

## Provincial Caribou Recovery Program Herd Planning Disclaimer



*The following herd plans are a result of Phase One planning and are an incomplete product. Additionally, the documents are 'living' reports and will be updated regularly as Phase Two progresses.*

Phase Two planning is currently underway for some herds however still at its early stages of development; many plans reflect this as they are in different stages along their scheduled project continuum.

One of the cornerstone guiding principles to the Caribou Recovery Program (the Program) is to use consistent, fact-based approaches for all woodland caribou herds in the province. The Program has refined and adopted a new format to herd planning that will effectively:

- ❖ Provide a consistent approach to managing all woodland caribou herds in BC
- ❖ Recognize the unique circumstances of each herd
- ❖ Build from current (legacy) caribou management plans
- ❖ Consider First Nations' and stakeholder interests and ideas
- ❖ Be included in larger regional plans

Completed herd plans will describe the status of each herd, and the threats faced by that particular herd. The plans will take note of previous actions, and actions that are planned to take place in the future. As we implement the herd plans, the Program will carefully monitor to which extent and magnitude the caribou respond, and modify its actions as accordingly. Herd plans will help us document our decisions and discuss issues with First Nations and with stakeholders.

Phase One consisted of:

- ✓ Status of herd or sub-population
- ✓ Identified threats
- ✓ Literature
- ✓ Previous work completed

Phase Two will consist of input from:

- Engagement with Indigenous communities
- Provincial Caribou Science Team
- Stakeholders
- Decision-support tools

# WOODLAND CARIBOU PLAN

## Tweedsmuir - Entiako

### Subpopulation

Tweedsmuir Local Population Unit



BRITISH  
COLUMBIA

**Recommended Citation:**

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## EXECUTIVE SUMMARY

DRAFT

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# 1 BACKGROUND

## 1.1 INTRODUCTION TO THE PROGRAM

All caribou within British Columbia are Woodland Caribou (*Rangifer tarandus caribou*). The Tweedsmuir - Entiako caribou are a subpopulation of the Northern caribou ecotype within the Southern Mountain National Ecological Area (SMNEA) and are listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and appear on Schedule 1 of the Federal Species at Risk Act (SARA) (EC, 2014; MCTAC, 2002). These caribou herds are blue listed in British Columbia and are included in the Provincial Identified Wildlife Management Strategy (IWMS) under the provincial Forest and Range Practices Act (FRPA).

In 2011, COSEWIC defined 12 designatable units (DUs) for caribou in Canada, which represent discrete and evolutionarily-significant units of caribou. Northern ecotype caribou in BC that are included in the SMNEA were reorganized into the central and northern caribou DUs. The Tweedsmuir – Entiako subpopulation falls into the northern caribou DU (DU7) (COSEWIC, 2014).

The northern caribou DU was assessed as special concern in May 2014 (COSEWIC, 2014). This recommended down-listing of DU7 was submitted to the Federal Minister of the Environment for listing consideration under SARA in fall 2014. The updated listing SARA listings have not yet been amended to follow this recommendation and the Tweedsmuir – Entiako subpopulation remain listed as SMNEA caribou and threatened under SARA.

Woodland Caribou are further divided into Local Population Units (LPU's) by Environment Canada. Within the proposed Northern Mountain Caribou group there are seven Local Populations. The Tweedsmuir - Entiako subpopulation is alone in the Tweedsmuir Local Population Unit (EC, 2014).

Recovery plans are required for all woodland caribou populations that will be designated as threatened or endangered in Canada (ECCC, 2016). While the designation for the Tweedsmuir - Entiako subpopulation will be “special concern”, current monitoring indicates that it has suffered recent declines and is in need of comprehensive recovery planning.

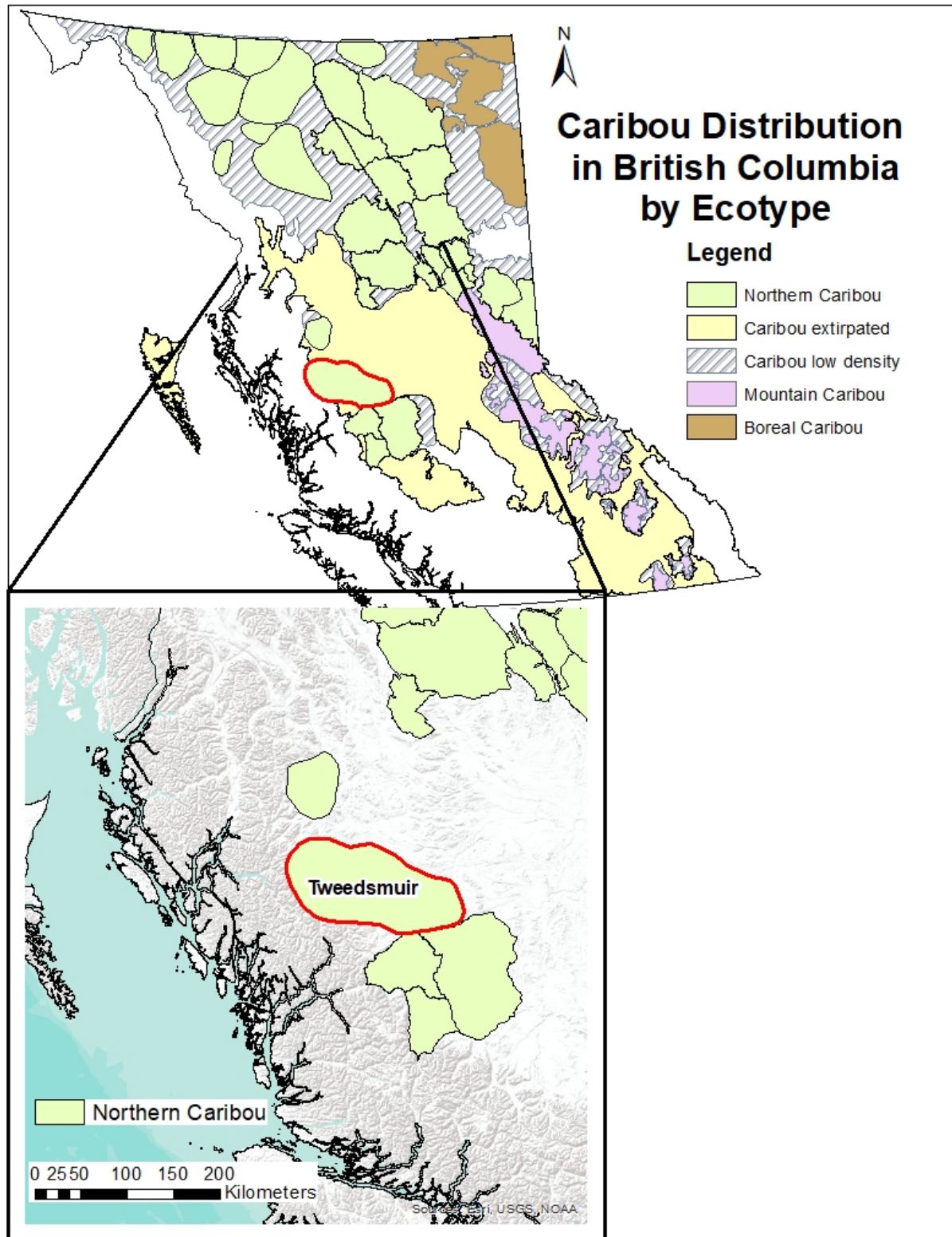
This document spans the divide between these disparate designations provincially and federally, compiling past research, knowledge and management actions into guidance for the management and recovery of the Tweedsmuir - Entiako Northern Mountain caribou subpopulation.

# 2 POPULATION DESCRIPTION

## 2.1 DISTRIBUTION

The Tweedsmuir - Entiako caribou range includes approximately 17,000 km<sup>2</sup> of the Nechako Plateau area and eastern slopes of the Coast Mountains in Central British Columbia (Figure 1), approximately 140 km south of Smithers BC and 180 km west of Prince George BC (Google Earth, 2017; Cichowski & Banner, 1992; Cichowski, 2015). These caribou have the longest migration of any caribou in British Columbia, moving up to 120 km from the calving areas in the low elevation Whitesail reach and high elevation North Tweedsmuir ranges to the historic winter habitat south of Tetachuk Lake (MFLNRO Skeena, 2017). Elevations range from 850 meters to 2350 meters above sea level (Google Earth, 2017). The Tweedsmuir - Entiako caribou subpopulation borders on the Rainbows and Itcha – Ilgachuz subpopulations to the south while the Telkwa subpopulation's range begins after a 30 km gap to the north.





**Figure 1.** Caribou distribution in BC by ecotype . The Tweedsmuir - Entiako subpopulation is outlined in red.



## 2.2 HABITAT AND BEHAVIOUR

In winter the Tweedsmuir - Entiako caribou subpopulation feed mostly on low elevation terrestrial lichens both south of Tetachuck Lake in the Entiako Lakes – Laidman Lake area and north of Tetachuck Lake in the East Ootsa area (MFLNRO Skeena, 2017; Steventon, 1996; Cichowski, 2015; Himmer, 2001). A smaller percentage move to higher elevations in the Fawnie Mountains in mid-winter to feed on terrestrial lichens on windswept slopes or on arboreal lichens in the subalpine. By the end of March they are usually all on the south side of Tetachuck Lake foraging on grasses, sedges, and forbs on low elevation snow free areas (MFLNRO Skeena, 2017; Himmer, 2001).

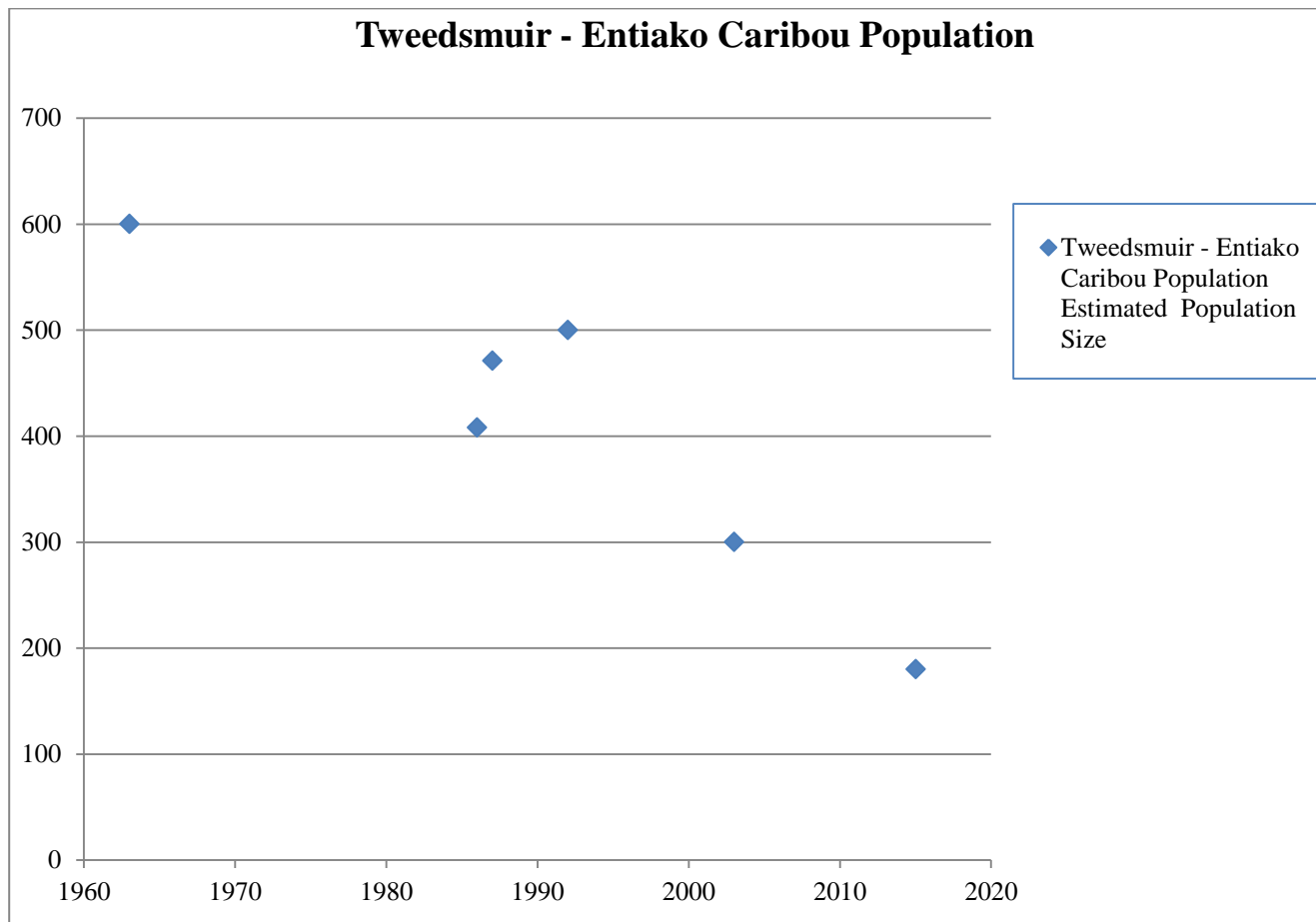
By mid-April they begin their spring migration north across Tetachuck Lake to the Chelaslie valley and northern Tweedsmuir Provincial Park. Some migrate further west along both shores of Eutsuk Lake or northwest across Whitesail Lake. Calving occurs at subalpine – alpine elevations throughout this area. Islands in Whitesail Lake have also historically been used for calving (MFLNRO Skeena, 2017; Cichowski, 2015; Himmer, 2001).

Summer habitat can range from alpine to low elevations, mostly within northern Tweedsmuir Provincial Park (Cichowski & Banner, 1993) and further west as far as Tahtsa Lake (Cichowski, 2015). In early October they congregate for the rut in the Quanchus Mountains and other areas of Tweedsmuir Provincial Park prior to the fall migration to the Tetachuck Lake area (MFLNRO Skeena, 2017; Cichowski, 2015).

Preliminary data and observations indicate that habitat-use patterns are changing as a result of a large-scale fire that burnt much of the winter range in 2014 (MFLNRO Skeena, 2017).

## 2.3 POPULATION SIZE AND TREND

The Tweedsmuir – Entiako caribou population is difficult to determine as a significant part of the population may be below treeline at any time (Cichowski, 2015). Several survey methods have been used. The earliest estimate was 600 animals in 1963 (Cichowski, 2015). By 2003 the estimate had declined to 200 – 300 caribou, and by 2015 further declines to an estimate of 150-180 caribou (MFLNRO Skeena, 2017). Adult female caribou mortality rates have been consistently moderate to high, while calf recruitment rates have been low to moderate over this period (MFLNRO Skeena, 2017; Roberts, 2016). On a positive note the October 2017 rut survey resulted in a minimum count of 146 caribou, a continued increase from the 94 counted in 2013 (Roberts & Grant, 2017). What really stands out in this rut count however is that 26% of the total counts were calves (Roberts & Grant, 2017), well above the 15% suggested for a stable population (Bergerud, 1996).



**Figure 2:** Tweedsmuir - Entiako caribou population trend (minimum estimate) 1963 – 2015.

### 3 THREATS AND LIMITING FACTORS

Current declines in woodland caribou populations have been ultimately attributed to direct and indirect effects of human activities and climate change (Vors & Boyce, 2009; Festa-Bianchet, et al., 2011; EC, 2014). These effects have resulted in lowered rates of adult female survival and/or juvenile recruitment, two demographic rates that have high influence on caribou population dynamics (DeCesare, et al., 2012). For most populations, these effects have led to unsustainable rates of predation (McLoughlin, et al., 2003; Wittmer, et al., 2005b; Apps, et al., 2013). Compared to other ungulates, caribou are particularly vulnerable to increasing predation because they have low reproductive rates (Bergerud, 2000). To reduce predation risk, caribou generally occur at low densities and have evolved to live in low productivity habitats that spatially separate them from other ungulates and their generalist predators (Bergerud, 1992). Effects from human activities and climate change likely compromise this spacing strategy by changing the abundance and spatial distribution of these other ungulates and predators, increasing the likelihood of caribou-predator encounters and consequently increasing predation rates (Festa-Bianchet, et al., 2011).

The federal *Recovery Strategy* for SM caribou (EC, 2014) identified a number of threats potentially affecting caribou populations and their habitat. These threats, in descending order of importance, included: predation, industrial activities, roads and other linear features, recreational activities, natural disturbances (e.g. fire), hunting, climate change and parasites and diseases. This section follows a similar approach, discussing these threats – and

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others – though their order does not reflect their relative importance to a specific population. Note that while threats are discussed individually, they are not mutually exclusive as they may interact and their effects on caribou population dynamics are likely cumulative (Sorensen, et al., 2008; Johnson, et al., 2015).

### 3.1 PREDATION

Multiple GPS and radio telemetry studies throughout BC have indicated that the dominant, proximal cause of woodland caribou mortality is predation (Wittmer, et al., 2013). Woodland caribou have evolved with their predators and have persisted despite millennia of predation. Their impact on woodland caribou populations has increased due to the result of three dominant processes: apparent competition mediated by increased alternative prey abundance (Hebblewhite, et al., 2007), apparent competition mediated by expanding alternative prey distribution (Wittmer, et al., 2007; DeCesare, et al., 2009; Latham, et al., 2011b), and enhanced predator access to woodland caribou habitat mediated by roads and other industrial developments (James & Stuart-Smith, 2000; Latham, et al., 2011a).

More generally, Bergerud (2007) has calculated that wolf densities greater than 6.5 wolves/1000 km<sup>2</sup> will result in woodland caribou declines. Most caribou mortality investigations conclude wolf predation (Thiessen, C. pers. comm. 2017) and anecdotal evidence suggests a relatively high wolf population (MFLNRO Skeena, 2017).

While not specific to the Tweedsmuir - Entiako caribou subpopulation, studies have demonstrated that bears negatively impact calf recruitment and may impact adult survival (Adams, et al., 1995; Wittmer, et al., 2005a). Cougars are not thought to be major predators of caribou in northern BC (Wittmer, et al., 2005a).

### 3.2 FOOD LIMITATION

Lichens form the main part of caribou's winter diet, while in the summer a variety of vegetation is consumed. A comprehensive study of mountain caribou using bone marrow fat of deceased collared caribou suggests that population declines are linked to excessive predation, not body condition (McLellan, et al., 2012). Other studies also suggest that absolute quantity and quality of food does not limit growth of Woodland Caribou populations as long as adequate range is available to deal with severe snow conditions or loss of lichen producing habitat (Schaefer & Pruitt, 1991; Bergerud, 1996). However the result of supplemental feeding on the Kennedy Siding subpopulation suggests that caribou movements to reduce predation risk may reduce food intake and therefore lower nutritional condition (Heard & Zimmerman, 2017).

### 3.3 HUMAN ACTIVITIES

#### 3.3.1 INDUSTRIAL

##### 3.3.1.1 FORESTRY

Woodland caribou are an old-growth forest dependent species (Bergerud, 2000; Theberge & Oosenbrug, 1977) hence forest management affects their distribution and populations. Although some populations live seasonally in treeless, alpine ecosystems, all spend some of the year in forests. For this reason, forestry will affect woodland caribou populations. Forestry effects include very general "habitat loss" that reduces the amount of old-growth forest, to reduction in forest-based food resources to creating more, early seral forest habitat for apparent competitors such as deer and moose (Simpson & Woods, 1987; Cichowski, 1989; Seip, 1990; Stevenson, 1991). Factors such as the type of forest (Cichowski, 1989) and the size of cutblocks (Edmonds & Bloomfield, 1984) play a role in the effect of forestry practices on woodland caribou populations.

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Most caribou summer habitat is protected within Tweedsmuir Provincial Park (Cichowski & Banner, 1992) and substantial winter habitat is protected within Entiako Provincial Park and Entiako Protected Area (MFLNRO Skeena, 2017). However a considerable amount of low elevation winter habitat is unprotected. By the early 1970's little forest harvesting had taken place in this unprotected winter range (Cichowski, 2015), by the year 2000 large scale clearcut logging dominated these areas (Google Earth, 2017; Cichowski, 2015).

### 3.3.1.2 MINING

Mineral exploration and mine sites deter caribou both for the activities that occur there when they are active as well as for the habitat they destroy. Mines have a 2 km ZOI when they are active, but this shrinks to the physical footprint of the mine site when mines are dormant, inactive or abandoned (Polfus, et al., 2011). This physical footprint usually includes linear features such as roads and possibly powerlines, which increase predator travel efficiency, thus increasing the predation risk to the caribou (Latham, et al., 2011a; DeMars & Boutin, 2017).

The geology underlying some of the Tweedsmuir - Entiako caribou range has high metallic mineral values and mineral claims cover most of the caribou's range outside of the parks and protected areas. Exploration roads, trails, and drill sites are extensive in some areas (Cichowski, 2015). The Huckleberry mine, an open pit copper mine, has been operating in the northwestern part of the caribou range since 1997. The mine property encompasses 20,000 ha, although the current footprint is much smaller (Imperial Metals, 2017). Across the Tahtsa Reach of Ootsa Lake Gold Reach Resources operates an active exploration camp with road access on a 22,056 ha property that has potential for several hard metals (GoldReach Resources, 2017). In addition silver, lead, and zinc concentrations were found in the Mt. Davidson area near the eastern portion of the caribou range in 1973, an open pit gold mine with a footprint of 3300 ha is now proposed for that area (Newgold Inc., 2012).

### 3.3.1.3 OIL AND GAS

The potential impacts on caribou of oil and gas development would likely be similar but possibly more extensive than mining. However currently the oil and gas potential is low in this area.

### 3.3.1.4 CLEAN ENERGY

Clean energy projects could include large hydroelectric dams and reservoirs, smaller run of the river hydroelectric projects, wind farms, and solar power generating projects.

Research in southern British Columbia correlated hydroelectric development with declines in caribou populations (Simpson, 1987b). The construction of the Kenney dam in the 1950's and the subsequent formation of the Nechako reservoir may have contributed to the abandonment of winter ranges to the north of the Whitesail and Ootsa portions of the Nechako reservoir (MFLNRO Skeena, 2017; Cichowski, 2015). Initially the new reservoirs were responsible for higher caribou mortality as floating debris prevented them from reaching shore when crossing lakes (Cichowski, 2015). The higher waters also flooded islands that may have been used as secure calving locations.

There are no current run of the river hydroelectric, wind, or solar power generating installations or proposals in the Tweedsmuir - Entiako caribou subpopulation area.

### 3.3.1.5 OTHER

No other forms of industrial development are currently planned or underway within the Tweedsmuir - Entiako subpopulation area.

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### 3.3.2 RECREATION

Recreational activities, both motorized and non-motorized, can impact caribou populations by displacing individuals into sub-optimal habitats (Seip, et al., 2007; Lesmerises, et al., 2018), increasing stress levels (Freeman, 2008) and / or facilitating predator movement into caribou habitat (Whittington, et al., 2011). Unnecessary movements can deplete critical fat reserves, potentially decreasing the likelihood of successful parturition and calf rearing the following summer and potentially decreasing the ability to avoid predators (Seip, et al., 2007). Additional winter movements may also increase the amount of exposure to steep terrain, increasing the risk of mortality due to avalanches (Simpson, 1987a; Seip, et al., 2007).

Recreational activities in the Tweedsmuir – Entiako caribou range are predominately water based and focussed during the summer months. Backcountry recreation levels are considered low in the winter and low – moderate in the summer (Cichowski, 2015). However a proposed through road on the east side of the range could draw more recreational users into the area (MFLNRO Skeena, 2017).

#### 3.3.2.1 SNOWMOBILE

The highest potential for snowmobiling lies within Tweedsmuir Provincial Park. However access is poor to non-existent and snowmobiling is not permitted in this area of the Park (BC Ministry of Environment and Parks, 1988). The Tweedsmuir - Entiako caribou primarily use low elevation forested habitat during the winter months which is not as attractive to most snowmobilers as high elevation areas. One exception is the Fawnie Mountains where observations indicate that radio collared caribou have been displaced by snowmobile use (Cichowski, 2015).

#### 3.3.2.2 HELI-SKI / CAT SKI

There are no commercial helicopter or snowcat skiing operators within the Tweedsmuir - Entiako caribou subpopulation boundaries (HeliCat Canada, 2017).

#### 3.3.2.3 OTHER

Backcountry skiing, snowshoeing, ATV use, hiking, mountain biking, and other similar activities could also stress or displace caribou from preferred habitat (MFLNRO Skeena, 2017). However due to the remoteness of the area levels of these activities are generally considered low, although ATV use is becoming a concern in a couple areas (Cichowski, 2015).

### 3.3.3 OTHER

#### 3.3.3.1 AGRICULTURE

Agricultural development can impact caribou populations in several ways. These include the direct losses of habitat as forests are converted to fields and the supplementation of natural food sources for alternate prey such as elk and deer potentially increasing their populations, which in turn may support increased numbers of predators, increasing the predation risk to the caribou. In addition, domestic livestock could harbour diseases and parasites. Transmission to caribou has not been established within British Columbia (Martin, et al., 2011; Vors & Boyce, 2009).

Agricultural development within the Tweedsmuir - Entiako caribou range is limited, what there is lies along the north shore of Ootsa Lake and a smaller amount near Tatelkuz Lake (Google Earth, 2017; Cichowski, 2015).

#### 3.3.3.2 HIGHWAY CORRIDORS

Direct mortality from collisions with vehicles is the most obvious threat when roads pass through caribou habitat. Less obvious threats include direct loss of habitat along road right of ways; fragmentation of habitat, especially if

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traffic volumes form a crossing barrier (Apps & McLellan, 2006); the maintenance of permanent early seral along road edges supporting alternate prey and therefore predators; improved travel efficiencies for predators increasing predation risk; and improving human access for recreational use.

Currently there are no highways within the Tweedsmuir - Entiako caribou range. The only paved road accesses the north shore of Ootsa Lake (Cichowski, 2015). There are numerous forestry and mine roads in the northern and eastern portions of the caribou range. However there is a proposal to construct a road through the Tweedsmuir - Entiako caribou's winter range connecting Highway 20 near Anahim Lake to Highway 16 near Vanderhoof.

### 3.3.3.3 LINEAR FEATURES

Linear features could include roads as mentioned above but could also include powerlines, pipelines, railways, and seismic lines. These features often result in direct loss of habitat, create permanent early seral conditions that benefit alternate prey and their predators, and improve travel and therefore hunting efficiency for predators (DeMars & Boutin, 2017). Avoidance by caribou may extend the area of impact well beyond the physical footprint (Vistnes & Nellemann, 2008).

There are currently no powerlines, pipelines, railways, and seismic lines through the Tweedsmuir - Entiako caribou's range. However the proposed Newgold Blackwater mine would include a power transmission corridor (Newgold Inc., 2012).

### 3.3.3.4 HUNTING

Excessive hunting of caribou is likely responsible for the initial declines in populations throughout the southern two thirds of the province (Spalding, 2000), including the Tweedsmuir - Entiako Mountains. Overhunting was likely the cause of extirpation of caribou from the Babine Mountains to the north in the 1940's (Theberge & Oosenbrug, 1977). Harvest rates of Tweedsmuir - Entiako caribou was low from 1984 to 2002 and hunting was closed in 2003. Indications are that First Nations caribou harvest is generally very low and has not occurred since the Chelaslie fire in 2014 (MFLNRO Skeena, 2017).

Moose, deer, and goat hunting continues within the Tweedsmuir - Entiako caribou sub-population range (BC Government, 2016a; BC Government, 2016c). While reduction in alternative prey can be beneficial to woodland caribou, active hunting on caribou winter range may also contribute to accidental death by hunters who misidentify their prey. The specific impact to the Tweedsmuir - Entiako caribou sub-population is unknown.

## 3.4 NATURAL DISTURBANCE

Caribou populations are subject to impacts from a number of natural disturbances. Being dependent on old-growth forests, caribou are impacted by forest fires. In northern and boreal habitats, it takes 80 years for a forest to recover from a fire to become caribou habitat again. In addition the early seral habitat created post-fire may facilitate population increases in alternate prey and their predators. Although caribou are likely adapted to the natural forest fire regime within and adjacent to their ranges, effects of forest fire may act cumulatively with human-mediated disturbances to negatively impact caribou demography (Sorensen, et al., 2008). Caribou may also be affected by insect or disease outbreaks that affect forest stand condition. For mountain-dwelling caribou, avalanches constitute another type of natural disturbance that can potentially impact demography, though under normal conditions their importance as a mortality should be small unless population sizes are small (Hebblewhite, et al., 2007; Seip & Cichowski, 1996).

The recent mountain pine beetle epidemic was first detected within the Tweedsmuir - Entiako caribou's winter range in the early 1990's, and affected significant areas of mature lodgepole pine caribou winter ranges (Cichowski, 2007). In 2001 a project was launched to monitor the response of terrestrial lichens to the mountain



pine beetle attack and to subsequent forest harvesting, and to monitor changes to coarse woody debris as an indicator of caribou movement barriers (Cichowski, 2007; Cichowski, 2015). In 2005 caribou were collared to assess changes in habitat use due to the mountain pine beetle epidemic. After 3 years, while in the grey attack stages, caribou habitat use and seasonal movements were consistent with patterns recorded prior to the epidemic (Cichowski, 2010; Cichowski, 2015).

### 3.5 PARASITES AND DISEASES

Caribou can be impacted by a range of native and introduced diseases and parasites (Bergerud, et al., 2008; Schwantje, et al., 2014). Disease and parasite outbreaks can limit caribou populations by affecting survival and reproductive rates (Albon, et al., 2002; Klein, 1991) and effects of disease and parasites may interact with other limiting factors such as predation and nutrition. Threats from disease and parasites are predicted to increase with climate change (see *Section 3.6* below), particularly if spatial overlap between caribou and other ungulate species increases (Bradley, et al., 2005; Dobson, 2009; Kutz, et al., 2005). For example, increasing expansion of white-tailed deer into caribou range may increase the prevalence of meningeal worm in caribou, a parasite that is highly pathogenic to caribou and whose usual host is white-tailed deer (Anderson, 1972).

Impacts from parasites and disease on the population dynamics of the Tweedsmuir - Entiako caribou subpopulation are not well studied. Evidence to date from an extensive study involving the mountain caribou ecotype suggests that mortality from natural causes (i.e. diseases and nutrition) is low (McLellan, et al., 2012; Apps, et al., 2013) and diseases and parasites are not thought to be a major driver of current declines in populations of southern mountain caribou (EC, 2014).

### 3.6 CLIMATE CHANGE

Climate change can potentially exert numerous effects on caribou population dynamics. Warmer winters may impact forage availability by increasing icing events and / or causing poor snow conditions that limit the ability of caribou to access lichens (Hansen, et al., 2011). A warming climate may also change the abundances and distribution of alternate prey and their generalist predators, potentially increasing rates of caribou predation (Latham, et al., 2011b; Dawe & Boutin, 2016). Climate change may alter the spatial and temporal distribution of insects, diseases and parasites, potentially affecting individual fitness and population dynamics (Bradley, et al., 2005). Changes to the natural disturbance regime (e.g. fire interval, fire intensity, avalanche frequency) may further impact caribou through mechanisms outlined in *Section 3.4*.

There is no specific information on how climate change may be affecting the Tweedsmuir - Entiako subpopulation of caribou, although the mountain pine beetle infestation described above has likely been exuberated by warmer winters (COSEWIC, 2014).

### 3.7 SMALL POPULATION SIZE EFFECTS

Caribou subpopulations that are small and isolated may be subject to negative demographic effects that can occur as a result of their small size (Caughley, 1994). However with an estimated current population of 150- 180 caribou the Tweedsmuir – Entiako caribou may not currently fit into this category.

## 4 MANAGEMENT HISTORY

### 4.1 HABITAT

#### 4.1.1 PROTECTION

Tweedsmuir Provincial Park, established in 1938, originally included most of the Tweedsmuir – Entiako caribou range. However in 1956 mountainous areas to the south of the Tweedsmuir – Entiako caribou range was included in the park and winter caribou habitat in the east and summer habitat in the north-west was excluded, resulting in a 446,093 ha park (Cichowski, 2015; MFLNRO Skeena, 2017). While forest harvesting has not been permitted in the park, originally mining was allowed. In 1988 most of it was upgraded to a Class A park which prohibits mining (BC Ministry of Environment and Parks, 1988). A further portion was reclassified to Class A status in 2000, leaving 10,000 ha of the park where mineral exploration is allowed (Cichowski, 2015). In 1996 the Kitlope watershed was designated as a protected area, upgraded to the Huchsduwachsdu Nuyem Jees / Kitlope Heritage Conservancy in 2008 (BC Parks, 2012). Although the conservancy covers 321,572 ha, only a portion of it is used by caribou (MFLNRO Skeena, 2017). In 1999 and 2000 Entiako Provincial Park and Entiako Protected Area respectively were established. In 2007 these two areas were combined into one Class A park, totaling 126,023 ha (BC Ministry of Environment, 2006; MFLNRO Skeena, 2017).

Forest harvesting and road building is limited in a further 35,063 ha of low elevation caribou winter range through Old Growth Management Areas (OGMA's) and Ungulate Winter Ranges (UWR) (MFLNRO Skeena, 2017).

Despite the large amounts of protection afforded the Tweedsmuir – Entiako caribou habitat, a significant amount of critical caribou habitat remains within the Provincial forest and has very limited to no protection (MFLNRO Skeena, 2017).

#### 4.1.2 ENHANCEMENT AND RESTORATION

Caribou habitat enhancement and restoration relates both to recreating or improving habitats for caribou seasonal range as well as managing linear disturbances (roads, seismic lines, pipelines, transmission rights of way) to prevent facilitated predator access (Alberta Woodland Caribou Recovery Team, 2005; Dickie, et al., 2017; Dickie, et al., 2016). As well, habitat enhancement and restoration must be accompanied by protection to be effective (Schneider, et al., 2010). Restoration of caribou habitat takes place naturally through succession from early seral stages to mature and old forest. Standard silviculture practices could aid this process. Further habitat enhancement and / or restoration has not taken place within the Tweedsmuir - Entiako caribou subpopulation area.

### 4.2 RECREATION AND ACCESS MANAGEMENT

#### 4.2.1 SNOWMOBILE

Snowmobiling is not permitted in any of the three provincial parks within the Tweedsmuir – Entiako caribou range (BC Parks, 2012; BC Ministry of Environment, 2006; BC Ministry of Environment and Parks, 1988). The only snowmobile restrictions outside of provincial parks are located within the area of the Morice Land and Resources Management Plan (LRMP), where the area south of Coles Lake is zoned as winter non-motorized (Cichowski, 2015).

### 4.2.2 HELI SKI / CAT SKI

The helicopter and cat skiing industry is guided by best management practices. However there are no commercial helicopter or snowcat skiing operators within the Tweedsmuir - Entiako caribou subpopulation boundaries (HeliCat Canada, 2017).

### 4.2.3 SUMMER RECREATION

The provincial parks within the Tweedsmuir – Entiako caribou range are focussed on non-motorized backcountry recreation, however motor boats are permitted on the large lakes and floatplane access is permitted. Outside of provincial parks the areas south of Tahtsa Lake and south of Troitsa Lake above 1000 m in elevation are zoned as summer non-motorized with some exceptions under the Morice LRMP (Cichowski, 2015).

## 4.3 PREDATORS

### 4.3.1 WOLF MANAGEMENT

A wolf-collaring program is ongoing for the Tweedsmuir-Entiako caribou area. However the number of wolves collared is small due to difficulty in locating and collaring wolves. Conducting wolf censuses for this herd area may be difficult to achieve in isolation of a collaring program and may not be feasible in the low-elevation wooded habitats of the Tweedsmuir-Entiako winter range (MFLNRO Skeena, 2017).

Wolf hunting is managed as general open seasons through the provincial hunting regulations. The limit on the number of wolves harvested per person annually (annual bag limit) for the Tweedsmuir - Entiako caribou subpopulation area (Management Units (MUs) 5-9, 5-10, 6-1, 6-2, 6-4) is 3 (BC Government, 2016a). Wolves are also trapped by registered trappers for their fur. There is no requirement for compulsory inspection or compulsory reporting of wolves harvested in Regions 5 or 6 (BC Government, 2016a).

Hunting and trapping does not usually result in the removal of complete packs, remaining pack members can reproduce and recover within one year providing food resources are available. Partial pack removal can also splinter packs, resulting in more wolves as their territorial system is compromised (B. McLellan, pers. comm. 2017). Complete pack removal, usually carried out from a helicopter, would likely be more effective. An aerial wolf cull has not been carried out within Tweedsmuir - Entiako caribou subpopulation area.

### 4.3.2 COUGAR MANAGEMENT

Cougar populations are thought to be low within the Tweedsmuir - Entiako caribou subpopulation area. The annual bag limit for cougar in MU 5-9 is two, and in MU's 6-1, 6-2, and 6-4 is one. Cougar hunting is not permitted in MU 5-10. There is a requirement for compulsory inspection of cougars harvested in Regions 5 and 6 (BC Government, 2016a).

### 4.3.3 OTHER

Bear and wolverine predation on neonates and caribou in the spring can also have a significant impact on caribou populations (Wittmer, et al., 2005a; MFLNRO Skeena, 2017). However bears and wolverine populations are likely not greater than historic levels, instead grizzly bears and wolverines themselves may be at risk in some areas (BC Conservation Data Centre, 2017). In addition, as bears are more abundant than caribou and only a small portion of the diet of any one bear would be caribou, a very large number of bears would have to be culled to have an effect (MFLNRO LNG, 2015).

### 4.4 PRIMARY PREY

Managing the abundance and distribution of other ungulate species (e.g. moose and deer) has been a fundamental recommendation for recovering southern mountain caribou (MCTAC, 2002; Messier, et al., 2004; MCST, 2006; EC, 2014; Boutin & Merrill, 2016). To date there have not been changes to hunting management of primary prey for caribou recovery purposes.

#### 4.4.1 MOOSE MANAGEMENT

Information on moose and other ungulate populations that thrive in early seral habitats within caribou range areas is limited. Data collected as part of the Provincial Moose Research Program (Entiako) and by provincial Fish and Wildlife Staff for overlapping Wildlife Management Units will provide information on moose populations. However, the frequency at which these data are collected is not consistent across management units within the range, may not provide complete coverage, and typically is only collected on a 5-7 year survey cycle. In addition, survey scheduling and methods are designed to address management objectives for species other than caribou (MFLNRO Skeena, 2017).

Hunting moose in the Tweedsmuir – Entiako caribou range is managed through a combination of general open seasons and limited entry hunts (BC Government, 2016a).

#### 4.4.2 DEER MANAGEMENT

Both mule deer and white tail deer are present within the Tweedsmuir - Entiako caribou subpopulation area. There is a general open season for both white tail and mule deer bucks (BC Government, 2016a).

#### 4.4.3 OTHER

Elk are not abundant in the Tweedsmuir - Entiako caribou range and there is no general open or limited entry hunting seasons (BC Government, 2016a).

### 4.5 POPULATION REINFORCEMENT

#### 4.5.1 MATERNITY PENNING

Maternal penning to increase calf recruitment is a tool that has not been used with the Tweedsmuir - Entiako caribou subpopulation. It is not a viable tool for caribou populations over 100 animals (MFLNRO LNG, 2015). Penning requires a minimum of 60% of the female population penned and an annual female survival rate greater than 85% to be effective (DeMars, 2017). The number of females that would have to be penned to produce a significant increase to recruitment rates would be cost prohibitive.

#### 4.5.2 CAPTIVE BREEDING

Captive breeding is defined as “keeping and selectively breeding caribou in captivity, usually at an ex-situ facility, over a relatively long period of time with the purpose of releasing individuals back into the wild” (Hayek, et al., 2016). To date, captive breeding of caribou has not been implemented and is not in the plans as a management tool for conserving wild caribou populations.

#### 4.5.3 TRANSLOCATION

Translocation refers to the movement of individuals from one population (or subpopulation) to another (Hayek, et al., 2016). Numerous translocation efforts for caribou have taken place across North America (Bergerud & Mercer, 1989; Hayek, et al., 2016).

There have been no translocations of caribou into the Tweedsmuir - Entiako caribou subpopulation.

### 4.5.4 OTHER

Predator exclusion fencing or other forms of population reinforcement have not been implemented for the Tweedsmuir - Entiako caribou subpopulation.

### 4.6 STEWARDSHIP/OUTREACH

Stewardship Management Agreements (SMA's) are in place for many caribou subpopulation areas that also experience high recreational snowmobile use. The general concept is that while key areas of caribou are closed to snowmobile use, the snowmobiling community will act as stewards in implementing best management practices in other areas of caribou habitat that remain open to snowmobile use. Considerable outreach efforts at industry trade shows, snowmobile retailers, etc. may also be undertaken. The Tweedsmuir - Entiako caribou are not at high risk of displacement from preferred habitat by recreational activities so this area is not part of these stewardship or outreach activities

### 4.7 RESEARCH AND MONITORING

There have been decades of research into caribou biology and conservation. This body of work has informed scientists and policy makers of the key factors that contribute to caribou population dynamics, important threats and potential solutions. Key findings have been the proximate role of predation and apparent competition in caribou population fluctuations and the ultimate role of habitat destruction in caribou population declines. While these factors are well understood in a broad sense, ongoing research is necessary to fine tune caribou responses to ecological stimuli and human disturbance.

The Tweedsmuir - Entiako caribou subpopulation is at the forefront of research into the effects of the mountain pine beetle epidemic and subsequent forest die off on terrestrial lichens and subsequently on caribou habitat use (Cichowski & Haeussler, 2013; Cichowski, 2007; Cichowski, 2010; Cichowski & Williston, 2003; Cichowski, 2015).

## 5 IMPLICATIONS TO OTHER WILDLIFE

Management actions focused on conserving caribou will necessarily have impacts on other wildlife species. Caribou require landscapes where densities of other ungulates and predators are low; thus, management actions undertaken for caribou may result in population sizes of moose, deer, and wolf that are much lower than those currently experienced (Serrouya, et al., 2015; Serrouya, et al., 2017). Reducing the populations of these species may occur from either direct management actions (e.g. lethal control) or through environmental changes (e.g. habitat restoration for caribou) that lowers the extent of suitable habitat.

Conserving caribou will likely benefit a myriad of other species co-occurring within old-growth forests. In this context, caribou may be considered an “umbrella” species (Bichet, et al., 2016). Such species generally have large spatial requirements and are sensitive to environmental changes, both attributes associated with caribou. Meeting the habitat requirements of caribou will therefore result in the habitat needs of many other species also being met.

## 6 IMPLICATIONS TO OTHER VALUES

Enacting measures to conserve caribou will likely have impacts on social, political and economic values. Most woodland caribou populations occur in working landscapes managed for natural resource extraction. Conserving caribou in these landscapes will likely require limits on these activities, which will likely invoke socioeconomic

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costs (Schneider, et al., 2011). To effectively mitigate these impacts while conserving caribou in multi-use landscapes, conservation planning will need to incorporate both economic costs and the biological needs of caribou in a spatially-explicit modelling framework (Schneider, et al., 2011; Schneider, et al., 2012).

In many caribou ranges, reducing the current densities of other ungulate species will be fundamental to conserving caribou (Serrouya, et al., 2015). Lowered populations of big-game species such as moose will result in reduced hunting opportunities. While incorporating hunters in the initial lowering of these populations can be advantageous and seen as a “win-win” (Serrouya, et al., 2015), the long-term suppression of these populations will likely require support from the regional hunting community.

Caribou have evolved a life history strategy that is dependent on large landscapes of intact wilderness (Bergerud, 2000). For many, such landscapes have inherent and intangible value. Intact wilderness also has economic benefits, including climate regulation, sedimentation control and nutrient cycling (Balmford, et al., 2002).

Caribou conservation can also elicit ethical issues. For many small and rapidly declining populations, management actions may include direct control of predators and other ungulates (Hervieux, et al., 2014). Such actions can elicit considerable controversy and, consequently, require substantial scientific support and justification for their implementation (Boertje, et al., 2010).

## 7 PARTNERS / NEIGHBOURS

**Partners** are bodies, currently existing or with strong future potential, that can assist in some aspect of management, such as expertise, financial contribution, in-kind support or moral support.

**Neighbours** are bodies within in the caribou subpopulation area that are currently not participating in caribou management that could be affected by caribou management, such as local governments, industry tenure holders, and recreation groups. These neighbours could potentially become future partners.

## 8 RECOMMENDED ACTIONS

Recommended actions were adapted from (MFLNRO Skeena, 2017). Values are estimates only. There is uncertainty in the costs associated for program delivery and all estimates are subject to change based on more recent information and varying conditions. Estimates include costs associated with contracts for work that cannot be resourced internally.



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### 8.1 SHORT TERM (WITHIN 6-12 MONTHS)

Activity	Timeline	Cost	FTE
<b>Population Monitoring and Management</b>			
Caribou surveys, spring and fall, including calf recruitment and adult female survival	Annual for 5 years	\$75,000 / yr.	0.15
Maintain XX number of collars on caribou to monitor mortality cause and census sightability, conduct mortality investigations, collect samples for health and pregnancy	Annual		
Moose Surveys	Winter 2017 / 2018 then every 3-5 years	\$80,000 / survey	TBD
Wolf surveys / collaring / monitoring	Winter 2017 / 2018	\$50,000 / yr.	0.02
Bear survey in Whitesail	2018		
Initiate wolf control if densities > XX /1000 km <sup>2</sup>	2018 / 2019	\$200,000 / yr	1.0
<b>Habitat Protection and Management</b>			
Quantify the amount of habitat protection in the Tweedsmuir range by critical habitat type	2018	TBD	TBD
Quantify the number of authorizations (all agencies) issued since the 2014 recovery strategy	2018	TBD	TBD
Quantify the amount and type of habitat disturbance in the Tweedsmuir range by critical habitat	2018	TBD	TBD

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<b>Habitat Protection and Management (cont'd)</b>			
Develop access management principles	2018	TBD	TBD
Establish Coal Land Reserves under the Coal Act	2018	TBD	TBD
Establish Mineral Reserves under the Mineral Tenure Act	2018	TBD	TBD
Establish reserves under Section 16 and 17 of the Land Act	2018	TBD	TBD
Work with BC Parks to Ensure permits are aligned with caribou management objectives And wildfire response is aligned with protection of remaining high value winter ranges	Ongoing	TBD	TBD
Implement mitigation and offsetting for mining development in caribou habitat	2018	TBD	TBD
Develop and provide information workshops and BMPs for permitting within caribou habitat to regulatory agencies	2018	TBD	TBD
WHA Establishment for Whitesail area	2018	TBD	TBD
Work with Cheslatta FN to develop caribou management plan for the South Ootsa area and to ensure all permits are consistent with caribou habitat management	2018	TBD	TBD
Work with Canfor to develop caribou management plan(s) for the Whitesail and the Vanderhoof areas and to ensure all cutting permits within caribou critical habitat are consistent with caribou habitat management	2018	TBD	TBD
Work with FLRNO sectors and other agencies to align decision support with caribou habitat management objectives	2018	TBD	TBD

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<b>Habitat Protection and Management (cont'd)</b>			
Develop a coordinated approach to joint-range management with the Southern adjacent populations	2018	TBD	TBD
Develop and Implement a restoration strategy including restoration of burnt areas	2018	\$25,000	0.08
Continue lichen monitoring and initiate lichen restoration	2018	\$60,000 / yr for 3 yrs	0.02
Validate fire severity from recent fire severity mapping	2018	\$20,000	0.01
Scenario analyses to support FCI?? initiatives in winter range, to support predator and prey management, to support land base decisions and plan for climate change scenarios	2018	\$40,000	0.1
Support proponent led restoration activities to achieve targets set with support from scenario analysis processes	2018	\$2000	0.05
<b>Recreation Management</b>			
Identify and assess recreation-use pressures in the TEC herd range	2018	\$8000	0.01
<b>Community Engagement</b>			
Collaborative wildlife management	2018	TBD	TBD
South Skeena website	2018	TBD	TBD

### 8.2 MEDIUM TERM (WITHIN 12-24 MONTHS)

Activity	Timeline	Cost	FTE
Shoreline cleanup along Whitesail Lk to restore migratory routes	TBD	\$340,000	TBD

### 8.3 LONG TERM (WITHIN 24-48 MONTHS)

Activity	Timeline	Cost	FTE
Extend current moose research program in Entiako past 2019	TBD	TBD	TBD
Introduce moose cow / calf LEH	TBD	TBD	TBD

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if moose density becomes greater than X moose / km <sup>2</sup>			
Supplemental feeding	TBD	TBD	TBD

## 9 LITERATURE CITED

Adams, L., Singer, F. & Dale, B., 1995. Caribou calf mortality in Denali national park, Alaska. *Journal of Wildlife Management*, Volume 59, pp. 584-594.

Alberta Woodland Caribou Recovery Team, 2005. *Alberta woodland caribou recovery plan 2004/05 - 2013/14*, Edmonton, Alberta: Alberta Sustainable Resource Development, Fish and Wildlife Division.

Albon, S. et al., 2002. The role of parasites in the dynamics of a reindeer population. *Proceedings of the Royal Society of London: Biological Sciences*, Volume 269, p. 1625–1632.

Anderson, R., 1972. The ecological relationships of meningeal worm and native cervids in North America. *Journal of Wildlife Diseases*, Volume 8, pp. 304-310.

Apps, C. & McLellan, B., 2006. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. *Biological Conservation*, Volume 130, pp. 84-97.

Apps, C. et al., 2013. Spatial factors related to mortality and population decline of endangered mountain caribou.. *The Journal of Wildlife Management*, Volume 77, p. 1409–1419.

Balmford, A. et al., 2002. Economic reasons for conserving wild nature. *Science*, Volume 297, p. 950–953.

BC Conservation Data Centre, 2017. *BC Conservation Data Centre*. [Online]  
Available at: <http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre>  
[Accessed 4 October 2017].

BC Government, 2016a. *2016-2018 Hunting and trapping regulations synopsis*. Victoria, BC: s.n.

BC Government, 2016c. *British Columbia limited entry hunting regulations synopsis 2016-2017*, Victoria, BC: BC Ministry of Forests, Lands, and Natural resource Operations.

BC Ministry of Environment and Parks, 1988. *Tweedsmuir Master Plan*, Victoria, BC: BC Government.

BC Ministry of Environment, 2006. *Management direction statement and ecosystem management plan for Entiako Provincial Park and Entiako Protected Area*, Victoria BC: BC Parks.

BC Parks, 2012. *Huchsduwachsdu Nuyem Jees / Kitlope Heritage Conservancy management plan*, Victoria, BC: BC Parks.

Bergerud, A. & Mercer, W., 1989. Caribou introductions in eastern North America. *Wildlife Society Bulletin*, Volume 17, pp. 111-120.

Bergerud, A. T., 1992. Rareness as an antipredator strategy to reduce predation risk for moose and caribou. In: *Wildlife 2001: Populations*. Edited by DR. McCullough & R.B. Barrett. Elsevier, London, pp. 1008-1021.

## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

- Bergerud, A. T., 1996. Evolving perspectives on caribou population dynamics, have we got it right yet?. *Rangifer Spec. Issue*, 9, pp. 95-116.
- Bergerud, A. T., 2000. *Caribou*. Pp658-693 in S. Demarais and P.R.Karusmann, editors. *Ecology and Management of alrge Mammals in North America*. New Jersey: Prentice Hall.
- Bergerud, A. T., Luttich, S. N. & Camps, L., 2008. The return of caribou to Ungava.. *McGill-Queen's University Press*.
- Bichet, O. et al., 2016. Maintaining animal assemblages through single-species management: the case of threatened caribou in boreal forest. *Ecological Applications*, Volume 26, pp. 612-623.
- Boertje, R., Keech, M. & Paragi, T., 2010. Science and values influencing predator control for Alaska moose management. *The Journal of Wildlife Management*, Volume 74, p. 917-928.
- Boutin, S. & Merrill, E., 2016. *A review of population-based management of southern mountain caribou in BC.*, Revelstoke, BC.: Columbia Mountains Institute.
- Bradley, M., Kutz, S., Jenkins, E. & O'Hara, T., 2005. The potential impact of climate change on infectious diseases of Arctic fauna. *International Journal of Circumpolar Health*, Volume 64, pp. 468-477.
- Caughley, G., 1994. Directions in conservation biology. *The Journal of Animal Ecology*, Volume 63, pp. 215-244.
- Cichowski, D., 2007. *Tweedsmuir - Entiako caribou project - Effects of a mountain pine beetle epidemic on northern caribou habitat use, annual summary 2006/2007*, Smithers BC: s.n.
- Cichowski, D., 2010. *Tweedsmuir-Entiako caribou project: Effects of a mountain pine beetle epidemic on northern caribou habitat use - final report*, Smithers BC: Prepared for the BulkleyValley Centre for Natural Resources Research and Management.
- Cichowski, D., 2015. *Tweedsmuir-Entiako caribou population status and background information summary*, Smithers, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- Cichowski, D. B., 1989. *Seasonal movements, habitat use, and winter feeding ecology of woodland caribou in west-central British Columbia*, Vancouver, BC.: University of British Columbia.
- Cichowski, D. & Banner, A., 1992. *Management strategy and options for the Tweedsmuir - Entiako caribou winter range*, Smithers, BC: BC Ministry of Forests.
- Cichowski, D. & Banner, A., 1993. *Management strategy and options for the Tweedsmuir - Entiako caribou winter range*, Smithers, BC: BC Ministry of Forests.
- Cichowski, D. & Haeussler, S., 2013. The response of caribou terrestrial forage lichens to mountain pine beetles and forest harvesting in the East Ootsa and Entiako areas: annual report - 2012/2013 - year 11..
- Cichowski, D. & Williston, P., 2003. *The response of caribou terrestrial lichens to forest harvesting and mountain pine beetle.*, Smithers BC: s.n.

## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

- COSEWIC, 2014. COSEWIC assessment and status report on the Caribou *Rangifer tarandus*, Northern Mountain population, Central Mountain population and Southern Mountain population in Canada. *Committee on the Status of Endangered Wildlife in Canada*, p. xxii + 113.
- Dawe, K. & Boutin, S., 2016. Climate change is the primary driver of white-tailed deer (*Odocoileus virginianus*) range expansion at the northern extent of its range; land use is secondary. *Ecology and Evolution*, Volume 6, p. 6435–6451.
- DeCesare, N. et al., 2012. Estimating ungulate recruitment and growth rates using age ratios. *The Journal of Wildlife Management*, Volume 76, pp. 144-153.
- DeCesare, N. J., Hebblewhite, M., Robinson, H. S. & Musiani, M., 2009. Endangered, apparently: the role of apparent competition in endangered species conservation. *Animal Conservation*, Volume 13, pp. 353-362.
- DeMars, C., 2017. *Recovery action plan for Southern Mountain caribou within the Kootenay Region.*, s.l.: s.n.
- DeMars, C. A. & Boutin, S., 2017. Nowhere to hide: effects of linear features on predator-prey dynamics in a large mammal system. *Journal of Animal Ecology*.
- Dickie, M. et al., 2017. Evaluating functional recovery of habitat for threatened woodland caribou. *Ecosphere*.
- Dickie, M., Serrouya, R., McNay, R. & Boutin, S., 2016. Faster and farther: wolf movement on linear features and implications for hunting behaviour. *Journal of Applied Ecology*, Volume 54, pp. 253-263.
- Dobson, D., 2009. Climate variability, global change, immunity, and the dynamics of infectious diseases. *Ecology*, Volume 90, pp. 920-927.
- EC, 2014. Environment Canada. Recovery Strategy for the Woodland Caribou, Southern Mountain population (*Rangifer tarandus caribou*) in Canada. *Species at Risk Act Recovery Strategy Series*, p. vii + 103.
- EC, 2014. Environment Canada. Recovery Strategy for the Woodland Caribou, Southern Mountain population (*Rangifer tarandus caribou*) in Canada. *Species at Risk Act Recovery Strategy Series*, p. vii + 103.
- ECCC, 2016. *Environment and Climate Change Canada. Range Plan Guidance for Woodland Caribou, Boreal Population*, Ottawa: Environment and Climate Change Canada.
- Edmonds, E. J. & Bloomfield, M., 1984. *A study of woodland caribou (Rangifer tarandus caribou) in west-central Alberta, 1979 to 1983. Unpublished report AFW-84-045*, s.l.: Alberta Energy and Natural Resources Fish and Wildlife Division.
- Festa-Bianchet, M. et al., 2011. Conservation of caribou (*Rangifer tarandus*) in Canada: an uncertain future. *Canadian Journal of Zoology*, Volume 89, pp. 419-434.
- Freeman, N., 2008. *Motorized backcountry recreation and stress response in mountain caribou (Rangifer tarandus caribou)*. M.Sc. thesis, Vancouver, BC: University of British Columbia.
- GoldReach Resources, 2017. *GoldReach Resources Ltd.*. [Online]  
Available at: <http://www.goldreachresources.com/projects/>  
[Accessed 22 November 2017].
- Google Earth, 2017. Mountain View, California: Google Incorporated.



## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

- Hansen, B. et al., 2011. Climate, icing, and wild arctic reindeer: past relationships and future prospects. *Ecology*, Volume 92, pp. 1917-1923.
- Hayek, T. et al., 2016. An exploration of conservation breeding and translocation tools to improve the conservation status of boreal caribou populations in western Canada. *Centre for Conservation Research, Calgary Zoological Society, Calgary, AB.*
- Heard, D. & Zimmerman, K., 2017. *Supplemental feeding of Kennedy Siding caribou, September 2016 to January 2017*, Vancouver, BC.: Peace Northern Caribou Program.
- Hebblewhite, M. J. et al., 2007. Conditions for caribou persistence in the wolf-elk-caribou systems of the Canadian Rockies. *Rangifer*, Volume Special Issue 17, pp. 79-90.
- HeliCat Canada, 2017. *Wilderness skiing operations in British Columbia - Map - Canada helicopter and snowcat skiing operators*. [Online]  
Available at: <http://www.helicat.org/member-operators/>  
[Accessed 28 September 2017].
- Hervieux, D. et al., 2014. Managing wolves (*Canis lupus*) to recover threatened woodland caribou (*Rangifer tarandus caribou*) in Alberta. *Canadian Journal of Zoology*, Volume 92, p. 1029–1037.
- Himmer, S., 2001. *Wildlife species habitat models for the Chelaslie River area*, Burns Lake, BC: BC Ministry of Forests.
- Imperial Metals, 2017. *Imperial Metals - Huckleberry Mine Overview*. [Online]  
Available at: <https://www.imperialmetals.com/our-operations/huckleberry-mine/overview>  
[Accessed 13 11 2017].
- James, A. & Stuart-Smith, A., 2000. Distribution of caribou and wolves in relation to linear corridors. *Journal of Wildlife Management*, Volume 64, pp. 154-159.
- Johnson, C., Ehlers, L. & Seip, D., 2015. Witnessing extinction – Cumulative impacts across landscapes and the future loss of an evolutionarily significant unit of woodland caribou in Canada. *Biological Conservation*, Volume 186, pp. 176-186.
- Klein, D., 1991. Limiting factors in caribou population ecology. *Rangifer*, Volume 11, pp. 30-35.
- Kutz, S., Hoberg, E., Polley, L. & Jenkins, E., 2005. Global warming is changing the dynamics of Arctic host-parasite systems. *Proceedings of the Royal Society of Biological Sciences*, Volume 272, p. 2571–2576.
- Latham, A., Latham, M., Boyce, M. & Boutin, S., 2011a. Movement responses by wolves to industrial linear features and their effect on woodland caribou in northeastern Alberta. *Ecological Applications*, Volume 21, p. 2854–2865.
- Latham, A., Latham, M., McCutchen, N. & Boutin, S., 2011b. Invading white-tailed deer change wolf-caribou dynamics in northeastern Alberta. *Journal of Wildlife Management*, Volume 75, pp. 204-212.
- Lesmerises, F., Dery, F., Johnson, C. & St Laurent, M., 2018. Spatiotemporal response of mountain caribou to the intensity of backcountry skiing. *Biological Conservation*, Volume 217, pp. 149-156.

## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

- Martin, C. et al., 2011. A survey of the transmission of infectious diseases/infections between wild and domestic ungulates in Europe. *Veterinary research*, Volume 42, p. 70.
- McLellan, M. et al., 2012. Implications of body condition on the unsustainable predation rates of endangered mountain caribou. *Oecologia*, Volume 169, pp. 853-860.
- McLoughlin, P., Dzus, E., Wynes, B. & Boutin, S., 2003. Declines in populations of woodland caribou. *The Journal of Wildlife Management*, Volume 67, pp. 755-761.
- MCST, 2006. *Management options and related actions for mountain caribou in British Columbia*, Victoria, BC: Mountain Caribou Science Team.
- MCTAC, 2002. *A strategy for the recovery of mountain caribou in British Columbia*, Victoria, BC: Mountain Caribou Technical Advisory Committee, Ministry of Water, Land and Air Protection.
- Messier, F., Boutin, S. & Heard, D., 2004. *Revelstoke mountain caribou recovery: an independent review of predator-prey-habitat interactions*, Revelstoke, BC: Revelstoke Caribou Recovery Committee.
- MFLNRO LNG, 2015. *LNG Caribou Program: A plan to support the conservation and management of Northern and Mountain Caribou populations and habitat potentially affected by LNG pipeline projects*, North Area: MFLNRO.
- MFLNRO Skeena, 2017. *South Skeena caribou strategy - a plan to support the conservation and management of the Telkwa, Tweedsmuir-Entiako and Takla caribou herds*, Smithers, BC: s.n.
- Newgold Inc., 2012. *Newgold Inc. Blackwater Gold Project, Project Description Summary*. Canadian Environmental Assessment Agency. [Online]  
Available at: <https://www.ceaa-acee.gc.ca/050/documents/p80017/83283E.pdf>  
[Accessed 13 11 2017].
- Polfus, J., Hebblewhite, M. & Heinemeyer, K., 2011. Identifying indirect habitat loss and avoidance of human infrastructure by northern mountain woodland caribou. *Biological Conservation* 144:2637–2646.. *Biological Conservation*, Volume 144, pp. 2637-2646.
- Roberts, A., 2016. *Tweedsmuir-Entiako caribou recruitment survey: March 2016*, Smithers, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- Roberts, A. & Grant, L., 2017. *Roberts, A. and Grant L. 2017. Tweedsmuir-Entiako caribou rut survey: October 2017*, Smithers, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- Schaefer, J. & Pruitt, W., 1991. Fire and woodland caribou in southeastern Manitoba. *Wildlife Monographs, A Publication of the Wildlife Society*, Volume 116.
- Schneider, R., Hauer, G., Adamowicz, W. & Boutin, S., 2010. Triage for conserving populations of threatened species: The case of woodland caribou in Alberta. *Biological Conservation*, Volume 143, pp. 1603-1611.
- Schneider, R. et al., 2012. Selection of reserves for woodland caribou using an optimization approach. *PLoS ONE* 7:e31672.

## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

- Schneider, R. et al., 2011. Achieving conservation when opportunity costs are high: optimizing reserve design in Alberta's oil sands region. *PLoS ONE* 6:e23254.
- Schwantje, H., Macbeth, B., Kutz, S. & Elkin, B., 2014. *British Columbia boreal caribou health program progress report: year 1 (November 1, 2013 - December 31, 2014)*, Victoria, BC: Science, Community and Environmental Knowledge fund .
- Seip, D. & Cichowski, D., 1996. Population ecology of caribou in British Columbia. *Rangifer* 16:73–80.. *Rangifer*, Volume 16, pp. 73-80.
- Seip, D. R., 1990. *Ecology of woodland caribou in Wells Gray Provincial Park. No. B-68*, Victoria, BC.: British Columbia Ministry of Environment and Parks.
- Seip, D. R., Johnson, C. & Watts, G., 2007. Displacement of mountain varibou from winter habitat by snowmobiles. *Journal of Wildlife Management*, Volume 71, p. 1539–1544.
- Serrouya, R. et al., 2017. Experimental moose reduction lowers wolf density and stops decline of endangered caribou. *PeerJ* 5, Volume e3736.
- Serrouya, R. et al., 2015. Using predator-prey theory to predict outcomes of broadscale experiments to reduce apparent competition. *The American Naturalist*, Volume 185, pp. 665-679.
- Simpson, K., 1987a. *The effects of snowmobiling on winter range use of mountain caribou*, Nelson, BC: Ministry of Environment and Parks, Wildlife Branch.
- Simpson, K., 1987b. *Impacts of hydro-electric reservoir on populations of caribou and grizzly bear in southern British Columbia. BCEP--WR-24*, Victoria, BC: British Columbia Ministry of Environment and Parks.
- Simpson, K. & Woods, G. P., 1987. *Ecology of woodland caribou in Wells Gray Provincial Park.* , Victoria, BC: British Columbia Ministry of Environment and Parks, No. B-67.
- Sorensen, T. et al., 2008. Determining sustainable levels of cumulative effects for boreal caribou. *Journal of Wildlife Management*, Volume 72, pp. 900-905.
- Spalding, D., 2000. The early history of woodland caribou (*Rangifer tarandus caribou*) in British Columbia. *BC Ministry of Environment, Lands, and Parks, Wildlife Branch Wildlife Bulletin No. 100*, p. 61.
- Stevenson, S. K., 1991. Forestry and caribou in British Columbia. *Rangifer* , Volume 11, pp. 124-129.
- Steventon, D., 1996. *Caribou habitat use in the Chelaslie River migration corridor and recommendations for management*, s.l.: British Columbia Ministry of Forests.
- Theberge, J. & Oosenbrug, S., 1977. *Analysis for potential for an ecological reserve in the Telkwa Mountains, British Columbia, to protect mountain caribou*, Faculty of Environmental Studies, University of Waterloo, Ontario: BC Department of Environment and BC Department of Recreation and Travel Industry.
- Vistnes, I. & Nellemann, C., 2008. The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. *Polar Biology*, Volume 31, pp. 399-407.
- Vors, L. & Boyce, M., 2009. Global declines of caribou and reindeer.. *Global Change Biology*, Volume 15, p. 2626–2633.

## Woodland Caribou Plan for the Tweedsmuir - Entiako Subpopulation

Whittington, J. et al., 2011. Caribou encounters with wolves increase near roads and trails: a time-to-event approach. *Journal of Applied Ecology*, Volume 48, p. 1535–1542.

Wittmer, H., Sinclair, A. & McLellan, B., 2005b. The role of predation in the decline and extirpation of woodland caribou. *Oecologia*, Volume 144, pp. 257-267.

Wittmer, H. U. et al., 2005a. Population dynamics of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada.. *Canadian Journal of Zoology*, Volume 83, pp. 407-418.

Wittmer, H. U., McLellan, R., Serrouya, R. & Apps, C. D., 2007. Changes in landscape composition influence the decline of a threatened woodland caribou population. *Journal of Animal Ecology*, Volume 76, pp. 568-579.

Wittmer, H. U., Serrouya, R., Elbroch, L. M. & Marshall, A. J., 2013. Conservation Strategies for Species Affected by Apparent Competition. *Conservation Biology*, Volume 27, pp. 254-260.