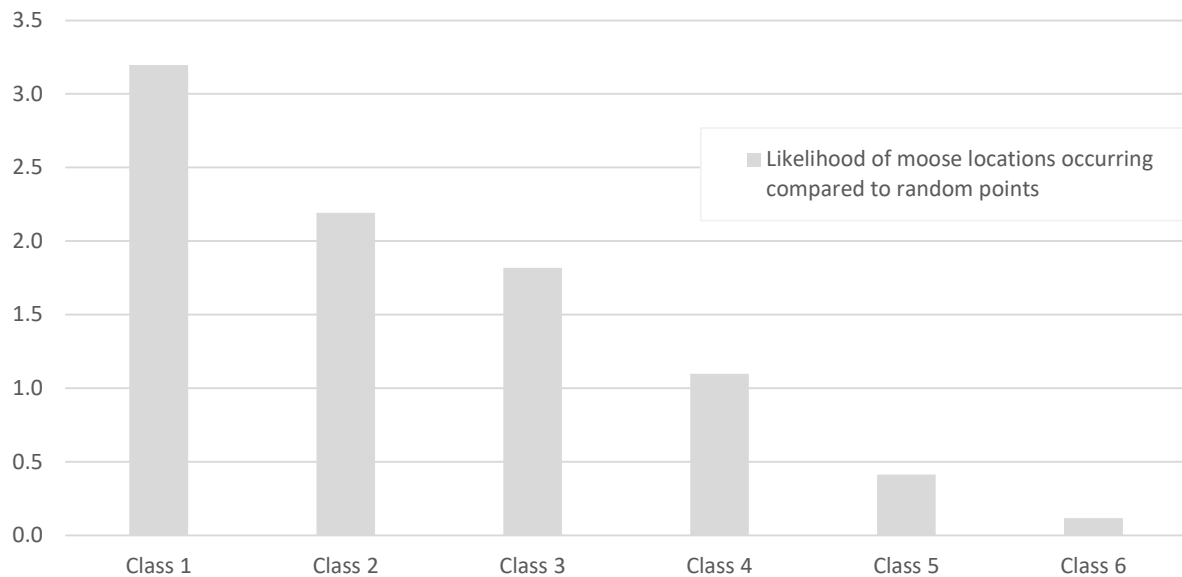


Figure 2: Occurrence of moose locations by habitat rating class relative to occurrence of randomly distributed locations, after model adjustment.

5. LIMITATIONS/CONFIDENCE

The moose model is an expert-based model; consequently, biases in the knowledge and opinions of the authors are reflected in the model. Model development relied on spatial ecosystem data from VRI datasets that were not field verified prior to use in the model, and as a result, inconsistencies between datasets and real-world conditions may vary. The spatial data resolution also limited the ability to provide accurate ratings for some areas (i.e., some urban areas can provide suitable habitat for moose; however, urban spatial data were unable to fully describe the habitat present, therefore all urban areas were treated uniformly and considered to be unsuitable). Therefore, the overall confidence in the model is moderate because of the relatively well-known habitat requirements for moose in the project area and relative confidence in the ecosystem spatial data.

6. SUMMARY OF MAPPING RESULTS

Table 11 and Appendix A detail moose model habitat suitability ratings by study area. High, moderately high, and moderate habitats are generally located mid to low slope and along valley bottoms in the Telkwa, Bulkley, and Morice River corridors. Wetlands and static forage near security/thermal habitats in the SBS biogeoclimatic zone are most similar to the provincial benchmark for winter/living moose habitat. Shrubby cutblocks and burns are an important source of suitable moose habitat; however, their associated access roads reduce their habitat value. Low, very low, and nil habitats are generally found in the Bulkley and Telkwa mountain ranges, with very low habitat occurring at elevations over 1,200 m and nil occurring in alpine ecosystem units.

Table 11: Moose Model Habitat Suitability Rating by Study Area

Habitat Suitability Rating	Study Area (ha)			
	Wildlife LSA (ha)	Wildlife LSA (%)	Wide-Ranging Wildlife RSA (ha)	Wide-Ranging Wildlife RSA (%)
High	1,759.7	4.9	8,495.0	2.4
Moderate High	4,483.0	12.5	27,123.1	7.6
Moderate	8,041.7	22.4	47,764.8	13.4
Low	8,964.5	25.1	102,104.0	28.6
Very Low	7,882.5	22.1	110,965.6	31.0
Nil	4,621.6	12.9	61,134.5	17.1
Total	35,725.88	100.0	357,587.04	100.0

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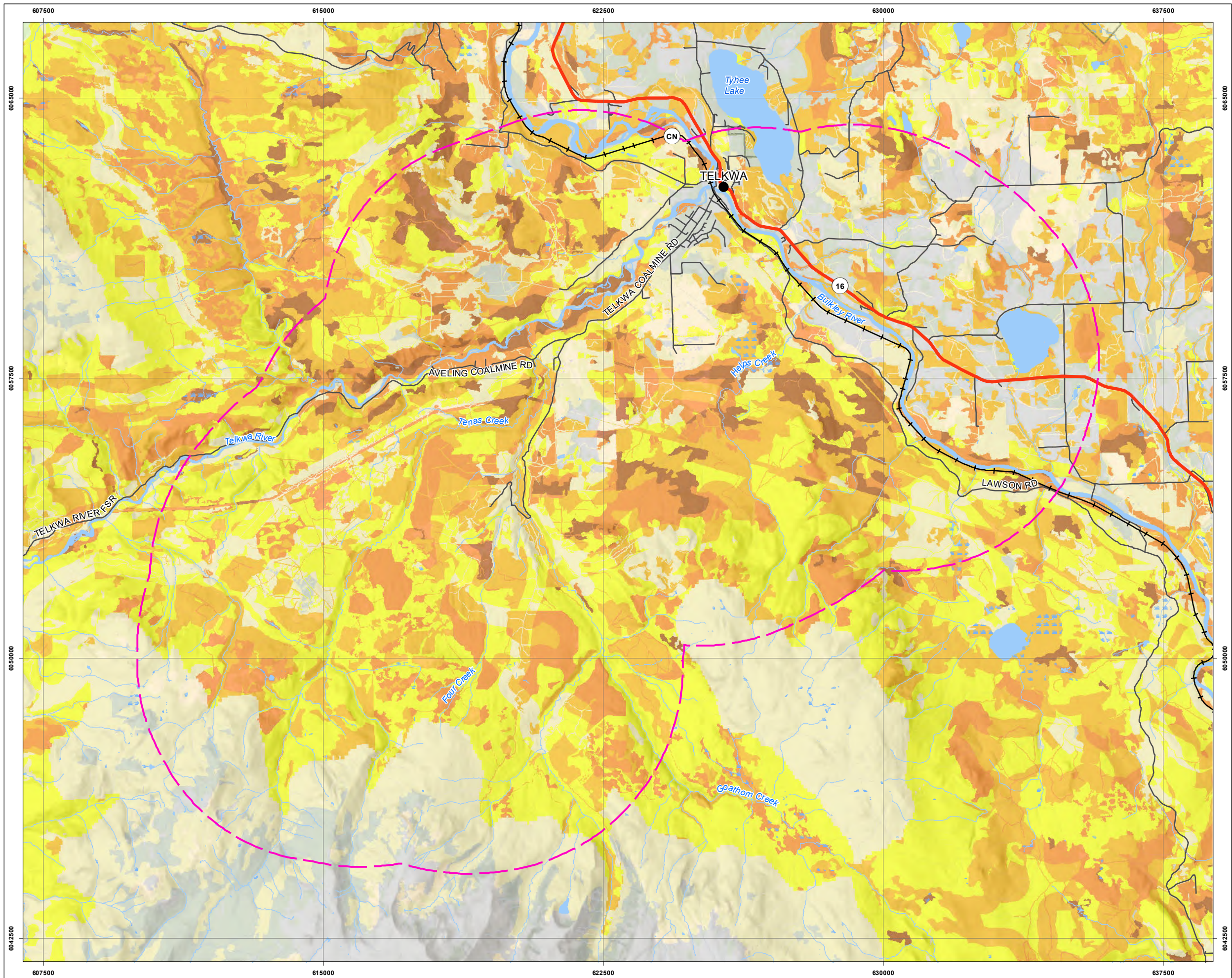
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Appendix A Moose Winter Habitat Suitability Mapping

Path: L:\PROJECT\2018\18P0172_Tenas_MooseMapping\REPORTING\EA\Wildlife\Baseline\Fig_8_20_Moosehabitat_WLSA_20210824.mxd



Tenas Project

Habitat suitability model ratings for moose Living in the winter within the Wildlife Local Study Area

Legend

- City/Town
- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- Wildlife Local Study Area

Habitat Rating

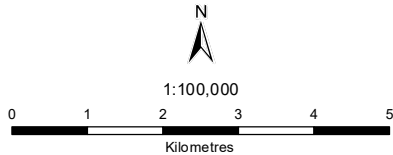
- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of British Columbia
- Basemap: World Topographic Map. ESRI.

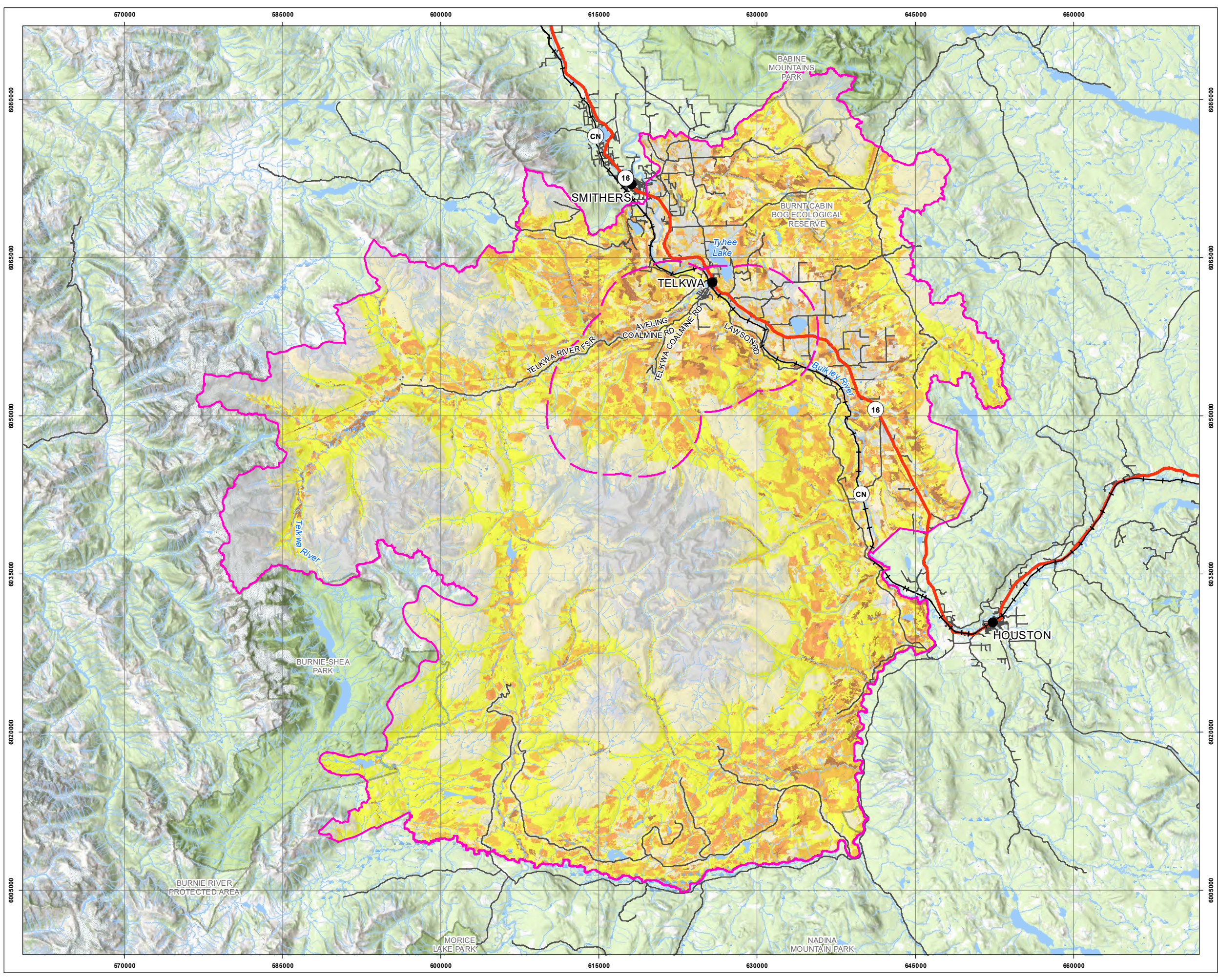


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Tenas Project

Habitat suitability model ratings for moose
Living in the winter within the
Wide-ranging Wildlife Regional Study Area

Legend

● City/Town

—+— Rail Line

— Highway

— Road

— Watercourse

Wetland

Waterbody

Park or Protected Area

Wildlife Local Study Area

Wilde-Ranging Wildlife Regional Study Area

Habitat Rating

High

Moderately High

Moderate

Low

Very Low

Nil

Notes

1. All mapped features are approximate and should be used for discussion purposes only.

2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of British Columbia

- Basemap: World Topographic Map. ESRI.

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