Tweedsmuir-Entiako Caribou (*Rangifer tarandus*) Tactical Restoration Plan

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*Figure 5 will be included once Provincial Caribou linework is released.

Cover photograph:

BC Ministry of Forests, Lands and Natural Resource Operations, Smithers, B.C. Photo taken from a remote camera from the Whitesail shorelines cleanup project (provided by Anne-Marie Roberts).

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EXECUTIVE SUMMARY

The Tweedsmuir-Entiako caribou (*Rangifer tarandus*) range in west-central British Columbia (BC) has experienced a variety of human-caused (anthropogenic) and natural disturbances including the flooding of the Nechako Reservoir in the mid 1950s, forest harvesting, mineral exploration and development, roads associated with industrial activities, an extensive mountain pine beetle (*Dendroctonus ponderosae*) epidemic, and most recently, multiple large wildfires. The most significant threat to southern mountain caribou is increased predation resulting from habitat alteration due to industrial activities (EC 2014).

This Tactical Restoration Plan was developed to provide guidance on priorities for restoration in the Tweedsmuir-Entiako caribou range. The plan includes a framework for selecting priorities for restoration with an emphasis on functional restoration of linear corridors to reduce predator movement and predation risk, and is intended to be used as a planning tool for restoration activities on the range.

Specific objectives of the Tactical Restoration Plan for the Tweedsmuir-Entiako caribou range include:

- to produce a comprehensive habitat disturbance map for the range;
- to develop criteria for prioritizing restoration activities and identifying restoration sites within priority restoration areas;
- to engage with First Nations to incorporate knowledge and interests, develop criteria, and coordinate priority areas for restoration activities within the range;
- to develop preliminary restoration implementation plans for two priority restoration sites; and,
- to develop a monitoring plan for collecting data to assess treatment success and wildlife response to restoration activities.

As part of this project, we engaged with First Nations with traditional territories that overlapped the Tweedsmuir-Entiako caribou range including: Ulkatcho First Nation (Southern Dakelh Nation Alliance; SDNA), Lhoosk'uz Dené First Nation (SDNA), Cheslatta Carrier Nation, Saik'uz First Nation (Carrier Sekani Tribal Council), Nee Tahi Buhn Indian Band, and Office of the Wet'suwet'en to incorporate knowledge and interests, develop criteria, and coordinate priority areas for restoration activities within the Tweedsmuir-Entiako caribou range.

Habitat alteration can result in a number of effects on caribou depending on the type of habitat alteration. Human-caused (anthropogenic) habitat alteration can negatively affect caribou populations through: direct habitat loss; facilitating an increase in predation by increasing predator efficiency on linear corridors such as roads, and converting habitat into early seral habitats favoured by other prey; and, improving access for humans. Consequently, objectives for restoration include: reducing predator travel/hunting efficiency to reduce caribou-predator encounters and predation risk to caribou; reducing human access to reduce displacement of caribou from preferred habitats and to reduce potential for direct mortality (e.g. collisions, hunting, poaching);

and increasing habitat quality for caribou, including habitat intactness. Restoration objectives can be achieved through treatment options that focus on functional and/or ecological restoration.

The primary objective of functional restoration is to reduce predator travel/hunting efficiency and human access. Functional restoration quickly reduces the factors contributing to caribou declines, but may not result in ecological recovery. Ecological restoration focuses on re-establishing ecosystem components and processes to preferred caribou habitat conditions, and on improving overall ecological integrity. The long-term ecological recovery of a site may also result in achieving functional restoration objectives.

Currently, anthropogenic (human-caused) habitat alteration is primarily focussed in the northern and northwestern portions of the range in low elevation summer range, high elevation summer/winter range and matrix range, and in the eastern portion of the range in low elevation winter range, high elevation summer/winter range and matrix range. Total anthropogenic disturbance (including a 500 m buffer) covers 31% of the total range, 6% of the high elevation summer/winter range, 41% of the low elevation winter range, 73% of the winter matrix range, 12% of the low elevation summer range, and 26% of the summer matrix range. Total combined disturbance (anthropogenic + natural) <40 years old covers 18% of the high elevation winter and/or summer range, 38% of the low elevation summer range, and 76% of the low elevation winter range plus Type 1 matrix range, all of which exceed levels identified for critical habitat for southern mountain caribou (EC 2014). Across the Tweedsmuir-Entiako caribou range, almost all recorded disturbance since the 1950s (96% of fire disturbance, and almost 100% of anthropogenic disturbance) occurred within the last 40 years.

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD) identified three Priority Restoration Areas: two in the traditional winter range (Chelaslie, Vanderhoof) and one in the summer range (Whitesail). The primary habitat alterations in the Chelaslie and Vanderhoof Priority Restoration Areas are forest harvesting, roads associated with industrial activities, fire and mountain pine beetle attack. The primary habitat alterations in the Whitesail Priority Restoration Area are forest harvesting, roads associated with industrial activities, mountain pine beetle attack, and floodwaters in the Nechako Reservoir.

The primary restoration objective for both the Chelaslie and Vanderhoof Priority Restoration Areas is to functionally (immediate priority) and ecologically restore anthropogenic linear features (roads) that lead into areas that are currently used by caribou. Restoration objectives for the Whitesail Priority Restoration Area include: to reduce large woody debris along shorelines of calving islands and along shorelines of islands and the mainland that are used by caribou during migration and for accessing calving islands; and to functionally (immediate priority) and ecologically restore anthropogenic linear features (roads) along migration routes and areas used by caribou in summer and fall.

For each Priority Restoration Area, we developed a hierarchical approach for selecting sites for restoration, which first identified the most important areas within the Priority

Restoration Areas to restore for caribou (restoration zones) and then identified priority restoration sites within those zones first based on value to caribou, and then on practical considerations including likelihood of success/longevity, and synergies with other values, funding sources, and other projects. For the Whitesail Priority Restoration Area, we also developed criteria for selecting priorities for shoreline cleanup for islands and mainland shorelines.

The Chelaslie Priority Restoration Area includes 17 restoration zones with the highest priorities for restoration in zones that lie in the western portion of the Priority Restoration Area and are in or adjacent to Old Growth Management Areas that were designated for caribou and that are currently being used by caribou. The Vanderhoof Priority Restoration Area includes 23 restoration zones with the highest priorities for restoration in zones that lie in and adjacent to Entiako Park and in the alpine/subalpine portion of the Fawnie Mountains that is not included in Entiako Park. Those zones are priorities because they are in or adjacent to areas used by caribou since the 2014 and 2018 fires. The Whitesail Priority Restoration Area includes four land-based restoration zones with the highest priority in the easternmost zone where caribou exit Whitesail Lake during spring migration. We also delineated 16 shoreline segments and 16 island groups, with the largest calving island and the shoreline along Tweedsmuir Park that is used to access that island as the highest priority for shoreline cleanup. Second priority islands and shorelines included islands that had evidence of use during calving and migration, and shorelines that had been used to access islands used for calving or migration, or that had been used for migration.

We developed a monitoring plan to guide implementation and effectiveness monitoring at the population/range, individual, and site scales, which includes monitoring options and techniques, assessing treatment success and tracking levels of disturbance. We also provide examples of implementation plans for two priority restoration sites, which summarize restoration objectives, field verification, activities and timelines, engagement, permits, strategies for protecting restoration from future potential disturbances, and monitoring.

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1 INTRODUCTION

The Tweedsmuir-Entiako caribou (*Rangifer tarandus*) population is listed as Threatened under the federal *Species at Risk Act* as part of the Southern Mountain caribou population. In the *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada*, the overall approach to achieving a self-sustaining population is "to conduct population management actions in the short term, concurrent with habitat restoration activities, until suitable habitat is restored" (EC 2014). As part of the recovery strategy, critical habitat is identified, which includes minimum targets for the amount of undisturbed habitat within caribou range (EC 2014). The Tweedsmuir-Entiako caribou range has experienced a variety of human-caused (anthropogenic) and natural disturbances including the flooding of the Nechako Reservoir in the mid 1950s, forest harvesting, mineral exploration and development, roads associated with industrial activities, an extensive mountain pine beetle (*Dendroctonus ponderosae*) epidemic, and most recently multiple large wildfires (Cichowski 2015).

Habitat restoration is a key component of caribou recovery efforts and the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD) is currently conducting restoration activities on caribou ranges in BC. The ultimate goal of habitat restoration for caribou is to provide range conditions that are consistent with supporting a self-sustaining population of caribou. Habitat restoration efforts focus on activities that a) reduce the time required to achieve structural and ecological conditions favoured by caribou (e.g. winter range with mature forests with abundant lichens and sufficient tree canopies for snow interception), and b) provide conditions that functionally reduce mortality risk (e.g. rehabilitating roads to reduce predator travel rates and hunting efficiency).

This Tactical Restoration Plan was developed to provide guidance on priorities for restoration in the Tweedsmuir-Entiako caribou range. The plan includes a framework for selecting priorities for restoration with an emphasis on functional restoration of linear corridors to reduce predator movement and predation risk, and is intended to be used as a planning tool for restoration activities on the range.

Specific objectives of the Tactical Restoration Plan for the Tweedsmuir-Entiako caribou range include:

- to produce a comprehensive habitat disturbance map for the range;
- to develop criteria for prioritizing restoration activities and identifying restoration sites within priority restoration areas;
- to engage with First Nations to incorporate knowledge and interests, develop criteria, and coordinate priority areas for restoration activities within the range;
- to develop preliminary restoration implementation plans for two priority restoration sites; and,
- to develop a monitoring plan for collecting data to assess treatment success and wildlife response to restoration activities.

This report consists of four sections. The first section (Introduction) provides background information about the Tweedsmuir-Entiako caribou population and range, and methods used to develop the disturbance spatial layer and the Tactical Restoration Plan. Section 2 (Tweedsmuir-Entiako caribou range) summarizes the current condition of the range, and of each of the three Priority Restoration Areas. Section 3 covers the Tactical Restoration Plan, which includes a discussion of engagement with First Nations, selection criteria, Priority Restoration Zones for each Priority Restoration Area, and a monitoring plan. The last section provides examples of implementation plans for two Priority Restoration Sites.

1.1 Study area

The Tweedsmuir-Entiako caribou range is located in west-central BC, approximately 80 km south of Smithers, and covers over 2.3 million hectares (Figure 1). The southern portion of the range lies adjacent to the Itcha-Ilgachuz and Rainbow caribou ranges.

The eastern portion of the range consists of mostly flat or gently rolling terrain on the Nechako Plateau, which rises up to the Fawnie Mountains in the southeast portion of the range and up to the Quanchus Mountains in the northeastern portion of the range in northern Tweedsmuir Park. Biogeoclimatic zones in this part of the range include the Sub-Boreal Spruce (SBS) and Sub-Boreal Pine-Spruce (SBPS) zones at low elevations, and Engelmann Spruce-Subalpine Fire (ESSF) and Boreal Altai-Fescue Alpine (BAFA) zones at higher elevations (Banner et al. 1993). Forest cover at lower elevations is dominated by lodgepole pine (*Pinus contorta*) and hybrid white spruce (*Picea glauca x engelmanni*), and by subalpine fir (*Abies lasiocarpa*) and hybrid white spruce at higher elevations. The eastern portion of the range experiences a dry, continental climate with generally cool, short and dry summers and long, cold and dry winters. Snow accumulation during winter is relatively low due to the rain-shadow effect from the Coast Mountains.

The western portion of the range lies on the eastern edge of the Coast Mountains and consists mostly of mountainous terrain, deep valleys and the transition zone between the Coast Mountains and Nechako Plateau. Low elevations include the Coastal Western Hemlock (CWH) biogeoclimatic zone and high elevations include the Mountain Hemlock (MH), ESSF, BAFA and Coastal Mountain-Heather Alpine (CMA) zones (Banner et al. 1993). Forest cover includes amabalis fir (*Abies amabalis*), western hemlock (*Tsuga hetoerophylla*), mountain hemlock (*Tsuga mertensiana*), and subalpine fir. Climate in this portion of the range is influenced by coastal weather patterns with generally wet and snowy winters and short cool summers, resulting in more precipitation (both snow and rain) than in the eastern portion of the range.

Fire and forest insects are the two main large-scale disturbance factors in the eastern portion of the range, while the western portion of the range generally experiences smaller-scale disturbances such as avalanches. The recent mountain pine beetle epidemic was first detected in the Tweedsmuir-Entiako caribou range in the mid-1990s and by 2006 most of the attacked stands were in the grey phase of attack (Cichowski 2007). In 2014, the Chelaslie Arm fire burned over 130 000 ha in the eastern portion of

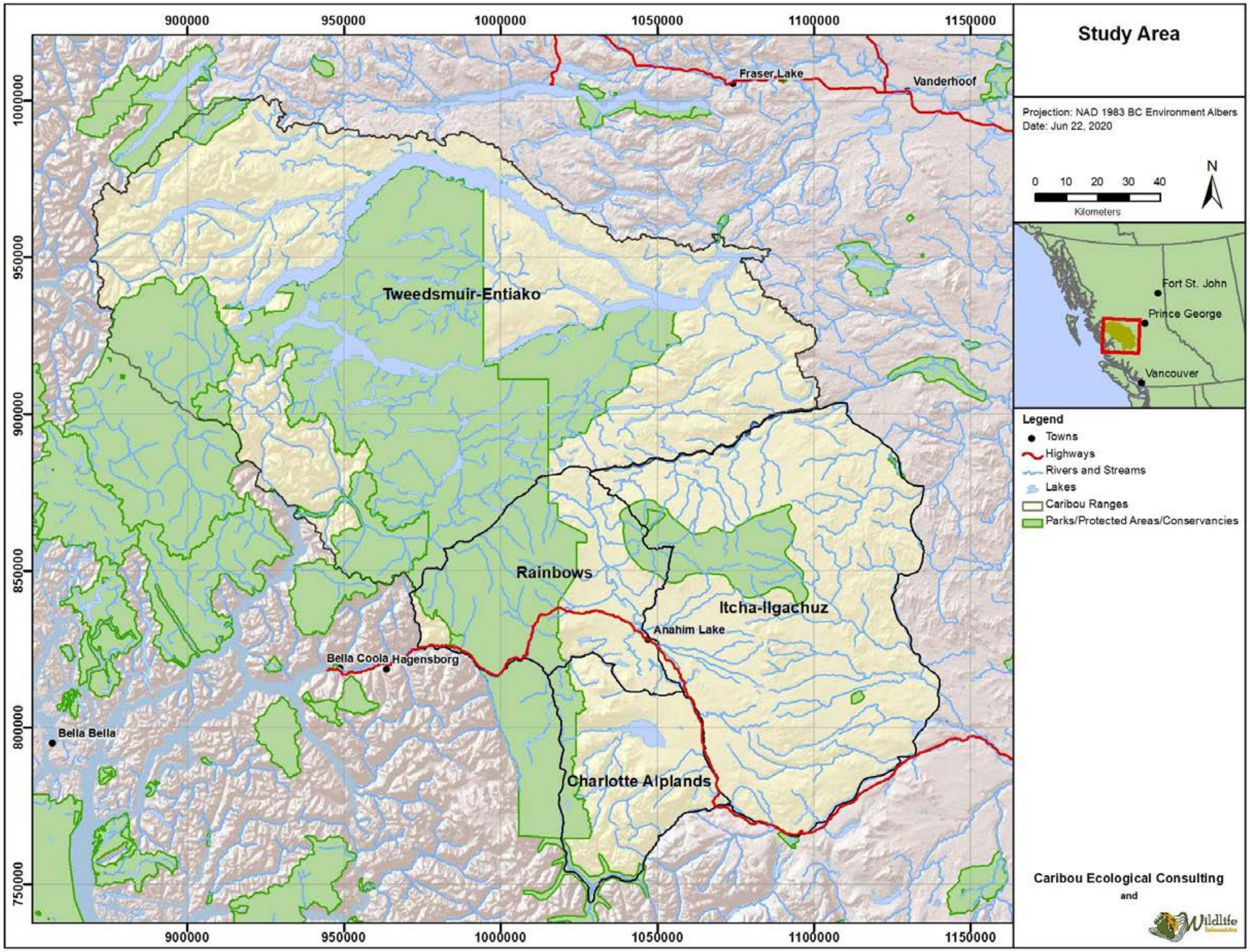


Figure 1. Location of Tweedsmuir-Entiako caribou range in west-central British Columbia. * Herd boundary estimate

the range, and a series of four fires burned almost 400,000 ha in the central portion of the range in 2018.

Large mammals in the Tweedsmuir-Entiako caribou range include caribou, moose (*Alces americanus*), mountain goats (*Oreamnos americanus*), deer (*Odocoileus* sp.), wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), coyote (*Canis latrans*) and lynx (*Lynx canadensis*).

Subsequent to completion of the digital disturbance layer, BC MFLNRORD updated the Tweedsmuir-Entiako caribou range boundary to reflect recent information on caribou and predator range use following the 2014 and 2018 fires. Disturbance data in this report is summarized for the portion of the updated caribou range that lies within the original range boundaries that were available when we developed the disturbance layer.

1.2 Tweedsmuir-Entiako caribou – overview

The following sections provide an overview of Tweedsmuir-Entiako caribou population condition, ecology and threats. More detailed accounts can be found in COSEWIC (2014), Cichowski (2015) and BC MFLNRO Skeena (2017).

1.2.1 Population condition

- Monitoring of radio-collared caribou in the Tweedsmuir-Entiako caribou population began in 1983. Since then, monitoring of radio-collared caribou has been ongoing with the exception of about 10 years (1989-1991, 2003-2005, 2010-2013).
- Most aerial surveys have been conducted in association with studies on radio-collared caribou.
- The Tweedsmuir-Entiako caribou population is currently (2019) estimated at 150-200 caribou (BC MFLNRORD 2019draft).
- The population has declined since monitoring began from an estimated 400-500 caribou in the late 1980s (Cichowski 2015).
- Wolf predation and bear predation are the primary known causes of adult mortality (Cichowski and MacLean 2005, Cichowski 2010, DeMars and Serrouya 2018).

1.2.2 Ecology

- Tweedsmuir-Entiako caribou typically winter in the eastern portion of their range and summer in the western portion of their range (Figure 2).
- Prior to the 2014 fire, during winter, Tweedsmuir-Entiako caribou primarily used low-elevation mature pine forests south of Tetachuck Lake in the Entiako Lake and Laidman Lake areas, and north of Tetachuck Lake in the East Ootsa area, where they foraged mostly on terrestrial lichens (Steventon 1996, Cichowski 2015, BC MFLNRO Skeena 2017).
- Caribou also forage on arboreal lichens, especially when snow conditions make it difficult for caribou to dig through the snow to obtain terrestrial lichens, such

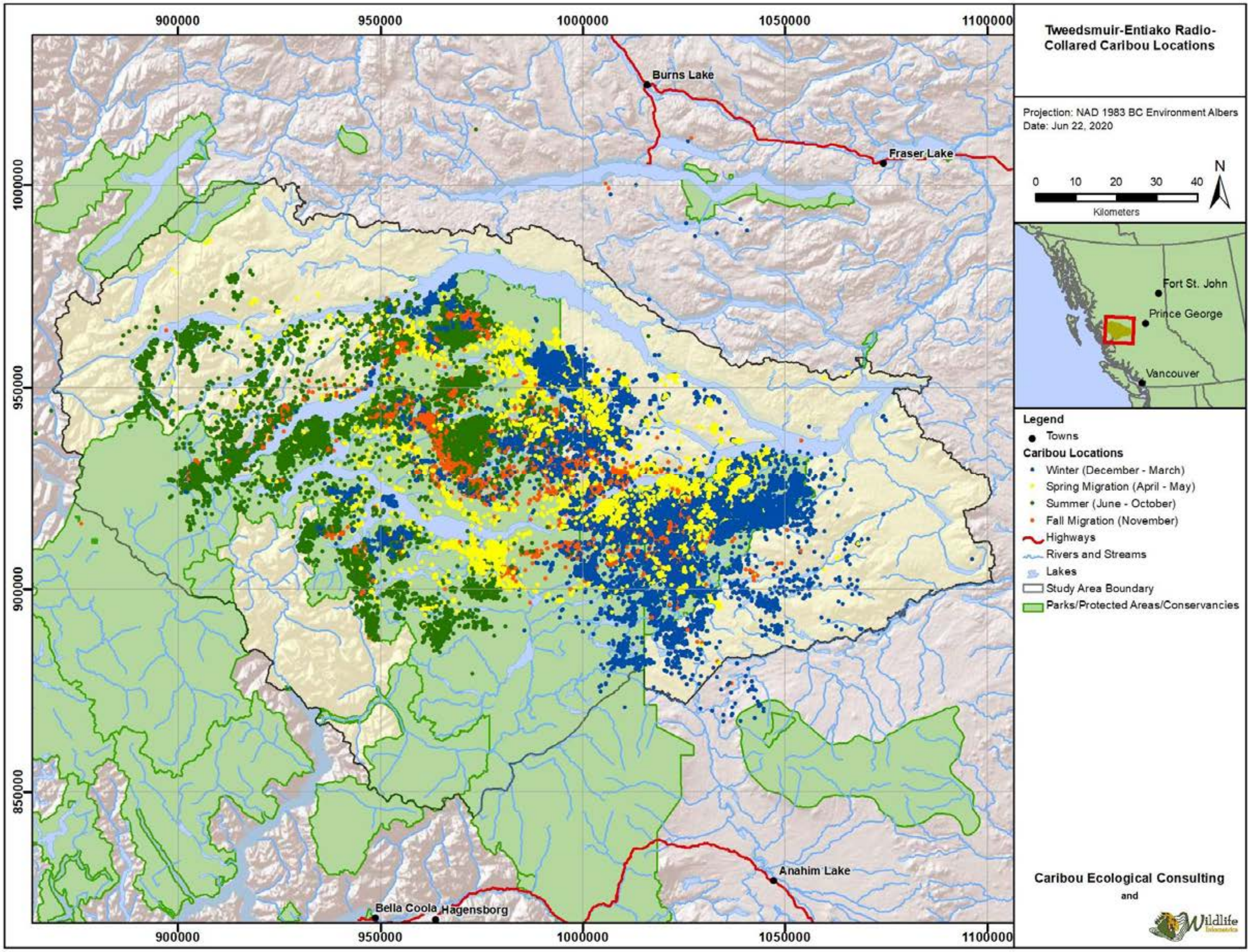


Figure 2. Seasonal distribution of radio-collared Tweedsmuir-Entiako caribou locations, 1983-2018.* Herd boundary estimate

as during late winter or during winters with frequent freeze/thaw cycles, and/or in moister habitats where arboreal lichens are more abundant (Cichowski 2015).

- Caribou also forage for horsetails (*Equisetum* sp.) in spruce seepage forests during winter (Cichowski 2010, 2016).
- During some winters, up to 25% of the subpopulation move to higher elevations in the Fawnie Mountains in mid-winter to feed on terrestrial lichens on windswept alpine slopes and/or on arboreal lichens in the subalpine (Cichowski and MacLean 2005).
- Some radio-collared Tweedsmuir-Entiako caribou have also wintered as far south as high elevation habitat in the Ilgachuz Mountains and in low elevation forested areas along the upper Dean River, as far east as Kuyakuz Mountain, and in both alpine/subalpine and low elevation forested habitat in northern Tweedsmuir Park (Cichowski 1993, Cichowski and MacLean 2005, Cichowski 2010, BC MFLNRORD unpubl. data).
- Historically, caribou wintered on windswept alpine slopes in the Quanchus Mountains in northern Tweedsmuir Park, and in low elevation forests along Ootsa Lake and in the Cheslatta Lake area (Cichowski and MacLean 2005).
- Following the peak of the mountain pine beetle epidemic, although terrestrial lichen abundance initially declined (Cichowski and Haeussler 2013) and snow interception by the canopy presumably decreased, during the early stages of grey attack in the mid to late 2000s caribou continued the seasonal movement, seasonal range and habitat use, and winter foraging patterns that they exhibited prior to the mountain pine beetle epidemic (Cichowski 2010).
- Following the 2014 and 2018 fires, caribou have wintered in the East Ootsa area in the area north of the burns, in the Entiako Park area within the burn perimeter, and in unburned areas to the west, east and southeast of the burn (BC MFLNRORD, unpublished data). In the winter following the 2014 fire, caribou that were using areas within the burn perimeter appeared to be using unburned patches throughout the winter, and in mid to late March, also appeared to be using burned areas that were relatively snowfree where they may have been foraging for grasses/sedges and forbs (A. Roberts, pers. comm.). There has also been increased use of areas within northern Tweedsmuir Park during portions or all of winter, in habitats ranging from low elevation forests to alpine/subalpine habitat (BC MFLNRORD, unpublished data).
- Spring migration begins in mid-April, with most caribou travelling along low elevation snowfree or low snow routes in the Chelaslie River drainage and through the Quanchus Mountains to summer ranges further west, while some animals migrate west along the south and north shores of Eutsuk Lake (Cichowski 1993, Steventon 1996).
- Calving occurs in alpine and subalpine areas as well as in low elevations throughout the summer range, including on islands in Whitesail Lake and Eutsuk Lake (Cichowski 2015, BC MFLNRO Skeena 2017). Caribou that calve at high elevations or on islands in lakes below treeline have higher calving success than those that calve below treeline on the mainland (Seip and Cichowski 1996, Cichowski and MacLean 2005).
- Dispersed calving at high elevations is an anti-predator strategy, with caribou forgoing higher forage quality at low elevations to distance themselves away

from other prey and predators such as wolves (Bergerud and Page 1987, Seip 1989). Calving on islands is also an anti-predator strategy where caribou distance themselves away from other prey and predators (Shoesmith and Storey 1977, Bergerud 1985).

- Caribou use a variety of habitats during summer ranging from low to high elevations, and are highly dispersed throughout the summer range (Cichowski 2015).
- Caribou rut in October throughout their summer range with part of the population concentrating in the Quanchus Mountains. Fall migration in November is more diffuse than spring migration and likely triggered by snow accumulation in high elevation rutting areas (Cichowski and MacLean 2005).
- In addition to seasonal habitats and range, caribou also require matrix range, which consists of areas adjacent to seasonal habitats/range where predator-prey dynamics influence predation within the core of the caribou range (EC 2014). Although caribou may not use matrix range directly, or may use it only infrequently such as during movement between summer and winter ranges, matrix range is an important component of caribou range because habitat conditions in matrix range influence predator-prey relationships that affect caribou.

1.2.3 Threats

Figure 3 summarizes threats to caribou in BC and linkages between threats.

While predation is considered the main proximate limiting factor for caribou populations, large-scale habitat alterations that affect abundance, habitat use and movements of predators and alternate prey ultimately affect caribou populations (Festa-Bianchet *et al*. 2011).

The most significant threat to Southern Mountain caribou is increased predation resulting from habitat alteration due to industrial activities (EC 2014). Forest harvesting, mineral exploration and development, and hydro-electric generation (Nechako Reservoir) are the primary industrial activities on the Tweedsmuir-Entiako caribou range. Habitat alteration due to industrial activities convert mature and old forests favoured by caribou into early seral habitats favoured by other prey species such as moose and deer. In ranges with habitat alterations that provide favourable conditions for other prey species, wolf numbers can increase, resulting in increased caribou mortality due to predation and subsequently to declines in caribou numbers (Seip 1991; Seip 1992a; Wittmer *et al*. 2005).

Roads associated with forest harvesting and mineral exploration and development can lead to increased predator travel rates and hunting efficiency, and improved access for humans. Ploughed roads and packed trails during winter can further contribute to improved access and travel. Direct effects of roads on caribou include increased mortality due to collisions, hunting or poaching. Indirect effects of roads and associated human activities include increased stress, displacement of caribou from preferred

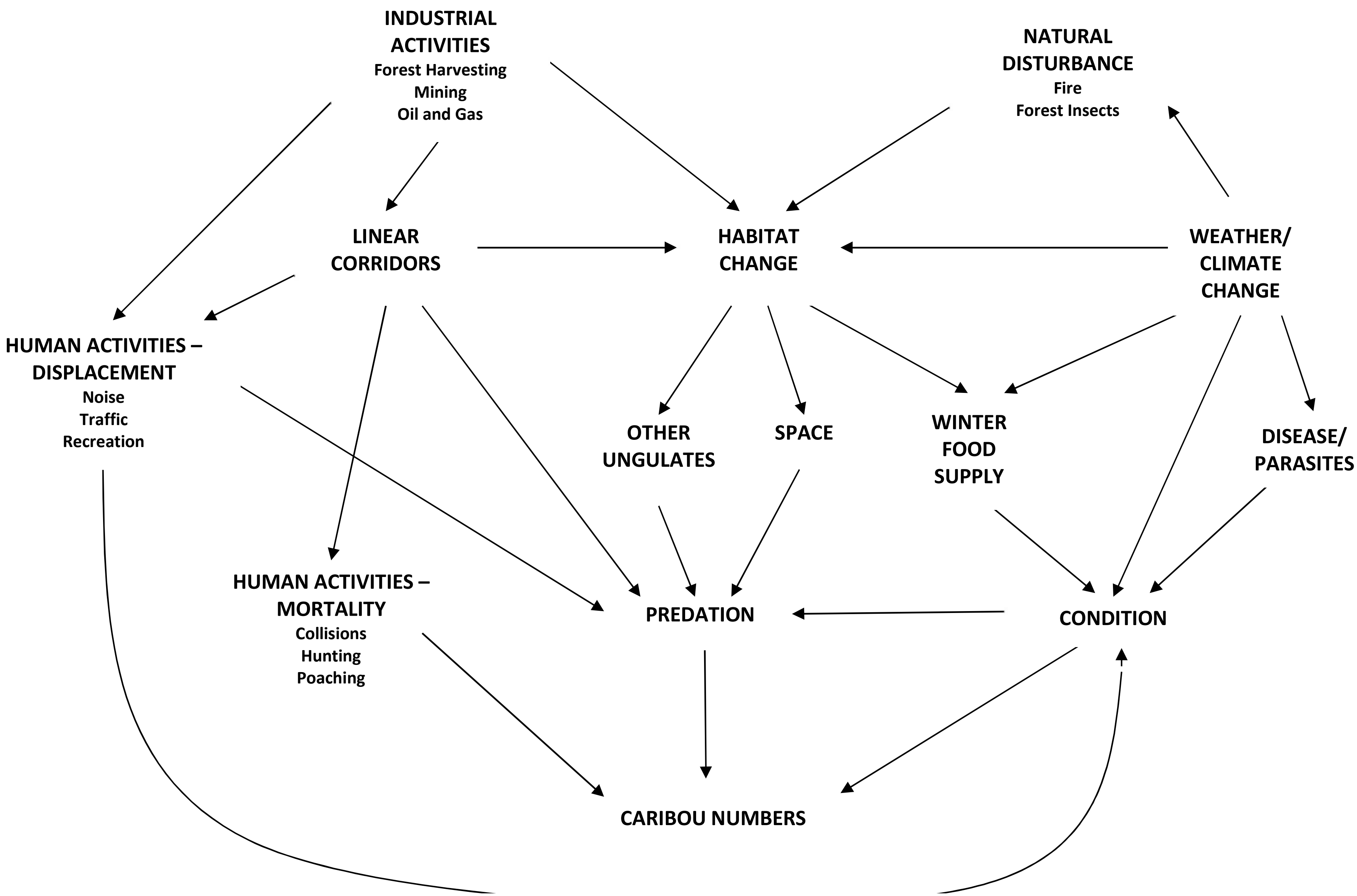


Figure 3. Linkages between threats to caribou in BC (adapted from Cichowski and MacLean 2005).

habitats into habitats with potentially higher mortality risks or lower food quantity or quality, and increased energy expenditure (and potential effects on body condition) resulting from displacement.

In addition to changes in predator/prey dynamics, following habitat alteration due to industrial activities, forest structure and lichen abundance can take decades to recover to conditions suitable for caribou habitat. Fire and forest insects also affect forest structure and lichen abundance but, unlike industrial activities, are not accompanied by roads, although roads and fireguards may be built for fire suppression activities. Historically, when natural disturbance occurred, caribou could shift their use of habitat from affected areas to areas that were more suitable. However, with the increase in habitat alteration due to industrial activities and natural disturbances, caribou have fewer options for finding suitable undisturbed habitat.

The flooding of approximately 45 000 ha of low elevation habitat for the Nechako Reservoir in the 1950s may have contributed to abandonment of winter ranges to the north of the Whitesail and Ootsa portions of the Nechako Reservoir (Cichowski 2015, BC MFLNRO Skeena 2017). Initially, debris along the shorelines contributed to higher caribou mortality as debris prevented them from reaching shore when crossing lakes (M. Robertson, pers. comm.). Currently, log debris along the Nechako Reservoir may affect the ability of caribou to access shorelines while crossing the lake.

Climate change could affect caribou through: increased frequency and severity of fire and forest insects leading to habitat change; shifts in vegetation composition due to changes in environmental conditions; shifts in distribution of other ungulates, and increased incidence of existing and novel diseases and parasites (Vors and Boyce 2009). Climate change could also result in increased freeze/thaw events that could lead to increased predator efficiency and/or reduced access to forage resulting from icing events on the ground.

1.3 Disturbance Mapping Methods

1.3.1 GIS analyses and products

We used ArcGIS Desktop 10.7 to complete the GIS portion of the project. The software facilitated the collation of disturbance data, digitization of missing disturbance features, spatial analysis, and map production.

1.3.2 Disturbance mapping

We used the disturbance layer provided by BC MFLNRORD as the baseline for developing the disturbance map for the Tweedsmuir-Entiako caribou range (Figure 4).

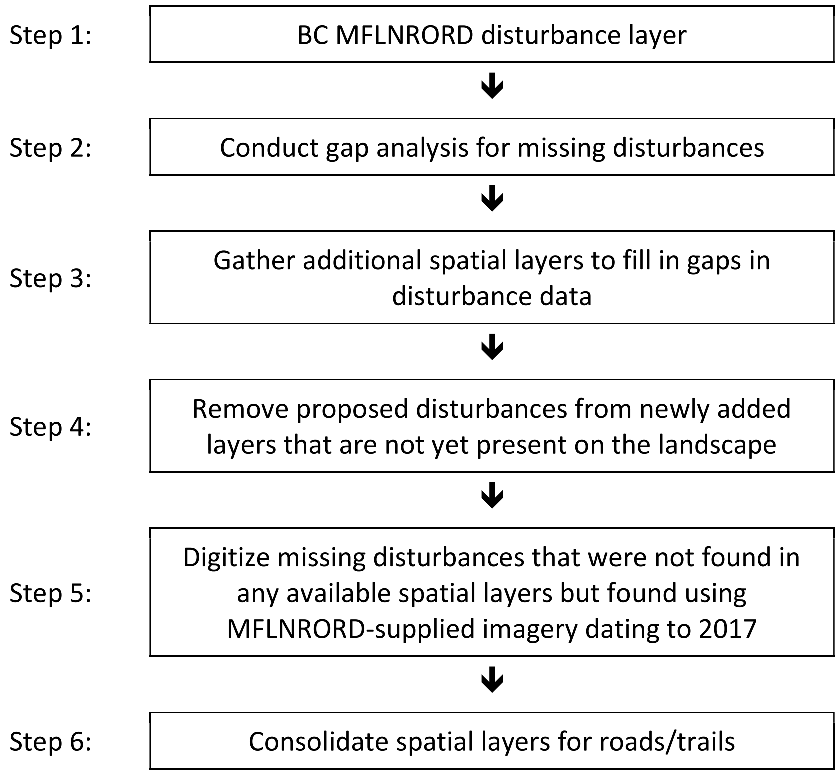


Figure 4. Procedure used to finalize the disturbance layer for the Tweedsmuir-Entiako caribou range.

1.3.2.1 BC MFLNRORD disturbance layer (Step 1)

Disturbance categories in the BC MFLNRORD disturbance layer (Table 1) were based on disturbance categories used by Environment and Climate Change Canada for identification of critical habitat for boreal caribou (EC 2011, 2012), and southern mountain caribou (EC 2014).

Most categories of anthropogenic disturbance in the Tweedsmuir-Entiako caribou range are permanent or semi-permanent disturbances (the disturbed area is maintained as a permanent or long-lasting feature on the landscape where vegetation succession and recovery is not occurring; Table 1). Information on the date that those disturbances occurred was not consistently available in datasets. Datasets for temporal disturbances (vegetation re-establishes and eventually recovers after the initial disturbance) such as forest harvesting and natural disturbances (fire, forest insects) did include information on the date the disturbance occurred, and were grouped by decade in the BC MFLNRORD disturbance layer.

In the BC MFLNRORD disturbance layer, spatial data for several disturbances were sourced from spatial layers developed for a cumulative effects project, while others were sourced from spatial layers available from the DataBC Data Catalogue (Table 2). Definitions of each BC MFLNRORD disturbance category were similar to those in EC

(2011). Individual recreational and trapping cabins were not included in anthropogenic disturbance categories in EC (2011) or in the BC MFLNRORD disturbance layer, and therefore are not included in the anthropogenic footprint in this project. For this project we included lodges in existing spatial layers in the Recreation category. A summary of how spatial data for each disturbance category was processed for this project is provided in Table 2 and a more detailed account is provided in Appendix 1.

Table 1. Disturbance categories within the Tweedsmuir-Entiako caribou range.

Disturbance category	Disturbance type		Availability of date of disturbance
	Permanent/ semi-permanent[1]	Temporal[2]	
Anthropogenic disturbance			
Urban	X		
Agriculture	X		
Recreation	X		
Airstrip	X		
Reservoir	X		X
Dam	X		
Fireguards	X		X
Transmission line	X		
Road/trail	X		
Seismic line	X		
Mining	X		
Forest harvesting		X	X (since 1950s)
Natural disturbance			
Fire		X	X (since 1950s)
Mountain pine beetle		X	X (since 1970s)
Spruce bark beetle		X	X (since 1970s)
Balsam bark beetle		X	X (since 1970s)

[1] The disturbed area is maintained as a permanent or long-lasting feature on the landscape where vegetation succession and recovery is not occurring
[2] Vegetation re-establishes and eventually recovers following the initial disturbance
[3] Intensity of attack was assessed as low in most areas

1.3.2.2 Missing disturbance gap analysis (Step 2)

We used satellite imagery provided by BC MFLNRORD (BlackBridge Geomatics Mosaic Streaming v1.3.0), current to 2017, to search for disturbances on the landscape that were not captured in the disturbance layer provided by BC MFLNRORD (Figure 4). We superimposed the 20 km BC map grid over the Tweedsmuir-Entiako caribou range to aid in localizing where missing disturbances were detected and to keep track of which areas had been examined to limit the possibility of missing visible features.

Table 2. Description of disturbance categories, sources, and data processing for the spatial disturbance layer provided by BC MFLNRORD.

Category: BC MFLNRORD[1]	**Data source: BC MFLNRORD**	**Disturbance category definition**		**Spatial data processing for this project (e.g. additions/modifications)**
		BC MFLNRORD	**EC (2011)**	
Urban	• Cumulative effects project	• Housing or developed areas derived from tenure data and refined by satellite imagery	• A built-up area of infrastructure associated with urban areas such as cities, towns and villages. May include small groups of buildings that are not clearly associated with other feature types including industrial areas and water treatment plants. Does not include infrastructure associated with agriculture.	• Used satellite imagery to digitize urban features not included in existing spatial layers • Digitized/added Alcan campground/boat launch site
Agricultural Land	• Cumulative effects project	• Agriculture areas based on tenure data and refined by satellite imagery	• All land cleared for cropland or pastureland including all infrastructure (e.g. barns, farmhouse, etc.)	• Removed forested portions of agricultural tenures and added areas of pasture and hay production that were visible in satellite imagery
Recreation Sites/Tenures	• WHSE - Forest tenure (recreation)	• Recreation features (recreation reserve, recreation site, or an interpretive forest)	• N/A	• (Tetachuck Lodge is currently the only feature in this category)
Airstrip	• WHSE - TRIM - Airfields	• Helipads and airfields (active and inactive)	• Runways used by aircraft. May include public and private airstrips not already associated with any surrounding settlement or infrastructure.	• Used satellite imagery to digitize airstrips not included in existing spatial layers
Dam	• WHSE - Water management – dams	• Dam (structure only)	• An obvious barrier constructed across a watercourse.	• Included the Skins Lake Spillway and saddle dams
Reservoirs	• WHSE – Water management - reservoirs	• Reservoirs	• Large bodies of water upstream of a known major dam location.	• Incorporated linework for pre-reservoir waterbodies to assess area of land flooded
Fireguards	• N/A	• N/A	• N/A	• Added fireguards constructed in the 2010s, which were primarily associated with the 2014 Chelaslie Arm fire (source: BC MFLNRORD)

Category: BC MFLNRORD[1]	Data source: BC MFLNRORD	Disturbance category definition		Spatial data processing for this project (e.g. additions/modifications)
		BC MFLNRORD	EC (2011)	
Transmission lines	• derived from several data sources representing unique inventories: BC Hydro, Private, Independent Power Producers, and Terrain Resource Information Management (TRIM)	• High voltage electrical transmission lines for distributing power throughout the province.	• Infrastructure and the right-of-way corridor associated with the transmission of electrical power.	• (Powerline from the dam at Kemano is the only feature in this category)
Road/trail	• Standardized road dataset for the caribou program	• Roads and trails (data did not discriminate between the two) including forest service roads and access roads	• All road types regardless of classification (e.g. forestry roads, major highway, etc.) that could be interpreted from Landsat imagery	• Added roads from spatial layers supplied by BC Forest Service (Nadina and Vanderhoof Natural Resource Districts) and Canfor • Developed a procedure to reduce double-counting of road features (see Section 1.3.2.4) • Used satellite imagery to digitize roads associated with forest harvesting and mineral exploration/development not included in existing road layers • Used satellite imagery of currently un-roaded areas to identify and remove road linework (originating from spatial layers) for roads that presently do not exist
Seismic line	• Cumulative effects project	• Seismic lines	• Linear features resulting from clearing and surface disturbance due to oil and gas and mineral exploration.	• Used satellite imagery to identify and remove seismic linework (originating from spatial layers) for seismic lines that presently do not exist
Mining (EC = Mine)	• Cumulative effects project	• Mine footprint	• Area of exposed land associated with mineral or aggregate extraction operations, including quarries,	• Used satellite imagery to digitize infrastructure from mineral exploration (e.g. camps) not included in mining layer

Category: BC MFLNRORD[1]	**Data source: BC MFLNRORD**	**Disturbance category definition**		**Spatial data processing for this project (e.g. additions/modifications)**
		BC MFLNRORD	**EC (2011)**	
			slag heaps, tailing piles, tailings ponds and associated mining infrastructure.	
Forest harvesting	• Local data set updated for a disturbance analysis completed in 2016	• Cutblocks consolidated by decade	• An area of land within a forested landscape that is actively managed for harvest operations. • Can range from clear cut to partial or strip cuts	• Added cutblocks from spatial data supplied by BC Forest Service (Nadina and Vanderhoof Natural Resource Districts) and Canfor • Digitized cutblocks from satellite imagery not included in consolidated cutblock layers, and estimated cutblock ages by comparing to neighbouring blocks of known age
Fire	• WHSE – historical fire	• Fires (consolidated by decade)	• Fires <40 years	•
Mountain pine beetle	• WHSE – pest infestation	• Mountain pine beetle attack (consolidated by decade)	• N/A	•
Spruce bark beetle	• WHSE – pest infestation	• Spruce bark beetle attack (consolidated by decade)	• N/A	•

[1] BC MFLNRORD categories are based on categories in EC (2011). The names of some BC MFLNRORD categories differed from those in EC (2011) including: Urban (EC 2011 = Settlements); Transmission Lines (EC 2011 = Powerlines); Mining (EC 2011 = Mine).

1.3.2.3 Addressing missing disturbances (Steps 3-5)

As much as possible, missing disturbances were subjectively categorized based on satellite imagery to determine what additional datasets were required. The majority of missing disturbances were forest harvest cutblocks and roads/trails, and to a lesser extent fireguards, mineral exploration disturbances, and some other anthropogenic disturbances.

To fill in gaps in the cutblock and roads/trails dataset, we secured spatial data from BC MFLNRORD from the Nadina and Vanderhoof Natural Resource Districts, and from Canadian Forest Products Ltd. Some of the datasets included proposed cutblocks and roads, some of which were already present on the landscape based on satellite imagery. Therefore, we retained cutblocks that were scheduled for harvesting up to and including 2019, and deleted cutblocks scheduled for harvesting in the 2020s or later. We then used publicly accessible Sentinel Hub imagery (current to Sept 2019) to assess whether proposed roads that were located beyond developed areas were currently present on the landscape and removed roads that were not present. Appendix 1 contains a more detailed account of the process used to finalize the cutblock spatial layer.

We obtained spatial layers for fireguards constructed for fires in the 2010s (mostly for the 2014 Chelaslie Arm Fire) from BC MFLNRORD and added any missing fireguards.

In addition, we obtained a spatial layer of the pre-reservoir waterbodies provided by BC Parks to assess the amount of land that was flooded by the Nechako Reservoir.

For missing disturbances that were not included in additional datasets that we were able to secure, we digitized the disturbances from satellite imagery provided by BC MFLNRORD (BlackBridge Geomatics Mosaic Streaming v1.3.0) and estimated year of disturbance for cutblocks based on data available from neighbouring cutblocks that appeared to be harvested at the same time and for which date of disturbance was available. The overwhelming majority of digitized cutblocks were recently harvested. As a result, the potential error in estimating their year of disturbance is limited. A total of 107 cutblocks were digitized from imagery using this approach.

1.3.2.4 Consolidating road/trail spatial layers (Step 6)

Road information was composed of features derived from five separate layers provided by BC MFLNRORD and forest licensees, and was further augmented by features digitized from imagery dated to 2017 provided by BC MFLNRORD (BlackBridge Geomatics Mosaic Streaming v1.3.0) where features were visible but not represented in any of the pre-existing GIS layers. We observed extensive overlap between the layers where the same road feature was represented by slightly different lines in the GIS layers. The overlaps prevented a simple merge of the road layers as this would introduce error into any calculations of road length or density. We circumvented this problem by developing a procedure to identify and eliminate overlaps while adding previously unrepresented features when merging the road layers together.

1. First, we chose the most spatially-complete layer as a base onto which additional features could be added (Digital Road Atlas Transport Lines - https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-demographic-partially-attributed-roads).
2. We buffered these features by a distance of 20 m on either side of the road centerline.
3. We then selected one of the additional road layers and erased all features from the additional layer that fell within the 20m buffer.
    - A distance of 20 m was chosen after we examined the duplicated features visually and concluded that 20 m provided a balance between eliminating duplicate features (although some larger deviations persisted) and, minimizing the loss of road length where the newly added roads connected to the digital road atlas network to ~20 m per added road.
4. Since the attributes between the two layers varied because of their differing provenance, we standardized the attributes to the extent that was possible.
5. We then merged the two layers together to add in the features missing from the Digital Road Atlas.
6. Using the merged layer from the previous step, we repeated steps 2 -5 until all of the road layers were added together.
7. The digitized features (n=1245) were not subject to any erasing because they were digitized from features that did not occur in any of the other layers and as a result contained no duplicated features that needed erasing. These features were simply merged in to create a final master road layer.

This procedure eliminated the vast majority of analogous road features, but it also introduced 20 m gaps where the roads that were added didn't connect to the remainder of the network. However, the amount of road lost to this was a negligible fraction of the length of the road network, with far less impact than retaining the duplicate features, and was therefore deemed to be an acceptable minor error to introduce into the road layer. Overall, this process eliminated over 25 500 km of duplicate roads leaving a remaining road network comprised of ~11 000 km across the whole range.

1.3.3 Disturbance calculations

We applied a 500 m buffer to anthropogenic disturbances, consistent with procedures used in EC (2011), and consistent with disturbance calculations for critical habitat for southern mountain caribou (EC 2014). The 500 m buffer accounts for avoidance of anthropogenic disturbance by caribou (EC 2014). The 500 m buffer was not applied to reservoirs. There is no buffer for natural disturbances (EC 2011, 2014).

For individual types of anthropogenic disturbance, we merged the buffer around each individual disturbance polygon with adjoining overlapping buffers to eliminate "double-counting" of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, we merged the footprints of all anthropogenic disturbances and buffers around each type of disturbance to eliminate double-counting overlapping disturbances and their buffers. For total disturbance, we merged the total combined anthropogenic disturbance layer with the total fire layer to calculate total disturbance, consistent with EC (2011, 2014). Forest insect disturbance is not included in the calculation of total disturbance (EC 2011, 2014).

Some disturbance polygons are identified as more than one type of disturbance. For example, an “urban” disturbance also overlaps with “road/trail” disturbances, or a cutblock may have been subsequently consumed in a fire. As a result, one polygon could include the footprint of more than one type of disturbance. Therefore, total anthropogenic disturbance and total disturbance are more accurately represented by the combined (merged) disturbance calculation rather than by the sum of the area of individual types of disturbance (which will overestimate the total area disturbed).

For temporal disturbances, we calculated the total amount of disturbance within the last 40 years (since the 1980s), within the last 50 years (since the 1970s), and for all years since the 1950s.

2 TWEEDSMUIR-ENTIAKO CARIBOU RANGE

The land portion of the Tweedsmuir-Entiako caribou range covers approximately 2.2 million hectares (Table 3). Forty-five percent of the range is made up of matrix range (winter and summer), which mostly lies along the periphery of the range and surrounds the winter and summer ranges to the west, north and east (Table 3, Figure 5). There is no matrix range in the southern portion of the range because the range lies adjacent to, and in some places, overlaps the Itcha-Ilgachuz and Rainbow caribou ranges in that area.

Low elevation winter range and high elevation winter range are located in the eastern half of the Tweedsmuir-Entiako caribou range and make up 20% and 1% of the range respectively. Low elevation summer range and high elevation summer range are located in the western half of the range and make up 18% and 16% of the range respectively.

Table 3. Area of seasonal range types on the Tweedsmuir-Entiako caribou range.

Seasonal Range Type	**Area (ha)**	**% of Total Area (land portion)**
High elevation winter	18 803	1
High elevation summer/winter	354 134	16
Low elevation summer	382 918	18
Low elevation winter	446 228	20
Matrix – winter[1]	380 828	17
Matrix – summer[2]	606 626	28
Total area (land portion)	2 189 538	100
Nechako Reservoir	89 484	N/A
Lakes >250 ha (excluding reservoir)	57 948	N/A
Total area (land + water)	2 336 970	N/A

[1] Includes 229 261 ha with compiled disturbance data, and 151 567 ha without disturbance data
[2] Includes 498 275 ha with compiled disturbance data, and 108 351 ha without disturbance data

Figure will be included when provincial linework is released by the British Columbia Caribou Recovery Program.

Figure 5. Distribution of seasonal range types on the Tweedsmuir-Entiako caribou range in west-central British Columbia.

For the Tweedsmuir-Entiako caribou range, we have differentiated between matrix associated with winter range and matrix associated with summer range because of the difference between the role of large-scale natural disturbances (primarily fire) in the two portions of the range. The winter range and matrix located in the eastern portion of the range consists of fire-dominated ecosystems, whereas the summer range and matrix extends into the eastern portion of the Coast Mountains, where fire and other large-scale natural disturbances are rare.

2.1 Current range condition

Currently, anthropogenic (human-caused) habitat alteration is primarily focussed in the northern and northwestern portions of the range in low elevation summer range, high elevation summer/winter range and matrix range, and in the eastern portion of the range in low elevation winter range, high elevation summer/winter range and matrix range (Figure 6, Table 4). Total anthropogenic disturbance (including a 500 m buffer) covers 31% of the total range, 6% of the high elevation summer/winter range, 41% of the low elevation winter range, 73% of the winter matrix range, 12% of the low elevation summer range, and 26% of the summer matrix range (Table 4).

Across the Tweedsmuir-Entiako caribou range, almost all recorded disturbance since the 1950s (96% of fire disturbance, and almost 100% of anthropogenic disturbance) occurred within the last 40 years, and differences between the level of disturbance <70 years, <50 years, and <40 years were negligible (Table 4). The most extensive anthropogenic disturbances in the Tweedsmuir-Entiako caribou range are forest harvesting and roads/trails associated with human activities (Table 4). Disturbance from mineral exploration and development includes Huckleberry Mine on the north side of the Nechako Reservoir, and mineral exploration activities in the northwestern portion of the range on the north side of the Nechako Reservoir and in the Whitesail area, and in the southeastern portion of the range, including the Blackwater Gold project. Agriculture disturbance is located mostly on the north side of the Nechako Reservoir and in the Tatelkuz Lake area. Settlements are also located mostly on the north side of the Nechako Reservoir, as is reservoir infrastructure including the Kenney Dam at the east end of the reservoir, and a spillway on the northeast shoreline. Seismic lines are located primarily in the southeastern portion of the range.

Forest harvesting began in the Tweedsmuir-Entiako range as early as the 1950s in the western portion of the range along coastal valley bottoms, and in the 1970s in the eastern (interior) portion of the range with the peak of harvesting in the 2000s (Table 5). Fires burned about 1% and 0.5% of the range in the 1950s and 1960s respectively, then were relatively uncommon from the 1970s to 1990s, then peaked in the 2010s with two major fire years in 2014 and 2018 (Table 5). The Chelaslie Arm fire burned over 130 000 ha in the eastern portion of the range in 2014, and a series of four fires burned almost 400,000 ha in the central portion of the range in 2018. Since monitoring of forest insects began in the

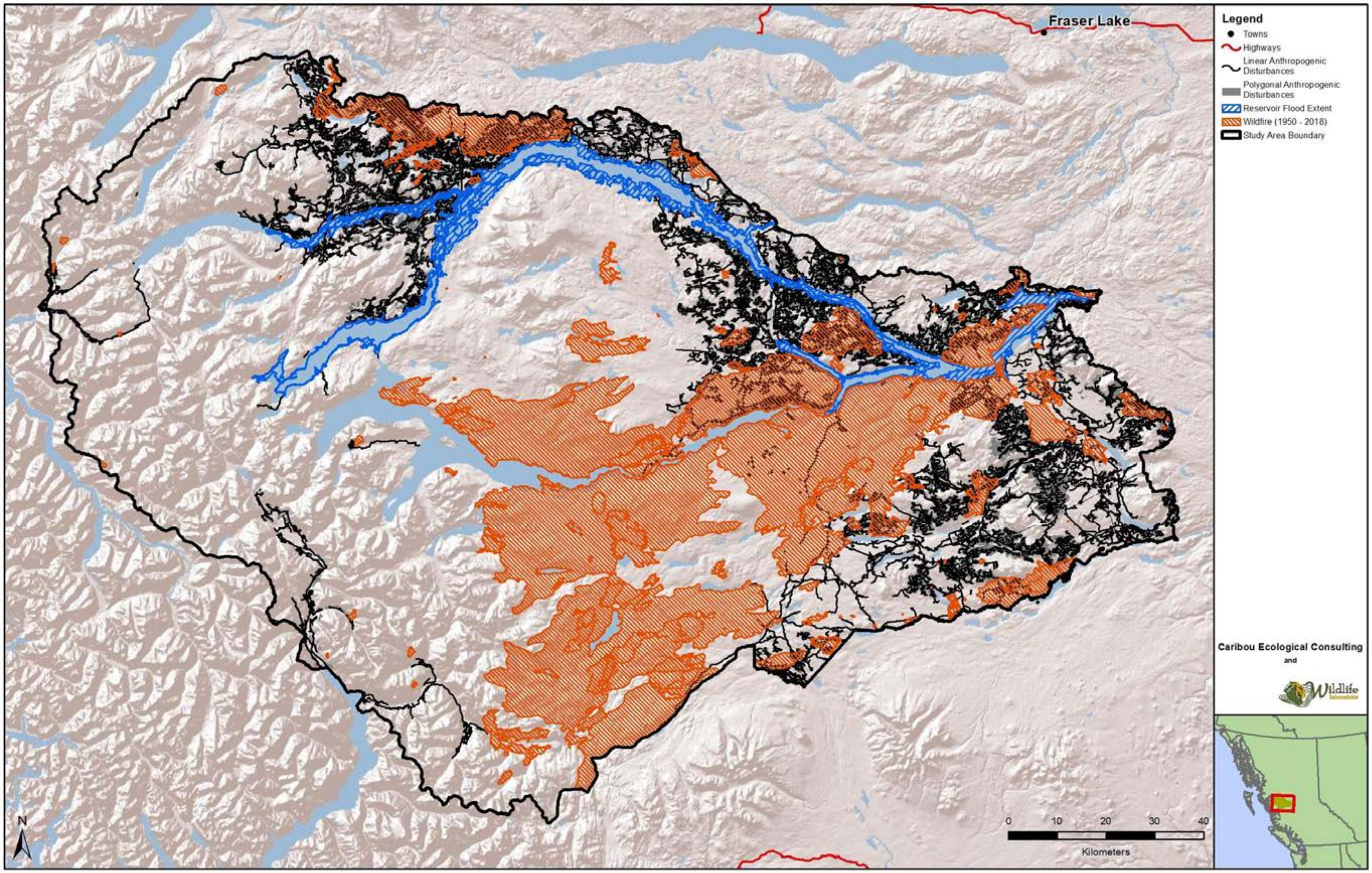


Figure 6. Current distribution of disturbances on the Tweedsmuir-Entiako caribou range in west-central British Columbia. * Herd boundary estimate

Table 4. Current extent of disturbances in each seasonal range type in the Tweedsmuir-Entiako caribou range.

Tweedsmuir-Entiako caribou range (Total) (ha)[1]:	2 160 798	Total km of linear features:	10 301
Tweedsmuir-Entiako caribou range (Portion with disturbance data) (ha)	2 072 202	Km/km^2 of linear features:	0.53
Nechako Reservoir (ha):	89 484		
Flooded portion of Nechako Reservoir (ha):	*44 723*		
Lakes >250 ha not part of Nechako Reservoir (ha):	52 948		
Tweedsmuir-Entiako caribou range – Land portion (ha)[1]:	1 929 810		

Type of disturbance[2,3]	**Total Range[4]**		**High Elevation Summer/ Winter[4,5]**		**Low Elevation Summer[4]**		**Low Elevation Winter[4]**		**Matrix Winter[4]**		**Matrix Summer[4]**	
	Area (ha)	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**
Anthropogenic disturbance (includes 500 m buffer)												
Urban	3 028	0.2	0		0		678	0.2	1 724	0.8	626	0.1
Agriculture	17 171	0.9	0		0		1 353	0.3	8 915	3.9	6 903	1.4
Recreation	123	<0.1	0		33	<0.1	89	<0.1	0		0	
Airstrip	1 807	0.1	0		413	0.1	625	0.1	249	0.1	521	0.1
Dam	557	<0.1	0		0		0		557	0.2	0	
Old District Lot cutlines[7]	1 633	0.1	0		0		1 633	0.4	0		0	
Transmission line	437	<0.1	0		0		0		0		437	0.1
Road/trail	498 885	25.9	19 776	5.3	43 338	11.3	168 685	37.8	149 896	65.4	117 190	23.5
Seismic line	13 386	0.7	214	0.1	255	0.1	1 813	0.4	8 791	3.8	2 313	0.5
Fireguards	21 927	1.1	898	0.2	0		13 802	3.1	948	0.4	6 279	1.3
Mineral exploration and development	9 029	0.5	248	0.1	2 231	0.6	111	<0.1	6 235	2.7	205	<0.1
Forest harvesting (all years)	436 984	22.6	14 375	3.9	35 758	9.3	138 425	31.0	139 537	60.9	108 889	21.9
Forest harvesting (<50 years)	435 946	22.6	14 375	3.9	35 758	9.3	138 425	31.0	138 874	60.6	108 513	21.8
Forest harvesting (<40 years)	427 578	22.2	14 375	3.9	35 226	9.2	137 801	30.9	138 367	60.4	101 810	20.4
All anthropogenic disturbance combined (all years)[8]	546 669	28.3	21 760	5.8	46 237	12.1	184 013	41.2	167 648	73.1	127 011	25.5

All anthropogenic disturbance combined (<50 years)[8]	546 295	28.3	21 760	5.8	46 237	12.1	184 013	41.2	167 454	73.0	126 832	25.5
All anthropogenic disturbance combined (<40 years)[8]	544 949	28.2	21 760	5.8	46 182	12.1	183 890	41.2	147 358	73.0	125 759	25.2
Natural disturbance (no buffer)												
Fire (all years)	467 174	24.2	46 766	12.5	100 108	26.1	210 878	47.3	45 612	19.9	63 811	12.8
Fire (<50 years)	449 693	23.3	46 260	12.4	99 541	26.0	207 891	46.6	33 134	14.5	62 866	12.6
Fire (<40 years)	448 285	23.2	46 260	12.4	99 541	26.0	207 840	46.6	33 134	14.5	61 509	12.3
Mountain pine beetle (<50 years)	1 285 056	66.6	165 353	44.3	287 125	75.0	441 919	99.0	224 784	98.0	165 874	33.3
Mountain pine beetle (<40 years)	1 285 041	66.6	165 353	44.3	287 125	75.0	441 919	99.0	224 784	98.0	165 860	33.3
Spruce bark beetle (<50 years)	63 757	3.3	8 164	2.2	12 234	3.2	29 089	6.5	4 012	1.7	10 258	2.1
Spruce bark beetle (<40 years)	63 695	3.3	8 164	2.2	12 234	3.2	29 028	6.5	4 012	1.7	10 258	2.1
Mountain pine beetle + spruce bark beetle (<50 years)	1 288 968	66.8	165 998	44.5	288 285	75.3	441 950	99.0	224 830	98.1	167 905	33.7
Mountain pine beetle + spruce bark beetle (<40 years)	1 288 954	66.8	165 998	44.5	288 285	75.3	441 950	99.0	224 830	98.1	167 890	33.7
Total disturbance (anthropogenic with 500 m buffer + fire with no buffer[9]												
All years[8]	900 917	46.7	67 655	18.1	145 851	38.1	333 733	74.8	190 483	83.1	163 196	32.8
<50 years[8]	888 699	46.1	67 477	18.1	145 290	37.9	333 039	74.6	180 584	78.8	162 308	32.6
<40 years[8]	887 492	46.0	67 477	18.1	145 237	37.9	332 924	74.6	180 488	78.7	161 366	32.4
Total area												
Total area	1 929 810		372 936		382 918		446 228		229 261		498 275	

[1] The Tweedsmuir-Entiako caribou range boundary provided by BC MFLNRORD excludes lakes larger than 250 ha. Lakes less than 250 ha are incorporated into the land portion of the range.

[2] The anthropogenic disturbance footprint includes a 500 m buffer consistent with the 500 m buffer used for anthropogenic disturbance in EC (2014). For individual types of disturbance, the buffer around each individual disturbance polygon is merged with adjoining overlapping buffers to eliminate "double-counting" of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, buffers around each type of disturbance are merged to eliminate double-counting overlapping buffers of different disturbance types.

[3] As a result of overlapping types of disturbance and overlapping buffers for anthropogenic disturbances, some disturbance polygons are identified as more than one type of disturbance (e.g. an "urban" disturbance also overlaps with "road/trail" disturbances). As a result, one polygon could include the footprint of more than one disturbance type and therefore adding up

the area of individual types of anthropogenic disturbance will exceed the combined area of “All anthropogenic disturbance combined”, which merges all anthropogenic disturbances and their buffers to eliminate overlaps. Similarly, “Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)” also merges the footprints of fire and anthropogenic disturbances to eliminate double-counting overlapping disturbances (e.g. a 120 ha cutblock may have been subsequently consumed in a fire).

[4] Seasonal range linework from BC MFLNRORD. Note – the Province does not manage matrix disturbance separated as summer and winter, the separation in this table is to identify focal areas for restoration. Total matrix disturbance can be calculated by totalling the areas of these zones together.

[5] BC MFLNRORD distinguishes between high elevation winter range and high elevation summer or winter range; this column includes the total of those two categories

[6] “%” = % of the total area (land portion) within the seasonal range type or total range, that is covered by the disturbance or combined disturbance.

[7] These linear features appeared to correspond to old District Lot boundaries in Entiako Park. The digital data for these linear features identified them as seismic lines but did not provide any supporting information to confirm

[8] Date of disturbance is available only for forest harvesting (since 1950s), fire (since 1950s), mountain pine beetle (since 1970s) and spruce bark beetle (since 1970s). Date of disturbance is not available for other disturbances; therefore the amount of disturbance <50 years and <40 years is only summarized individually for forest harvesting, fire, mountain pine beetle and spruce bark beetle. The amount of all anthropogenic disturbance combined, and total disturbance (anthropogenic + fire) are also summarized for <50 years and <40 years since all other anthropogenic disturbances are maintained as permanent/semi-permanent features on the landscape where vegetation succession and recovery is not occurring.

[9] Total disturbance is calculated as the combined area of anthropogenic disturbance (including a 500 m buffer) and fire (no buffer), consistent with the calculation of total disturbance in EC (2014). Area disturbed by forest insects is not included in this calculation.

1970s, mountain pine beetle numbers began increasing in the 1990s and peaked in the 2000s, affecting two-thirds of the range (Table 4,Table 5, Figure 7).

Table 5. Area (hectares) disturbed by forest harvesting, fire and forest insects during each decade since the 1950s in the Tweedsmuir-Entiako caribou range.

Decade[1]	Forest harvesting (no buffer)	Forest harvesting (+ 500 m buffer)	Fire	Mountain pine beetle	Spruce bark beetle
1950s	3	120	17 546	N/A	N/A
1960s	442	4 260	11 281	N/A	N/A
1970s	13 013	49 362	1 663	368	61
1980s	21 035	82 715	3 702	879	37 950
1990s	37 133	180 886	1 806	62 760	1
2000s	59 998	266 209	13 422	1 277 557	12 827
2010s[2]	42 866	166 979	438 018	170 180	13 052
Total combined	174 490	436 984	461 174	1 288 968	63 757

[1] Values in this table for each decade show the amount of area that was newly disturbed by each type of disturbance during each individual decade and do not include disturbance that occurred in previous decades. "Total combined" disturbance represents the amount of each type of disturbance (dating back to the 1950s) currently present on the landscape and incorporates/merges any overlap of individual types of disturbance among decades.

[2] The "2010s" decade includes cutblocks proposed for 2019 but does not include fires or forest insects in 2019 (however there were no significant fires in the Tweedsmuir-Entiako caribou range in 2019 as of September 1, 2019)

2.2 Priority Restoration Areas

BC MFLNRORD identified three Priority Restoration Areas in the Tweedsmuir-Entiako caribou range (Figure 8), which are the portions of the Tweedsmuir-Entiako caribou range with the highest priority for conducting restoration activities. These Priority Restoration Areas:

- have been consistently used by caribou;
- focus on primarily high elevation winter/summer range, low elevation winter range or low elevation summer range; and,
- include moderate to high levels of anthropogenic disturbance.

Within each Priority Restoration Area, Restoration Zones have been identified and prioritized for restoration, and selection criteria have been developed for prioritizing individual disturbances within Restoration Zones (see Section 3.5.2).

The Whitesail Priority Restoration Area is located in the northwestern portion of the range and consists of primarily low elevation summer range including calving islands in Whitesail Lake (Figure 8, Table 6). The Chelaslie and Vanderhoof Priority Restoration Areas are located in the eastern portion of the range and include primarily low elevation and high elevation winter range (Figure 8, Table 6). Each Priority Restoration Area is described in more detail in the following sections.

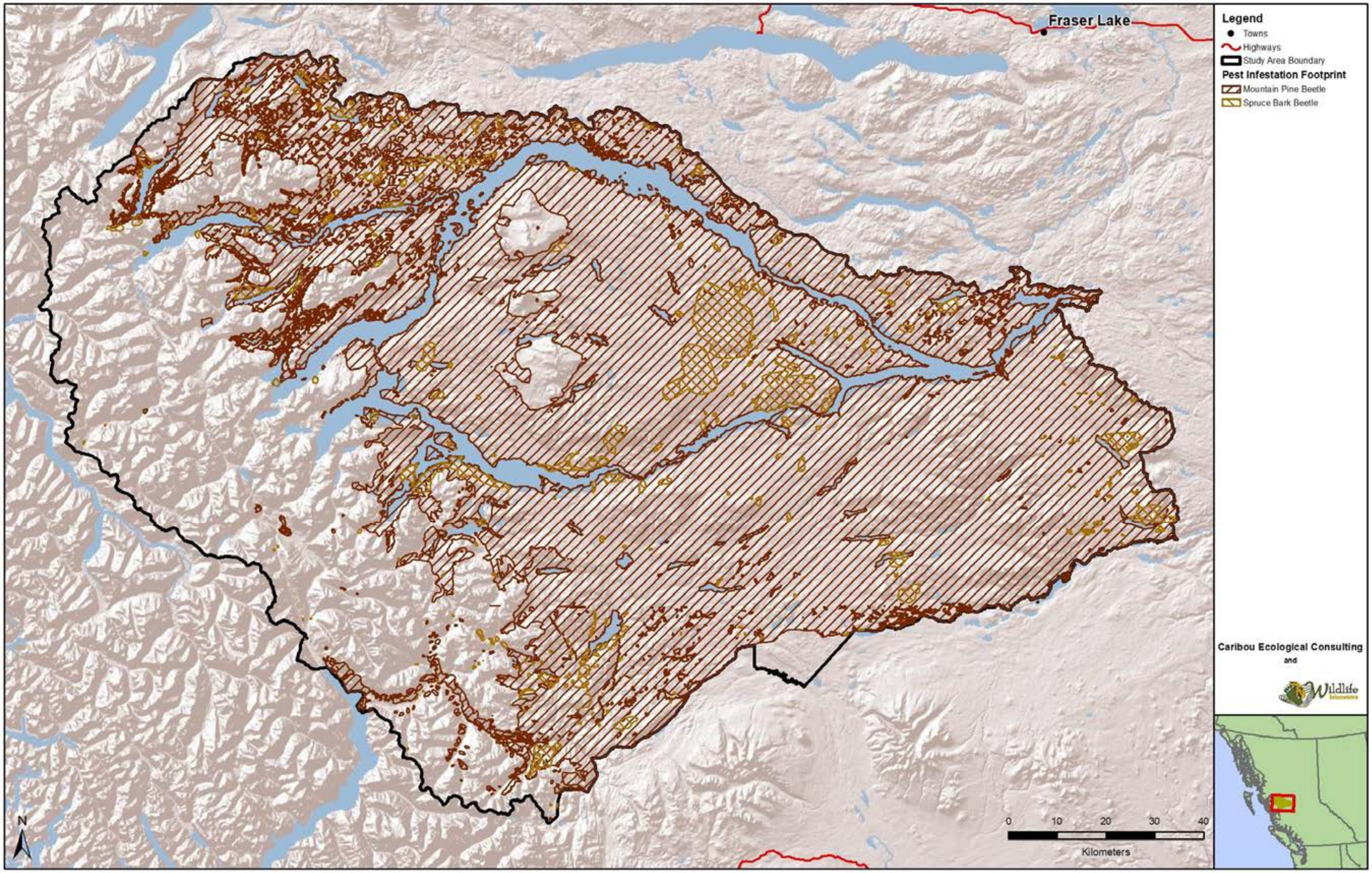


Figure 7. Current distribution of mountain pine beetle and spruce bark beetle outbreaks on the Tweedsmuir-Entiako caribou range in west-central British Columbia between 1970 and 2019.

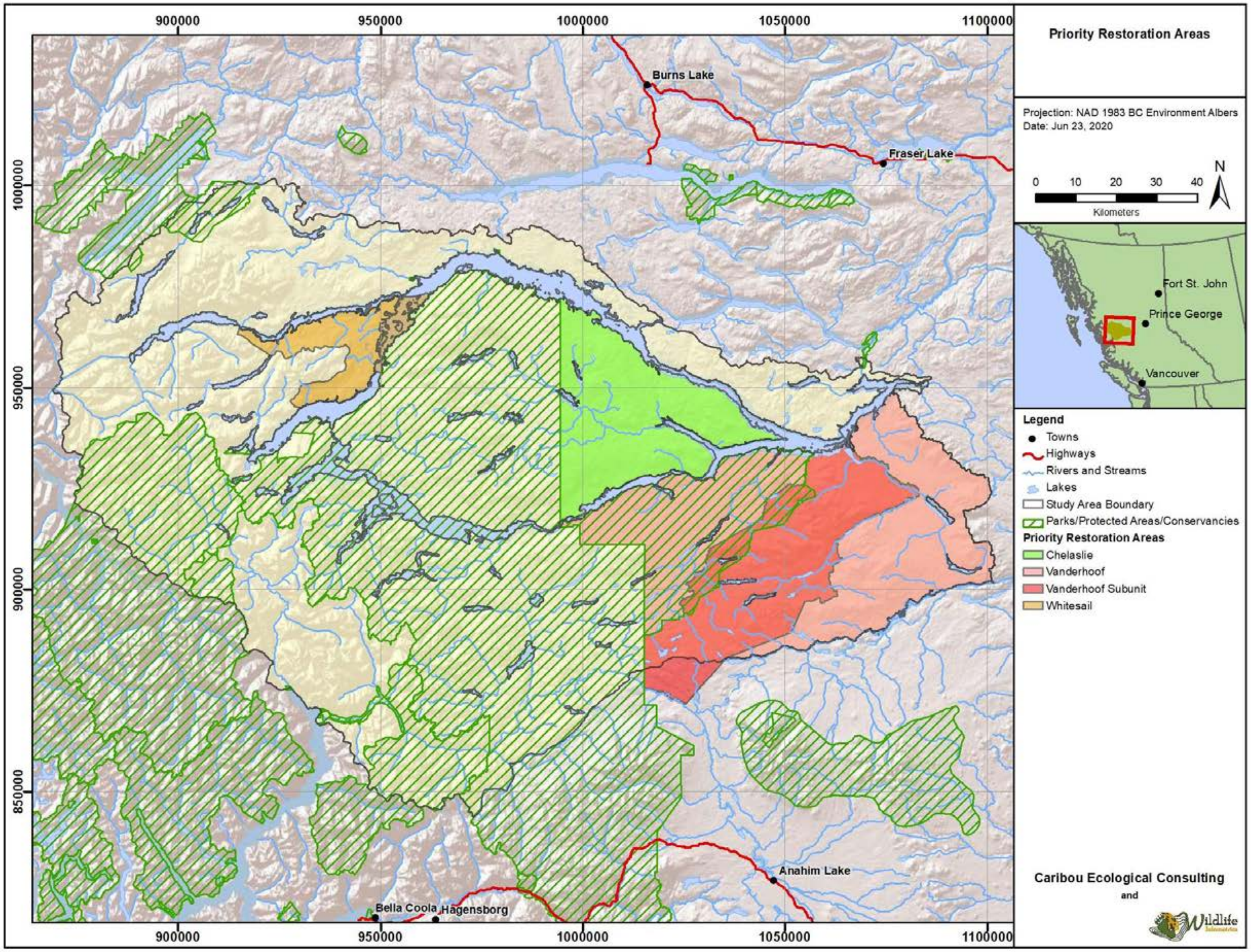


Figure 8. Location of Priority Restoration Areas in the Tweedsmuir-Entiako caribou range.

Areas with moderate to high levels of anthropogenic disturbance outside of the three priority restoration areas are located mostly in matrix range north of the Nechako Reservoir where direct use by caribou is lower than in the priority restoration areas, and which are further away from core winter ranges.

Table 6. Percent of each seasonal range type in each Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

	Seasonal Range Types[1]				
Priority Restoration Area	**High elevation summer/ winter[2]**	**Low elevation summer**	**Low elevation winter**	**Matrix Winter**	**Matrix Summer**
Whitesail	0.3	10.0			
Chelaslie	5.5		26.9		
Vanderhoof Total (Subunit)	5.0 (4.7)		51.9 (25.3)	33.0 (5.0)	
Not in a Priority Restoration Area	89.2	89.9	21.1	67.0	100.0
Total area (land portion) (ha)	372 937	382 918	446 228	380 820	606 626

[1] Seasonal range types from BC MFLNRORD
[2] Includes combined High elevation summer/winter range and High elevation winter range

2.3 Whitesail Priority Restoration Area

The western boundary of Whitesail Priority Restoration Area follows the eastern boundary of the Tahtsa-Troitsa No Timber Harvest Area as defined in the Morice LRMP (BC Ministry of Agriculture and Lands 2007). The rest of the boundary uses the shoreline of the Nechako Reservoir with the eastern boundary following the western shoreline of Tweedsmuir Park in the vicinity of the calving islands in Whitesail Reach. The area consists primarily of low elevation forested habitat below 1200 m. Legal objectives within the Whitesail Priority Restoration Area include a Section 7 order for caribou calving habitat in the Whitesail Reservoir with a maximum allowable impact on the timber harvesting landbase of 570 ha (Province of British Columbia 2004a). BC MFLNRORD is currently working on establishing a Wildlife Habitat Area that will include the Whitesail Priority Restoration Area and that will incorporate the order for caribou calving habitat.

2.3.1 Significance

Significant features of the Whitesail Priority Restoration Area for the Tweedsmuir-Entiako caribou population include:

- calving islands in Whitesail Reach;

- migration routes for caribou calving and summering in the northwestern portion of their range;
- shoreline points of entry and exit for caribou crossing Whitesail Reach during spring and fall migration; and,
- low elevation calving, summer and fall range.

One of the most significant features of the Whitesail Priority Restoration Area for the Tweedsmuir-Entiako caribou population is the calving islands in Whitesail Reach. Calving on islands in lakes is a strategy used by caribou to avoid predation (Shoesmith and Storey 1977, Bergerud 1985), and Tweedsmuir-Entiako caribou that calve on islands have higher calving success than caribou that calve in other low elevation terrain (Seip and Cichowski 1996, Cichowski 2015). Caribou that calve on islands may remain there throughout the summer and fall, and other caribou may also use the islands during parts or all of the summer and into the fall.

The calving islands and adjacent shorelines are also part of the most consistently used migration area used by caribou during migration to and from calving and summer ranges in the northwestern portion of the range, including the Sibola Mountains. Within the mainland portion of the Whitesail Restoration Area, migrating caribou travel along low elevation routes either southwest/northeast on the north side of Whitesail Reach, or west-east in the area south of Tahtsa Reach. Calving success of caribou that calve at high elevations in the area north and west of northern Tweedsmuir Park, tends to be high; therefore, connectivity to those ranges is important for contributing to overall calf survival and recruitment into the population.

Some Tweedsmuir-Entiako caribou also use the Whitesail Priority Restoration Area during summer and fall and as late as November, prior to returning to wintering areas in the eastern portion of their range.

2.3.2 Current range condition

Anthropogenic disturbances in the land portion of the Whitesail Priority Restoration Area include forest harvesting, mineral exploration and development, and associated roads/trails (Figure 9, Table 7). Forest harvesting in this area began in the 1990s and peaked in the 2000s (Table 8). Consequently, all forest harvesting disturbance is less than 30 years old. The current footprint from forest harvesting is distributed throughout the priority restoration area with the exception of 1) some of the higher elevation portions along the western boundary, 2) the area west of Kasalka Creek, and 3) the area west of an un-named creek near the southwestern boundary. Forest harvesting is not permitted on the calving islands (BC Ministry of Agriculture and Lands 2007). Although the mapped mining footprint is 141 ha (including a 500 m buffer), Surge Copper Corp has an active mineral exploration camp about 2 km east of Kasalka Creek, with mineral claims encompassing almost all of Whitesail Priority Restoration Area (Surge Copper Corp 2019). The mining disturbance footprint is largely overlapped by the forest harvesting footprint, except for some mineral exploration roads and trails in the area east of Kasalka Creek.

In addition to anthropogenic disturbance on land, 90% of the area covered by the Nechako Reservoir in the Whitesail Priority Restoration Area was flooded, representing

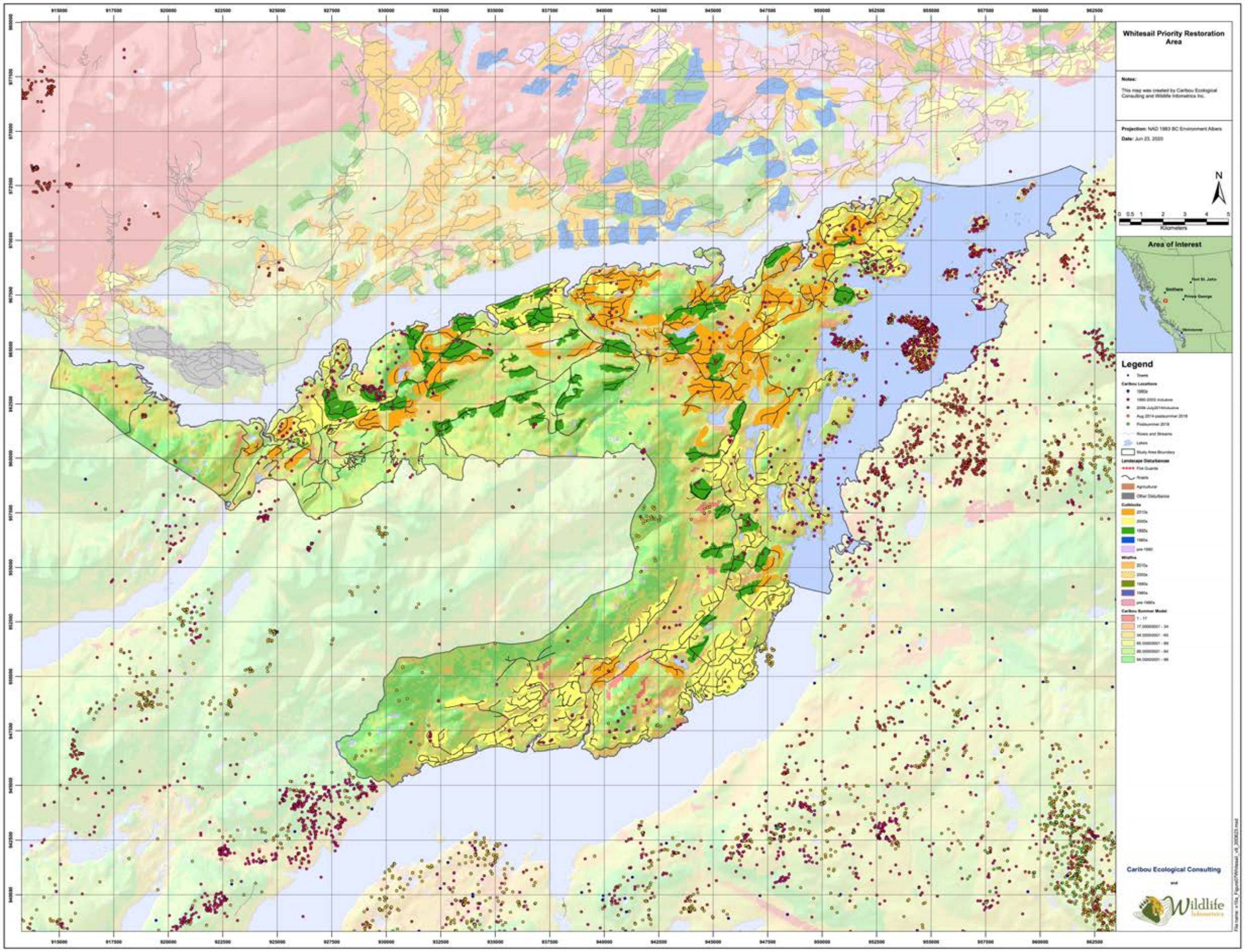


Figure 9. Distribution of disturbances in the Whitesail Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Table 7. Current extent of disturbances in each seasonal range type in the Whitesail Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Whitesail Priority Restoration Area (ha)[1]:	46 801	Total km of linear features:	580
Nechako Reservoir (ha):	7 208	Km/km² of linear features:	1.46
Flooded portion of Nechako Reservoir (ha):	*6 458*		
Lakes >250 ha not part of Nechako Reservoir (ha):	0		
Whitesail Priority Restoration Area – Land portion (ha)[1]:	39 593		

Type of disturbance[2,3]	Total Whitesail Priority Restoration Area[4]		High Elevation Summer/Winter[4,5]		Low Elevation Summer[4]	
	Area (ha)	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**
Anthropogenic disturbance (includes 500 m buffer)						
Urban	0		0		0	
Agriculture	0		0		0	
Recreation	0		0		0	
Airstrip	0		0		0	
Dam	0		0		0	
Transmission line	0		0		0	
Road/trail	27 400	69.2	277	22.7	27 123	70.7
Seismic line	0		0		0	
Fireguards	0		0		0	
Mineral exploration and development	141	0.4	0		141	0.4
Forest harvesting (all years)	26 911	68.0	0		26 911	70.1
Forest harvesting (<50 years)	26 911	68.0	0		26 911	70.1
Forest harvesting (<40 years)	26 911	68.0	0		26 911	70.1
All anthropogenic disturbance combined (all years)[7]	29 350	74.1	277	22.7	29 073	75.8
All anthropogenic disturbance combined (<50 years)[7]	29 350	74.1	277	22.7	29 073	75.8
All anthropogenic disturbance combined (<40 years)[7]	29 350	74.1	277	22.7	29 073	75.8
Natural disturbance (no buffer)						
Fire (all years)	0		0		0	
Fire (<50 years)	0		0		0	
Fire (<40 years)	0		0		0	
Mountain pine beetle (<50 years)	36 211	91.5	1 100	90.3	35 110	91.5
Mountain pine beetle (<40 years)	36 211	91.5	1 100	90.3	35 110	91.5
Spruce bark beetle (<50 years)	53	0.1	0		53	0.1
Spruce bark beetle (<40 years)	53	0.1	0		53	0.1
Mountain pine beetle + spruce bark beetle (<50 years)	36 211	91.5	1 100	90.3	35 110	91.5

Mountain pine beetle + spruce bark beetle (<40 years)	36 211	91.5	1 100	90.3	35 110	91.5
Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)[8]						
All years[7]	29 350	74.1	277	22.7	29 073	75.8
<50 years[7]	29 350	74.1	277	22.7	29 073	75.8
<40 years[7]	29 350	74.1	277	22.7	29 073	75.8
Total area						
Total area	39 593		1 218		38 375	

[1] The Tweedsmuir-Entiako caribou range boundary provided by BC MFLNRORD excludes lakes larger than 250 ha. Lakes less than 250 ha are incorporated into the land portion of the range.

[2] The anthropogenic disturbance footprint includes a 500 m buffer consistent with the 500 m buffer used for anthropogenic disturbance in EC (2014). For individual types of disturbance, the buffer around each individual disturbance polygon is merged with adjoining overlapping buffers to eliminate “double-counting” of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, buffers around each type of disturbance are merged to eliminate double-counting overlapping buffers of different disturbance types.

[3] As a result of overlapping types of disturbance and overlapping buffers for anthropogenic disturbances, some disturbance polygons are identified as more than one type of disturbance (e.g. an “urban” disturbance also overlaps with “road/trail” disturbances). As a result, one polygon could include the footprint of more than one disturbance type and therefore adding up the area of individual types of anthropogenic disturbance will exceed the combined area of “All anthropogenic disturbance combined”, which merges all anthropogenic disturbances and their buffers to eliminate overlaps. Similarly, “Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)” also merges the footprints of fire and anthropogenic disturbances to eliminate double-counting overlapping disturbances (e.g. a 120 ha cutblock may have been subsequently consumed in a fire).

[4] Seasonal range linework from BC MFLNRORD.

[5] BC MFLNRORD distinguishes between high elevation winter range and high elevation summer or winter range; this column includes the total of those two categories

[6] “%” = % of the total area (land portion) within the seasonal range type or Whitesail Priority Restoration Area, that is covered by the disturbance or combined disturbance.

[7] Date of disturbance is available only for forest harvesting (since 1950s), fire (since 1950s), mountain pine beetle (since 1970s) and spruce bark beetle (since 1970s). Date of disturbance is not available for other disturbances; therefore the amount of disturbance <50 years and <40 years is only summarized individually for forest harvesting, fire, mountain pine beetle and spruce bark beetle. The amount of all anthropogenic disturbance combined, and total disturbance (anthropogenic + fire) are also summarized for <50 years and <40 years since all other anthropogenic disturbances are maintained as permanent/semi-permanent features on the landscape where vegetation succession and recovery is not occurring.

[8] Total disturbance is calculated as the combined area of anthropogenic disturbance (including a 500 m buffer) and fire (no buffer), consistent with the calculation of total disturbance in EC (2014). Area disturbed by forest insects is not included in this calculation.

Table 8. Area (hectares) disturbed by forest harvesting, fire and forest insects during each decade since the 1950s in the Whitesail Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Decade[1]	Forest harvesting (no buffer)	Forest harvesting (+ 500 m buffer)	Fire	Mountain pine beetle	Spruce bark beetle
1950s	0	0	0	N/A	N/A
1960s	0	0	0	N/A	N/A
1970s	0	0	0	0	0
1980s	0	0	0	0	0
1990s	2 339	11 382	0	0	0
2000s	5 429	17 686	0	36 173	0
2010s[2]	3 526	12 420	0	18 072	53
Total combined	11 294	26 911	0	36 211	53

[1] Values in this table for each decade show the amount of area that was newly disturbed by each type of disturbance during each individual decade and do not include disturbance that occurred in previous decades. "Total combined" disturbance represents the amount of each type of disturbance (dating back to the 1950s) currently present on the landscape and incorporates/merges any overlap of individual types of disturbance among decades.

[2] The "2010s" decade includes cutblocks proposed for 2019 but does not include fires or forest insects in 2019 (however there were no significant fires in the Tweedsmuir-Entiako caribou range in 2019 as of September 1, 2019)

a loss of almost 6 500 ha of low elevation forests and other habitat in this area to the reservoir (Figure 9).

Almost 92% of the Whitesail Priority Restoration Area was affected by mountain pine beetles with the peak of activity in the 2000s (Table 8). No large fires have been recorded in the area since monitoring began in the 1950s, and only 53 ha of spruce bark beetles have been detected since the 1970s (Table 7, Table 8).

2.3.3 Potential future disturbances

Canadian Forest Products Ltd. has cutblocks planned in the Whitesail Priority Restoration Area in the next 20 years.

Surge Copper Corp's claim area has potential for a number of hard metals and includes 3 advanced stage deposits (Surge Copper Corp 2019), which could potentially lead to one or more mines in the area.

With climate change, wildfires and insect outbreaks are expected to increase. Although there has been no fire activity in the Whitesail Priority Restoration Area since prior to the 1950s, change in climate conditions will likely increase fire risk in this area. And, although much of the lodgepole pine forests have already been affected by the MPB epidemic, other forest insects could affect other species, and MPB will play a role once regenerating forests mature.

2.4 Chelaslie Priority Restoration Area

The Chelaslie Priority Restoration Area encompasses the area surrounded by the Nechako Reservoir that lies east of northern Tweedsmuir Park (Figure 10). It contains all four zones of the Chelaslie Caribou Migration Corridor (low, moderate, high, very high) as defined in the Lakes LRMP (Lakes District LRMP Resource Council 2000). Legal objectives for the zones include seral stage objectives (BC Ministry of Sustainable Resource Management 2003) and Old Growth Management Areas (BC Ministry of Agriculture and Lands 2007).

2.4.1 Significance

Significant features of the Chelaslie Priority Restoration Area for the Tweedsmuir-Entiako caribou population include:

- spring and fall migration routes/habitat between winter range in the Entiako and Chelaslie areas, and summer range in northern Tweedsmuir Park and in areas further to the west and northwest;
- unburned low elevation winter range; and,
- unburned mid-high elevation winter range.

The Chelaslie Priority Restoration Area includes a low elevation migration route that is consistently used by caribou migrating between winter and summer ranges. Prior to the 2014 Chelaslie Arm Fire, during spring migration most caribou wintering in the Entiako area would swim north across Tetachuck Lake, spend some time on the north side of the lake, then move north to the area around the Chelaslie River, and move northwest along the Chelaslie River and Chief Louis Lake before moving through low elevation routes through the Quanchus Mountains in northern Tweedsmuir Park (Marshall 1986, Cichowski 1989, Steventon 1996, Cichowski and MacLean 2005, Cichowski 2010).

Low elevation portions of the Chelaslie Priority Restoration Area along the north side of Tetachuck Lake, and in the Chief Louis Lake and Uduk Lake areas have also been used by a portion of the Tweedsmuir-Entiako caribou population during winter (Cichowski 1989, Steventon 1996, Cichowski and MacLean 2005, Cichowski 2010). Caribou have also used higher elevation areas in the Windfall Hills area during winter, and in the southwestern portion of the during early winter (Cichowski 1991, Steventon 1996, Cichowski and MacLean 2005).

Following the 2014 Chelaslie Arm Fire, which burned most of the highest value winter range in the Entiako area and on the north side of Tetachuck Lake, the unburned portions of the Chelaslie Priority Restoration Area have become more intensely and consistently used by caribou during winter, especially in the areas along the Chelaslie River, Chief Louis Lake and Uduk Lake (BC MFLNRORD, unpubl. data). During winter 2014/15, the first winter following the fire, caribou were also using lower quality winter range/habitat in the eastern portion of the Chelaslie Priority Restoration Area (BC MFLNRORD, unpubl. data). More use of high elevation habitat in the Chelaslie Priority Restoration Area has also been observed (BC MFLNRORD, unpubl. data). Overall, the unburned portions of the High and Moderate use zones, and the central portion of the

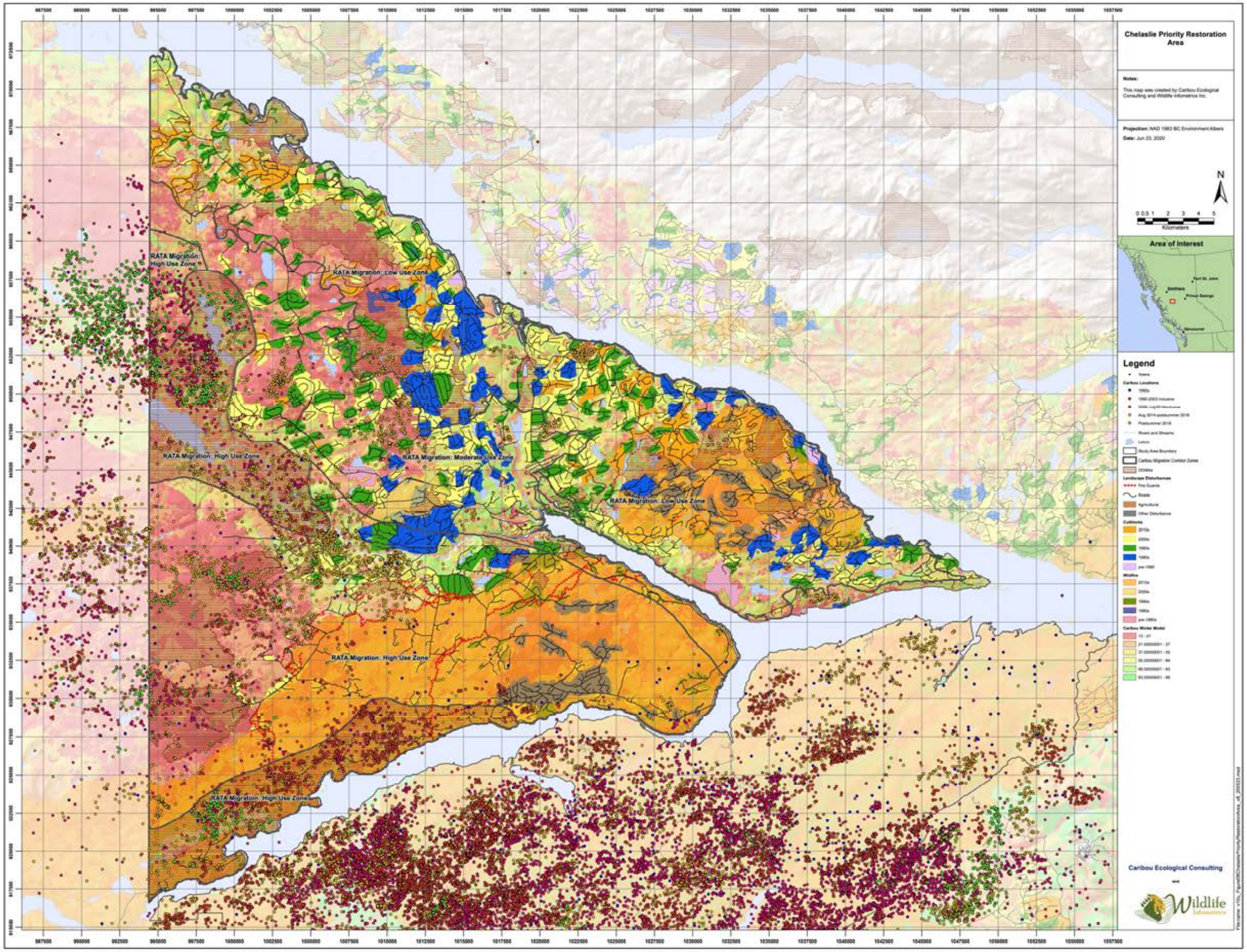


Figure 10. Distribution of disturbances in the Chelaslie Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Low use zone, have increased in relative value as caribou winter range following the 2014 Chelaslie Arm Fire, due to the conversion of higher value forested caribou habitats in other parts of the range to early successional habitats following the fire.

The migration route along the Chelaslie River and Chief Louis Lake also continues to be an important spring migration route following the 2014 Chelaslie Arm Fire (BC MFLNRORD, unpubl. data).

2.4.2 Current range condition

The primary anthropogenic disturbances in the Chelaslie Priority Restoration Area are forest harvesting and associated roads/trails (Table 9). There are also a number of fireguards that were constructed for the 2014 Chelaslie Arm Fire. The urban, recreation and airstrip disturbances are associated with Tetachuck Lodge at the west end of Tetachuck Lake. There are no disturbances associated with mineral exploration or development.

Forest harvesting in this area began in the 1970s but most forest harvesting activity was conducted from the 1980s to the 2000s, with the peak of harvesting in the 2000s (Table 10). Consequently, almost all forest harvesting disturbance is less than 40 years old. The current footprint from forest harvesting is concentrated in the Caribou Low and Moderate Use zones, with some harvesting distributed in portions of the Caribou High Use Zone (Figure 10).

Almost 100% of the Chelaslie Priority Restoration Area was affected by mountain pine beetles with the peak of activity in the 2000s (Table 9, Table 10). Spruce bark beetles were detected in 22% of the Chelaslie Priority Restoration Area in the 1980s. Fires were relatively uncommon in the Chelaslie Priority Restoration Area until the 2010s (Table 10). Almost one third of the area has been recently burned, primarily during the 2014 Chelaslie Arm Fire.

2.4.3 Potential future disturbances

Forest harvesting has been planned primarily in the Caribou Low Use Zone.

With climate change, wildfires and insect outbreaks are expected to increase. Although almost one-third of the Chelaslie Priority Restoration Area has been burned in the last 40 years, change in climate conditions will likely increase fire risk in the unburned portion of the area. And, although much of the lodgepole pine forests have already been affected by the MPB epidemic, other forest insects could affect other species, and MPB will play a role once regenerating forests mature.

Table 9. Current extent of disturbances in each seasonal range type in the Chelaslie Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Chelaslie Priority Restoration Area (ha)[1]:	141 508	Total km of linear features:	2085
Nechako Reservoir (ha):	0	Km/km² of linear features:	1.48
Flooded portion of Nechako Reservoir (ha):	*0*		
Lakes >250 ha not part of Nechako Reservoir (ha):	867		
Chelaslie Priority Restoration Area – Land portion (ha)[1]:	140 640		

Type of disturbance[2,3]	**Total Chelaslie Priority Restoration Area[4]**		**High Elevation Summer/Winter[4,5]**		**Low Elevation Winter[4]**		**Low elevation Summer[4]**	
	Area (ha)	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**
Anthropogenic disturbance (includes 500 m buffer)								
Urban	136	0.1	0		136	0.1	0	
Agriculture	0		0		0		0	
Recreation	109	0.1	0		89	0.1	20	47.3
Airstrip	213	0.2	0		201	0.2	12	29.7
Dam	0		0		0		0	
Transmission line	0		0		0		0	
Road/trail	90 606	64.4	8 148	39.9	82 422	68.6	35	85.2
Seismic line	259	0.2	0		259	0.2	0	
Fireguards	8 559	6.1	666	3.3	7 893	6.6	0	
Mineral exploration and development	0		0		0		0	
Forest harvesting (all years)	91 921	65.4	8 295	40.7	83 626	69.6	0	
Forest harvesting (<50 years)	91 921	65.4	8 295	40.7	83 626	69.6	0	
Forest harvesting (<40 years)	91 783	65.3	8 295	40.7	83 488	69.5	0	
All anthropogenic disturbance combined (all years)[7]	99 639	70.8	9 181	45.0	90 419	75.2	39	94.9
All anthropogenic disturbance combined (<50 years)[7]	99 639	70.8	9 181	45.0	90 419	75.2	39	94.9
All anthropogenic disturbance combined (<40 years)[7]	99 615	70.8	9 181	45.0	90 395	75.2	39	94.9
Natural disturbance (no buffer)								
Fire (all years)	44 393	31.6	905	4.4	43 447	36.1	40	97.3
Fire (<50 years)	43 820	31.2	905	4.4	42 875	35.7	40	97.3
Fire (<40 years)	43 820	31.2	905	4.4	42 875	35.7	40	97.3
Mountain pine beetle (<50 years)	139 468	99.2	20 349	99.7	119 077	99.1	41	100.0
Mountain pine beetle (<40 years)	139 468	99.2	20 349	99.7	119 077	99.1	41	100.0
Spruce bark beetle (<50 years)	31 316	22.3	5 726	28.1	25 590	21.3	0	

Spruce bark beetle (<40 years)	31 255	22.2	5 726	28.1	25 529	21.3	0	
Mountain pine beetle + spruce bark beetle (<50 years)	139 539	99.2	20 398	100.0	119 100	99.1	41	100.0
Mountain pine beetle + spruce bark beetle (<40 years)	139 539	99.2	20 398	100.0	119 100	99.1	41	100.0
Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)[8]								
All years[7]	110 475	78.6	9 673	47.4	100 762	83.8	41	99.6
<50 years[7]	110 243	78.4	9 673	47.4	100 530	83.6	41	99.6
<40 years[7]	110 236	78.4	9 673	47.4	100 523	83.6	41	99.6
Total area								
Total area	140 640		20 405		120 194		41	

[1] The Tweedsmuir-Entiako caribou range boundary provided by BC MFLNRORD excludes lakes larger than 250 ha. Lakes less than 250 ha are incorporated into the land portion of the range.

[2] The anthropogenic disturbance footprint includes a 500 m buffer consistent with the 500 m buffer used for anthropogenic disturbance in EC (2014). For individual types of disturbance, the buffer around each individual disturbance polygon is merged with adjoining overlapping buffers to eliminate "double-counting" of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, buffers around each type of disturbance are merged to eliminate double-counting overlapping buffers of different disturbance types.

[3] As a result of overlapping types of disturbance and overlapping buffers for anthropogenic disturbances, some disturbance polygons are identified as more than one type of disturbance (e.g. an "urban" disturbance also overlaps with "road/trail" disturbances). As a result, one polygon could include the footprint of more than one disturbance type and therefore adding up the area of individual types of anthropogenic disturbance will exceed the combined area of "All anthropogenic disturbance combined", which merges all anthropogenic disturbances and their buffers to eliminate overlaps. Similarly, "Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)" also merges the footprints of fire and anthropogenic disturbances to eliminate double-counting overlapping disturbances (e.g. a 120 ha cutblock may have been subsequently consumed in a fire).

[4] Seasonal range linework from BC MFLNRORD.

[5] BC MFLNRORD distinguishes between high elevation winter range and high elevation summer or winter range; this column includes the total of those two categories

[6] "%" = % of the total area (land portion) within the seasonal range type or Chelaslie Priority Restoration Area, that is covered by the disturbance or combined disturbance.

[7] Date of disturbance is available only for forest harvesting (since 1950s), fire (since 1950s), mountain pine beetle (since 1970s) and spruce bark beetle (since 1970s). Date of disturbance is not available for other disturbances; therefore the amount of disturbance <50 years and <40 years is only summarized individually for forest harvesting, fire, mountain pine beetle and spruce bark beetle. The amount of all anthropogenic disturbance combined, and total disturbance (anthropogenic + fire) are also summarized for <50 years and <40 years since all other anthropogenic disturbances are maintained as permanent/semi-permanent features on the landscape where vegetation succession and recovery is not occurring.

[8] Total disturbance is calculated as the combined area of anthropogenic disturbance (including a 500 m buffer) and fire (no buffer), consistent with the calculation of total disturbance in EC (2014). Area disturbed by forest insects is not included in this calculation.

Table 10. Area (hectares) disturbed by forest harvesting, fire and forest insects during each decade since the 1950s in the Chelaslie Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Decade[1]	Forest harvesting (no buffer)	Forest harvesting (+ 500 m buffer)	Fire	Mountain pine beetle	Spruce bark beetle
1950s	0	0	360	N/A	N/A
1960s	0	0	213	N/A	N/A
1970s	653	2 142	0	0	61
1980s	10 413	29 277	137	58	31 006
1990s	9 859	43 440	0	650	0
2000s	15 078	63 943	1 629	139 459	0
2010s[2]	4 581	18 593	42 214	5 645	248
Total combined	40 584	91 921	44 393	139 468	31 316

[1] Values in this table for each decade show the amount of area that was newly disturbed by each type of disturbance during each individual decade and do not include disturbance that occurred in previous decades. "Total combined" disturbance represents the amount of each type of disturbance (dating back to the 1950s) currently present on the landscape and incorporates/merges any overlap of individual types of disturbance among decades.

[2] The "2010s" decade includes cutblocks proposed for 2019 but does not include fires or forest insects in 2019 (however there were no significant fires in the Tweedsmuir-Entiako caribou range in 2019 as of September 1, 2019)

2.5 Vanderhoof Priority Restoration Area

The Vanderhoof Priority Restoration Area consists of the portion of the Tweedsmuir-Entiako caribou range that lies south of the Nechako Reservoir, including all of Entiako Park, and including an overlap with the Itcha-Ilgachuz and Rainbow caribou ranges just east of Tweedsmuir Park and north of the Dean River (Figure 11). The Vanderhoof Priority Restoration Area Subunit primarily consists of the portion of the Tweedsmuir-Entiako winter range that lies south of the 2014 Chelaslie Arm Fire and that includes most of the known caribou use south of Entiako Park. Legal objectives in the Vanderhoof Priority Restoration Area include: seral stage and old forest objectives for biodiversity (BC Ministry of Sustainable Resource Management 2004); a Section 7 order for caribou calving/rutting range, mineral licks and matrix range with a maximum allowable impact on the timber harvesting landbase of 6100 ha (Province of British Columbia 2004b); and Ungulate Winter Range #U-7-012 for caribou (BC Ministry of Environment 2005).

2.5.1 Significance

Significant features of the Vanderhoof Priority Restoration Area for the Tweedsmuir-Entiako caribou population include:

- the core of the Tweedsmuir-Entiako caribou winter range (mostly burned in the 2014 and 2018 fires);
- unburned low elevation winter range; and,
- unburned high elevation winter range.

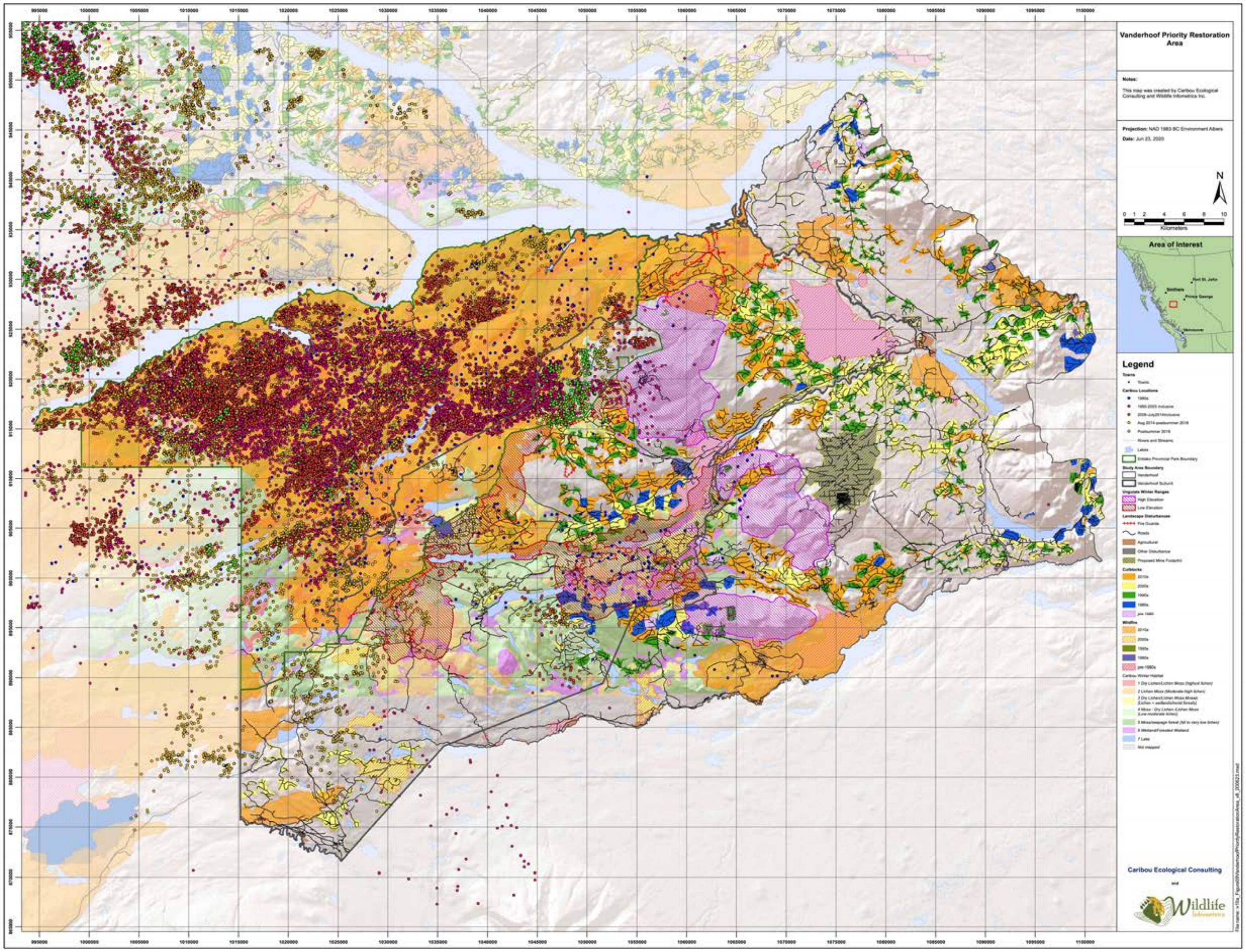


Figure 11. Distribution of disturbances in the Vanderhoof Priority Restoration Area and Subunit in the Tweedsmuir-Entiako caribou range.

Most of the currently unburned low elevation winter range and high elevation winter range in the Vanderhoof Priority Restoration Area is located in the Subunit.

Prior to the 2014 Chelaslie Arm Fire and additional large fires in 2018, the core of the Tweedsmuir-Entiako caribou range was centred in Entiako Park (Cichowski 1989, 2010, 2015, Cichowski and McLean 2005). The park contains the highest value caribou winter habitat in the winter range, and was the most heavily and consistently used part of the winter range when the area was covered by mature and old forests, where lichens are most abundant (Figure 11). Since the 2014 and 2018 fires, which converted mature and old forests to an early successional state where lichens are largely absent, caribou have started relying more on unburned portions of their winter range, especially in the areas that support relatively higher quality winter habitat (BC MFLNRORD, unpubl. data). Although the park still contains habitat with the highest capability for supporting caribou, the post-fire condition renders it currently largely unsuitable for caribou. As a result, caribou have shifted their winter use patterns to areas where mature forests still exist, but where overall caribou winter habitat quality is lower (BC MFLRNROD, unpubl. data).

Since the 2014 and 2018 fires, the unburned portion of the Vanderhoof Priority Restoration Area Subunit has increased in importance as caribou winter range.

2.5.2 Current range condition

The primary anthropogenic disturbances in the Vanderhoof Priority Restoration Area and Subunit are forest harvesting and associated roads/trails (Table 11, Table 12).

Current disturbance due to mineral exploration and development is focussed in the Blackwater Gold project area on Mt. Davidson (outside the Subunit), and in the Fawnie Nose area (in the Subunit). Urban and agriculture disturbances are concentrated around private land near Tatelkuz Lake (outside the Subunit) and Moose Lake (in the Subunit). There are also a number of fireguards that were constructed for and since the 2014 Chelaslie Arm Fire.

Forest harvesting in this area began in the 1970s but most forest harvesting activity was conducted from the 1990s to the 2010s, with the peak of harvesting in the 2000s (Table 13). Consequently, almost all forest harvesting disturbance is less than 40 years old. The current footprint from forest harvesting is concentrated in the low elevation portions of the Vanderhoof Priority Restoration Area east of the Moose Lake area, with additional recent forest harvesting in the southwestern corner (Figure 11).

Almost 100% of the Vanderhoof Priority Restoration Area and Subunit have been affected by mountain pine beetles with the peak of activity in the 2000s (Table 11, Table 12, Table 13). Spruce bark beetle activity has been relatively low (<2%), with most spruce bark beetle attack detected since the 2000s. Some fire activity was present in the 1950s and 1960s, but fires were relatively uncommon from the 1970s to the 1990s then increased in the 2000s and peaked in the 2010s (Table 13). Currently, about one third of the Vanderhoof Priority Restoration Area, and about one quarter of the Subunit have been burned, primarily during the 2014 and 2018 fires.

Table 11. Current extent of disturbances in each seasonal range type in the Vanderhoof Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Vanderhoof Priority Restoration Area (ha)[1]:	403 968	Total km of linear features:	3 829
Nechako Reservoir (ha):	4	Km/km² of linear features:	1.02
Flooded portion of Nechako Reservoir (ha):	*4*		
Lakes >250 ha not part of Nechako Reservoir (ha):	3 590		
Vanderhoof Priority Restoration Area – Land portion (ha)[1]:	376 211		

Type of disturbance[2,3]	**Total Vanderhoof Priority Restoration Area[4]**		**High Elevation Summer/Winter[4,5]**		**Low Elevation Winter[4]**		**Matrix Winter[4]**		**Low Elevation Summer[4]**	
	Area (ha)	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**
Anthropogenic disturbance (includes 500 m buffer)										
Urban	542	0.1	0		542	0.2	0		0	100.0
Agriculture	2 245	0.6	0		1 353	0.6	893	0.7	0	
Recreation	14	<0.1	0		0		0		14	9.6
Airstrip	563	0.1	0		424	0.2	139	0.1	0	
Dam	0		0		0		0		0	
Old District Lot cutlines[7]	1 633	0.4	0		1 633	0.7	0		0	
Transmission line	0		0		0		0		0	
Road/trail	176 241	46.8	7 097	37.7	85 739	37.0	83 392	66.5	13	8.8
Seismic line	7 860	2.1	214	1.1	1 554	0.7	6 093	4.9	0	
Fireguards	6 618	1.8	232	1.2	5 904	2.5	482	0.4	0	
Mineral exploration and development	6 236	1.7	0		111	<0.1	6 125	4.9	0	
Forest harvesting (all years)	135 683	36.1	5 685	30.2	54 554	23.5	75 444	60.1	0	
Forest harvesting (<50 years)	135 683	36.1	5 685	30.2	54 554	23.5	75 444	60.1	0	
Forest harvesting (<40 years)	135 106	35.9	5 685	30.2	54 068	23.3	75 353	60.0	0	
All anthropogenic disturbance combined (all years)[8]	195 363	51.9	7 872	41.9	92 984	40.1	94 493	75.3	14	9.6
All anthropogenic disturbance combined (<50 years)[8]	195 363	51.9	7 872	41.9	92 984	40.1	94 493	75.3	14	9.6

All anthropogenic disturbance combined (<40 years)[8]	195 263	51.9	7 872	41.9	92 886	40.1	94 491	75.3	14	9.6
Natural disturbance (no buffer)										
Fire (all years)	142 188	37.8	1 931	10.3	121 067	52.2	19 055	15.2	135	93.2
Fire (<50 years)	134 098	35.6	1 647	8.8	118 653	51.2	13 663	10.9	135	93.2
Fire (<40 years)	134 047	35.6	1 647	8.8	118 601	51.2	13 663	10.9	135	93.2
Mountain pine beetle (<50 years)	373 352	99.2	18 803	100.0	229 248	98.9	125 156	99.7	145	100.0
Mountain pine beetle (<40 years)	373 352	99.2	18 803	100.0	229 248	98.9	125 156	99.7	145	100.0
Spruce bark beetle (<50 years)	5 007	1.3	0		3 066	1.3	1 940	1.5	0	
Spruce bark beetle (<40 years)	5 007	1.3	0		3 066	1.3	1 940	1.5	0	
Mountain pine beetle + spruce bark beetle (<50 years)	373 360	99.2	18 803	100.0	229 257	98.9	125 156	99.7	145	100.0
Mountain pine beetle + spruce bark beetle (<40 years)	373 360	99.2	18 803	100.0	229 257	98.9	125 156	99.7	145	100.0
Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)[9]										
All years[8]	298 126	79.2	9 392	49.9	186 121	80.3	102 475	81.7	138	95.1
<50 years[8]	294 071	78.2	9 390	49.9	185 659	80.1	98 884	78.8	138	95.1
<40 years[8]	293 962	78.1	9 390	49.9	185 552	80.1	98 883	78.8	138	95.1
Total area										
Total area	376 211		18 803		231 773		125 490		145	

[1] The Tweedsmuir-Entiako caribou range boundary provided by BC MFLNRORD excludes lakes larger than 250 ha. Lakes less than 250 ha are incorporated into the land portion of the range.

[2] The anthropogenic disturbance footprint includes a 500 m buffer consistent with the 500 m buffer used for anthropogenic disturbance in EC (2014). For individual types of disturbance, the buffer around each individual disturbance polygon is merged with adjoining overlapping buffers to eliminate "double-counting" of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, buffers around each type of disturbance are merged to eliminate double-counting overlapping buffers of different disturbance types.

[3] As a result of overlapping types of disturbance and overlapping buffers for anthropogenic disturbances, some disturbance polygons are identified as more than one type of disturbance (e.g. an "urban" disturbance also overlaps with "road/trail" disturbances). As a result, one polygon could include the footprint of more than one disturbance type and therefore adding up the area of individual types of anthropogenic disturbance will exceed the combined area of "All anthropogenic disturbance combined", which merges all anthropogenic disturbances and their buffers to eliminate overlaps. Similarly, "Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)" also merges the

footprints of fire and anthropogenic disturbances to eliminate double-counting overlapping disturbances (e.g. a 120 ha cutblock may have been subsequently consumed in a fire).

[4] Seasonal range linework from BC MFLNRORD.

[5] BC MFLNRORD distinguishes between high elevation winter range and high elevation summer or winter range; this column includes the total of those two categories

[6] "%" = % of the total area (land portion) within the seasonal range type or Vanderhoof Priority Restoration Area, that is covered by the disturbance or combined disturbance.

[7] These linear features appeared to correspond to old District Lot boundaries in Entiako Park. The digital data for these linear features identified them as seismic lines but did not provide any supporting information to confirm

[8] Date of disturbance is available only for forest harvesting (since 1950s), fire (since 1950s), mountain pine beetle (since 1970s) and spruce bark beetle (since 1970s). Date of disturbance is not available for other disturbances; therefore the amount of disturbance <50 years and <40 years is only summarized individually for forest harvesting, fire, mountain pine beetle and spruce bark beetle. The amount of all anthropogenic disturbance combined, and total disturbance (anthropogenic + fire) are also summarized for <50 years and <40 years since all other anthropogenic disturbances are maintained as permanent/semi-permanent features on the landscape where vegetation succession and recovery is not occurring.

[9] Total disturbance is calculated as the combined area of anthropogenic disturbance (including a 500 m buffer) and fire (no buffer), consistent with the calculation of total disturbance in EC (2014). Area disturbed by forest insects is not included in this calculation.

Table 12. Current extent of disturbances in each seasonal range type in the Vanderhoof Priority Restoration Area Subunit in the Tweedsmuir-Entiako caribou range.

Vanderhoof Priority Restoration Area Subunit (ha)[1]:	159 765	Total km of linear features:	1 830
Nechako Reservoir (ha):	6	Km/km² of linear features:	1.22
Flooded portion of Nechako Reservoir (ha):	*6*		
Lakes >250 ha not part of Nechako Reservoir (ha):	1 466		
Vanderhoof Priority Restoration Area – Land portion (ha)[1]:	149 391		

Type of disturbance[2,3]	**Total Vanderhoof Priority Restoration Area[4]**		**High Elevation Summer/Winter[4,5]**		**Low Elevation Winter[4]**		**Matrix Winter[4]**	
	Area (ha)	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**	**Area (ha)**	**%[6]**
Anthropogenic disturbance (includes 500 m buffer)								
Urban	542	0.4	0		542	0.5	0	
Agriculture	589	0.4	0		545	0.5	44	0.2
Recreation	0		0		0		0	
Airstrip	424	0.3	0		424	0.4	0	
Dam	0		0		0		0	
Old District Lot cutlines[7]	0		0		0		0	
Transmission line	0		0		0		0	
Road/trail	84 556	56.6	7 097	40.7	65 349	57.9	12 109	63.4
Seismic line	1 186	0.8	214	1.2	910	0.8	63	0.3
Fireguards	6 556	4.4	232	1.3	5 903	5.2	421	2.2
Mineral exploration and development	104	0.1	0		104	0.1	0	
Forest harvesting (all years)	63 970	42.8	5 685	32.6	45 658	40.4	12 627	66.1
Forest harvesting (<50 years)	63 970	42.8	5 685	32.6	45 658	40.4	12 627	66.1
Forest harvesting (<40 years)	63 503	42.5	5 685	32.6	45 191	40.0	12 627	66.1
All anthropogenic disturbance combined (all years)[8]	90 991	60.9	7 872	45.2	69 862	61.9	13 257	69.4
All anthropogenic disturbance combined (<50 years)[8]	90 991	60.9	7 872	45.2	69 862	61.9	13 257	69.4
All anthropogenic disturbance combined (<40 years)[8]	90 893	60.8	7 872	45.2	69 764	61.8	13 257	69.4
Natural disturbance (no buffer)								
Fire (all years)	36 391	24.4	667	3.8	30 432	27.0	5 292	27.7
Fire (<50 years)	29 169	19.5	383	2.2	28 450	25.2	336	1.8
Fire (<40 years)	29 118	19.5	383	2.2	28 399	25.2	336	1.8
Mountain pine beetle (<50 years)	148 492	99.4	17 419	100.0	111 993	99.2	19 079	99.9
Mountain pine beetle (<40 years)	148 492	99.4	17 419	100.0	111 993	99.2	19 079	99.9

Spruce bark beetle (<50 years)	2 105	1.4	0		2 065	1.8	41	0.2
Spruce bark beetle (<40 years)	2 105	1.4	0		2 065	1.8	41	0.2
Mountain pine beetle + spruce bark beetle (<50 years)	148 500	99.4	17 419	100.0	112 002	99.2	19 079	99.9
Mountain pine beetle + spruce bark beetle (<40 years)	148 500	99.4	17 419	100.0	112 002	99.2	19 079	99.9
Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)[9]								
All years[8]	107 684	72.1	8 128	46.7	82 890	73.4	16 666	87.3
<50 years[8]	103 831	69.5	8 126	46.6	82 445	73.0	13 260	69.5
<40 years[8]	103 724	69.4	8 126	46.6	82 338	72.9	13 260	69.5
Total area								
Total area	149 391		17 419		112 881		19 091	

[1] The Tweedsmuir-Entiako caribou range boundary provided by BC MFLNRORD excludes lakes larger than 250 ha. Lakes less than 250 ha are incorporated into the land portion of the range.

[2] The anthropogenic disturbance footprint includes a 500 m buffer consistent with the 500 m buffer used for anthropogenic disturbance in EC (2014). For individual types of disturbance, the buffer around each individual disturbance polygon is merged with adjoining overlapping buffers to eliminate “double-counting” of areas within overlapping buffers. Similarly, for all anthropogenic disturbances combined, buffers around each type of disturbance are merged to eliminate double-counting overlapping buffers of different disturbance types.

[3] As a result of overlapping types of disturbance and overlapping buffers for anthropogenic disturbances, some disturbance polygons are identified as more than one type of disturbance (e.g. an “urban” disturbance also overlaps with “road/trail” disturbances). As a result, one polygon could include the footprint of more than one disturbance type and therefore adding up the area of individual types of anthropogenic disturbance will exceed the combined area of “All anthropogenic disturbance combined”, which merges all anthropogenic disturbances and their buffers to eliminate overlaps. Similarly, “Total disturbance (anthropogenic with 500 m buffer + fire with no buffer)” also merges the footprints of fire and anthropogenic disturbances to eliminate double-counting overlapping disturbances (e.g. a 120 ha cutblock may have been subsequently consumed in a fire).

[4] Seasonal range linework from BC MFLNRORD.

[5] BC MFLNRORD distinguishes between high elevation winter range and high elevation summer or winter range; this column includes the total of those two categories

[6] “%” = % of the total area (land portion) within the seasonal range type or Vanderhoof Priority Restoration Area, that is covered by the disturbance or combined disturbance.

[7] These linear features appeared to correspond to old District Lot boundaries in Entiako Park. The digital data for these linear features identified them as seismic lines but did not provide any supporting information to confirm

[8] Date of disturbance is available only for forest harvesting (since 1950s), fire (since 1950s), mountain pine beetle (since 1970s) and spruce bark beetle (since 1970s). Date of disturbance is not available for other disturbances; therefore the amount of disturbance <50 years and <40 years is only summarized individually for forest harvesting, fire, mountain pine beetle and spruce bark beetle. The amount of all anthropogenic disturbance combined, and total disturbance (anthropogenic + fire) are also summarized for <50 years and <40 years since all other anthropogenic disturbances are maintained as permanent/semi-permanent features on the landscape where vegetation succession and recovery is not occurring.

[9] Total disturbance is calculated as the combined area of anthropogenic disturbance (including a 500 m buffer) and fire (no buffer), consistent with the calculation of total disturbance in EC (2014). Area disturbed by forest insects is not included in this calculation.

Table 13. Area (hectares) disturbed by forest harvesting, fire and forest insects during each decade since the 1950s in the Vanderhoof Priority Restoration Area and Subunit in the Tweedsmuir-Entiako caribou range.

Decade[1]	Forest harvesting (no buffer)	Forest harvesting (+ 500 m buffer)	Fire	Mountain pine beetle	Spruce bark beetle
Vanderhoof Priority Restoration Area					
1950s	0	0	2 744	N/A	N/A
1960s	0	0	7 523	N/A	N/A
1970s	1 225	5 168	51	0	0
1980s	4 345	14 489	884	134	980
1990s	12 288	53 461	0	9 228	0
2000s	20 921	84 791	3 083	373 347	1 090
2010s[2]	19 784	63 390	131 675	1 158	2 952
Total combined	58 563	135 683	142 188	373 352	5 007
Vanderhoof Priority Restoration Area Subunit					
1950s	0	0	2 286	N/A	N/A
1960s	0	0	4 947	N/A	N/A
1970s	576	2 628	51	0	0
1980s	2 259	7 607	579	5	0
1990s	5 224	22 796	0	1 861	0
2000s	10 672	44 009	1 685	148 489	0
2010s[2]	8 694	27 013	27 493	387	2 105
Total combined	27 424	63 760	36 391	148 492	2 105

[1] Values in this table for each decade show the amount of area that was newly disturbed by each type of disturbance during each individual decade and do not include disturbance that occurred in previous decades. ”Total combined” disturbance represents the amount of each type of disturbance (dating back to the 1950s) currently present on the landscape and incorporates/merges any overlap of individual types of disturbance among decades.

[2] The “2010s” decade includes cutblocks proposed for 2019 but does not include fires or forest insects in 2019 (however there were no significant fires in the Tweedsmuir-Entiako caribou range in 2019 as of September 1, 2019)

2.5.3 Potential future disturbances

Canadian Forest Products Ltd. has cutblocks planned in the Vanderhoof Priority Restoration Area in the next 20 years.

The Blackwater Gold project on Mt. Davidson received an Environmental Assessment Certificate in June 2019 to proceed with the project. Most of the Vanderhoof Priority Restoration Area outside of Entiako Park is covered by mineral claims, which could potentially lead to additional mineral exploration activities and mine developments.

With climate change, wildfires and insect outbreaks are expected to increase. Although almost 20% of the Vanderhoof Priority Restoration Area has been burned in the last 40 years, change in climate conditions will likely increase fire risk in the unburned portion of the area. And, although much of the lodgepole pine forests have already been affected by the MPB epidemic, other forest insects could affect other species, and MPB will play a role once regenerating forests mature.

3 TACTICAL RESTORATION PLAN

3.1 Scope

This tactical restoration plan focuses on anthropogenic disturbances within the three Priority Restoration Areas identified by BC MFLNRORD (see Figure 8). Although additional anthropogenic disturbances are also concentrated on the north side of the Nechako Reservoir and scattered throughout other portions of the range, most of those disturbances are located in matrix range and are a lower priority for restoration.

3.2 First Nations Engagement

BC MFLNRORD has been engaging with First Nations on the restoration of the Tweedsmuir-Entiako caribou range. Opportunities for collaboration between BC MFLNRORD and First Nations through the planning, implementation and monitoring of restoration activities are ongoing. As part of this project, we engaged with First Nations to incorporate knowledge and interests, develop criteria, and coordinate priority areas for restoration activities within the Tweedsmuir-Entiako caribou range.

We contacted First Nations with traditional territories that overlapped the Tweedsmuir-Entiako caribou range: Ulkatcho First Nation (Southern Dakelh Nation Alliance; SDNA), Lhoosk'uz Dené First Nation (SDNA), Cheslatta Carrier Nation, Saik'uz First Nation (Carrier Sekani Tribal Council), Nee Tahi Buhn Indian Band, Skin Tyee First Nation, and Office of the Wet'suwet'en. Meetings were held with Nee Tahi Buhn Indian Band on February 22, 2019, SDNA on February 26, 2019, and Cheslatta Carrier Nation on June 6, 2019. Office of Wet'suwet'en and Saik'uz First Nation provided input by email.

The Whitesail and Chelaslie Priority Restoration Areas were areas of interest for the Nee Tahi Buhn. The Whitesail area contains a least two old cabins where people lived in the past, and prior to the flooding the lake system was used for travel. Concerns included ensuring access and use of culturally important sites and the need for shoreline cleanup. Nee Tahi Buhn expressed an interest in collaborating on restoration and monitoring activities.

Areas of interest for SDNA included the Vanderhoof and Chelaslie Priority Restoration Areas. The Tweedsmuir-Entiako caribou range is in the heart of Ulkatcho traditional territory and areas with high cultural values include the Tanya Lakes area and Gatcho Lake. Concerns raised included ensuring that: community members are not alienated from the land; culturally sensitive sites are considered; planning results in implementation of recommended actions; restoration activities are planned and conducted collaboratively; effectiveness monitoring is conducted; restored areas are protected so that they continue benefitting caribou into the long term; and, other tools such as predator management are considered. Suggested selection criteria included caribou habitat value, and potential for creating more contiguous areas of secured/protected habitat.

Areas of interest for the Cheslatta Carrier Nation included the Whitesail and Chelaslie Priority Restoration Areas. Concerns included: impact of caribou conservation on economic development, which has been exacerbated by the recent large fires; impact of the Nechako Reservoir on caribou; the need for shoreline cleanup especially for calving islands; maintaining roads for potential future fire fighting efforts and creating a fireguard in the Chelaslie Priority Restoration Area; maintaining roads for forest harvesting; and maintaining access for berry picking along Whitesail Lake. The Cheslatta Carrier Nation are interested in conducting restoration and monitoring activities.

Saik'uz First Nation is supportive of restoration efforts for caribou in its territory and is concerned about proposed new disturbances within the caribou range.

The Office of the Wet'suwet'en traditional territory overlaps with the Whitesail Priority Restoration Area. Concerns expressed included: importance of protecting habitat in addition to restoring habitat; and maintaining adequate shoreline access to calving islands.

3.3 Restoring caribou range

Restoration of caribou range is a relatively new discipline. Most available information on restoring caribou range is limited to restoration activities, studies and discussion papers on boreal caribou (Neufeld 2006, Ray 2014, Silvacom 2015, GA 2015, 2018a); however, restoration planning and activities have increased recently on northern ecotype caribou ranges (Woods et al. 2018, GA 2018b, Woods 2019). Although there are some differences between range composition (topography, habitats), habitat use, and dominant anthropogenic disturbances on boreal caribou ranges compared to the Tweedsmuir-Entiako caribou range, relevant concepts from literature on restoration for boreal caribou ranges are discussed below.

3.3.1 Restoration targets

3.3.1.1 Total disturbance

Currently, direction available on total disturbance on caribou ranges is based on levels of undisturbed range used in the identification of critical habitat in the recovery strategy for the southern mountain caribou population (EC 2014). This can be used to guide how much restoration and habitat recovery is required within the Tweedsmuir-Entiako caribou range. The Tweedsmuir-Entiako caribou population belongs to the Northern Group of southern mountain caribou where the intent is for minimal to no disturbance in low elevation summer range and in high elevation winter and/or summer range, and a maximum of 35% disturbance in low elevation winter range and matrix (Table 14).

The 35% disturbance threshold for low elevation winter range + Type 1 matrix range is based on a disturbance analysis of boreal caribou (EC 2014, ECCC 2020). Although a similar analysis for southern mountain caribou is not available, the 35% disturbance threshold was chosen as a reference level because fire plays a significant role in disturbance in low elevation winter ranges and adjacent matrix ranges for Northern

Group caribou, similar to the role of fire (and consequently natural disturbance dynamics) in boreal caribou ranges (EC 2014).

Table 14. Maximum disturbance thresholds for critical habitat categories for the Northern Group of southern mountain caribou (from EC 2014).

Critical habitat category	**Maximum disturbance threshold**[1]	**Tweedsmuir-Entiako caribou range % disturbance (<40 years)**
High elevation winter and/or summer range	Minimal (i.e. close to 0%)	18%
Low elevation summer range	Minimal (i.e. close to 0%)	38%
Low elevation winter range + Type 1 matrix range[2]	35%	76%[3]

[1] Disturbance = anthropogenic disturbance (including a 500 m buffer) + fire (no buffer)
[2] Type 1 matrix range = matrix range within the annual range (from EC 2014)
[3] Includes only the "winter" portion of matrix range; total disturbance on the low elevation winter range only is 41%

The Northern Group caribou in west-central BC are unique among southern mountain caribou in that they use low elevation summer ranges in addition to high elevation summer ranges. In the Tweedsmuir-Entiako caribou range, the western portion of the summer range includes the eastern portion of the Coast Mountains, where fire plays a relatively minor role in habitat disturbance. Therefore, for the Tweedsmuir-Entiako caribou range, we have included only the "winter" matrix range (the portion of the matrix range associated with the winter range) in the calculation of disturbance on the Low elevation winter range +Type 1 matrix range.

Disturbance on the Tweedsmuir-Entiako caribou range currently exceeds the maximum disturbance thresholds identified for critical habitat for southern mountain caribou (Table 14). Most of the disturbance in low elevation summer range is located in the Whitesail Priority Restoration Area. Most of the disturbance in the high elevation summer/winter range is located in the Vanderhoof Priority Restoration Area and Subunit. Outside of Entiako Park, low elevation winter range is located almost entirely within the Chelaslie and Vanderhoof Priority Restoration Areas; consequently, almost all disturbance in low elevation winter range is located within those two areas.

Although we calculated levels of disturbance dating back to the 1950s (past 70 years) and for the past 40 years and 50 years, 96% of fire disturbance and almost 100% of anthropogenic disturbance has occurred within the last 40 years so the differences between the three time periods (<70 years, <50 years, <40 years) are negligible.

ECCC's method for mapping anthropogenic disturbances was based on disturbances that could be detected using 1:50,000 scale Landsat satellite imagery (from 2008 to 2010) and using ancillary data to aid in categorizing the type of disturbance (EC 2011). Fire disturbance was mapped using provincial datasets and a limit of 40 years was used because availability of fire data for boreal caribou ranges varied among provinces and was only available for a maximum of 40 years in some provinces (EC 2011). Initial disturbance analyses (EC 2008) used a maximum of 50 years (consistent with methods used by Sorensen et al. 2008), using the Canadian Forest Service's Canadian National Fire Database. ECCC's methods differ slightly from the methods used for anthropogenic disturbance in the Tweedsmuir-Entiako caribou range in that we used spatial data layers compiled by BC MFLNRORD and augmented them with additional spatial datasets and digitizing of missing disturbances as required, rather than solely using satellite imagery to identify and digitize visible anthropogenic disturbances. This could potentially result in differences between the two methods in determining the amount of anthropogenic disturbance on the landscape. However, because roads/trails accounted for a significant portion of the anthropogenic disturbance footprint in the Tweedsmuir-Entiako caribou range, we used satellite imagery to remove linework for roads/trails that were not present on the landscape (as of September 1, 2019) in otherwise unroaded areas, and employed a method to consolidate spatial layers of roads (see Section 1.3.2.4) to reduce potential errors in duplicating road/trail disturbances from multiple spatial layers. Also, because most of the anthropogenic disturbances in the Tweedsmuir-Entiako caribou range were roads/trails and cutblocks that were less than 40 years old, those disturbances would still be visible on 1:50 000 scale satellite imagery and therefore the disturbance footprint derived from both methods should be similar.

Regardless of potential differences in methods used for representing the anthropogenic disturbance footprint, the level of disturbance within each range category exceeds the disturbance thresholds in EC (2014) indicating that restoration is required. In addition, disturbance calculations did not include insect outbreaks so the recent MPB outbreak will result in additional impacts on caribou.

3.3.1.2 Density of linear features

Another potential metric for assessing restoration levels required is based on density of linear features (km/km^2). For boreal caribou in BC the draft recovery implementation plan provided a maximum linear feature density target (excluding low impact seismic) of 2 km/km^2 across a boreal caribou range (BC MOE and MFLNRO 2017). However, boreal caribou ranges generally consist of mostly low elevation flat to gently rolling terrain, and therefore linear feature density targets for boreal caribou may not be relevant for use in the Tweedsmuir-Entiako caribou range, which consists of much more diverse terrain.

Linear feature thresholds were also developed for caribou in the Muskwa-Kechika area in northeastern BC (Salmo Consulting and Diversified Environmental Services 2003), which includes mountainous and low-lying terrain similar to the Tweedsmuir-Entiako caribou range. They provide a tiered approach to linear feature thresholds with target densities of 1.8 km/km^2 in enhanced resource development areas, 1.5 km/km^2 in general resource management areas and 1.2 km/km^2 in special resource management areas, and cautionary densities of 1.5 km/km^2 in enhanced resource development areas, 1.2 km/km^2 in general resource management areas and 1 km/km^2 in special resource management areas. Target thresholds represent the point at which restrictive protections measures would be initiated (Salmo Consulting and Diversified Environmental Services 2003), while cautionary thresholds reflect the point at which monitoring or enhanced protection measures would be implemented to slow the rate of change and determine actual ecological response (Salmo Consulting and Diversified Environmental Services 2003). With the tiered approach, targets can be applied to portions of the range, such as in Priority Restoration Areas.

The intent of the Priority Restoration Areas may be best represented by the special resource management area category since caribou are a high priority for management. The current linear features densities in the Chelaslie Priority Restoration Area (1.42 km/km^2) and Whitesail Priority Restoration Area (1.46 km/km^2) exceed both the target and cautionary thresholds developed by Salmo Consulting et al. (2003) for linear features for special resource management areas. The density of linear features in the Vanderhoof Priority Restoration Area (0.98 km/km^2) is almost at the cautionary density. However, 30% of the Vanderhoof Priority Restoration Area lies within Entiako Park. The density of linear features in the Vanderhoof subunit, which largely excludes Entiako Park (1.18 km/km^2) exceeds the cautionary threshold and is almost at the target density.

3.3.1.3 Spatial configuration of habitat alteration

In addition to total habitat alteration in ranges/seasonal ranges and density of linear features, the spatial configuration of habitat alteration is also important to consider. For boreal caribou in NWT, Nagy (2011) defined secure habitat as unburned areas >400 m from anthropogenic linear features. Population growth rates were higher in areas where caribou had access to large patches (>500 km^2) of secure, unburned habitat (Nagy 2011). Although currently there are no guidelines or targets for spatial configuration of undisturbed habitat for Northern Mountain DU caribou contiguous areas of undisturbed habitat are recognized as being important, and selection criteria for restoration proposals for the Caribou Habitat Restoration Fund include areas that are adjacent to intact habitat (see Section 3.5.2).

3.3.2 Restoration categories and objectives

The cause of declines of forest-dwelling caribou in Canada has been attributed to industrial activities resulting in increased abundance of other prey species such as moose and deer, leading to increased predation on caribou (Festa-Bianchet et al. 2011). Linear features associated with industrial activities also result in increased travel rates and hunting efficiency of wolves (James 1999, James and Stuart-Smith 2000, Dickie et al. 2016) and facilitate access for humans. Repeated human use of linear features can compromise vegetation recovery and result in soil compaction (Lee and Boutin 2006). Forest harvesting, through removal of the forest canopy, also affects important characteristics of caribou habitat including canopy interception for snow, and terrestrial and arboreal lichen abundance and availability. In the Tweedsmuir-Entiako caribou range, the Nechako Reservoir has also resulted in a legacy of coarse woody debris along shorelines because the forests were not harvested prior to the flooding, and the mountain pine beetle epidemic and large wildfires in 2014 and 2018 have resulted in concentrations of blowdown in some areas.

Key considerations for caribou for range/habitat restoration are:

- predator travel/hunting efficiency;
- alternate prey habitat;
- human access; and,
- characteristics of preferred caribou habitat.

Restoration of caribou range can be defined in terms of habitat function and habitat structure/composition (Ray 2014). Restoration of habitat function for caribou (functional restoration) involves reducing presence and mobility of predators, alternate prey, and humans, while restoration of habitat structure/composition (ecological restoration) involves restoring structural attributes of preferred caribou habitat, including mature forest condition, availability of terrestrial and arboreal lichens, and unobstructed movement routes (Ray 2014).

The objectives for restoration of habitat function focus on restoring disturbances that are not consistent with natural ecosystem disturbance dynamics (Table 15). The low elevation portion of the Tweedsmuir-Entiako caribou range that lies east of the Coast Mountains experiences frequent stand-initiating fires (approximately every 100-125 years), which results in a mosaic of mature, early and mid-seral stands (BC MOF and BC Environment 1995). Consequently, the objective addressing moose habitat in that portion of the range focuses on the amount of early seral habitat over and above what is typically present on the landscape. Similarly, because linear features such as roads are not typically a component of undisturbed caribou range, all linear features are potential candidates for restoration.

Table 15. Restoration objectives for caribou in the Tweedsmuir-Entiako caribou range.

Restoration category	**Restoration focus**	**Restoration objective**	**Disturbances targeted for restoration**
Habitat function (Functional restoration)	• Moose habitat	• Reduce increased amount of early seral habitat resulting from temporal disturbances	• Forest harvesting • Fire • Linear features
	• Predator travel	• Reduce increased predator travel/efficiency resulting from linear features associated with anthropogenic disturbance	• Linear features
	• Human access	• Reduce/eliminate human access on recovering linear features	• Linear features
Habitat structure/ composition (Ecological restoration)	• Caribou habitat	• Restore preferred caribou habitat conditions (e.g. mature forest conditions, abundant lichens, unobstructed travel routes,	• Forest harvesting • Fire/MPB • Linear features • Reservoir

		minimum undisturbed patch size)	

3.3.3 Restoration priorities

Priorities for restoration need to be considered at the landscape (multiple caribou ranges), caribou range, and site levels (Ray 2014, Silvacom 2015, GA 2018a). For the Tweedsmuir-Entiako caribou range, BC MFLNRORD has already identified three Priority Restoration Areas. In this tactical restoration plan, we address area-based and site level priorities within the three priority restoration areas.

Although industrial activity on caribou ranges is the ultimate cause of caribou declines, predation is the proximate cause (Festa-Bianchet et al. 2011). For the Tweedsmuir-Entiako caribou population, both wolf and bear predation are important mortality factors (Cichowski and MacLean 2005, Cichowski 2010, DeMars and Serrouya 2018). Consequently, in the short term, priorities for restoration at the site level should focus on habitat function to reduce predation risk.

Reducing predator travel rates/hunting efficiency by restoring linear features is one component of caribou habitat restoration for reducing predation risk. To fully address predation risk, both predator efficiency and predator numbers need to be considered (Ray 2014). Because predator numbers depend on numbers of their primary prey, an increase in the amount of early seral habitat available for moose could lead to an increase in predator numbers. Consequently, restoring habitat to conditions that are not favoured by moose, is another important component of restoration to reduce predation risk (Ray 2014). In BC, free-to-grow standards for reforestation of forest harvesting cutblocks already play a role in facilitating conifer regeneration and minimizing growth of shrub species that are preferred moose forage.

Although short-term priorities may need to focus on restoration of habitat function to address predation risk to caribou, ultimately, restoration of habitat structure/composition to a preferred caribou habitat state (mature forest canopy, abundant lichens, unobstructed travel routes) must also be achieved (Ray 2014).

For the three priority restoration areas in the Tweedsmuir-Entiako caribou range, the order of priority for restoration activities is:

1. To reduce predator travel/hunting efficiency and human access;
2. To reduce amount of moose habitat that exceeds natural levels; and,
3. To re-establish conditions that are characteristic of preferred caribou habitat.

3.3.4 Restoration treatment options

In boreal caribou ranges where the priority is to restore anthropogenic linear features, recommended restoration treatment options include mechanical site preparation (mounding, ripping), spreading (or removal) of woody materials, tree felling/tree bending (pushing trees over from the adjacent forest across linear features), tree/shrub planting, and installing fences (GA 2015). For the Tweedsmuir-Entiako caribou range, restoration treatment options are summarized in Table 16 and address linear features, forest harvesting, fire, MPB, and woody debris resulting from the Nechako Reservoir. In addition to the five recommended treatments for boreal caribou, treatment options for

Table 16. Potential restoration treatment options for the Tweedsmuir-Entiako caribou range.

			Treatment options							
			Immediate results[1]						**Delayed results[2]**	
Restoration category	**Restoration focus**	**Disturbances targeted**	**Mechanical site prep (mounding/ripping)**	**Spreading of woody debris**	**Tree felling/tree bending**	**Fences**	**Obstruction removal (mechanical)**	**Obstruction removal (fire)**	**Tree/shrub planting**	**Lichen seeding**
Habitat Function	Predator travel	Linear	X	X	X	X			X	
	Human access	Linear	X	X	X	X			X	
	Moose habitat	Forest harvest							X	
		Fire							X	
		Linear	X						X	
Habitat structure/ composition	Caribou habitat	Forest harvest							X	X
		Fire/MPB					X	X	X	X
		Linear	X						X	X
		Reservoir					X	X		

[1] Immediate results = restoration objectives are achieved immediately as a result of treatment

[2] Delayed results = restoration objectives are achieved some time in the future following treatment (e.g. for addressing predator travel, planted trees achieve restoration objectives only when they have grown enough to obstruct sight-lines and reduce travel rates)

the Tweedsmuir-Entiako caribou range also include removal of obstructions, and lichen seeding.

Mechanical site preparation (mounding, ripping), spreading of woody materials, tree felling/tree bending and installing fences are treatments that can be used to immediately reduce ease of travel and line-of-sight distances on linear features (GA 2015). For restricting human access, mechanical site preparation and spreading of woody debris may be less effective at restricting winter activities than summer activities, and longer lengths of linear features treated with spreading of woody debris, especially at access points, are stronger deterrents for human access than shorter lengths (GA 2015). Mounding is also beneficial for creating planting sites for tree seedlings in wetter habitats (GA 2015). Mechanical site preparation and coarse woody debris can also be used to construct earthen berms to limit line-of-sight. In the Tweedsmuir-Entiako caribou range, mechanical site preparation can also be used for preparing roadbeds (the dominant linear feature) for planting conifers, which in turn will accelerate the establishment of conifers on the site to help limit the growth of preferred moose forage species in the short to mid term, and to achieve structure/composition of preferred caribou habitat in the long term. For tree felling/tree bending, felling/bending trees partially across the linear feature is recommended with 2 or more trees on each side of the linear feature and with treatment locations occurring every 20 m (GA 2015). Spreading of woody debris and tree felling/tree bending increases fuel loading and could compromise fire management objectives (GA 2015). However, BC MFLNRORD guidelines tolerate higher levels of woody debris in areas distant from communities or populated areas and consequently, most of the Tweedsmuir-Entiako caribou range is located in the low risk zone as it relates to hazard abatement (BC MFLNRO 2012). Wooden fences could be installed where access control and line-of-sight breaks are required (GA 2015). Although geotextile or other types of fencing could also be installed (GA 2015), Bohm et al. (2015) found that snow fences constructed in the summer were often damaged and buried by snow and were ineffective in winter months.

In contrast to linear features, which improve travel/access and line-of-sight through caribou habitat, some disturbances can result in excessive coarse woody debris that could obstruct caribou access to important caribou habitat and/or obstruct caribou movement, especially in areas that are used as travel routes. Blowdown resulting from large-scale natural disturbances such as the MPB epidemic and the 2014 and 2018 fires have the potential for obstructing caribou travel. In addition, floating woody debris that has accumulated on shorelines of the Nechako Reservoir could also affect caribou that migrate to summer ranges beyond the reservoir, and that use the islands in the Whitesail Lake portion of the reservoir during calving, summer or fall. Two treatment options for immediately reducing obstructions for caribou include mechanical removal or fire (Table 16). A pilot project is currently being conducted to mechanically remove woody debris from some islands in Whitesail Lake (see Section 4.1).

Tree/shrub planting can be used to address all components of caribou range and all disturbances except excessive debris accumulation (Table 16). Conifer planting accelerates the establishment of conifers on the site, which will: 1) reduce ease of travel and line-of-sight distances, 2) help limit the growth of preferred moose forage species, and 3) achieve structure/composition of preferred caribou habitat in a shorter period of time. For shrubs, only shrubs such as alder (*Alnus* sp.) that are not preferred forage for moose should be used. Unlike the other treatment options already discussed, the benefits of tree/shrub planting will not necessarily be realized immediately following treatment. Trees/shrubs will have to grow before restoration objectives are achieved. However, planting groups of trees 1.2 to 1.5 meters in height in a staggered design can greatly reduce the amount of time trees will need to grow to achieve restoration objectives. Dickie et al. (2017) found that on boreal caribou ranges, the greatest reduction in wolf travel speeds on linear features (primarily seismic lines) occurred once vegetation was 0.5-1.0 m in height, and that travel speeds slowed to travel speeds in undisturbed forest when at least 30% of a linear feature was more than 4.1 m in height. They suggest that a vegetation height of <0.5 m is a reasonable measure for prioritizing restoration of linear features, but should not be used as a threshold for when habitat is recovered sufficiently to stabilize caribou populations or when linear features no longer contribute to elevated rates of predation (Dickie et al. 2017). Similarly, Finnegan et al. (2018) recommended that seismic lines with a vegetation height of <1 m should be prioritized for restoration. Neither Dickie et al. (2017) nor Finnegan et al. (2018) provide any recommendations on vegetation density. Trees/shrub planting treatment may be compromised if human access (ATVs, snowmachines, other mechanized vehicles) retards tree/shrub growth before growth is sufficient to impede travel.

In the Tweedsmuir-Entiako caribou range, over 450 000 hectares were burned in fires in 2014 and 2018, including most of the core of the winter range. Although where predators such as wolves are present, caribou numbers are limited by predation and not by food resources, the extent of these fires has resulted in caribou concentrating in unburned portions of their winter range (BC MFLNRORD, unpubl. data), which could lead to localized reductions in forage abundance. Lichen seeding is a treatment option for accelerating re-establishment of terrestrial lichens in burned areas of the winter range. Although operational terrestrial lichen re-seeding over the entire burned area is likely not practical, re-seeding terrestrial lichens in patches throughout the burned portion of the winter range could create pockets of source lichen that would help accelerate re-establishment of terrestrial lichens across the burns. Results from a lichen re-seeding trial in the 2014 Chelaslie Arm Fire in the Tweedsmuir-Entiako caribou winter range suggest that by one year following treatment, transplanted lichens survived the transplant and there appeared to be no measurable difference between survival of lichens transplanted by hand or from a helicopter (Ronalds 2019). Similar to tree/shrub planting, the benefits of terrestrial lichen re-seeding will not be realized immediately after treatment, and possibly may take decades before the treatments achieve the objective of restoring the terrestrial lichen component of caribou habitat.

In a review of boreal caribou habitat restoration projects in Alberta, Pyper et al. (2014) characterized mounding, ripping, rollback and coarse woody material, tree felling and planting as “working” with respect to restoration of habitat structure/composition.

For the Tweedsmuir-Entiako caribou range, a combination of treatments will need to be conducted to achieve restoration objectives. In addition to physical restoration treatments, policy or regulatory restrictions could also aid in management of human access.

3.3.5 When is caribou habitat considered restored?

Currently, there are no clear definitions of when caribou habitat can be considered restored. All three restoration priorities (reducing predator travel/efficiency and human access, reducing increased moose habitat, restoring attributes of caribou preferred habitat) need to be addressed for caribou habitat to be fully restored (Ray 2014). Therefore, it is important to distinguish between restoration priorities/objectives and the timing of effects of restoration activities when defining whether caribou habitat is considered restored.

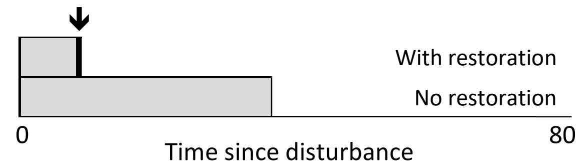
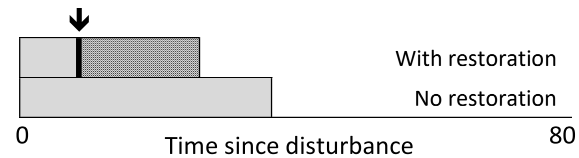
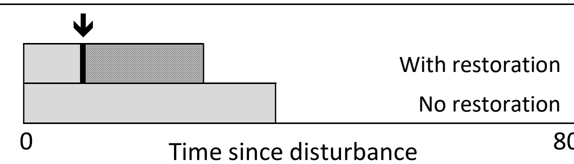
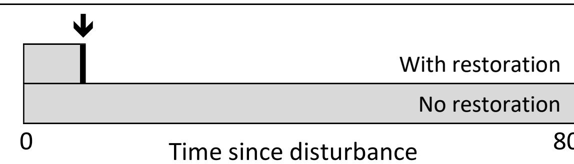
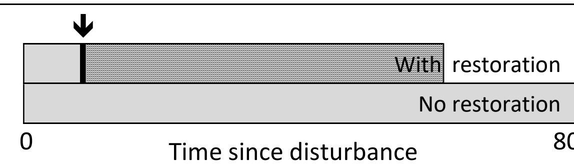
Without any restoration efforts, reduction in predator travel/human access along linear features could potentially occur within 10-20 years; however, a return to a state of preferred caribou habitat state (mature forest canopy, abundant lichens) is expected to take much longer (e.g., 50-80 years; Table 17). Effective functional restoration could potentially have some immediate effects, but restoration with delayed effects, although better than no restoration at all, may still take a long time to be effective (Table 17). However, for declining caribou populations, reducing the time required to achieve restoration even by 5-10 years could be significant.

For boreal caribou and southern mountain caribou, identification of critical habitat includes disturbance thresholds based on anthropogenic disturbances that were visible on satellite imagery and fires that were <40 years in age (EC 2012, 2014). A maximum of 40 years was used for fire age because at the time the analyses were conducted, provincial fire datasets were only consistently reliable for that period of time (EC 2011, see Section 3.3.1) and not necessarily because caribou habitat was considered restored 40 years post-fire. Forty years is also considered when habitat no longer provides characteristics that are favoured by moose (A. Roberts, pers. comm. 2019). However, a single age threshold does not take into account different vegetation responses due to differences in site conditions (e.g. productive vs. unproductive), which could result in varying degrees of habitat quality for caribou depending on site, and does not consider habitat quality as a function of age after the disturbance has reached the age threshold (e.g. canopy characteristics and lichen abundance could vary substantially between stands that are 45 years old and 80 years old). An age threshold also does not consider the spatial configuration of undisturbed, restored and disturbed areas (see Section 3.3.1.3).

For predator travel, Dickie et al. (2017) found that the greatest reduction in wolf travel speeds occurred when vegetation on linear features was 0.5-1.0 m in height, but cautioned against using 0.5 m as a threshold for when a habitat is considered restored. Following fire disturbance, recovery of preferred caribou terrestrial forage lichens could take 50-80 years (Ahti 1977). For all three restoration priorities/objectives, time required for restoration will also vary with ecological conditions at a site.

Defining when habitat is considered restored is important for habitat supply modelling and predicting impacts of future disturbances. Once habitat is considered restored, it is recruited back into the undisturbed range calculation. Therefore, how restoration is defined will affect when disturbed habitat is considered recruited as undisturbed range. Undisturbed range calculations should be reassessed as thresholds and characteristics of restored habitat are better defined.

Table 17. Relative time since disturbance required to achieve restoration objectives.

Priority	Restoration objectives	Approximate time since disturbance to achieve restoration without restoration activities	Restoration activity	Relative time since disturbance required to achieve restoration with restoration activities (top) and without restoration activities (bottom)[1]
1	• Reduce increased predator travel/efficiency resulting from linear features associated with anthropogenic disturbance • Reduce/eliminate human access on recovering linear features	Short – mid term (0-40+ years)	• Mechanical site prep • Spreading of woody debris • Tree felling/tree bending • Fences	
			• Tree/shrub planting	
2	• Reduce increased amount of early seral habitat resulting from temporal disturbances	Short – mid term (0-40 years)	• Tree/shrub planting (could include mechanical site prep on roads)	
3	• Restore preferred caribou habitat conditions (e.g. mature forest canopy, terrestrial lichens, arboreal lichens, unobstructed travel routes)	Mid – long term (50- 80 years)	• Removal of obstructions (mechanical, fire)	
			• Tree/shrub planting • Lichen seeding	

[1] Arrow and thick line indicate timing of restoration activity

= Relative time since disturbance until restoration is achieved   = Relative time required after restoration activity to achieve restoration

3.4 Principle considerations for selecting sites to be restored

3.4.1 Value to caribou

The primary consideration for selecting sites to be restored in the Tweedsmuir-Entiako caribou range is their value to caribou. Currently, 46% of the range and 75% of the low elevation winter range have been affected by anthropogenic or fire disturbance in the past 40 years, most of which has occurred in the past 10-20 years. The high level of disturbance has resulted in caribou concentrating their use in localized undisturbed[1] areas (BC MFLNRORD, unpubl. data). Because most of the highest value caribou winter range was burned in the 2014 and 2018 fires, areas currently used have relatively lower value as winter range. However, the areas currently being used are the highest value range that is currently available to caribou and therefore have increased in significance to caribou in the short term.

3.4.1.1 Long-term vs short-term benefits

Due to the high level of disturbance on the winter range, the balance between short-term and long-term benefits of restoration activities need to be considered. Restoring the highest value caribou range will provide the greatest benefits to caribou in the long term. However, because caribou use of those areas has declined significantly since the 2014 and 2018 fires and the post-fire habitat may not be suitable for caribou in the short to mid term, and because those fires have resulted in less undisturbed[1] forest available for caribou to use in the short term, the highest priority for restoration of caribou habitat should focus on restoration activities that offer short-term benefits (e.g. protection, access management, functional restoration) that is the most likely to be used by caribou in the short term.

Any ecological restoration efforts, which offer long-term benefits to caribou, should target higher value habitat that is currently not being used by caribou due to habitat disturbance.

3.4.2 Current restoration initiatives

Opportunities for conducting restoration activities will depend on available funding. Currently, two potential funding sources for conducting restoration in the Tweedsmuir-Entiako caribou range include the Caribou Habitat Restoration Fund (CHRF) through the Habitat Conservation Trust Foundation (HCTF), and the Forest Carbon Initiative (FCI; Table 18). The CHRF focuses specifically on restoring caribou habitat, while FCI includes broader objectives of reforestation of roads and reforestation of areas affected by natural disturbances.

[1] “Undisturbed” by fire or anthropogenic activities, but most of the low elevation portions of these areas were affected by the MPB epidemic.

Table 18. Potential sources for funding restoration activities on the Tweedsmuir-Entiako caribou range.

Potential funding source	**Relevant restoration activities funded[1,2]**
Forest Carbon Initiative (FCI)	• Reforestation – roads • Reforestation – natural disturbances
Caribou Habitat Restoration Fund (CHRF)	• Functional restoration of linear features leading to areas of intact high-value caribou habitat • Restoration of disturbed ecosystems where vegetation recovery is not occurring • Reduction of the suitability of matrix habitat for primary prey

[1] FCI also funds fertilization, fibre utilization and tree improvement projects, which are not considered here as relevant to caribou habitat restoration objectives
[2] CHRF funding priorities for 2020/21

There are five restoration projects currently being planned or conducted in the Tweedsmuir-Entiako caribou range, three of which specifically target caribou (
Table 19). Although the other two projects focus on a) reforestation of the 2014 Chelaslie Arm Fire and of roads in the Chelaslie Priority Restoration Area, and b) on rehabilitation of roads in the Vanderhoof Priority Restoration Area, objectives for those projects align with objectives for restoration of caribou range.

3.4.3 State of disturbances

At the site level, the need for restoration of disturbances will depend on how much vegetation re-establishment and recovery has occurred since the disturbance, and whether restoration is even possible. Even if vegetation recovery has not yet been achieved in a disturbance, vegetative regeneration may be on a sufficient trajectory to achieve recovery. Some restoration treatments could compromise vegetation already growing on the site and result in a longer time required to achieve recovery than had the treatment not been conducted.

3.4.4 Intactness

At a broader level, the amount of disturbance in the area surrounding the treatment site will influence the effectiveness of the restoration treatment Restoring a feature in an area of relatively little disturbance and adjacent to undisturbed habitat will return more caribou range by expanding the area covered by “intact” habitat (i.e undisturbed + restored habitat), than restoring the same feature in an area of relatively high disturbance, and/or in an area surrounded by disturbance, and/or in an area where disturbance activities are ongoing.

3.4.5 Proposed anthropogenic activities

The likelihood of whether future anthropogenic activities could negate restoration efforts will need to be considered. Long-term success of restoration efforts will be

Table 19. Restoration projects in the Tweedsmuir-Entiako caribou range.

Project	Objective	Partners	Funding Source[1]
Whitesail Priority Restoration Area			
Whitesail Reach Woodland Caribou Habitat Restoration Project	• To clear woody debris from the shoreline of calving islands of Whitesail Lake	• BC MFLNRORD • SERNbc • Cheslatta Carrier Nation	CHRF ECCC
Chelaslie Priority Restoration Area			
Tweedsmuir-Entiako Caribou Lichen Restoration Area	• To seed terrestrial lichen fragments over 50 ha of areas impacted by the 2014 Chelaslie Arm Fire	• BC MFLNRORD • SERNbc • Cheslatta Carrier Nation	CHRF ECCC
Nadina-South Ootsa Woodland Caribou Road Rehabilitation Project	• To identify temporary resource roads that will not be involved in future extraction activities and that are not part of existing licensee obligations, as candidates for rehabilitation	• BC MFLNRORD • SERNbc • Cheslatta Carrier Nation	FCI CHRF ECCC
Forest Carbon Initiative Reforestation Planning Project (Northeast, Omineca and Skeena Regions)	• To identify priority under-stocked areas that do not have legal reforestation obligations such as stands killed by fire (specifically the 2014 Chelaslie Arm Fire), insects and disease, and other denuded areas such as seismic lines and non-status roads.	• BC MFLNRORD • SERNbc	FCI
Vanderhoof Priority Restoration Area			
Stuart Nechako Road Rehabilitation Project	• To identify temporary roads with no current or future use, as candidates for rehabilitation	• BC MFLNRORD • SERNbc	FESBC[2]

[1] CHRF=Caribou Habitat Restoration Fund; ECCC=Environment and Climate Change Canada; FCI=Forest Carbon Initiative; FESBC=Forest Enhancement Society of British Columbia
[2] FESBC projects funded through FCI

higher in areas that already have some form of protection and/or restrictions on further anthropogenic disturbance, such as in protected areas, Old Growth Management Areas, Ungulate Winter Ranges, or caribou management zones with legal objectives. Restoration efforts in areas where forest harvesting or mineral development is proposed in the next 10-20 years may have a lower likelihood of success and a higher potential for loss of any investments made in restoration efforts.

3.4.6 Potential natural disturbances

Restoration efforts could also be affected by potential natural disturbances in the future. In the Tweedsmuir-Entiako caribou range, 67% of the range has already been affected by the recent mountain pine beetle epidemic and 23% of the range has been affected by fire in the past 40 years. Most of the disturbance due to mountain pine beetle and fire overlaps. Although mountain pine beetles have affected 67% of the range, they have affected 90-99% of the three priority restoration areas. Most of the remaining area unaffected by MPB in the range (33%) either consists of unvegetated areas or non-pine forest types. With the high degree of mountain pine beetle attack already on the landscape, it is unlikely that an epidemic of a similar magnitude will occur again in the near future, however, small infestations will likely continue to occur where there are sufficient mature trees to support mountain pine beetle populations.

Almost one quarter of the range, and one third of the mountain pine beetle-killed stands in the range were consumed in fires that have occurred in the last 20 years, most of which have occurred in the last 10 years, consequently reducing the risk of fire in those stands in the short to mid term. However, large accumulations of blowdown in some parts of the burns (e.g. the area along the south shoreline of Tetachuck Lake) could contribute to increased intensity of potential fires in those areas once regeneration has grown to provide sufficient small to medium fuel conditions for fire ignition. The combination of blowdown and advanced regeneration in the mountain pine beetle-killed stands that remain unburned could contribute to increased fire risk in those stands. Almost 60% of the unburned portion of the range is represented by areas above treeline and biogeoclimatic zones where large stand-initiating fires are rare (e.g. Mountain Hemlock, Coastal Western Hemlock). Although individual wildfires are impossible to predict, with climate change, fire risk is expected to increase.

3.5 Restoration selection criteria - overview

3.5.1 Examples of selection criteria

Examples of criteria for selecting priorities for restoring caribou habitat include priorities for restoration projects funded by the Habitat Conservation Trust Foundation's Caribou Habitat Restoration Fund, and the Preliminary Tactical Restoration Plan for the South Peace Northern Caribou Ranges (GA 2018b, Table 20). Priorities focus on the value of the area to caribou, status of the area, accessibility, and probability that the treated area will not be disturbed after the restoration has been completed.

In addition, the Caribou Habitat Restoration Fund prioritizes projects that focus on:

- functional restoration of roads or other linear features adjacent or leading to areas of intact, high-value caribou habitat;
- treating disturbances where natural vegetation recovery is not occurring, or is limited, with the treatment focussing on the site-specific limiting factor; and,
- reducing the suitability of matrix habitat for primary prey such as planting or treating areas with high shrub production.

Table 20. Examples of criteria for selecting priorities for restoring caribou habitat.

Habitat Conservation Trust Foundation – Caribou Habitat Restoration Fund [1]	**Preliminary Tactical Restoration Plan for the South Peace Northern Caribou Ranges (GA 2018b)**
• High-use and high-value caribou areas: areas used by caribou where development has resulted in increased use of the area by primary prey and their predators. • Areas that will improve core habitat, are adjacent to intact habitat or where another caribou habitat restoration project is planned. • Areas already under some form of habitat protection. • Areas of high predation risk: movement corridors or known overlaps with predators in historical caribou refuge areas. • Areas with low potential future industrial and recreational disturbance (areas with low tenure activity and low potential for future disturbance). • Areas accessible for restoration. • Areas where a coordinated access management plan has been developed or is underway. • Sites that are available for treatment (i.e. not under active disposition or provincial designation, such as a designated recreational trail) and that are not permanent disturbance features. • Sites that are unlikely to regenerate naturally without intervention.	• Areas of high caribou use • Overlap with core habitat (high elevation winter range, high elevation summer range, low elevation winter range) • Areas where restoration would have the support of First Nations and primary stakeholders • Overlap with provincially-designated areas (e.g. provincial parks, old growth management areas (OGMAs), Wildlife Habitat Areas (WHAs), etc.) • Overlap with existing areas where linear disturbance has occurred • Extent of linear disturbance features extending from low to high elevation caribou habitat • Extent of cutblocks and presence of moose and other ungulates at low to mid-elevation caribou habitat • Areas where restoration of caribou habitat will have an indirect positive benefit to other ecological values

[1] https://hctf.ca/grants/caribou-habitat-restoration-grants/ (accessed June 2020)

3.5.2 Tweedsmuir-Entiako caribou range

For the Tweedsmuir-Entiako caribou range, we provide a hierarchical approach for selecting sites for restoration:

- restoration zones – value to caribou;
- restoration sites – value to caribou; and,
- restoration sites – likelihood of success/longevity, synergies with other values, funding sources, and other projects.

The purpose of the hierarchical approach is to first identify what are the most important areas and sites to restore for caribou, and then to assess which sites within those areas are the most practical to restore.

Priorities among restoration zones are based on value to caribou and are categorized into three priority classes for land-based restoration zones, and four or five priority classes for shorelines and islands in Whitesail Reach respectively. Value to caribou focused primarily on use by caribou (recent, prior to 2014). Within restoration zones, we provide selection criteria for assessing priority sites for restoration based first on value to caribou (e.g. proximity to large areas of intact range, reduction of linear penetration into areas used by caribou) and then on how likely the results of the restoration activity would persist into the future (e.g. level of protection/land status, proposed future activities) and how well restoration sites align with other values, criteria for funding sources, and other restoration projects that are not focussed solely on caribou.

3.6 Restoration Priorities

3.6.1.1 Priorities across the Tweedsmuir-Entiako caribou range

Establishing priorities for restoration across all of the Tweedsmuir-Entiako caribou range is challenging. The western portion of the range is primarily used during summer and the eastern portion of the range is used primarily during winter. Ecologically, the summer range is generally wetter and slightly more productive than the winter range, and caribou use their summer and winter ranges differently and are exposed to different risks on the different ranges. Also, for the Tweedsmuir-Entiako caribou range, range condition differs between Priority Restoration Areas in the winter range and Priority Restoration Areas in the summer range. A large part of the winter range in the Chelaslie and Vanderhoof Priority Restoration Areas burned in the 2014 and 2018 fires, while recent fires have had much less impact on the portion of the summer range in the Whitesail Priority Restoration Area (where there has been no fire in the past 40-50 years). Therefore, restoration objectives and priorities will differ between summer and winter ranges, making it difficult to prioritize restoration activities across the summer and winter ranges.

For the Tweedsmuir-Entiako caribou range, we developed one set of selection criteria for priority restoration areas in the summer range (Whitesail Priority Restoration Area), and one set of selection criteria for priority restoration areas in the winter range (Chelaslie Priority Restoration Area, Vanderhoof Priority Restoration Area). For the land-based portions of the priority restoration areas where restoration will focus on functional restoration of linear features, we delineated restoration zones based on radio-collared caribou use, the spatial pattern of road networks and associated anthropogenic disturbances, and topographical features (heights of land, watercourses). As much as possible, we attempted to delineate restoration zones so that there were only one or two access points into a zone. For the shorelines and islands portion of the Whitesail Priority Restoration Area, we delineated shoreline zones based on radio-collared caribou use, and proximity to islands and the opposite shoreline.

3.6.2 Whitesail Priority Restoration Area

3.6.2.1 Restoration objectives

The Whitesail Priority Restoration Area includes calving islands in Whitesail Lake, shoreline points of entry/exit for caribou migrating across Whitesail Lake, migration routes for caribou summering in and west of the Whitesail area, and low elevation calving/summer/fall range. The primary disturbances are forest harvesting, roads associated with industrial activities, and large woody debris accumulations along the shorelines of the Nechako Reservoir.

Restoration objectives for the Whitesail Priority Restoration Area are:

- to reduce large woody debris along shorelines of calving islands;
- to reduce large woody debris along shorelines of islands and the mainland, which are used by caribou during migration and for accessing calving islands; and,
- to functionally (immediate priority) and ecologically restore anthropogenic linear features (roads) along migration routes and areas used by caribou in summer and fall.

3.6.2.2 Selection criteria

We developed separate selection criteria for assessing restoration zones for linear disturbances on the land-based portion of the Whitesail Priority Restoration Area, and for shoreline cleanup on islands and mainland shorelines.

For the land-based portion of the Whitesail Priority Restoration Area, we prioritized restoration zones based on value to caribou during spring migration (Table 21).

For shoreline cleanup on islands, we prioritized islands based on caribou use (Table 22). The largest calving island was the highest priority for restoration because it was the island that was most consistently used by the most caribou since monitoring of radio-collared caribou began (BC MFLNRORD unpubl. data). The other islands were prioritized based on season of use, with islands used during calving and migration prioritized over islands used only during summer/fall.

For shoreline cleanup on mainland shorelines, we prioritized shorelines based on radio-collared caribou use and proximity to islands or the opposite shoreline (Table 23). For mainland shorelines, we were unable to determine precisely where most caribou exited or entered the lake during migration or during travel to access islands because the speed at which they crossed was faster than the interval between telemetry locations. Consequently, we characterized caribou use as the “probability of use”.

Table 21. Criteria for prioritizing Restoration Zones in the land-based portion of the Whitesail Priority Restoration Area.

<table>
<tr><th>Contains shorelines heavily used by caribou exiting Whitesail Lake during migration</th><th>Contains the primary east/west spring migration corridor to calving/summer range</th><th>Contains a constriction in width of east/west low elevation migration corridor (< 1000 m) of <2km</th><th>Priority for restoration</th></tr>
<tr><td>Yes</td><td>Yes</td><td>No</td><td>Priority 1</td></tr>
<tr><td rowspan="2">No</td><td rowspan="2">Yes</td><td>Yes</td><td>Priority 2</td></tr>
<tr><td>No</td><td>Priority 3</td></tr>
</table>

	No	-	

Table 22. Criteria for prioritizing islands in Whitesail Reach for shoreline restoration.

Largest calving island	Island used during calving[1]	Island used during migration[1]	Island used during summer/fall[1]	Priority for restoration
Yes	Yes	Yes	Yes	Priority 1
No	Yes	Yes	Yes	Priority 2
			No	
		No	Yes	
			No	
	No	Yes	Yes	
			No	Priority 3
		No	Yes	Priority 4
			No	Priority 5

[1] Use based on radio-collared caribou locations

Table 23. Criteria for prioritizing shorelines along Whitesail Reach for shoreline restoration.

Probability of use for accessing the largest calving island[1]	Probability of use for accessing any calving island[1]	Probability of use during migration[1]	Probability of use for accessing islands used by caribou in summer/fall[1]	Closest point to calving island/ opposite shore[1]	Priority for restoration
High	High	High	-	< 1 km	Priority 1
				> 1 km	Priority 2
Low	High	High	-	< 1 km	
				> 1 km	Priority 3
		Low	-	< 1 km	
				> 1 km	
	Low	High	High		Priority 2
			Low		
		Moderate	High		Priority 3
			Low		
		Low	High		
			Low		Priority 4

[1] Use is based on "probability" of radio-collared caribou use because we were unable to determine precisely where most caribou exited or entered the lake during migration or during travel to access islands because the speed at which they crossed was faster than the interval between telemetry locations.

3.6.2.3 Restoration zones

The Whitesail Priority Restoration Area includes four land-based restoration zones (Figure 12). The highest priority for restoration is Restoration Zone C, where caribou exit Whitesail Lake during spring migration. The second priority is Restoration Zone A, which is the main spring migration route for caribou accessing calving and summer ranges further to the west. Caribou rely on low elevation routes during spring migration where snow depth is lower than at higher elevations. In the western portion of Restoration Zone A, the low elevation migration route constricts to <2 km in width, where caribou may experience higher predation risk due to concentration of both caribou and predator use.

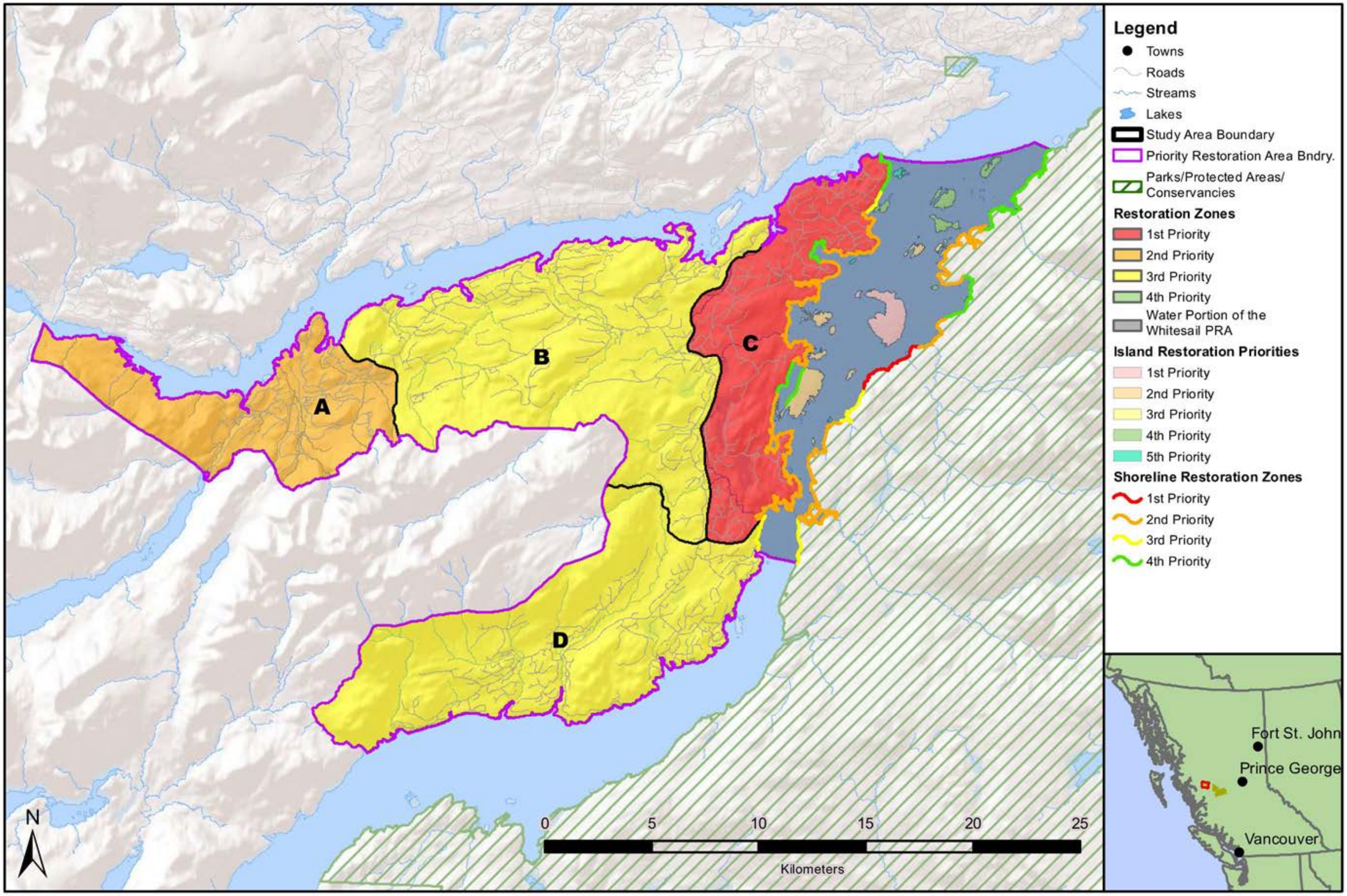


Figure 12. Restoration zones and priorities in the Whitesail Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Priorities for shoreline cleanup include both islands and mainland shorelines (Table 24, Figure 13). We delineated 16 shoreline segments and 16 island groups. Thirteen island groups were single islands, and three groups were made up of two or three islands: islands K+L; islands M+N; and islands O+Q+R. The highest priorities for cleanup were the island group K+L and the shoreline along Tweedsmuir Park that is used to access that island. Priority 2 islands and shorelines included islands that had evidence of use during calving and migration, and shorelines that had been used to access islands used for calving or migration, or that had been used for migration.

Table 24. Summary of priority rankings for islands and mainline shorelines.

Priority	Mainland shorelines	Islands[1]
Priority 1	L	(K+L)
Priority 2	C, E, G, J, M, O	(M+N), (O+Q+R), P, G, F[2]
Priority 3	B, H, I, K	T
Priority 4	A, D, F, N[3], P	A, C, D, E, I, J
Priority 5	(Not applicable)	B, H, S

[1] Islands in brackets are combined into one island group

[2] Although island F keyed out as Priority 4 (no caribou use during calving or migration), we moved it up to Priority 2 due to the high probability that it is used during migration due to its location between shoreline O and Island G, which are used during migration; although there were spring locations on this island in two caribou-years, the caribou did not cross the lake and therefore the locations were not considered as spring migration locations

[3] Although mainland shoreline N keyed out as Priority 3 due to its proximity to Island J, we moved it to Priority 4 because we felt that the significance of Island J did not fit in with the intent of Priority 3

For evaluating priority of restoration sites within land-based restoration zones, we provide two sets of criteria. The first set of criteria to be applied are based on value to caribou (Table 25), after which criteria based on probability of success are applied (Table 26).

For value to caribou, a higher priority is given to long continuous lengths of roads that are likely more significant travel routes for wolves, especially those that penetrate areas with low levels of anthropogenic disturbance and that are currently being used by caribou. Shorter road segments, such as in-block roads and skid trails, are given a lower priority because restoration will likely not affect wolf hunting efficiency. A higher priority is also given to linear features that traverse forested areas since the linear feature is the most direct route through the forested area with the greatest line-of-sight. In young clearcuts and especially in burned clearcuts, line-of-sight and ease of travel likely do not differ much between the linear feature and the burned or clearcut area. And, if data are available on wolf use of linear features (e.g. radio-collared wolf locations, trail cameras), a higher priority is given to linear features with higher demonstrated use by wolves.

For likelihood for success, a higher priority is given to linear features in areas with various levels of protection, and areas where industrial activities are not planned for at least 40 years. Higher priority is also given to restoring roads without tenures, and to restoring sites where there are synergies with other restoration projects.

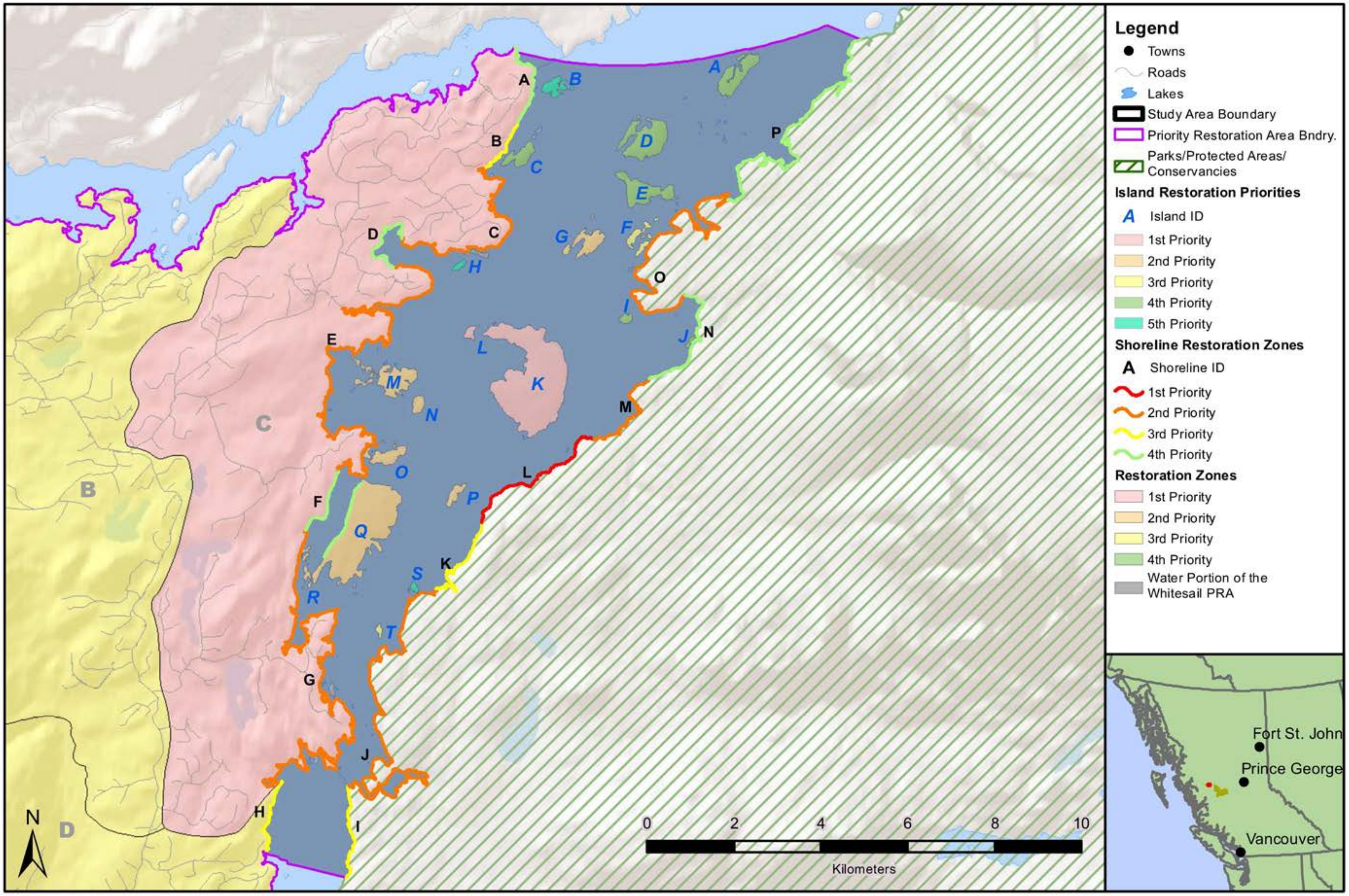


Figure 13. Island and shoreline restoration zones and priorities in Whitesail Reach in the Whitesail Priority Restoration Area.

Table 25. Criteria for prioritizing restoration sites for value to caribou.

Criterion	Condition		Score
Will restoring the segment of road reduce the distance that a long linear feature penetrates into areas with no or low levels of anthropogenic habitat alteration?	No		0
	Yes	0-0.5 km	1
		0.5-1.5 km	2
		1.5-5 km	5
		> 5 km	10
Will restoring the segment of road reduce the distance that a long linear feature penetrates into areas currently used by caribou?	No		0
	Yes	0-0.5 km	1
		0.5-1.5 km	2
		1.5-5 km	5
		> 5 km	10
Is there evidence of use by wolves	No (or unknown)		0
	Yes	Several wolves/locations	8
		Few wolves/locations	4
What is the condition of landscape that the road traverses?	Unburned	Forested	10
		Clearcut	5
	Burned	Forested	5
		Clearcut	1

Table 26. Criteria for prioritizing restoration sites for likelihood for success.

Criterion	Condition		Score
Is the site in an area with some protections	No		0
	Yes	Protected area (park, protected area, ecological reserve)	10
		UWR/WHA – no roads allowed	8
		UWR/WHA – other	5
		Legal objectives – no roads allowed	8
		Legal objectives - other	5
Are industrial activities planned?	No		10
	Yes	0-20 years	0
		20-40 years	2
		40-60 years	6
		> 60 years	10
	Unknown		2
Has the site been identified as a potential restoration site by another project?	Yes		5
	No		0
Is there a tenure on the road	No		10
	Yes	Potential to change	5
		No potential to change	0

3.6.3 Chelaslie Priority Restoration Area

3.6.3.1 Restoration objectives

The Chelaslie Priority Restoration Area includes an important migration route between winter and summer ranges, and unburned low elevation and mid-high elevation winter range. The primary disturbances are forest harvesting, roads associated with industrial activities, and fire.

The primary restoration objective for the Chelaslie Priority Restoration Area is:

- to functionally (immediate priority) and ecologically restore anthropogenic linear features (roads) that lead into areas that are currently used by caribou.

3.6.3.2 Selection criteria

For the Chelaslie Priority Restoration Area, we prioritized restoration zones based on radio-collared caribou use within and adjacent to the restoration zone (Table 27). The highest priority restoration zones were those that were in or adjacent to areas used consistently over time, including both before and after the 2014 and 2018 fires. Lower priority rankings were assigned to restoration zones that had various combinations of caribou use after the 2014 fire, after the 2018 fires and before the 2014 fire (Table 27).

Table 27. Criteria for prioritizing restoration zones in the Chelaslie Priority Restoration Area.

<table>
<tr><th>Restoration zone in or adjacent to areas used by caribou since the 2014 fire</th><th>Restoration zone in or adjacent to areas used by caribou since the 2018 fires</th><th>Restoration zone in or adjacent to areas used by caribou prior to the 2014 fire</th><th>Priority for restoration</th></tr>
<tr><td rowspan="9">Many caribou/ locations[1]</td><td rowspan="3">Many</td><td>Many</td><td>Priority 1</td></tr>
<tr><td>Some</td><td rowspan="6">Priority 2</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">Some</td><td>Many</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">None</td><td>Many</td></tr>
<tr><td>Some</td><td rowspan="2">Priority 3</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="9">Some caribou/ locations</td><td rowspan="3">Many</td><td>Many</td><td rowspan="4">Priority 2</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">Some</td><td>Many</td></tr>
<tr><td>Some</td><td rowspan="4">Priority 3</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">None</td><td>Many</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td><td>Priority 4</td></tr>
<tr><td colspan="2" rowspan="3">No caribou/locations</td><td>Many</td><td>Priority 3</td></tr>
<tr><td>Some</td><td rowspan="2">Priority 4</td></tr>
<tr><td>None</td></tr>
</table>

[1] Based on a visual assessment of the relative number of radio-collared caribou locations in the restoration zone or adjacent area

3.6.3.3 Restoration zones

The Chelaslie Priority Restoration Area includes 17 restoration zones (Figure 14). The highest priorities for restoration are Restoration Zones C, D, H and K, which lie in the western portion of the priority restoration area and are in or adjacent to Old Growth Management Areas that were designated for caribou. The second highest priorities include Restoration Zones B, G, I, J and L, which are also located in the western portion of the priority restoration area.

Restoration Zones H to O are located south of the Chelaslie River and are accessed by the Chelaslie River bridge near the northwest corner of Candidate Area I. West Fraser is considering removing the bridge, which would eliminate access to Restoration Zones O to H for restoration activities. Although there are two Priority 1 and three Priority 2 restoration zones south of the Chelaslie River, a large portion of the area was burned in the 2014 and 2018 fires, and subsequently caribou use of the area has declined (BC MFLNRORD, unpubl. data). Prior to the 2014 and 2018 fires, caribou consistently used Restoration Zones H to L during spring migration, winter and fall. Restoration efforts in those restoration zones would benefit caribou in the mid to long term once they start using those areas again, especially since habitat value is higher than in other parts of the Chelaslie Priority Restoration Area. Currently caribou use in the priority restoration area is focussed more around Priority 1 Restoration Zones C and D, which are therefore a higher priority for restoration in the short term. Ideally, restoration activities are first conducted in Restoration Zones C and D, where they will provide short-term benefits, and later in restoration zones south of the Chelaslie River, where benefits may not be realized until the mid to long term because caribou may not start using those areas again until the mid to long term. However, if the Chelaslie River bridge is removed, then the benefits of conducting restoration activities in priority restoration zones south of the bridge prior to bridge removal (which will result in benefits in the long term) need to be weighed against the benefits of conducting restoration activities in priority restoration zones north of the bridge (which will result in benefits in the short term), and risks associated with not conducing restoration activities in priority restoration zones south of the bridge before the bridge is removed.

For evaluating priority of restoration sites within restoration zones, we provide the same two sets of criteria as we did for the land-based portion of the Whitesail Priority Restoration Area. The first set of criteria to be applied are based on value to caribou (see Table 25), after which criteria based on probability of success are applied (see Table 26).

3.6.4 Vanderhoof Priority Restoration Area

3.6.4.1 Restoration objectives

The Vanderhoof Priority Restoration Area includes unburned low elevation and mid-high elevation winter range. The primary disturbances are forest harvesting, roads associated with industrial activities, and fire.

The primary restoration objective for the Vanderhoof Priority Restoration Area is:

- to functionally (immediate priority) and ecologically restore anthropogenic linear features (roads) that lead into areas that are currently used by caribou.

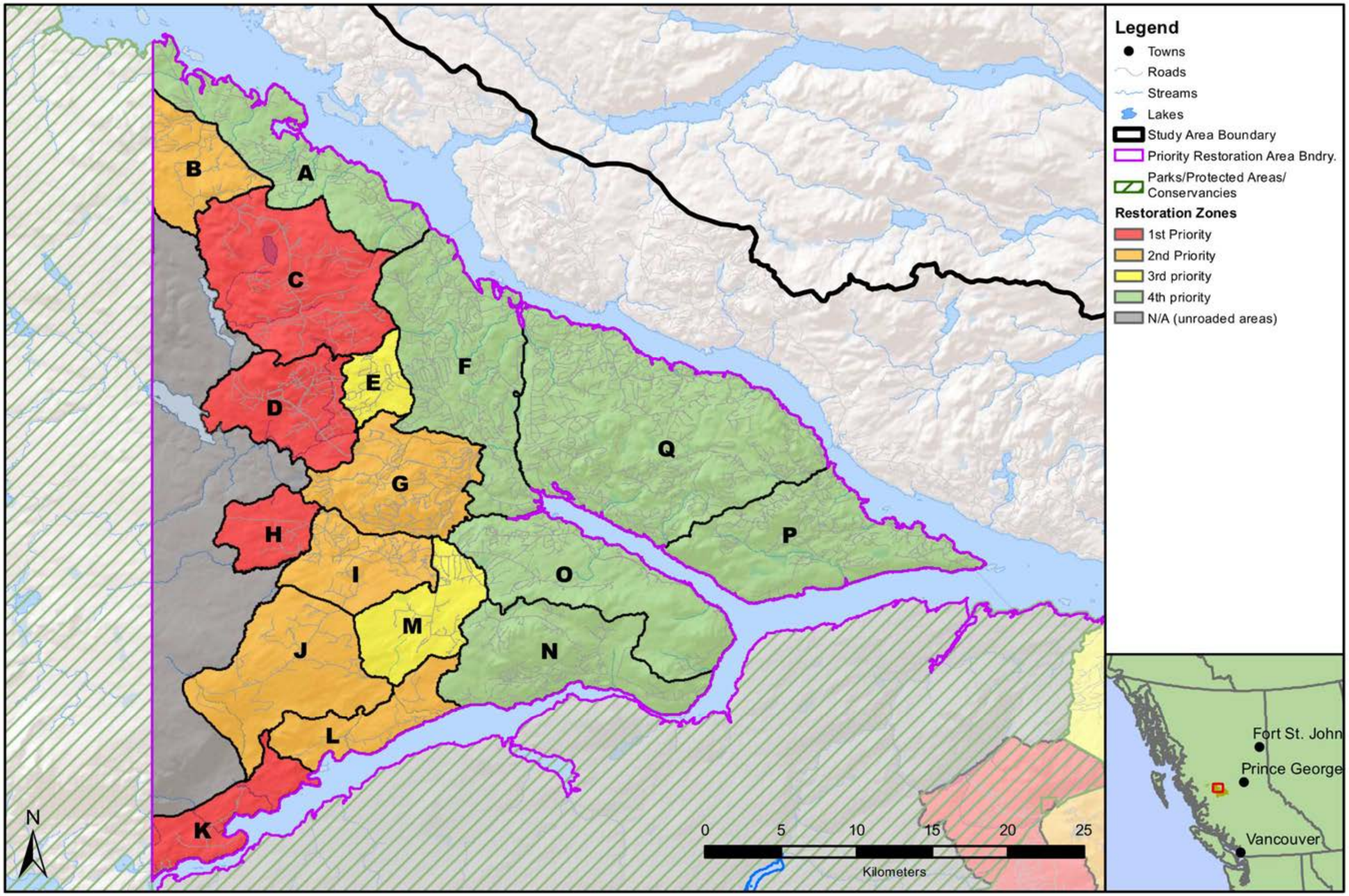


Figure 14. Restoration zones and priorities for restoration in the Chelaslie Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

3.6.4.2 Selection criteria

For the Vanderhoof Priority Restoration Area, we used the same criteria to prioritize restoration zones as we did for the Chelaslie Priority Restoration area, which were based on radio-collared caribou use within and adjacent to the restoration zone (Table 28). The highest priority restoration zones were those that were in or adjacent to areas used consistently over time, including both before and after the 2014 and 2018 fires. Lower priority rankings were assigned to restoration zones that had various combinations of caribou use after the 2014 fire, after the 2018 fires and before the 2014 fire (Table 28).

Table 28. Criteria for selecting priority restoration zones in the Vanderhoof Priority Restoration Area.

<table>
<tr><th>Restoration zone in or adjacent to areas used by caribou since the 2014 fire</th><th>Restoration zone in or adjacent to areas used by caribou since the 2018 fires</th><th>Restoration area in or adjacent to areas used by caribou prior to the 2014 fire</th><th>Priority for restoration</th></tr>
<tr><td rowspan="9">Many caribou/ locations[1]</td><td rowspan="3">Many</td><td>Many</td><td>Priority 1</td></tr>
<tr><td>Some</td><td rowspan="6">Priority 2</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">Some</td><td>Many</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">None</td><td>Many</td></tr>
<tr><td>Some</td><td rowspan="2">Priority 3</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="9">Some caribou/ locations</td><td rowspan="3">Many</td><td>Many</td><td rowspan="4">Priority 2</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">Some</td><td>Many</td></tr>
<tr><td>Some</td><td rowspan="4">Priority 3</td></tr>
<tr><td>None</td></tr>
<tr><td rowspan="3">None</td><td>Many</td></tr>
<tr><td>Some</td></tr>
<tr><td>None</td><td>Priority 4</td></tr>
<tr><td rowspan="3" colspan="2">No caribou/locations</td><td>Many</td><td>Priority 3</td></tr>
<tr><td>Some</td><td rowspan="2">Priority 4</td></tr>
<tr><td>None</td></tr>
</table>

[1] Based on a visual assessment of the relative number of radio-collared caribou locations in the restoration zone or adjacent area

3.6.4.3 Restoration zones

The Vanderhoof Priority Restoration Area includes 23 restoration zones (Figure 15). The highest priorities for restoration are Restoration Zones G and Q, which lie in and adjacent to Entiako Park. The second highest priority includes only one Restoration

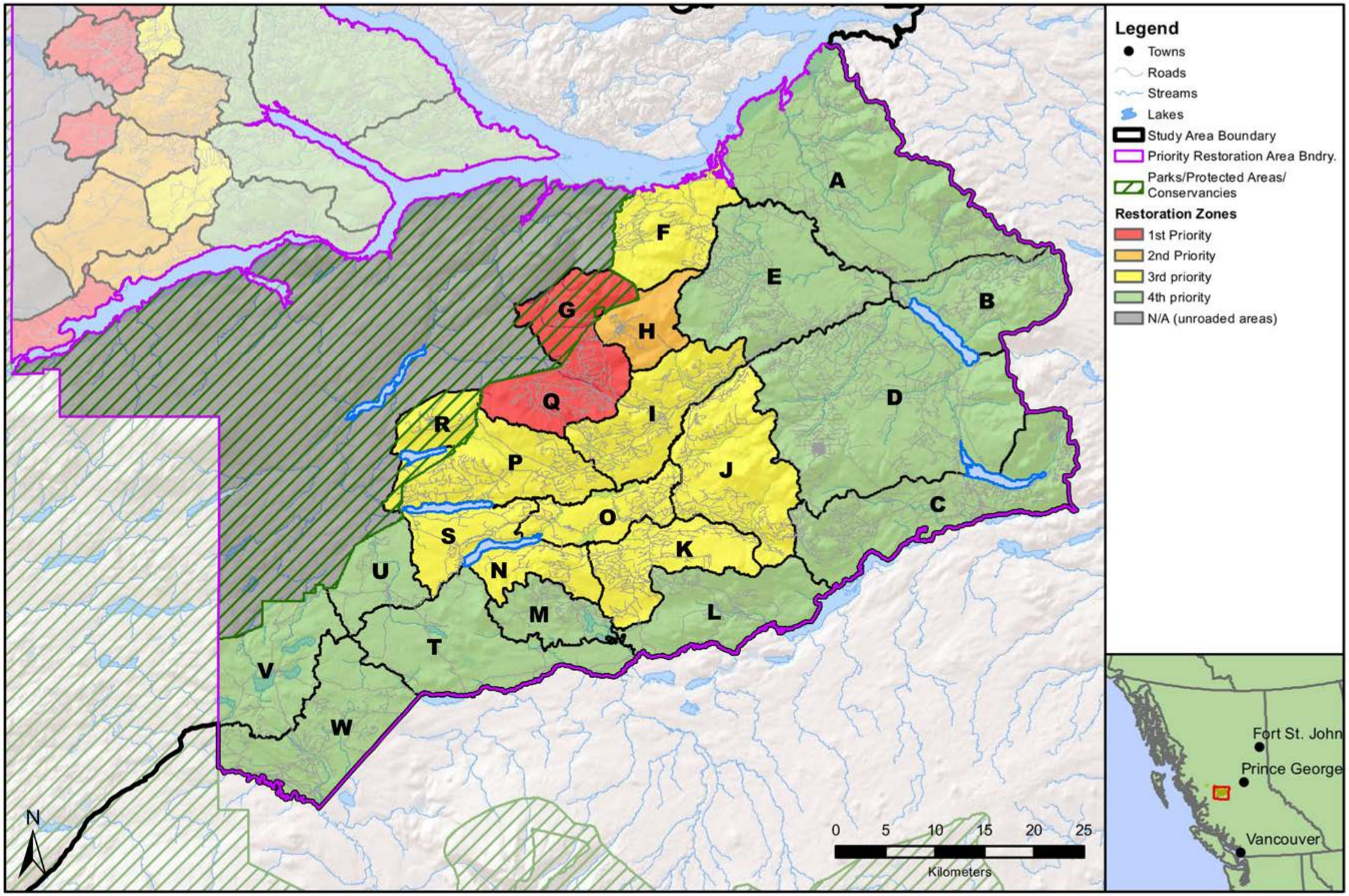


Figure 15. Restoration zones and priorities for restoration in the Vanderhoof Priority Restoration Area in the Tweedsmuir-Entiako caribou range.

Zone, H, which includes most of the alpine portion of the Fawnie Mountains that is not included in Entiako Park. Those three restoration zones are priorities because they are in or adjacent to areas used by caribou since the 2014 and 2018 fires.

For evaluating priority of restoration sites within restoration zones, we provide the same two sets of criteria as we did for the land-based portion of the Whitesail Priority Restoration Area. The first set of criteria to be applied are based on value to caribou (see Table 25), after which criteria based on probability of success are applied (see Table 26).

3.7 Monitoring plan

3.7.1 Introduction

The role of monitoring is to determine if restoration activities have been successful in achieving restoration goals. Monitoring should consider: project restoration goals and objectives; what to monitor; the spatial and temporal scale at which a response is expected; length of time that monitoring is required; logistics; and costs. Monitoring is an essential component of restoration activities and should be conducted to assess both restoration implementation and effectiveness.

3.7.2 Implementation monitoring

Implementation or compliance monitoring focuses on determining whether the restoration activities were completed as proposed through a visit to the restoration site. Implementation monitoring is important for ensuring that the desired spatial configuration and level of restoration activity occurred, which is especially important when restoration thresholds or targets are involved, but is also useful for tracking any issues that arose while conducting restoration treatments.

Key questions for evaluating implementation include:

- Was the restoration treatment conducted in the desired location?
- Was the targeted extent and configuration of restoration achieved?
- Were there any issues with delivering the restoration treatment? If so, can methods be improved to avoid those issues?

3.7.3 Effectiveness monitoring

Effectiveness monitoring focuses on whether the restoration treatment has achieved its objectives, and can be assessed at different scales including:

- population/range;
- individual; and,
- site.

To evaluate effectiveness, information must be collected prior to and following the restoration treatment.

The ultimate management objective for caribou at the population level is to achieve a self-sustaining population. Although individual restoration treatments may not necessarily impact caribou at the population scale, the goal is that multiple restoration treatments combined will result in a cumulative positive impact. Monitoring for effectiveness at the population scale will require monitoring caribou population trend. Other objectives at the population scale include a reduction in predator-prey encounter rates, and a reduction in caribou kill rates.

At the individual scale, effectiveness monitoring focuses on the behavioural response of caribou, their predators, and humans. Monitoring for effectiveness at the individual scale will depend on the objective of the restoration treatment. For restoration of roads where the objective is to reduce predator and human travel, monitoring will involve assessing predator and human use of the restored area. For reducing accumulation of log debris along shorelines in Whitesail Lake to improve caribou travel, and for lichen seeding to re-establish lichens on a site, monitoring will involve assessing caribou use of those areas.

At the site scale, effectiveness monitoring focuses on the structural/vegetative characteristics of the site and will also depend on the objective of the restoration treatment. For restoration of roads to reduce predator travel, monitoring will involve assessing line of sight and ease of travel. For reducing accumulation of log debris on shorelines, levels of coarse woody debris will need to be monitored, and for re-establishing lichens, monitoring will involve assessing lichen abundance.

3.7.3.1 Monitoring options/techniques

Table 29 outlines potential techniques for monitoring restoration treatment effectiveness at the population, individual and site scales.

As discussed in the previous section, although individual restoration treatments on their own may not affect caribou at the population scale, population monitoring is useful for assessing the cumulative effects of restoration treatments and other management activities. The key indicator to monitor is population trend (lambda, λ). Because the Tweedsmuir-Entiako caribou population is difficult to census, monitoring population trend based on population census is not recommended. The most reliable method to calculate population trend for the Tweedsmuir-Entiako caribou population is using adult survival of radio-collared caribou, and calf recruitment from late winter surveys. Late winter calf recruitment can also be used to assess population trend. Bergerud (1996) recommends a late winter calf recruitment rate of 15% calves to achieve population stability.

At the individual and site scales, monitoring needs to be conducted in both treated and untreated areas to allow for a comparative response over time.

For road restoration treatments to reduce predator and human travel, at the individual scale monitoring focuses on predator and human use, and at the site scale focuses on vegetation height and density (Table 29). If sufficient data are available, radio-collared predators can be used to assess travel rates on treated and untreated roads or road

Table 29. Potential techniques for monitoring effectiveness of restoration treatments.

Scale	**Objective**	**Indicator**	**Potential techniques**
Population	Maintain a self-sustaining caribou population[1]	• Population trend • Adult survival • Calf recruitment	• Sample of Radio-collared caribou
Individual	Reduce predator and human travel	• Predator use	• Radio-collared predators • Trail cameras • Ground plots (predator sign)
		• Human use	• Trail cameras • Ground plots (human sign)
	Improve caribou travel (shorelines)	• Caribou use	• Radio-collared caribou • Trail cameras • Ground plots (caribou sign)
	Increase forage		
Site	Reduce predator and human travel (line of sight, ease of travel)	• Vegetation height	• Lidar • Ground plots
		• Vegetation density/% cover	• Ground plots
	Improve caribou travel (shorelines)	• Coarse woody debris	• Ground plots • Aerial images (drones)
	Increase forage	• Lichen abundance	• Ground plots (lichen % cover)

[1] Suggested criteria for when a population is considered self-sustaining:
a) the annual growth rate is stable or positive (lambda $\lambda \geq 1$) in at least 4 years of any 5-year period, and
b) there is no need for direct population management to achieve that condition, and
c) that condition persists even under random negative pressures on the population, and
d) the condition is robust enough to sustain an annual, bull-only harvest by First Nations at a level of 3% of the estimated population size.

segments. Depending on the collar fix intervals (# locations/day), radio-collar data could also be used to assess predator presence/use, but lack of locations within treated areas does not necessarily indicate absence, especially if fix intervals are long. Alternatively, predator presence/use can be monitored using trail cameras and/or ground plots or transects, which can also be used to monitor human use. At the site level, monitoring road restoration treatments includes measures of vegetation height and density. Vegetation height can be assessed using Lidar (Finnegan et al. 2018), but vegetation height does not always indicate predator use since wildlife trails under taller vegetation may not be detected by Lidar (Tigner et al. 2014). Both vegetation height and density can be assessed using ground plots. Measures of vegetation composition and seedling vigour can also be included in ground plots, which can provide an assessment of habitat potential for alternate prey and seedling health. Overall, a monitoring approach that includes both ground plots and trail cameras can cover a broad range of indicators.

For shoreline debris clearing and lichen seeding, monitoring at the individual level focuses on caribou use, and monitoring at the site level focuses on coarse woody debris levels and lichen abundance respectively (Table 29). BC MFLNRORD maintains a sample of radio-collared caribou in the Tweedsmuir-Entiako caribou population. Similar to assessing predator presence/use, the usefulness of radio-collared caribou locations for assessing caribou presence/use in treated areas will depend on the collar location fix rate and the number of radio-collared caribou using the general area. Caribou presence/use can also be monitored using trail cameras and/or ground plots/transects of caribou sign. At the site level, ground-based plots or transects can be used to monitor levels of coarse woody debris and lichen abundance. In addition, for shoreline debris clearing, aerial images from drones can be used to estimate levels of coarse woody debris. For lichen seeding treatments, caribou use should only be assessed using ground plots, in conjunction with assessments of lichen abundance. Caribou use in these treated areas is anticipated to be low in the short to moderate term and therefore does not warrant trail camera monitoring.

3.7.3.2 Treatment success

Ideally, treatment success is evaluated against predetermined thresholds or criteria. However, because thresholds are lacking, especially at the individual and site scales, monitoring will have to focus on assessing whether treatments are on a trajectory to meet desired objectives. Information that will be collected during post-restoration monitoring sessions can be used in the future to evaluate success if/when thresholds are developed.

At the population/range scale, three potential thresholds could be used for the Tweedsmuir-Entiako caribou range: population trend, habitat disturbance levels, and density of linear features. For population trend (lambda, λ), the threshold is a stable or increasing population trend (lambda $\lambda \geq 1$). However, a number of factors can affect population trend so it is not necessarily an indicator of success of individual restoration treatments. The recovery strategy for southern mountain caribou (EC 2014) identified critical habitat, which included maximum disturbance levels for seasonal ranges (see Section 3.3.1.1, and Section 3.7.4 below). Thresholds have also been developed in northeast BC for density of linear features (see Section 3.3.1.2), which can be applied to portions of the range.

There are no thresholds yet specifically for caribou at the individual and site scales. At the site scale, a threshold could potentially be developed for vegetation height as an indicator of travel speed/ease for predators. Although two recent studies have found vegetation height affects wolf travel, they each suggest a vegetation height that could be used to prioritize restoration of linear features, but caution that it should not be used as a threshold for when habitat is recovered sufficiently to stabilize caribou populations or when linear features no longer contribute to elevated rates of predation (Dickie et al. 2017, Finnegan et al. 2018).

Depending on restoration objectives, treatment success may not be realized until sometime in the future (see Section 3.3.5), in which case multiple monitoring sessions at pre-determined intervals will need to be conducted until restoration objectives are met. In the Boreal Caribou Habitat Restoration Monitoring Framework, GA (2016) recommend conducting monitoring after one, five, ten and fifteen growing seasons.

Because caribou habitat restoration science is relatively new, an adaptive management approach (i.e. "learning by doing") should be used when evaluating treatment success. Information collected during monitoring sessions should be used to modify and refine restoration practices, if needed, to improve the likelihood of success both for the area that was treated, and for areas to be treated in the future.

Assessment of treatment success should also be reviewed and updated as new thresholds or criteria for assessing treatment success are developed.

3.7.4 Tracking levels of disturbance

Once restoration treatments have achieved their objectives, the disturbance can be recruited back into the portion of the range that is undisturbed. For the seasonal range disturbance targets (i.e. <35% habitat alteration in low elevation winter and matrix range, and minimal [i.e. close to 0%] in high elevation winter and/or summer range and low elevation summer range; see Section 3.3.1), only the portion of the disturbance and its surrounding buffer that do not overlap with other existing disturbances and their buffers can be recruited back into the undisturbed portion of the range. Disturbance levels should be updated annually by incorporating new disturbances, updating the state of recovery of treated and untreated disturbances, and recruiting disturbances that have achieved restored status back into the undisturbed portion of the range.

Similarly, linear feature density should also be updated annually by incorporating new linear features and re-attributing linear features that have achieved restored status. We have created a spatial dataset of disturbance that is current as of 2018. The spatial dataset includes a linear features dataset that was cleaned up to exclude duplicate linear features. We recommend using that spatial layer as a baseline and following methods described in Section 1.3.2.4 to incorporate new linear features.

4 IMPLEMENTATION PLAN

The following sections provide two examples of key steps for implementation of restoration treatments in the Tweedsmuir-Entiako caribou range.

4.1 Priority Restoration Site: Whitesail Island "K"

Whitesail Island "K" is the largest calving island in Whitesail Reach. This island has been consistently used by caribou during calving, spring and fall migration, summer, and fall and is the highest priority island for restoration. Large woody debris from the flooding of the Nechako Reservoir has accumulated on shorelines of the reservoir and islands, with a recent increase resulting from the exposed portions of flooded trees breaking off (AM Roberts, pers. comm. 2019). Accumulated woody debris may be affecting the ability of caribou to access calving islands in and migration routes across Whitesail Reach.

4.1.1 Restoration objectives

The restoration objective is:

- to reduce large woody debris along the southeastern shoreline of Whitesail Island “K” to promote access to the island for caribou.

A project to clear large woody debris from shorelines of calving islands and mainland entry/exit stretches along Whitesail Reach was initiated in 2019 (DWB 2019). Initially, the southeastern shoreline Whitesail Island “K” was targeted because it was the closest shoreline to the eastern side of Whitesail Reach, and was the most likely place where caribou were accessing the island.

4.1.2 Field verification

Within priority restoration zones, priority restoration sites are selected using criteria specified in each Priority Restoration Area, and identified using spatial disturbance data, satellite images and/or aerial photos. However, field verification is needed to confirm that restoration at a specific site is required, and to confirm and/or identify environmental and archaeological considerations.

For debris shoreline cleanup on Whitesail Island “K”, the priority restoration sites were selected based on aerial photos (DWB in prep. a). Field verification was planned to inspect shorelines for: potential short- and long-term environmental concerns; wildlife sign within and around targeted woody debris; bird nests within and around woody debris and water-bound standing trees (e.g. osprey); and significant cultural or heritage material (DWB in prep. a). Other planned field verification activities included: identification, GPS and flagging of any sensitive features, potential barge access locations and potential danger trees that may require assessment; estimation of debris volumes; and identification of any other logistical planning considerations (DWB in prep. a).

4.1.3 Activities and timelines

As much as possible, activities should be conducted when caribou are not using the area. Caribou use Whitesail Island “K” from spring (mid to late May) to fall (October to early November) with the most critical period during the calving and post-calving seasons (late May to mid July). Ideally all activities would be conducted after most caribou have left the area in November. If activities have to be conducted while caribou are still using the area, fall is the least risk time period for caribou.

Planned activities for debris removal included: site reconnaissance, site access management, mechanized clearing of foreshore and nearshore submerged and emergent standing timber; transport of merchantable timber and non-merchantable wood debris; piling and burning non-merchantable woody debris (offsite); chipping and/or composting non-merchantable woody debris (offsite); potential installation of log booms for long-term debris management; environmental monitoring, and re-vegetation (DWB 2019).

To avoid and/or mitigate any potential adverse effects of treatment activities, management and monitoring plans are required. For the project, management and monitoring plans included: environmental monitoring plan, wildlife management plan, air quality management plan, invasive plant management plan, archaeology management plan, erosion and sediment control plan, spill prevention and response plan, and waste management plan.

Actual project activities included: site reconnaissance (August); site access management (August); mechanized clearing of woody debris (November 12-26); piling and burning of woody debris onsite November 12-26); and monitoring (see Section 4.1.7 below).

4.1.4 Engagement

Implementation of restoration treatments will require engagement with First Nations, local stakeholders and active tenure holders. The Cheslatta Carrier Nation were involved with planning and conducting shoreline clean-up activities.

4.1.5 Permits

Each restoration treatment must obtain required permits and/or licences before work is conducted. Potential required permits for the woody debris clearing project will be site-specific and may include: Forest Licence to Cut (BC *Forest Act*); Special Use Permit (BC *Forest Act*); Road Permit and/or Road Use Agreement (BC *Forest Act*); Change Approval for Instream Works (BC *Water Sustainability Act*); Burning Permit (Burn Registration Number; BC *Forest and Range Practices Act*); permits for tracking or monitoring wildlife (BC *Wildlife Act*); Wildlife Salvage Permit (BC *Wildlife Act*); and Request for Review (Canada *Fisheries Act*) (DWB in prep. a).

4.1.6 Strategies for protecting restoration from future potential disturbances

The main risk to shoreline woody debris removal treatments, is additional woody debris potentially accumulating in the treatment area. This could occur if the exposed portions of additional flooded trees break off and are deposited on the shoreline, or if woody debris on other shorelines begins to float at high waterlevels and are redeposited in the treated area. Installation of log booms to intercept floating woody debris was proposed (DWB in prep. a), but not implemented (AM Roberts, pers. comm. 2019).

4.1.7 Monitoring

Effectiveness monitoring for the woody debris removal project includes pre and post-treatment monitoring at both the individual and site scales. At the individual scale, trail cameras were installed in likely high use areas along the southwestern shoreline of Whitesail Island “K” in late March 2019. Additional cameras were installed in late May 2019 and 2020 in areas where caribou may potentially exit the west side of the reservoir during spring migration (Lee in prep.). Various cameras were revisited during field sessions in May, July, September, October and November 2019 (Lee in prep.). No radio-collared caribou migrated across or calved on the island and therefore there are no radio-collared caribou locations available to assess for pre and post treatment use (AM Roberts pers. comm. 2019). At the site scale, levels of woody debris were assessed with ground transects on September 20, 2019 prior to treatment (Lee in prep.). Post-treatment monitoring will be conducted in August 2020 (delayed due to Covid19). Pre-treatment shoreline imagery by drone was not completed due to weather and scheduling issues (Lee in prep.)

4.2 Priority Restoration Site: Chelaslie – Area 4 – Road Segment 24B

Road segment 24B in Area 4 in the Chelaslie Priority Restoration Area is located in the northwestern portion of the priority restoration area in Restoration Zone C (Priority 1). It is approximately 2.5 km in length (DWB 2020) leading into winter habitat currently used by caribou in the Uduk Lake area. This area contains important winter habitat that has been used by caribou both before and after the 2014 Chelaslie Arm Fire. Road segment 24B accesses several cutblocks that are adjacent to an Old Growth Management Area.

4.2.1 Restoration objectives

The restoration objective is:

- to functionally restore anthropogenic linear features (roads) that lead into areas that are currently used by caribou, to reduce predator hunting efficiency and travel.

Treatment prescriptions for road rehabilitation activities in the Chelaslie Priority Restoration Area were developed in 2020.

4.2.2 Field verification

Field verification in 2019 confirmed that the roadbed was still largely unvegetated and that Road Segment 24B was indeed a candidate for restoration.

4.2.3 Activities and timelines

As much as possible, activities should be conducted when caribou are not using the area. Prescribed activities include: ripping and mounding of the roadbed; planting lodgepole pine, hybrid spruce and western larch at a density 1800 stems/ha and a minimum inter-tree distance (the target distance between the planted trees and/or planted trees and natural colonizing trees) of 1.6 m; tree falling/bending; and spreading of coarse woody debris (DWB 2020). Restoration activities will be conducted during snowfree months and therefore will not overlap with caribou use of the area.

To avoid and/or mitigate any potential adverse effects of treatment activities, environmental considerations include: caribou and fisheries timing windows, invasive plant management, and water quality and erosion control (DWB in prep. b).

4.2.4 Engagement

The Cheslatta Carrier Nation were involved with planning restoration activities and will be involved with conducting restoration activities (DWB 2020).

4.2.5 Permits

Each restoration treatment must obtain required permits and/or licences before work is conducted. Potential required permits for the road rehabilitation project will be site-specific and may include: Forest Licence to Cut (BC *Forest Act*); Special Use Permit (BC *Forest Act*); Road Permit and/or Road Use Agreement (BC *Forest Act*); Change Approval for Instream Works (BC *Water Sustainability Act*); permits for tracking or monitoring wildlife (BC *Wildlife Act*); and Wildlife Salvage Permit (BC *Wildlife Act*) (DWB in prep. b).

4.2.6 Strategies for protecting restoration from future potential disturbances

The primary risks for road rehabilitation treatments are active removal of barriers to human use, and continued use of the restored road resulting in damage to regenerating vegetation and maintenance of a travel route along the roadbed. To protect road rehabilitation from future potential disturbances, access control structures consisting of berms built from large debris (e.g. boulders, coarse woody debris) and earth, may be constructed at the start of the road segment (DWB 2020).

4.2.7 Monitoring

A monitoring plan is currently being developed to assess implementation and effectiveness of road restoration treatments in the Chelaslie Priority Restoration Area (BC MFLNRORD in prep.). Functional restoration will be conducted in 2020 and tree planting will be conducted in 2021. Implementation monitoring includes a functional restoration assessment in 2020 following treatment, and seedling survival and seedling establishment surveys in 2022, one year following planting (BC MFLNRORD in prep.). Effectiveness monitoring will include vegetation and line condition monitoring (ground plots and drone imaging), remote camera monitoring, and caribou population monitoring. Effectiveness monitoring will be conducted on treatment roads as well as reference roads (untreated roads used as comparisons to treated roads). Vegetation and line condition monitoring will be conducted in 2021 for reference roads and in 2022 for treatment roads and then for both reference and treatment roads in 2024, 2026, 2031 and 2036 (3, 5, 10 and 15 years post-planting respectively). Cameras will be deployed in 2020 and checked twice a year until 2024.

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6 APPENDIX 1. GIS DISTURBANCE PROCESSING SUMMARY

(Note: italics indicate filenames)

Fireguards:

The fireguard layer contained many features that were duplicated, were coincident with roads, or have not been constructed. The layer was reduced to existing features by:

1. Removing all features that were not constructed, retained only features with the following FLType values:
    a. 0 – Unknown
    b. 9 – Completed Dozer Line
    c. 11 – Completed Line
2. Deleted all duplicate features in the dataset
3. Removed all features that were coincident with roads
4. Some of the remaining fireguards were represented by more than one feature. In these cases one was typically more accurate than the other when compared to imagery. The less accurate feature of the two was deleted.
5. One feature, originally digitized as a road from satellite imagery, was deleted from the road layer after it was identified as a fire guard by Mark Parminter, and added to the fire guard layer. This feature is located ~7 km south of Capoose Lake.

Cutblocks:

Several cutblock layers were provided by FLNRORD (*Cut1960, Cut1970, Cut1980, Cut1990, Cut2000,* and *Cut2010*) along with others from Canfor and FLNRO (*EXISTING_OPENINGS,PENDING_CUTBLOCKS*, *Whitesail_harvested_blocks_cfp*, *Whitesail_proposed_to_permitted_unharvested_blocks_cfp_2018_12_11*, and *Blocks*). The Canfor layers were used to augment the FLNRORD-assembled layers as described below:

1. The FLRNORD layers were merged into a single layer
2. Each of the Canfor layers had all of their overlaps with the FLNRORD layer erased and were then merged onto the FLNRORD layer. Attributes from the Canfor layers were transferred to the fields of the FLNRORD layer wherever the information was compatible between layers. This process was repeated for each of the Canfor layers in sequence in order to build up a non-overlapping cutblock layer.
    1. Block IDs were a challenge:
        i. For the FLNRO blocks a unique ID was generated by appending the feature class OBJECTID to the "FLNRO_" e.g. FLNRO_476
        ii. For the *Whitesail_proposed_to_permitted_unharvested_blocks_cfp_2018_12_11* layer, the block ID was taken from the BLOCK_ID field
        iii. For the Blocks layer, the ID was a concatenation of the BLOCK_ID and MARK_ID fields as the BLOCK_ID field alone was not unique for each record in this layer.
    2. Harvest years were taken from the following fields:
        i. For FLNRO blocks, they came from the HARVEST__2 layer
        ii. For *Whitesail_proposed_to_permitted_unharvested_blocks_cfp_2018_12_11 blocks* they came from HS_DATE

        iii. For *Blocks*, they came from HS_DATE
        iv. Any proposed blocks that were not attributed with a planned harvest date were assigned a harvest year of 2020 (n=18)
    3. Data Source for block information came from:
        i. FLNRO: DATA_SOURC, if this field was blank information was taken from DATA_SOU_1
        ii. *Whitesail_proposed_to_permitted_unharvested_blocks_cfp_2018_12_11 blocks*: set to 'Canfor'
        iii. *Blocks*: set to 'Canfor'
    4. Block status information came from:
        i. FLNRO: no information available in parent table, it is assumed that all blocks in this layer are already in existence
        ii. *Whitesail_proposed_to_permitted_unharvested_blocks_cfp_2018_12_11*: BLOCK_STAT
        iii. *Blocks*: BLOCK_STATE
3. A new field called CUT_DECADE was added to the merged layer tracking the decade in which a block was (or is scheduled to be harvested) e.g. 1960-1969 = 1960s
4. During this process a large number of sliver polygons were generated where there were slight differences between polygons representing the same cutblocks in the various layers. These were dealt with in phases:
    1. There were a total 37771 polygons to start with. Many of these polygons were <0.5ha in size (chosen as a minimum polygon size based on map examination and professional judgement). In this case polygons were merged with adjacent polygons if the adjacent polygon had the same recorded harvest year as the sliver under the assumption and observation that blocks were rarely harvested adjacent to one another in the same year. This removed 25,150 sliver polygons leaving 12,621 cutblocks. Slivers smaller than 0.5ha still remain if they are not in contact with adjacent polyongs or if they were harvested at a different date than their neighbours. Because of their small size, these polygons were deleted (n=5557) to leave a final estimate of 7,064 cutblocks in the study area over 0.5ha in size The resulting shapefile is not precise but is much closer to reality than would have been possible without the above sliver elimination.
5. A grouping of four non-existent cutblocks in Tweedsmuir Park were deleted.
6. A new field which simplifies the BLOCKSTATE attribute was added to the attribute table of the resulting layer. This field is called IS_EXISTIN and contains a simple Y/N indication of whether a block is believed to exist on the landscape. It was populated based on the following assumptions:
    1. Any blocks with a harvest year later than 2018 are assumed to not yet be in existence (though some of the 2019 blocks may now be harvested or in progress)
    2. Any blocks with a harvest year before 2019 with a block state of 'Approved', 'Permitted', 'Layout Complete', or other more concrete indication of harvest are assumed to have been harvested.
    3. Any blocks with a harvest year before 2019 with a block state of 'Proposed' are assumed not to have been harvested. Only 1 polygon satisfied this condition.
7. Several layers of existing and proposed cutblocks were made available after the other layers which resulted in the addition of 422 polygons for a total of 7,486 polygons (from *LakesDistrict.gdb\EXISTING_OPENINGS, data.gdb\Results_Opening, data.gdb\FTEN_HB*, and *data.gdb\FTEN_Pending*).

8. After this process, there were still numerous blocks missing across the study area that were visible on 2017 imagery. These blocks were digitized (N=107), These blocks were assigned a status of 'HARVEST COMPLETE' and an age was estimated based on the visual appearance of the cutblock compared to neighbours whose age was known.

A review of the results of the forest harvesting disturbance by decade resulted in detection of an anomaly in one cutblock in the Whitesail Priority Restoration Area that reported a disturbance date in the 1970s. This was the only cutblock attributed to that decade. Otherwise, date of disturbance for all other cutblocks were in the 1990s or later. On closer examination, this cutblock was associated with a cutting permit for a cutblock north of Tahtsa Lake, which was harvested. However, none of the satellite imagery reviewed showed any evidence of forest harvesting in the location in the Whitesail Priority Restoration Area so it was removed from the dataset.

Recreation:

The recreation layer was augmented with several small polygons digitized from imagery to include campground and lodge features that were not otherwise included in existing spatial layers. In these cases, the digitized polygons incorporated the visible extent of the disturbance, not the extent of any associated tenure at the site.

Roads:

Roads were mostly composed of information from layers provided by FLNRORD (*a_integrated_roads_no_trim_Clip*, *a_roads_DRA_transport_line_Clip*, *a_RoadsErase_Clip*, *a_SkeenaRoadsJan2018_ResourceRdsNotOG_Clip*). Additional roads came from Canfor (*CFP_Tweedsmuir.gdb/Roads*). Any remaining roads that were visible on 2017-vintage satellite imagery were digitized in ArcMap.

1. Digitized roads: most digitized roads were those associated with mining exploration in alpine areas. If a road was not visible on the 2017 imagery, google maps and bing maps imagery were consulted to see if the connection to the remainder of the road network was visible there. If it was visible, the road was digitized accordingly, if not, the connecting segment was not digitized. A total of 1,226 road segments representing 656.3 km of road were digitized.
2. There was a very high level of overlap between the different layers, unfortunately, most of the time the features representing the same road were slightly different between the input layers so it was not possible to simply delete duplicate features to get a clean road layer so the following procedure was followed to eliminate the vast majority of duplicates and generate a road layer that was closer to reality.
    a. The *a_roads_DRA_transport_line_Clip* layer was chosen as the base layer to which roads from other layers would have duplicates removed and the remainder added on to build a new road layer. This layer was chosen because it has the most consistent attribution of all the input layers.
    b. After examining the spatial deviation between analogous features between road layers and trying several different buffer options, the *a_roads_DRA_transport_line_Clip* layer was buffered by 20 m. We then added roads from other layers that existed outside of this 20 m buffer. Some small portions of analogous roads remained even outside of this 20 m buffer, but this distance was chosen for its balance of being able to exclude duplicate features without deleting an excessing amount of road from other layers that added to the completeness of the final road network.

   c. Using the buffer, all features from the next road layer that were within the buffer were erased using the 'Erase' function in the ETGeoWizards ArcMap Extension.
   d. The remaining features were merged with the *a_roads_DRA_transport_line_Clip* layer and attributes were standardized as much as was possible.
   e. The merged layer was then buffered by 20 m and the erase, and merge process was repeated with the next input road layer and so on until all the available roads (and digitized roads were added and a final road layer was created.
   f. While this procedure does eliminate the vast majority (1000s of km) of analogous road features, it also introduced 20 m gaps where the roads being added on didn't connect to the remainder of the network. However, the amount of road lost to this is a negligible fraction of the length of the road network, but had far less impact than retaining the analogous features so it was deemed to be an acceptable minor error to introduce into the road layer. Overall this process eliminated a vast amount of duplicate features over simply merging all of the available input road layers, resulting in a reduction from 36,615.6km of road down to 11,036.2km.
   g. The existence of some roads within Tweedsmuir Park could not be verified through imagery or inquiry into available spatial layers. These features were deleted from consideration in the disturbance analysis but were retained in a separate GIS feature class in the event that they are required in the future.
3. Proposed roads: some of the input road layers contained features that were attributed as being proposed for construction. However, it was found that this attribution was not always current to the actual state of the roads as many were found to have since been constructed when viewing satellite imagery. This made it impossible to simply remove all roads that were marked as 'proposed'. To compensate for this we deleted those roads that were proposed but extended into presently un-roaded areas to limit over-estimating the area affected by anthropogenic disturbance.
4. One feature ~7km south of Capoose Lake that was digitized as a road was deleted from the road layer and added to the fire guard layer after it was identified as one by Mark Parminter.

Agriculture:

1. The agriculture layer available from public data maps all area under agricultural tenure or private agricultural land regardless of whether or not it is currently under cultivation. For this reason, any areas within these polygons that were composed of mature forest in the 2017 imagery were removed from the layer.
2. There were some missing polygons that were visibly under agricultural use in the 2017 imagery. These were digitized in ArcMap.

Mining:

The mining layer was augmented with several small polygons digitized from imagery to include borrow pit and gravel pit/quarry features that were not otherwise included in existing spatial layers. In these cases, the digitized polygons incorporated the visible extent of the disturbance, not the extent of any associated tenure at the site.

Urban:

The urban layer was augmented with small polygons digitized from imagery to include settlement and industrial features that were not otherwise included in existing spatial layers. In these cases, the digitized polygons incorporated the visible extent of the disturbance, not the extent of any associated tenure at the site.

Seismic:

The seismic layer was provided as a collection of polygonal disturbance footprints. In some cases there was no visible evidence that these lines were ever constructed after attempts to confirm them in imagery or via inquiry into available sources of spatial data. These lines were located in Tweedsmuir Park and were deleted from consideration in the disturbance analysis. The deleted lines were retained in a separate GIS feature class so that the information would not be lost in the event it was ever needed in the future.

Several other seismic features located in Entiako Park were deemed to correspond to district lot lines. These features were reclassified as district lot lines instead of seismic features in the disturbance analysis.

Determining a total length for the amount of seismic line disturbance required that the supplied seismic polygon footprints were re-digitized as centerlines inside the polygons. This process required some approximation and is likely to slightly overestimate the length of the individual line segments by 5-20 metres. The total error introduced in this manner is estimated to be <1% of the total length value determined for seismic lines in the study area.

District Lot Lines:

Several seismic features located in Entiako Park were deemed to correspond to district lot lines. These features were reclassified as district lot lines instead of seismic features in the disturbance analysis.