

WOODLAND CARIBOU PLAN

Quintette Subpopulation

Quintette Local Population Unit

DRAFT

Disclaimer: This is a draft, phase one herd plan. Work was completed by a contractor to identify 1) current state of herd at time of writing 2) threats 3) previous management actions 4) Literature for the herd. Information contained is for reference only, and not specifically linked to the direction, management actions that the government of British Columbia intends to implement.



BRITISH
COLUMBIA

Recommended Citation:

Photo credit: Doug Heard

EXECUTIVE SUMMARY

DRAFT

TABLE OF CONTENTS

Executive Summary.....	ii
1 Background.....	1
1.1 Introduction to the Program.....	1
2 Population Description	1
2.1 Distribution.....	1
2.2 Habitat and Behaviour.....	3
2.3 Population Size and Trend.....	3
3 Threats and Limiting Factors.....	4
3.1 Predation.....	4
3.2 Food Limitation	5
3.3 Human Activities.....	5
3.3.1 Industrial.....	5
3.3.1.1 Forestry.....	5
3.3.1.2 Mining	5
3.3.1.3 Oil and Gas	5
3.3.1.4 Clean Energy	6
3.3.1.5 Other.....	6
3.3.2 Recreation.....	6
3.3.2.1 Snowmobile.....	6
3.3.2.2 Heli-ski /Cat Ski	6
3.3.2.3 Other.....	6
3.3.3 Other	6
3.3.3.1 Agriculture.....	6
3.3.3.2 Highway Corridors	7
3.3.3.3 Linear Features	7
3.3.3.4 Hunting.....	7
3.4 Natural Disturbance.....	7
3.5 Parasites and Diseases	8
3.6 Climate Change	8
3.7 Small Population Size Effects	8
4 Management History	9

4.1	Habitat	9
4.1.1	Protection.....	9
4.1.2	Enhancement and Restoration	9
4.2	Recreation and Access Management	10
4.2.1	Snowmobile	10
4.2.2	Heli Ski / Cat Ski	10
4.2.3	Summer Recreation	10
4.3	Predators	10
4.3.1	Wolf Management	10
4.3.2	Cougar Management.....	10
4.3.3	Other	10
4.4	Primary Prey.....	11
4.4.1	Moose Management	11
4.4.2	Deer Management.....	11
4.4.3	Other	11
4.5	Population Reinforcement	11
4.5.1	Maternity Penning	11
4.5.2	Captive Breeding.....	11
4.5.3	Translocation	11
4.5.4	Other	11
4.6	Stewardship/Outreach.....	11
4.7	Research and Monitoring.....	12
5	Implications to Other Wildlife.....	12
6	Implications to Other Values.....	12
7	Partners / Neighbours	13
8	Recommended Actions.....	13
8.1	Short Term (Within 6-12 Months).....	13
8.1.1	Habitat Protection	13
8.1.2	Predator management	13
8.1.3	Maternal Penning.....	13
8.1.4	Functional Restoration.....	14
8.1.5	Ecological restoration	14
8.1.6	Recreation.....	14

8.1.7	Effectiveness Monitoring	14
8.1.8	Compliance and Enforcement.....	14
8.2	Medium Term (Within 12-24 Months).....	14
8.2.1	Habitat Protection	14
8.2.2	Predator management	15
8.2.3	Maternal Penning.....	15
8.2.4	Functional Restoration.....	15
8.2.5	Ecological restoration	15
8.2.6	Recreation.....	15
8.2.7	Alternate prey management.....	15
8.2.8	Effectiveness Monitoring	15
8.2.9	Compliance and Enforcement.....	15
8.3	Long Term (Within 24-48 Months).....	16
8.3.1	Habitat Protection	16
8.3.2	Predator management	16
8.3.3	Maternal Penning.....	16
8.3.4	Effectiveness Monitoring	16
9	Literature Cited.....	16

1 BACKGROUND

1.1 INTRODUCTION TO THE PROGRAM

All caribou within British Columbia are Woodland Caribou (*Rangifer tarandus caribou*). The Quintette caribou are a subpopulation of Central Mountain Caribou (Designatable Unit 8 or DU8), a designation proposed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2014). Under this proposal the Central Mountain population will be listed as Endangered under the federal Species at Risk Act (COSEWIC, 2014). Previously, and until the DU structure for caribou populations is formally adopted, the Quintette caribou are considered the Northern Caribou ecotype within the Southern Mountains National Ecological Area (SMNEA) (MCTAC, 2002). All caribou within the SMNEA are currently listed as Threatened under the Species at Risk Act (MCTAC, 2002; EC, 2014).

Provincially the Quintette subpopulation is Red Listed by the BC Conservation Data Center (BC Conservation Data Centre, 2017) and is listed as Identified Wildlife under the provincial Forest and Range Practices Act (FRPA).

Woodland Caribou are further divided into Local Population Units (LPUs) by Environment Canada. Within the proposed Central Mountain Caribou group there are two LPUs exclusively in BC, one shared by BC and Alberta, and three in Alberta. The Quintette subpopulation is alone in the Quintette Local Population Unit (EC, 2014).

Recovery plans are required for all woodland caribou populations that are designated as threatened or endangered in Canada (ECCC, 2016). This document spans the divide between these disparate designations in British Columbia and Canada, compiling past research, knowledge and management actions into guidance for the management and recovery of the Quintette Central Mountain caribou subpopulation.

2 POPULATION DESCRIPTION

2.1 DISTRIBUTION

The Quintette subpopulation of caribou inhabits 6078 km² of the eastern slopes of the Rocky Mountains roughly bounded by the continental divide on the southwest, the Sukunka River on the northwest, the Murray River on the northeast, and Kinuseo Creek on the southeast (Figure 1) (BC MOE, 2014). The subpopulation consists of two subgroups, with one subgroup wintering in alpine/subalpine complexes in the “Quintette Mountain block” and the other wintering in the “Mt. Spieker block” (MFLNRO & MOE, 2015). Over the summer, most of the herd migrates west, deeper into the Rocky Mountains, with some animals remaining along the front ridges (MFLNRO & MOE, 2015). The town of Tumbler Ridge lies along the northeast boundary, at the junction of Highways 29 and 52.

Elevations range from 600 meters to 2400 meters above sea level (Google Earth, 2017). The Quintette caribou subpopulation is in close proximity to the Burnt Pine (recently extirpated), Hart, Narraway, Kennedy Siding, and Moberly (Klinse Za) caribou subpopulations.

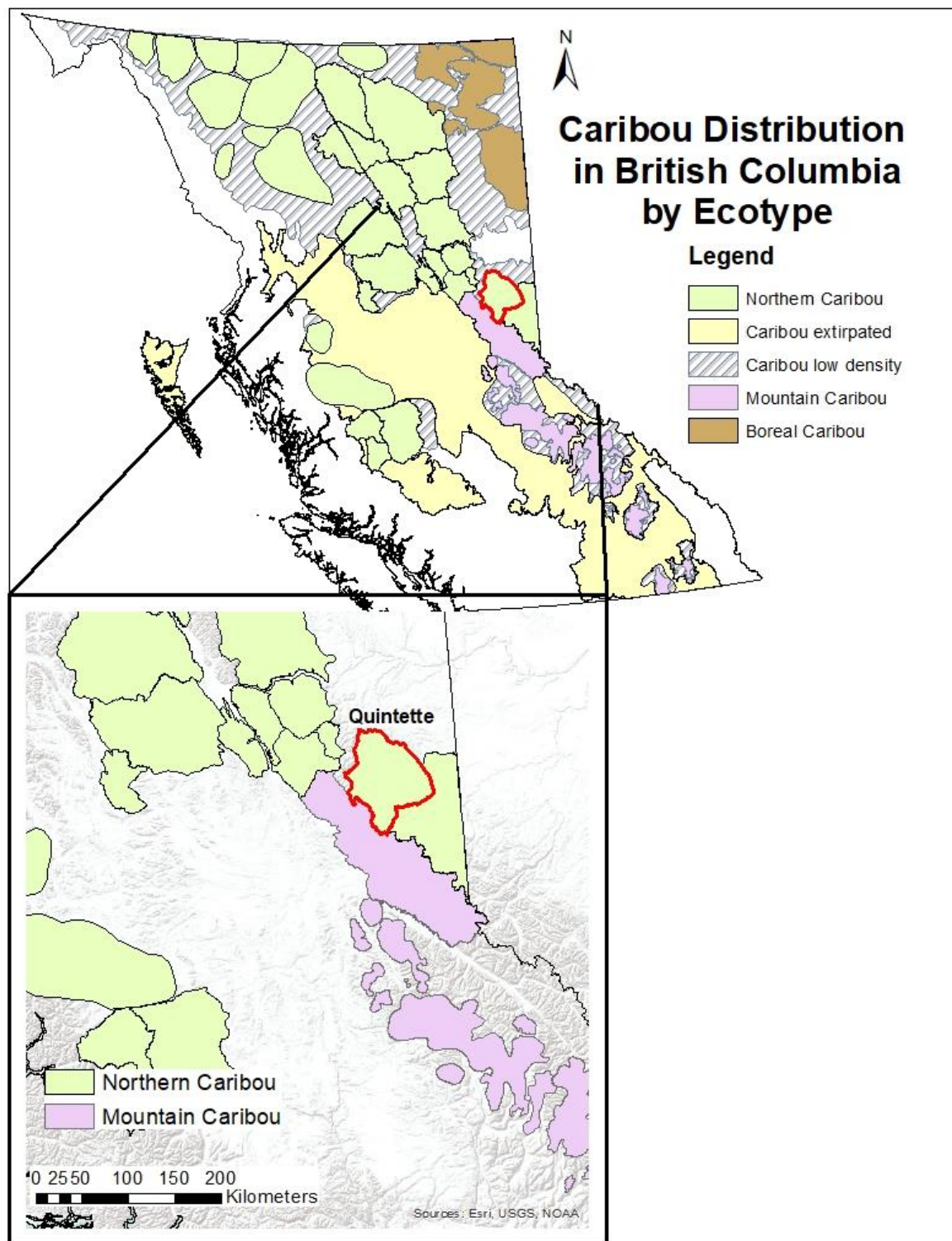


Figure 1. Caribou distribution in BC by ecotype . The Quintette subpopulation is outlined in red.

2.2 HABITAT AND BEHAVIOUR

The Quintette caribou subpopulation spends most of the year on high elevation wind swept ridges, less than 10% of telemetry locations are in low elevation winter ranges (BC Government, 2017; Seip & Jones, E., 2011). Low elevation habitat use is thought to have declined in the few decades prior to 1985 (Sopuck, 1985) however more recently caribou using the Quintette Mountain block have shifted from using the high elevation core winter range, which has been heavily impacted by mining activity, to low elevation forests (MFLNRO & MOE, 2015). Terrestrial lichens on wind swept alpine ridges are their main winter food source; arboreal lichens will be consumed where available (MFLNRO & MOE, 2015; Seip & Jones, 2015). During the spring and summer most of these caribou migrate to the west of the continental divide, overlapping with the Hart Ranges caribou subpopulation (Seip & Jones, E., 2011).

2.3 POPULATION SIZE AND TREND

In 1996 regional biologists estimated the Quintette caribou subpopulation at 200 animals (Heard & Vagt, 1998). Subsequent surveys between 2008 and 2016 have seen the subpopulation decline from a range of 173-218 in 2008 to 62 in 2016 (Figure 2) (Seip & Jones, 2016). Calf recruitment averaged 14.2% between 2003 and 2015 (Seip & Jones, 2016), very close to the 15% suggested for a stable population (Bergerud, 1996). Calf recruitment in 2017 is estimated to be 18% (Seip & Jones, 2017).

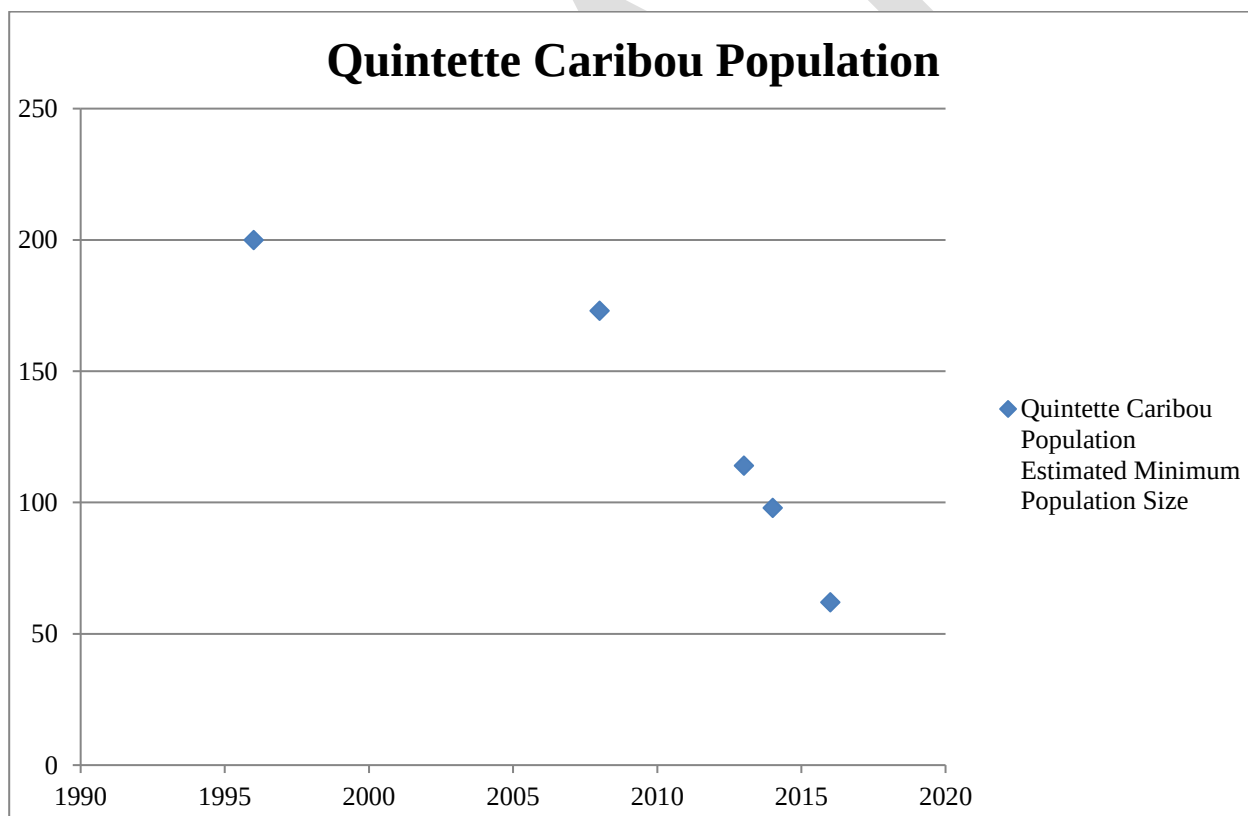


Figure 2: Quintette caribou population trend 1996 – 2016.

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; EC, 2014; Festa-Bianchet, et al., 2011). 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 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 km² will result in woodland caribou declines. Wolf surveys are planned but have not yet been conducted for the Quintette caribou subpopulation so the wolf densities and distribution are unknown; however 56 % of known collared caribou mortality causes from Quintette caribou between 2002 and 2015 were due to wolf predation (Seip & Jones, 2015).

While not specific to the Quintette 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). 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.

Within the Quintette caribou subpopulation boundaries large scale clearcut forest harvesting began in the 1970's (BC MOE, 2014). This forest harvesting and other human activities not including seismic lines have now disturbed 54% of the non-high elevation caribou habitat (BC MOE & ECCC, 2017).

3.3.1.2 MINING

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, which increase predator travel efficiency, thus increasing the predation risk to the caribou (Latham, et al., 2011a; DeMars & Boutin, 2017).

The Quintette caribou range sits on significant coal deposits. A network of exploration roads and several large scale open pit coal mines have been established in Quintette caribou habitat since the 1980's, currently with varying levels of operation (BC MOE, 2014).

3.3.1.3 OIL AND GAS

Similar to mine sites, active drilling sites may displace caribou from the vicinity. Seismic lines and drilling site access roads also create efficient travel corridors for predators, can support early seral plant communities, and their use can displace caribou from preferred habitat. Approximately 75% of the Quintette caribou subpopulation area has been heavily developed for conventional natural gas since the 1950's with extensive seismic line and access road development (BC MOE & ECCC, 2017; BC MOE, 2014).

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. All of these projects require access roads and powerlines, with potential impacts to caribou similar to the mining, oil, and gas sectors.

There is significant wind power potential in the Quintette caribou range area and three windfarms have recently been developed within the LPU boundaries. While the physical footprint for each individual wind tower may be relatively small the cumulative footprint of over 100 wind towers with associated access roads and powerlines could be significant (BC MOE, 2014). There are no current hydroelectric reservoirs, run of the river hydroelectric, or solar power generating installations or proposals in the Quintette caribou subpopulation area.

3.3.1.5 OTHER

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

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), 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).

3.3.2.1 SNOWMOBILE

High elevation winter habitat within the Quintette caribou range overlaps significantly with good snowmobiling conditions and is adjacent to significant human populations in the Peace River area. Local snowmobile enthusiasts maintain a lodge and groom trails in the Mt Babcock / Quintette Mountain area (TumberRidgeRiders, 2017).

3.3.2.2 HELI-SKI /CAT SKI

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

3.3.2.3 OTHER

Recreation values are high in the Quintette caribou range. Backcountry skiing (Lesmerises, et al., 2018), snowshoeing, ATV use, hiking, mountain biking, and other similar activities could also stress or displace caribou from preferred habitat.

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).

The Peace River area contains significant agricultural developments extending to within approximately 35 km of the Quintette caribou subpopulation's core habitat (Google Earth, 2017).

3.3.3.2 HIGHWAY CORRIDORS

Direct mortality from collisions with vehicles is the most obvious threat when highways pass through caribou habitat. Less obvious threats include direct loss of habitat along highway right of ways; fragmentation of habitat, especially if traffic volumes form a crossing barrier (Apps & McLellan, 2006); the maintenance of permanent early seral along highway edges supporting alternate prey and therefore predators; improved travel efficiencies for predators increasing predation risk; and improving human access for recreational use.

Highways 29 and 52 pass through the northeast side of the Quintette caribou range for approximately 90 km. and separate the most heavily used low elevation habitat from the high elevation habitat (Seip & Jones, 2017).

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).

Numerous electrical transmission lines and natural gas pipelines that service the coal mines and natural gas drill sites traverse the Quintette caribou subpopulation range, in addition to numerous seismic lines (Google Earth, 2017).

3.3.3.4 HUNTING

Local First Nations within the Quintette subpopulation area have voluntarily restricted hunting of caribou by their members in the 1970's. Hunting of caribou was closed in 2003 (BC MOE, 2014).

Moose, deer, elk, and goat hunting continues within the Quintette 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 Quintette 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 example, mountain pine beetle outbreaks can highly impact old-growth pine stands, affecting lichen availability (Cichowski & Haeussler, 2015) – a primary forage resource for caribou – and increasing the likelihood of fire (Lynch, et al., 2006). 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 magnitude of the annual impact of wildfires on the Quintette caribou subpopulation's habitat, and the change in this impact due to a warming climate, has not been calculated. Similarly salvage forest harvesting in response to the recent mountain pine beetle outbreak is also a concern that is not well quantified.

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 Quintette 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 Quintette 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). Such effects include inbreeding depression, genetic isolation from population fragmentation (Serrouya, et al., 2012), demographic stochasticity (e.g. all offspring produced are of one sex), environmental stochasticity (e.g. the population is extirpated by a random natural disturbance such as an avalanche; (Hebblewhite, et al., 2010)), and Allee effects (e.g. lowered demographic performance with decreasing population size; (Courchamp, et al., 1999)). For group-living ungulates such as caribou, McLellan et

al. documented a predation-mediated Allee effect where the predation rate may increase with declining population size because group size declines at a faster rate than the number of groups in the population and the number of groups dictates the rate of caribou-predator encounters (McLellan, et al., 2010).

With a current population estimate of 62 caribou the Quintette subpopulation may not fit into this category now, however with the steep decline in the past 20 years this could soon be an issue.

4 MANAGEMENT HISTORY

4.1 HABITAT

4.1.1 PROTECTION

A number of legislative instruments that manage caribou habitat within the 607,800 hectare (ha) Quintette caribou subpopulation range have been enacted over the years. As listed in the Quintette Strategic Action Plan (BC Government, 2017) these include:

- 94,270 ha of No Registration Reserves for coal, metal, and placer mining;
- 54,604 ha of Old Growth Management Areas (OGMA's);
- 60,181 ha of Provincial Parks;
- 79,158 ha of Resource Review Areas related to oil and gas extraction activities;
- 60,881 ha of Land Act Reserves for several activities usually permitted under the Land Act;
- 233,948 ha of Ungulate Winter Range (UWR);
- 58,059 ha of Wildlife habitat Areas (WHA).

There is considerable overlap between these instruments and indeed the sum exceeds the total area. In addition, some of these instruments dictate no development, while others are intended to manage development. There are still significant areas, especially in the high elevation summer and winter ranges, where there is little or no protection from industrial activities and developments (BC Government, 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). These two forms of restoration are termed “ecological restoration” and “function restoration” respectively in the Quintette Strategic Action Plan (BC Government, 2017). 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 however enhancement through functional and ecological restoration is in the plans (BC Government, 2017).

4.2 RECREATION AND ACCESS MANAGEMENT

4.2.1 SNOWMOBILE

There are currently no restrictions on snowmobiling within the Quintette caribou subpopulation area with the exception of the Bullmoose Mountain. / Mt. Chamberlain area above 1524 meters in elevation (BC Government, 2016a).

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 Quintette caribou subpopulation boundaries (HeliCat Canada, 2017).

4.2.3 SUMMER RECREATION

The south western corner of the Quintette caribou's range south of Hook Creek above 1400 meters in elevation is closed to motorized vehicle use year round except snowmobiles. The Bullmoose Mtn. / Mt. Chamberlain area above 1524 meters in elevation is closed to all motorized vehicle use year round (BC Government, 2016a).

4.3 PREDATORS

4.3.1 WOLF MANAGEMENT

Wolves are 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 Quintette caribou subpopulation area (Management Units (MUs) 7-20, 7-21, and 7-22) 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 Region 7 (BC Government, 2016a).

However 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 within Quintette caribou subpopulation area was recently initiated. Sixty-four wolves were removed by aerially shooting in 2016, a further twenty-five were removed using the same methods in 2017 (Seip & Jones, 2016; Seip & Jones, 2017).

4.3.2 COUGAR MANAGEMENT

Cougar populations are thought to be low within the Quintette caribou subpopulation area. The annual bag limit for cougar in Region 7 is one (BC Government, 2016a). There is no requirement for compulsory inspection or compulsory reporting of cougars harvested in Region 6 (BC Government, 2016a).

4.3.3 OTHER

Bear and wolverine predation can also have a significant impact on caribou populations (Wittmer, et al., 2005a). 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 killed 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) . There have not been changes to hunting management of primary prey for caribou recovery purposes.

4.4.1 MOOSE MANAGEMENT

Hunting moose in MU's 7-20, 7-21, and 7-22 is managed through general open seasons (BC Government, 2016a).

4.4.2 DEER MANAGEMENT

Both mule deer and white tail deer are present within the Quintette 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 also present and there is a general open season for bull elk within the Quintette caribou subpopulation area (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 Quintette caribou subpopulation. However if at least 60% of the female population were penned and female survival is greater than 85% a maternal penning project could produce significant results (DeMars, 2017).

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). Captive breeding of caribou has not been attempted in British Columbia.

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 Quintette caribou subpopulation.

4.5.4 OTHER

Predator exclusion fencing or other forms of population reinforcement have not been implemented for the Quintette 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. There are no SMA's in the Quintette caribou recovery area.

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.

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 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; BC Ministry of Environment, 2013).

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

The following recommended actions were all sourced from British Columbia's Quintette Strategic Action Plan, dated March 1, 2017 (BC Government, 2017).

8.1 SHORT TERM (WITHIN 6-12 MONTHS)

8.1.1 HABITAT PROTECTION

- Immediately recommend that the Chief Gold Commissioner designate all untenured high elevation summer range and high elevation winter range habitat within the Quintette LPU as Coal Land Reserve (CLR).
- Begin discussions with coal mining proponents on areas of high value caribou habitat for which mining and exploration activities may be voluntarily deferred, including an exploration of potential legal designations or mechanisms which support such medium term (+/- 20 years) deferments but which do not impact long term coal property rights.
- Initiate reserves over remaining untenured areas of high elevation summer range and high elevation winter range for major industrial uses – commence consultation spring 2017. Reserves for Land Act activities, placer mining, metal mining and natural gas will all be proposed.

8.1.2 PREDATOR MANAGEMENT

- Initiate discussions with Treaty 8 First Nations to investigate issues and interests related to predator management, including involvement in programs such as First Nations' led hunts and wolf trapping.
- Initiate/continue/expand a wolf tracking and research program to improve current knowledge of wolf movements and populations in advance of action on wolf removal.

8.1.3 MATERNAL PENNING

- Immediately initiate a science review of a proposed pen in the Quintette to verify that it will have meaningful impact at reasonable risk to caribou. A report should be completed by April 30, 2017. If the report recommends a pen be constructed, appropriate strategies for identification, construction and operations will be implemented..

- Should the pen be constructed, initiate/continue/expand a research program to improve current knowledge of maternal penning technology and best practices, working with other jurisdictions (e.g. Montana, Alberta) to maximize effectiveness of pens and minimizing risks to cow caribou through penning.

8.1.4 FUNCTIONAL RESTORATION

- Initiate discussions with Treaty 8 First Nations, tenure holders, communities and recreational groups to begin an access development plan for the Quintette with a focus on a small number of controlled access points from the low elevation to high elevation. This access plan will determine priorities for permanent closure and restoration.
- Initiate a Range Restoration Plan for the Quintette LPU within three months of approval, to be supported with a financial commitment of at least \$2M over five years to support range restoration activities. Target completion September 1, 2017. This Range Restoration Plan would guide both functional and ecological restoration and both will be delivered in a coordinated fashion.

8.1.5 ECOLOGICAL RESTORATION

- Initiate discussions with Treaty 8 First Nations, tenure holders, communities and recreational groups to begin a restoration plan in conjunction with the access development plan for the Quintette discussed under action 8.1.4)
- Initiate discussions with the forest industry to begin exploring silviculture and forestry management options and prescriptions which will increase the speed at which early seral forests mature. This will include legislative options under FRPA which could support this work.

8.1.6 RECREATION

- Incorporate recreation and snowmobiling management into the discussions with Treaty 8 First Nations, tenure holders, communities and recreational groups regarding the access development plan for the Quintette proposed in action 8.1.4.

8.1.7 EFFECTIVENESS MONITORING

- Initiate discussions with academic organizations and Treaty 8 First Nations to begin to explore the development of a comprehensive effectiveness monitoring program.
- Develop an inventory of existing monitoring programs which may be underway through mining, forestry, Treaty 8 First Nations or other tenure holders operating and in the Quintette area.

8.1.8 COMPLIANCE AND ENFORCEMENT

- Initiate the development of an “organizational compliance plan” to ensure that British Columbia compliance staff has a clear understanding of the roles each will lead on in the development of compliance actions.

8.2 MEDIUM TERM (WITHIN 12-24 MONTHS)

8.2.1 HABITAT PROTECTION

- Initiate/facilitate discussions with multiple industrial stakeholders (e.g. oil and gas, forestry, wind energy and coal) regarding other forms of high and low elevation habitat protection within the Quintette LPU Specific areas to discuss include:
 - Potential voluntary tenure trades, deferments or buy-backs; and,
 - Identification of areas of higher risk to caribou habitat and the appropriate form of habitat protection,

- Initiate discussions with Treaty 8 First Nations, communities, industrial stakeholders, the Oil and Gas Commission and Environment Canada regarding spatial protections and updated strategies on methods to decrease areas of early stage forests.

8.2.2 PREDATOR MANAGEMENT

- Develop an effectiveness monitoring program to monitor wolf movements, quantify predation (e.g. how many caribou are being taken by wolves and where) and make recommendations on adaptive management. Apply the program to develop an improved understanding on the relationship.

8.2.3 MATERNAL PENNING

- Monitor the effectiveness of the penning program if implemented and develop an adaptive management approach to managing the pen, being flexible on alternate locations, expansion or contraction of the program.

8.2.4 FUNCTIONAL RESTORATION

- Implement and monitor the effectiveness of the access management plan.
- Develop, in partnership with the Conservation Officer Service, compliance and outreach plan for the Quintette LPU in conjunction with Treaty 8 First Nations and stakeholders.

8.2.5 ECOLOGICAL RESTORATION

- Implement and monitor the effectiveness of the ecological restoration plan and develop an adaptive management approach to restoration.
- Initiate a mine reclamation research project which is particularly focused on caribou habitat needs, including forage, disturbance and caribou use of reclaimed mine areas.

8.2.6 RECREATION

- Implement and monitor the effectiveness of the access management plan proposed in action 8.1.4.
- Develop, in partnership with the Conservation Officer Service, compliance and outreach plan for the Quintette LPU in conjunction with the Treaty 8 First Nations and stakeholder group identified under action 8.1.4. A specific focus of the plan will be increasing understanding of the range of existing and potential motorized and non-motorized recreation opportunities in the Quintette.

8.2.7 ALTERNATE PREY MANAGEMENT

- Initiate a science-based review of increased hunting for ungulates (caribou excluded) as part of a revision to the Peace Northern Caribou Plan (PNCP).
- Review opportunity to expand moose monitoring programs, aligned with wolf population monitoring, to track population densities and travel over time.

8.2.8 EFFECTIVENESS MONITORING

- Develop and implement a monitoring and effectiveness strategy which incorporates existing monitoring efforts and seeks to either harmonize complementary efforts or uses resources to fill monitoring gaps.

8.2.9 COMPLIANCE AND ENFORCEMENT

- The Conservation Officer Service will develop and lead on the implementation of a public compliance and outreach plan for the Quintette LPU. This plan will focus on education, communications and engagement and will be developed to support the various access and recreational recovery plans.

8.3 LONG TERM (WITHIN 24-48 MONTHS)

8.3.1 HABITAT PROTECTION

- Explore designations or mechanisms to replace any temporary voluntary proponent tenure deferrals with an equivalent area of permanent high value caribou habitat.

8.3.2 PREDATOR MANAGEMENT

- It is expected that long-term wolf management will not be required when early seral stage forests are minimized and moose populations are potentially re-directed through habitat management (i.e. forage) techniques. Focus will be on monitoring wolf densities and wolf use in both core and matrix caribou habitat.

8.3.3 MATERNAL PENNING

- If a pen is not determined to be in the best interest of the Quintette subpopulation in early 2017, the Province will review the opportunity to install and operate a pen in 2018.
- Monitor the annual population growth through survival surveys of the Quintette subpopulation for, at minimum, the next 15 years. If subpopulation-specific data demonstrates a sustained growth rate greater than the projected 3-9%, the Province will increase its population targets above the 300 animals indicated for the Quintette.

8.3.4 EFFECTIVENESS MONITORING

- Through monitoring efforts, confirm assumptions and hypotheses and make recommendations to changes to the recovery actions to increase the effectiveness of resources and programs (e.g. if caribou are not using newly protected habitat, consider shifting into areas which are being utilized by caribou).

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 Government, 2017. *British Columbia's Quintette strategic action plan, southern mountain caribou herd recovery*, s.l.: s.n.
- BC Ministry of Environment, 2013. *Implementation plan for the ongoing management of South Peace Northern Caribou (Rangifer tarandus caribou pop. 15) in British Columbia.*, Victoria, BC: s.n.
- BC MOE & ECCC, 2017. *Canada - British Columbia Southern mountain caribou (central group) protection study (The Study)*, s.l.: British Columbia Ministry of Environment and Environment and Climate Change Canada.
- BC MOE, 2014. *Science update for the South Peace Northern Caribou (Rangifer tarandus caribou pop. 15) in British Columbia*, Victoria, BC: B.C. Ministry of Environment.
- 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.
- 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 large 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. 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. & Haeussler, S., 2015. 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..

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.

Courchamp, F., Clutton-Brock, T. & Grenfell, B., 1999. Inverse density dependence and the Allee effect. *Trends in Ecology & Evolution*, Volume 14, pp. 405-410.

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.
- Google Earth, 2017. Mountain View, California: Google Incorporated.
- 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. & Vagt, K., 1998. Caribou in British Columbia: a 1996 status report. *Rangifer*, Volume Special Issue No. 10, p. 117–123.
- 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.
- Hebblewhite, M., White, C. & Musiani, M., 2010. Revisiting extinction in National Parks: Mountain caribou in Banff. 24:341–344.. *Conservation Biology*, Volume 24, pp. 341-344.
- 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.
- 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.
- Lynch, H., Renkin, R., Crabtree, R. & Moorcroft, P., 2006. The influence of previous mountain pine beetle (*Dendroctonus ponderosae*) activity on the 1988 Yellowstone fires. *Ecosystems*, Volume 9, pp. 1371-1327.
- 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, B., Serrouya, R., Wittmer, H. & Boutin, S., 2010. Predator-mediated Allee effects in multi-prey systems. *Ecology*, Volume 91, pp. 286-292.
- 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 & MOE, 2015. *South Peace northern caribou standardized industry management practices.*, Prince George, BC: B.C. Ministry of Forests, Lands and Natural Resource Operations and B.C. Ministry of Environment.
- 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.
- 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.

- 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.
- 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. & Jones, E., 2011. *Population status of threatened caribou herds in the Central Rockies ecoregion of British Columbia, 2011*, s.l.: BC Ministry of Forests, Lands, and Natural Resource Operations.
- Seip, D. & Jones, E., 2015. *Population status of Central Mountain caribou herds within British Columbia, 2015*, s.l.: British Columbia Ministry of Forests, Lands, and Natural Resource Operations.
- Seip, D. & Jones, E., 2016. *Population status of Central Mountain Caribou herds in British Columbia and response to recovery mangement actions, 2016*, s.l.: British Columbia Ministry of Forests, Lands, and Natural Resource Operations.
- Seip, D. & Jones, E., 2017. *Population status of Central Mountain caribou herds within British Columbia, 2017. Unpublished report.*, Prince George: MoE.
- 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., 2012. Population size and major valleys explain microsatellite variation better than taxonomic units for caribou in western Canada. *Molecular Ecology*, Volume 21, pp. 2588-2601.
- 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. & 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.

- Sopuck, L., 1985. *Movements and distribution of caribou in relation to the Quintette Coal Development*, Sidney, BC: Prepared by Renewable Resources Consulting Services Ltd. for Denison Mines Ltd.
- Sorensen, T. et al., 2008. Determining sustainable levels of cumulative effects for boreal caribou. *Journal of Wildlife Management*, Volume 72, pp. 900-905.
- Stevenson, S. K., 1991. Forestry and caribou in British Columbia. *Rangifer*, Volume 11, pp. 124-129.
- 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.
- TumberRidgeRiders, 2017. *Tumbler Ridge Snowmobiling Club*. [Online]
Available at: <http://www.trridgeriders.com/trails>
[Accessed 06 11 2017].
- 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.
- 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.