

## 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

## Wells Gray North Subpopulation

Quesnel Highlands  
Local Population Unit



BRITISH  
COLUMBIA

**Recommended Citation:**

Photo credit: Doug Heard

## 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 Wells Gray North caribou are a subpopulation of the Mountain 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) (Environment Canada, 2014; MCTAC, 2002). These caribou herds are red 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. The Mountain Caribou ecotype in BC was reorganized into the Southern Mountain Caribou DU (DU9) (COSEWIC, 2014). They were assessed as Endangered in May 2014 (COSEWIC, 2014). This recommended listing of DU9 was submitted to the Federal Minister of the Environment for consideration under SARA in fall 2014.

Environment Canada is proposing a different categorization system, one where the SMNEA is divided into three groups, the Northern, Central, and Southern Groups. The Southern Group from the EC system would be DU9, identical to the Southern Mountain caribou under the COSEWIC system (EC, 2014; COSEWIC, 2014). No



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decision has been made and the Wells Gray South caribou subpopulation remains listed in the only category of SMNEA caribou and Threatened under SARA.

Woodland Caribou are further divided into Local Population Units (LPU's) by Environment Canada. Within the proposed Southern Mountain Caribou group there are eleven LPU's. Wells Gray North and Wells Gray South have at times been considered the same subpopulation (Wittmer, et al., 2005a) however they are split into two LPU's and as such they are treated separately here. The Wells Gray North subpopulation is in the Quesnel Highlands LPU together with the Barkerville subpopulation. The Wells Gray South subpopulation is in the Wells Gray - Thompson LPU along with the Groundhog subpopulation (Environment Canada, 2014). This is the only subpopulation in the province split between two LPU's.

Recovery plans are required for all woodland caribou populations that are designated as threatened or endangered in Canada (ECCC, 2016).

This document describes the current situation in British Columbia and Canada for caribou and particularly for the Wells Gray North caribou subpopulation. It compiles relevant research, knowledge and management actions into guidance for the management and recovery of the Wells Gray North caribou subpopulation within in the Quesnel Highlands LPU.

## 2 POPULATION DESCRIPTION

### 2.1 DISTRIBUTION

The Wells Gray North caribou range occupies approximately 5870 km<sup>2</sup> (Young & Freeman, 2003) and spans the width of the Cariboo Mountains in East Central British Columbia (Figure 1), approximately 60 km east of the city of Williams Lake, BC. The Quesnel Highlands LPU that the Wells Gray North subpopulation shares with the Barkerville subpopulation is 11200 km<sup>2</sup> in size. Elevations range from 730 – 2700 meters above sea level (Google Earth, 2017). Hobson and Clearwater Lakes separate Wells Gray North from Wells Gray South to the southeast. Adjacent caribou sub populations to the north are the Barkerville, North Cariboo Mountains, and Narrow Lake subpopulations (Wittmer, et al., 2005a).



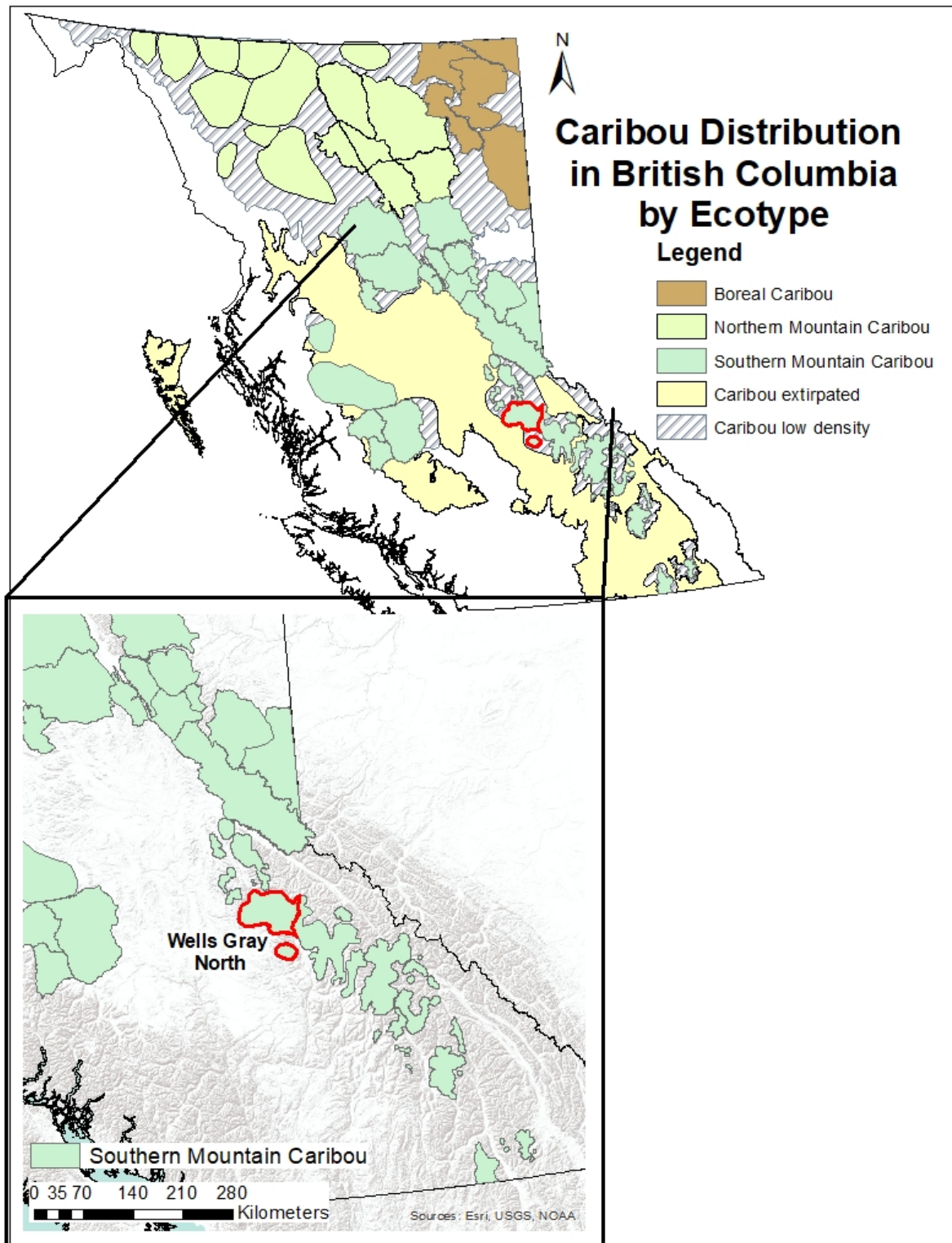


Figure 1: The geographical location of the Wells Gray North subpopulation of woodland caribou. The 5870 km<sup>2</sup> range (inset: red outline) is situated predominately within Cariboo Region.

### 2.2 HABITAT AND BEHAVIOUR

Mountain caribou live in the Interior Wet Belt that stretches from northern Idaho and Washington States to central British Columbia. In winter they live in a deep snowpack zone and feed on arboreal lichens (BC Government, 2017a; Young & Freeman, 2002). Mountain caribou generally choose habitats at different elevations at various times of the year; these movements are not generally considered migrations. Some also demonstrate a substantial horizontal movement, considered a migration. The Wells Gary caribou have both migratory and non-migratory groups. The migratory caribou moved between summer and winter ranges and had a linear migration distance varying between 10 and 60 km (Seip, 1990; Young & Freeman, 2002). Not all caribou from the migratory group migrated every year. Some of the migratory caribou used regular summer and winter ranges each year, others varied their seasonal ranges. In addition, migratory and non-migratory caribou at times overlapped (Young & Freeman, 2002). Both groups show bimodal elevational changes. Low points are in November (mean 1441 m elevation) and May (mean 1502 m elevation). High points are June to September (mean 1644 m elevation) and February – March (mean 1729 m elevation) (Young & Freeman, 2002).

### 2.3 POPULATION SIZE AND TREND

Early survey boundaries were based on limited knowledge of caribou distribution so this data may not be suitable for trend determination. Deployment of radio collars beginning in the mid 1980's allowed refinement of survey boundaries based on the collar data. Survey coverage of the complete Wells Gray North caribou range has been consistent since 1994 (Dodd, 2017).

The trend between the estimated population of 263 in 1994 and the estimated population of 204 in 2015 has been a 22% decline (Figure 2). While concerning this decline is considerably less than many other mountain caribou subpopulations (BC MFLNRO, 2017).

Calf recruitment over 19 surveys since 1994 has averaged 13.1% (Dodd, 2017), below the 15% minimum suggested for population growth (Bergerud, 1996).

## Woodland Caribou Plan for the Wells Gray North Subpopulation

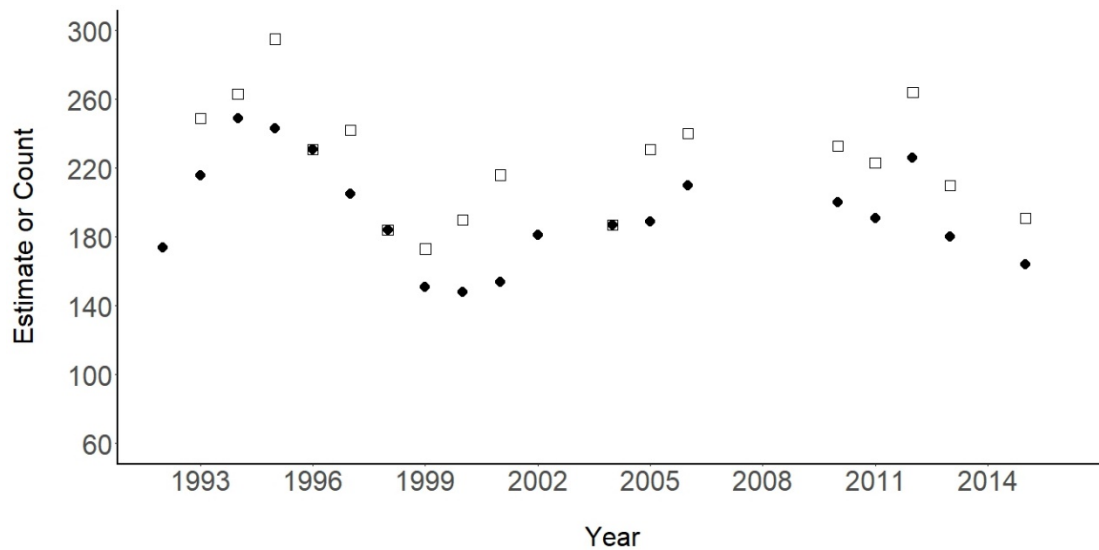


Figure 2: Caribou counts (filled dots) and estimates (hollow squares) for the Wells Gray North sub-population. Estimates are calculated in NOREMARK (White, 1996) using mean-sightability of radio collared caribou during winter flights from 1993-2006. Estimates from 2011–2015 are derived from average annual collar sightability for 1996-2006 (excluding 2003). Surveys conducted in 2003 and 2008 were incomplete so data were excluded. No surveys were conducted in 2007, 2009, 2014 and 2016. Counts made by Government of British Columbia staff in all years. All data from (Dodd, 2017)

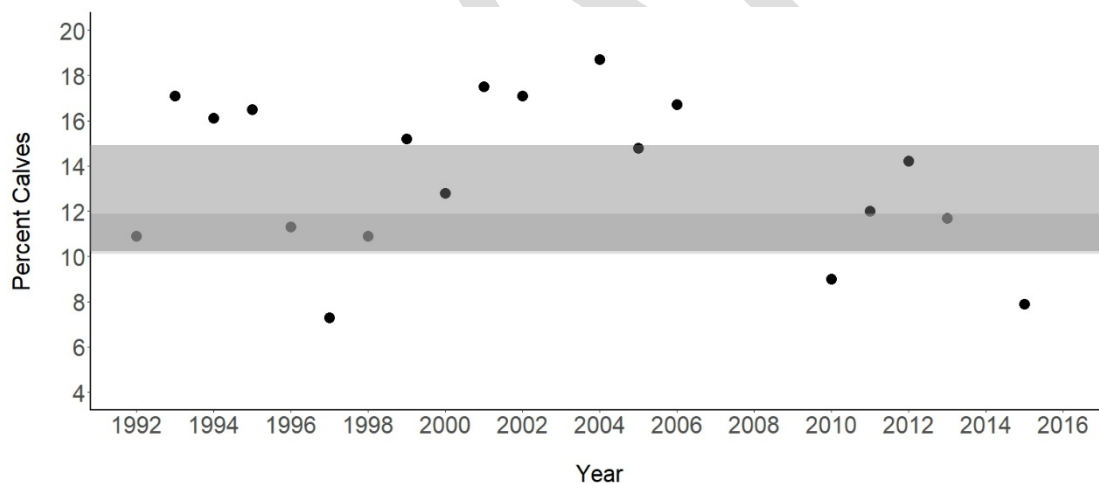


Figure 3: Caribou population recruitment measured in the Wells Gray North caribou subpopulation range. Recruitment is defined here as the percent of the estimated population that is in the calf cohort. Population growth is predicted when recruitment is greater than 15% (Bergerud, 1996) and population decline predicted when recruitment is below 10 - 12% (Bergerud & Elliot, 1986). The resulting grey zone, depicted here between 10 and 15%, is due to the fact that adequate recruitment to maintain a stable population is heavily dependent on adult female survival.

### 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; Environment Canada, 2014). For most populations, these effects have led to unsustainable rates of predation (McLoughlin, et al., 2003;

Wittmer, et al., 2005b; Apps, et al., 2013) resulting 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). 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, avalanches), 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

GPS collar and radio telemetry studies 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 (Bergerud, 1988). While the predator species killing caribou vary regionally (wolf, black bear, grizzly bear, cougar), their impact on woodland caribou populations has increased as the result of three dominant processes: apparent competition mediated by alternative prey hyperabundance (Hebblewhite, et al., 2007), apparent competition mediated by expanding alternative prey distribution (Wittmer, et al., 2007; DeCesare, et al., 2010b; Latham, et al., 2011a; Latham, et al., 2011c), and enhanced predator access to woodland caribou habitat (James & Stuart-Smith, 2000; Latham, et al., 2011b). 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. More recently, the federal recovery strategy identifies 3 wolves/1000 km<sup>2</sup> as a target (Environment Canada, 2014).

A study from 1984 to 1989 followed caribou and wolves and reported mortality sources (Seip, 1992). Over 79 caribou-years in both Wells Gray Provincial Park and Quesnel Lake, 11 collared females were killed by wolves (38%), 6 by bears (14%), 3 by accidents (10%), 2 from malnutrition (7%) and 7 from unknown causes (17%). Further research from 1993 to 2001 in the Wells Gray North subpopulation found that predation was the cause of 3 of 22 caribou deaths (14%) and the probable cause of a further 8 deaths (36%) (Young & Freeman, 2001). In both studies, predation was the dominant mortality source.

### 3.2 FOOD LIMITATION

Woodland caribou are herbivores and unique due to their preference for lichens (Johnson, et al., 2004). While lichen makes up the bulk of their winter diet (Johnson, et al., 2000; Parker, et al., 2005), it is a smaller proportion of their summer diet (Denryter, et al., 2017). Although habitat selection is predominantly thought to be influenced by predator avoidance, selected habitats must also be able to satisfy the animals' nutritional needs (O'Brien, et al., 2006; Brown, et al., 2007). Trade-offs between these two fundamental demands (avoiding predators, finding

food) raises the potential for woodland caribou to be food or energy limited as they seek predator refugia (Poole, et al., 2000; Gustine, et al., 2006). Estimates of caribou food abundance typically far exceed population needs (Courtois, et al., 2007).

Malnutrition is a measurable cause of mortality in caribou from the Wells Gray North subpopulation. From 1993 to 2001 it caused 7% of known mortality in radio-collared caribou (see above; Seip 1992) and 9% in a study from 1993 to 2001 (Young & Freeman, 2001). In the former study, starvation deaths were detected in the spring and summer, while in the latter study malnutrition deaths occurred in the fall and early winter (Seip, 1992; Young & Freeman, 2001).

### 3.3 HUMAN ACTIVITIES

Human activities have consequences for woodland caribou conservation throughout British Columbia. This section focusses on the consequences of human industrial, recreational and other (agriculture, highway, linear feature clearing) activities (Wolfe, et al., 2000).

#### 3.3.1 INDUSTRIAL

Industrial activities include forestry, mining, oil, gas and clean energy development. Caribou are affected by industrial activities both due to the infrastructure that is associated with it as well as the resulting impacts on their habitat. A key concept to measure and understand industrial effects on caribou is the Zone of Influence (ZOI) (Polfus, et al., 2011). This is the area beyond the actual footprint of an industrial development or activity that affects caribou (Dyer, et al., 2001). Zones of influence vary by activity and by the presence and absence of people.

##### 3.3.1.1 FORESTRY

Woodland caribou are an old-growth forest dependent species (Bergerud, 2000). Hence, forest management affects their distribution and population dynamics. Although Mountain Caribou populations live seasonally in treeless, alpine ecosystems, all spend some of the year in forests. For this reason, forestry and natural disturbances will affect woodland caribou populations through habitat destruction and fragmentation (Smith, et al., 2000). 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 (see below) such as deer and moose (Simpson & Woods, 1987; Cichowski, 1989; Seip, 1990; Stevenson, 1991; Cumming, 1992). 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. The ZOI of clearcuts for woodland caribou in Newfoundland was found to be 15 km beyond the actual cut block (Chubbs, et al., 1993). Hence, even an array of small forestry clearings can have a significant influence on caribou habitat availability.

The Wells Gray North caribou subpopulation overlaps the Williams Lake Timber Supply Areas (TSA), with a small fragment overlapping the Quesnel TSA in the north, the 100 Mile House TSA to the west and the Robson Valley TSA to the east. The Williams Lake TSA overlaps the northern part of the subpopulation range with an AAC of 3.0 million cubic meters over its entire 49,300 km<sup>2</sup> area. Wells Gray Provincial Park is excluded from the Timber Harvest Land Base for both TSAs. There are 2467 cutblocks in the subpopulation area for a total of 652.6 km<sup>2</sup> of area or about 7% of the total land base.



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### 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).

The Mt. Polley open pit gold / copper mine is within the Wells Gray North caribou management area.

### 3.3.1.3 OIL AND GAS

Oil and gas development threaten caribou populations through habitat destruction, human activity, access, habitat fragmentation and elevated predation (Dyer, et al., 2001; Boutin, et al., 2012; Hervieux, et al., 2013). Given the spatial scope of developments and the range of activities that take place in caribou habitat to develop oil and gas resources (well sites, access roads, pipelines, seismic lines) cumulative effects of this combined with other activities (e.g. forestry, hydroelectric) also play a large role in threatening resident caribou herds (Nitschke, 2008). A study of the energy consequences to caribou of being disturbed by oil and gas exploration found that individuals in active plays can lose more than 15% of body mass over winter attributed to noise displacement (Bradshaw, et al., 1998).

There are no oil and gas plays or tenures in the Wells Gray caribou subpopulation range.

### 3.3.1.4 CLEAN ENERGY

Clean energy refers to hydroelectric dams and wind farms. Hydroelectric reservoirs in caribou range can destroy or fragment habitat and cut off movement corridors. Research in southern British Columbia correlated hydroelectric development with declines in caribou populations (Simpson, 1987b). Hydroelectric dams, during their construction and operation have a ZOI that exceeds their footprint (Nellemann, et al., 2003). Wind farm development can destroy caribou habitat, reduce forage availability, displace caribou and increase early-seral habitat that promotes growth of alternative prey populations (BC MOE, 2014).

The Hen Ingram Lake Pumped Storage Hydro project is on the western edge of the range between Horsefly and Quesnel Lake (Eclipsol Energy Inc., n.d.).

### 3.3.1.5 OTHER

There are no other significant industrial developments in the range of the Wells Gray caribou subpopulation.

## 3.3.2 RECREATION

Recreational use of caribou habitat refers largely to fall and winter activities, including snowmobiling, commercial heli-skiing, commercial cat-skiing and hunting. In some jurisdictions, winter tour skiing and mountaineering are also relevant recreational activities as is summer use with off highway vehicles (OHVs). Numerous studies have shown that woodland caribou to varying degrees avoid mechanized winter activities (Simpson, 1987a; Simpson & Terry, 2000; Mahoney, et al., 2001; Kinley, 2003; Wilson & Hamilton, 2003; Seip, et al., 2007). Despite numerous records of displacement, no study has been able to draw a link between winter recreational use and woodland caribou population decline.

### 3.3.2.1 SNOWMOBILE

Snowmobile use in caribou habitat can result in their displacement (Simpson, 1987a; Apps, et al., 2001; Kinley, 2003; CCLUP, 2000). Studies in British Columbia and elsewhere have shown that caribou are far less likely to occupy winter habitats that are being used for recreational snowmobiling than equivalent habitats without

snowmobile use (Mahoney, et al., 2001; Seip, et al., 2007; CCRIG, 2005). The mechanisms of displacement include caribou avoiding or fleeing snowmobiles while they are in use, ease of access to caribou habitat by hunters and the facilitation of predator movement into caribou winter habitat from packed trails created by snowmobiles (Bergerud, 1988; Polfus, 2010).

Due to the extensive use of this area for snowmobile recreation, a number of management agreements and closure areas are in place in this area (see section 4.2.1 below). A 2007 study found 78 to 98% compliance with voluntary closures however there were twenty-one cases where snowmobiles came within 500 m of caribou. They did not report any animal reactions or immediate consequences of these interactions (CCLUP, 2007).

### 3.3.2.2 HELI-SKI / CAT-SKI

Helicopter skiing and cat skiing are backcountry recreational activities that enable off-piste skiers to access high mountain terrain using either a helicopter or a tracked snow-cat that shuttles them to the top of ski runs. This is a commercial activity with numerous operators in British Columbia represented under one umbrella organization, HeliCat Canada (HCC). In southern British Columbia, HCC partners with the British Columbia government and non-government organizations to monitor caribou and heli-cat ski operations and minimize operational impacts (Wilson & Nyberg, 2009).

Silvertip Lodge and Canadian Mountain Holidays have ski tenures in the Wells Gray North area. From 2013 to 2017, 287 caribou were encountered by these operations, largely in the eastern part of the tenures with a range of animal responses from none to being very alarmed (Wilson, 2010; Pasztor, 2013; Heard, 2016; Wilmschurst & Gordon, 2016).

### 3.3.2.3 OTHER

Backcountry tour skiing and mountaineering are recreational activities that occur in caribou habitat and can have an impact on woodland caribou conservation. Backcountry skiing (a term embracing of backcountry ski touring, unsupported, off-piste skiing and snowmobile assisted off-piste skiing) and mountaineering bring their participants into alpine areas that overlap with mountain caribou populations at sensitive times of the year (rut, winter). Unexpected encounters between individuals and people who are not in a vehicle can be very stressful for caribou and they can show a very strong flight response (McKay, 2007; Lesmerises, et al., 2018).

## 3.3.3 OTHER

Other human activities occur in caribou habitat and have the potential to harm caribou and / or affect caribou populations. Agriculture, transportation corridors, electrical transmission rights-of-way, oil and gas exploration and pipelines and hunting all have known effects on caribou populations (James & Stuart-Smith, 2000; Wolfe, et al., 2000).

### 3.3.3.1 AGRICULTURE

The effects of agriculture on caribou conservation are largely the result of conversion of low-elevation habitat to crops and pasture (habitat destruction) and the food subsidy they provide for alternative prey (deer, elk, moose). Habitat conversion is functionally similar to clearcut logging in that it removes overstory vegetation and can alter landscape properties like vegetation composition and local snow depth. Growing hay and grain crops within or adjacent to caribou range has the potential to increase the regional population size of deer, elk and moose that eat crops (Bowden, 1985; Cote, et al., 2004; Butler, et al., 2008; Hatter, et al., 2017). Access to crops improves population growth of these species and their predators like bears and wolves. These, in turn, predate on caribou, putting downward pressure on caribou populations.



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Spread of disease and parasites from and to cattle is also a threat to woodland caribou from agricultural operations (Neiland, et al., 1968; Sifton, 2001; Trainer, 1973; Wobeser, 1976) and is discussed in section 3.5 (Parasites and Disease).

While there is abundant land designated as Agricultural Land Reserve (ALR) to the west of the range of the Wells Gray caribou subpopulation there are only two small ALR designated areas near Horsefly Lake within the range. Some cattle operations exist, but in general, there is little agricultural activity in this area.

### 3.3.3.2 MAJOR HIGHWAY CORRIDORS

Where they occur in caribou habitat, highways have strong, negative effects on caribou populations (Johnson & Todd, 1977; Curatolo & Murphy, 1986; Apps & McLellan, 2006). Vehicle activity on highways poses a movement barrier for caribou as they are either reluctant to approach a roadway or get killed trying to cross it (Dyer, et al., 2002; Rytwinski & Fahrig, 2012). Habitat and population fragmentation results as populations are unable to move between ranges and populations decline. Highways and roadways can also provide access to people to caribou range that increases the potential for disturbance. Linear disturbances, such as roadways have a large ZOI (Wolfe, et al., 2000; Oberg, 2001; Polfus, et al., 2011; Whittington, et al., 2011). Between 1988 and 2009, ten caribou mortalities were recorded on highways in the Peace Highway District, four in the Thompson-Nicola Highway District (Sielecki, 2010), and three along Highway #3 in the Kootenays (L. DeGroot pers. comm).

There are no highways within the Wells Gray North caribou range however there are numerous gravel roads.

### 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 several linear features transecting the Wells Gray caribou subpopulation range. There are many forestry roads, residential access roads (e.g. Cariboo Lake Road).

### 3.3.3.4 HUNTING

Excessive hunting of caribou is likely responsible for the initial declines in and range contraction of sub populations throughout the southern two thirds of the province (Spalding, 2000; Freddy, 1974; Herbison, 1996), including the Wells Gray South caribou area.

The Wells Gray North caribou subpopulation range overlaps with Region 5 (Cariboo) and Region 3 (Thompson-Nicola) and within those regions substantial parts of 2 management units (5-15 and 3-46). Some of its official boundaries cross slightly into region 7A (Omineca) and other management units (BC Government, 2016a). While much of this area is covered by Wells Gray and Cariboo Mountains Provincial Parks, hunting is popular in the subpopulation range. Between 1976 and 1997, 55 caribou were killed by resident hunters and 21 killed by non-resident hunters. There has been no season for caribou since 1997. There are seasons for other games species (mule deer, white-tailed deer and moose), see Section 4.4.

### 3.3.3.5 POACHING

Caribou poaching is an unregulated, indiscriminate and largely unknown source of mortality across their range. Animals are taken in any season, of any age or sex and in any number. This kind of additive mortality can have a profound impact on caribou populations in British Columbia (Johnson, 1985) and interacts with habitat management and human access (Stevenson, 1990).

The British Columbia Environmental Violations Database does not report any caribou poaching charges from 2006 to 2017 in the Thompson region (Government of BC, 2017b).

## 3.4 NATURAL DISTURBANCE

Fire as a natural disturbance can have large-scale and long-lasting impacts on woodland caribou (Environment Canada, 2014). Fire kills individuals, destroys habitat and changes predator-prey dynamics by improving habitat for alternative prey and increasing wolf-caribou spatial overlap (Robinson, et al., 2012). Fire suppression, on the other hand, has increased the possibility of very large and intense fires that could alter entire range areas (Environment Canada, 2012a). Mountain pine beetle infestations are also natural disturbances with large-scale and long-term effects (Cichowski & Williston, 2005). Fire has been specifically identified as a threat to the Wells Gray caribou subpopulation, specifically attributed to lowland habitat burns (Edwards, 1954).

There have been many small and few large fires in the Wells Gray caribou subpopulation range since records began in 1920. From 1920 to 2015, 1760 km<sup>2</sup> burned (19% of the range area). 135 km<sup>2</sup> burned in 2016 and 2017. Compared with other areas of the province, the area in this caribou region that has been severely (357 km<sup>2</sup>) or very severely (84 km<sup>2</sup>) infested by mountain pine beetle has been small, amounting to 5% of the total area.

## 3.5 PARASITES AND DISEASES

Caribou are generally susceptible to a range of native and introduced diseases and parasites found in other ungulate species. Brucellosis is a contagious disease of ruminants which can cause spontaneous abortions particularly among first time breeding females (Neiland, et al., 1968). The bacteria causing brucellosis in caribou is primarily *Brucella suis* that also affects swine (Jones, 2014). Caribou are highly susceptible to the meningeal worm (*Parelaphostrongylus tenuis*) that is fatal in some, but not all, deer species (Anderson, 1972; Trainer, 1973). Early reports of woodland caribou declines in eastern Canada attributed it to their overlap with white-tailed deer who are meant to be the primary host of *P. tenuis* (Cringan, 1956). Besnoitiosis is a disease caused by infection with the protozoan parasite *Besnoitia besnoiti* and is known in wildlife and livestock around the world (Walden, et al., 2014). It can cause spontaneous abortions in pregnant females and infertility in males, but it is primarily expressed as facial hair loss in infected animals. It has been found in free-ranging woodland caribou in northern Saskatchewan in 1976 (Wobeser, 1976), captive caribou (Glover, et al., 1990).

Caribou are also susceptible to tape worms (*Echinococcus granulosus*, *E. multilocularis*, *Taenia ovis krabbei*), bot flies (Oestrinae), warble flies (Hypodermatinae), liver flukes (*Fascioloides magna*), lumpy jaw (*Actinomyces bovis*), muscle worms (*Parelaphostrongylus andersoni*, *P. odocoilei*), and winter tick (*Dermacentor albipictus*) (Miller, et al., 2014b).

There is no reported occurrence of brucellosis or tuberculosis in British Columbia in any species, severe symptoms of Besnoitiosis have not been found in caribou in British Columbia (Miller, et al., 2014a). However, many of the other parasites can be found in woodland caribou in British Columbia with effects on individuals, but no reported population-effects on the Wells Gray caribou subpopulation. Chronic wasting disease, which has the

potential for strong negative effects on this subpopulation has not been detected in British Columbia in any species (Schwantje, 2015).

### 3.6 CLIMATE CHANGE

For species such as woodland caribou that undergo seasonal migrations, have predators with seasonal cycles, respond to plant and insect phenology and are sensitive to snow depth and season length, climate change will have direct effects (Vors & Boyce, 2009). With alpine tundra habitats predicted to shrink in a warming climate, the effects of climate change on caribou may be profound (Harding & McCullum, 1997; Swift & Ran, 2012). Natural resource industries, such as forestry and oil and gas are both vulnerable and have a role to play in climate change mitigation (Houghton, et al., 2001). How they adapt may also have consequences for caribou (Racey, 2005). Climate change adds much complexity to managing caribou for long-term recovery, including how it affects the distribution of alternative prey (Seip, 2008; Dawe & Boutin, 2016) and available food (Parker, et al., 2009).

Climate change models for British Columbia suggest that areas in the Cariboo Mountains will experience increased winter snow loads (Dawson, et al., 2008; Griesbauer & Green, 2010) that could affect food access and mobility for animals. Such a change could be positive for snow adapted, arboreal lichen eating caribou. This benefit could be negated by more frequent freeze-thaw cycles (Plummer, et al., 2006) that will improve the ability to predators to move across frozen crusts as well as access to food for caribou (Gillett, et al., 2004; Dawson, et al., 2008). Predictions of forest type shifts due to climate change mediated by fires suggest that black spruce may be replaced by white spruce and lodgepole pine, affecting caribou habitat (Hebda, 1997).

A model of vegetation in Wells Gray Provincial Park indicates that habitat types found there that are important for caribou (Engelmann Spruce-Subalpine Fir) were under threat from climate change and not adequately represented in the protected areas in this region (Holmes, et al., 2013). Caribou population models that include climate change effects on habitat (snow, forest regeneration, insect outbreaks) predict that the Wells Gray caribou subpopulation will be extinct within 200 years (Wittmer, et al., 2010). Climate change can contribute to habitat fragmentation, further isolating already isolated groups within this subpopulation (van Oort, et al., 2010).

### 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 estimate of 200 caribou the Wells Gray North caribou may not currently fit into this category.

## 4 MANAGEMENT HISTORY

### 4.1 HABITAT

Habitats occupied by the Wells Gray caribou subpopulation include Englemann spruce / subalpine fir forests at mid and upper elevations (early winter, early spring, summer and autumn) up to alpine areas (late winter) and lower elevation subalpine fir / spruce forests in spring (Seip 1990). Particularly the lower elevation habitats are also subject to forestry (Card, 2015). Caribou do not tend to use cedar and Douglas fir stands in this area (Seip, 1990).

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Habitat management in this area is overseen by the provincial government and implemented by the forestry industry through application of their AAC (see above). Active restoration takes place in the form of cutblock replanting that accelerates seedling establishment (Cichowski, 1989; Cichowski, 1996). For their part, forestry regulations prescribe practices to manage resource use and protect forests that are caribou habitat (Seip, 1998).

### 4.1.1 PROTECTION

Provincial park legislation does not automatically protect caribou habitat from forestry, mining and petroleum resource activities. When land is acquired for a provincial park, with it comes the mineral and coal leases as well as timber and related licences (with compensation) (Government of British Columbia 1996a). Hunting is prohibited in some parks (BC Government, 2016a). Petroleum and natural gas tenures are permitted by the British Columbia Park Act (Section 33 Government of British Columbia 1996a) but are not relevant in this subpopulation range.

Within the Quesnel Highlands LPU 27% of the core caribou habitat and 10% of the matrix habitat is within Wells Gray and Cariboo Mountains Provincial Parks and has been off limits to forest harvesting since the parks were formed in 1939 and 1995 respectively (BC Government, 1986; Mahood, 2018; BC Parks, 2002).

In 2007 53 % of core caribou habitat outside of the provincial park was designated as no harvest Ungulate Winter Range (UWR) under Government Action Regulation (GAR) orders (Mahood, 2018; BC Government, 2018). Combined with the provincial parks a total of 66 % of core habitat and 14% of matrix habitat has been protected from further forest harvesting (Mahood, 2018).

There are also coal land reserves, mineral no registration reserves and old growth management areas (OGMA's) however these may overlap considerably with the UWR and therefore may not be cumulative (Mahood, 2018).

### 4.1.2 ENHANCEMENT AND RESTORATION

Large-scale habitat restoration and enhancement for caribou protection and recovery generally refers to oil and gas activities (well sites, seismic lines) rather than forestry. Habitat restoration is very expensive and rarely undertaken at a scale that is beneficial to caribou (Schneider, et al., 2010; Dickie, et al., 2017). Small-scale habitat restoration actions, like decommissioning roads, replanting seismic lines or installing movement and visual barriers along pipelines can be effective (MacNearney, et al., 2016; Pigeon, et al., 2016).

Beyond tree planting to restore forest resources, no large-scale habitat management or restoration has occurred in the range of the Wells Gray caribou subpopulation.

## 4.2 RECREATION AND ACCESS MANAGEMENT

Road access to woodland caribou habitat elevates conservation threats including conflicts with snowmobiles, hunting pressure, habitat fragmentation and in some cases predation (James, et al., 2004; Apps & McLellan, 2006; Seip, et al., 2007; Apps & Dodd, 2017). A key element of caribou life history is how they seek separation from competitors (moose, deer, elk) and their predators (Bergerud & Elliot, 1986; Wittmer, et al., 2007). Access roads constructed into woodland caribou habitat connect caribou to their threats and contributes to population declines (Dussault, et al., 2012).

Recreational use of the Wells Gray North caribou subpopulation range is high due to the Provincial Parks that overlap with their range, the density of resource roads and the proximity to Alberta from where many backcountry ski and snowmobile enthusiasts come.

### 4.2.1 SNOWMOBILE

Public snowmobiling is not allowed within Wells Gray Provincial Park or in most of Cariboo Mountains Provincial Park (BC Government, 1986; BC Parks, 2002). Fifty nine percent of core caribou habitat within the LPU but outside of provincial parks is closed to snowmobile use under the BC Wildlife Act (Mahood, 2018; BC Government, 2018). Snowmobiling in the remaining core habitat is managed through agreements with the local snowmobile clubs. The Conservation Officer Service provides education and conducts regular compliance and enforcement patrols. **Enforcement resulted in:**

### 4.2.2 HELI-SKI / CAT-SKI

The helicopter and cat skiing industry, through membership with Helicat Canada, Has been guided by best management practices since 2011 (under a Memorandum of Understanding (MOU)) that stipulate minimum distances that the helicopters and skiers should avoid caribou by (BC Government, 2014). Area closures in some locations were recommended in the 2005 Recovery Implementation Plan (HCRIG, 2005) but were not implemented (BC Government, 2018).

### 4.2.3 OTHER

There are no specific management actions to regulate or limit other recreational activities such as backcountry skiing or summer (non-hunting) OHV use outside of the provincial parks (Government of British Columbia 2017c).

## 4.3 PREDATORS

### 4.3.1 WOLF MANAGEMENT

Wolves are an important, year-round caribou predator. Caribou populations in northern British Columbia were shown to decline when wolf densities were 9–10/1000km<sup>2</sup> but increased at wolf densities from 1–4/1000km<sup>2</sup> (Bergerud & Elliot, 1986). For this reason, target wolf densities that would enable caribou recovery are set to 6.5/1000km<sup>2</sup>. In the absence of effective habitat or alternative prey management to achieve these densities, direct wolf management must be undertaken to achieve caribou conservation goals.

Wolf hunting is managed as general open seasons through the provincial hunting regulations. There are no restrictions on the number of wolves harvested per person annually (annual bag limit) and no closed season for the majority of the Wells Gray North caribou subpopulation area (Management Unit (MU) 5-15). However the portion within Wells Gray Provincial Park and west of Hobson and Clearwater Lakes has no hunting season for wolves (MU 3-46) (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 3 or 5 (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, may be more effective. However a unique wolf sterilization pilot project was carried out in the Wells Gray North area from 2001 to 2004 and again from 2007 to 2012 (Hayes, 2013; Roorda & Wright, 2012 ; CCLUP, 2007).

In this sterilization project wolves were captured and dominant wolves sterilized. Subordinate wolves were either collared and released or removed (Roorda & Wright, 2012 ). The intention was to have the dominant pairs



maintain and defend territories while lowering wolf densities due to the lack of offspring. Up to 39 - 77% of the wolf packs were subject to this fertility treatment and wolf densities were reduced by 39 - 48% to approximately 3 wolves per 1000 km<sup>2</sup> over 65% of the study area (Roorda & Wright, 2012 ; Hayes, 2013). A total of 64 wolves were culled, 47 were sterilized, and 40 were collared to track movements and mortality rates. The lower wolf density did not however increase caribou calf recruitment. The Wells Gray caribou subpopulation increased during that time period but nearby control populations increased as well. There was no statistical proof that the wolf sterilization project benefited the caribou. An independent review suggested the project continue until 2015 but unforeseen circumstances did not allow that to happen (Hayes, 2013).

### 4.3.2 COUGAR MANAGEMENT

The annual bag limit for cougar in MU 5-15, the majority of the Wells Gray North caribou range, is two. Cougar hunting is not permitted in MU 3-46. There is a requirement for compulsory inspection of cougars (BC Government, 2016a).

### 4.3.3 OTHER

Grizzly bears, black bears and wolverines are also woodland caribou predators (Seip, 1992; Wittmer, et al., 2005a). However, their protection status, seasonality and / or low predation rate and minimal dependence on caribou as food does not warrant management to benefit caribou populations (CCRIG, 2005). In rare cases associated with intensive caribou management programs (captive breeding, maternity penning) bear or wolverine removal may be conducted (CCRIG, 2005).

## 4.4 PRIMARY PREY

Moose, elk, white-tailed deer and mule deer (including black-tailed deer) share large, mammalian predators such as wolves, bears and cougars. In what is known as apparent competition (Holt, 1977) an increase in one prey population will lead to a decrease in a second prey population. It appears as if these two, prey species are competing with each other, but the decline of the second prey species is due to the boost that their shared predator population experiences because of the high density of the first prey species. Woodland caribou have avoided apparent competition by occupying habitats distant from other deer species. However, changes to their habitats, movement barriers and facilitated predator access have limited their ability to continued isolation. Across their range, woodland caribou populations have been subject to apparent competition (DeCesare, et al., 2010b; Wittmer, et al., 2013). For this reason, managing primary prey, either directly through hunting quotas, or indirectly through habitat management has become a needed management action (CCRIG, 2005).

### 4.4.1 MOOSE MANAGEMENT

Throughout British Columbia, moose are a common and sustaining prey of wolves (Messier, 1994). But their expanding range (Bergerud & Elliot, 1986), a wolf numerical response to moose densities (Messier & Joly, 2000) and apparent competition with woodland caribou mean that even moderate moose densities in or adjacent to caribou range poses a threat to caribou persistence (Seip & Cichowski, 1996; Lessard, et al., 2005; Serrouya, et al., 2017) . Moose densities respond positively to early seral forest habitat and negatively to human hunting, and moose numbers have been falling around the province in response to harvest pressure (Moose Management Technical Team 2015). Lessard et al. (2005) found that a 10% increase in the moose harvest could stabilize caribou populations.

Hunting moose in the Wells Gray North caribou range is managed through a combination of general open seasons and limited entry hunts (BC Government, 2016a; BC Government, 2016c). Setting and achieving targeted moose populations estimated to natural forest seral conditions (CCRIG, 2005) has not been attempted.

### 4.4.2 DEER MANAGEMENT

Managing deer populations in support of caribou conservation is a challenge. Both can support predator populations that have negative effects on caribou (Latham, et al., 2011b). Both can transmit diseases that could be catastrophic were they to spread to caribou populations (see above; Habib et al. 2011). Where mule deer and white-tail deer ranges overlap, mule deer tend to decline, perhaps also due to apparent competition (Robinson, et al., 2002). In British Columbia, there is active management to increase mule deer populations through habitat protection (British Columbia Ministry of Environment 2017) and manage white-tailed deer populations through hunting regulations (BC Government, 2016a). Neither are strictly regulated by either predators or food. White-tailed deer populations respond strongly to food availability as well as hunting or predation (Fryxell, et al., 1991; Messier, 1991; Dumont, et al., 2000). Mule deer are similar, but tend to be more vulnerable to predation, food availability, severe weather and loss of native winter habitat (Pierce, et al., 2012; Forrester & Wittmer, 2013; Bergman, et al., 2015). Indeed, regulating deer density using hunter tags must counter some difficult trends (declining number of hunters, increase prey refugia from hunters and increased use of residential areas by deer) to be successful (Brown, et al., 2000). Managing deer populations to a lower density will require managing artificial food sources (hay, grain), and access to high quality habitats as well as increased hunting pressure.

Both mule deer and white tail deer are present within the Wells Gray North caribou subpopulation area. There is a general open season for both white tail and mule deer bucks and limited entry hunts in some parts of the caribou range for antlerless mule deer only (BC Government, 2016a; BC Government, 2016c). Setting and achieving targeted deer populations estimated to natural forest seral conditions (CCRIG, 2005) has not been attempted.

### 4.4.3 OTHER

Elk are not abundant in the Wells Gray North caribou range and there is no general open or limited entry hunting seasons (BC Government, 2016a; BC Government, 2016c).

## 4.5 POPULATION REINFORCEMENT

The International Union of Conserving Nations (IUCN) has established guidelines for reintroductions and related conservation translocations (IUCN, 2012), of which population reinforcement is one tool. In this document, reinforcement is defined as an intentional movement and release of an organism into an existing population of conspecifics within its indigenous range. It differs from reintroduction in that the species has not been extirpated from that range (DeCesare, et al., 2010a), but existing populations are being added to. The management tools described in this section are based on the assumption that caribou populations are being reinforced and not reintroduced.

### 4.5.1 MATERNITY PENNING

Maternity penning is a technique to increase calf recruitment by capturing and temporarily penning pregnant females to protect them from predators. These females are held through parturition and for up to six weeks after calves are born. By this time calves are large and strong enough to better avoid predators, improving their survival probability and population recruitment. Thus, if young-of-the-year predation is a contributing factor to unsustainable population decline, maternity penning can be an effective mitigation (Hayek, et al., 2016).



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Maternity penning is an *in situ* method where the pen is constructed within their home range and animals are never moved outside of their home range.

Maternal penning to increase calf recruitment is a tool that has not been used with the Wells Gray North 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 a conservation method that captures both male and female animals and moves them permanently to a facility where they are bred under controlled conditions (IUCN, 2012). The objective is to create a surplus of female calves in the breeding facility that can then be translocated to ranges to reinforce small populations. To be effective, recipient populations should have low adult female survival that this action can reverse. This is a *ex situ* approach that takes animals away from their home range and returns animals to ranges that may not be where they originate (Harding & McCullum, 1997). A number of factors, such as source animals, animal husbandry, genetic bottlenecks, gene mixing with destination herds, status of destination herds, disease transmission, fate of male calves among others must be considered in such an effort (Dolman, et al., 2015; Hayek, et al., 2016). To date captive breeding of caribou has not been implemented in BC and is not in the plans as a management tool for conserving the Wells Gray North caribou subpopulation.

### 4.5.3 TRANSLOCATION

Translocation is the reinforcement of small populations by moving animals directly from a sustainable population (Ray, et al., 2015; Hayek, et al., 2016). The goal is to rapidly increase the numbers of animals of all ages and sexes in the target population (Miller, et al., 2007; Decesare, et al., 2010c). Animals are captured in their home range, transported to the target range and either soft released in a temporary pen that offers an opportunity for individuals to adjust to their new surroundings, or hard released directly into the destination habitat.

Compared with other reinforcement methods, translocation is a relatively cost-effective approach to add animals to small populations. It has been tried successfully and unsuccessfully with caribou populations in Canada and British Columbia (Compton, et al., 1995; Stronen, et al., 2007; Hayek, et al., 2016). There have been no translocations of caribou into or out of the Wells Gray North caribou subpopulation.

### 4.5.4 OTHER

The proximate cause of caribou population declines is predation. While predator management is a direct way to manage this threat, an alternative solution is predator exclusion fencing (Hayek, et al., 2016). In part, this approach is linked to direct predator management as any predators within an exclusion fence would be lethally removed, and it is linked to maternity penning as this is a form of small-scale, temporary predatory exclusion fencing. However, there are recent, and very large scale (thousands of hectares), proposals to erect predator exclusion fencing as a mitigation for caribou populations where habitat restoration is an unrealistic goal but the caribou population is critically low (Boutin & Merrill, 2016; Cornwall, 2016; Hebblewhite, 2017; Proulx & Brook, 2017). Such a project is not in the plans for the Wells Gray caribou subpopulation.

## 4.6 STEWARDSHIP/OUTREACH

Local communities and stewards are an essential part of caribou recovery. Management actions to recover very small populations are at times expensive, controversial and require the imposition of new and restrictive

regulations (Hayek, et al., 2016). Gaining the social licence to conduct management actions like predator management, translocation, captive breeding and access restrictions requires outreach. Effective outreach programs to local communities and regional populations must accompany planning for management actions (Antoniuk, et al., 2015). This includes information to municipal and regional administrations, business stakeholders, recreational groups, conservation organizations, farming organizations, hunting clubs among others. Outreach must be timely, targeted and inclusive to be effective (Wilkinson, 2010).

Stewardship Management Agreements (SMA's) are in place for many caribou subpopulation areas that experience high recreational snowmobile use including the Wells Gray North caribou range. 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.

### 4.7 RESEARCH

Every caribou subpopulation in British Columbia requires some degree of management action; habitat protection or restoration, population reinforcement, alternative prey management or predator control. Yet few caribou subpopulations in British Columbia have sufficient, herd-specific information to enable confident management decisions. To fill these gaps, scientific research and traditional ecological knowledge must be gathered to fill critical gaps.

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 their interactions are broadly understood, ongoing research to fine tune caribou responses to ecological stimuli and human disturbance including habitat fragmentation and primary prey density can improve our management.

In the 1980's caribou within Wells Gray Provincial Park were subject to one of the first in depth ecological studies of deep snow caribou (Seip, 1990). Three separate radio telemetry projects took place between 1984 and 2000 (CCLUP, 2000). More recently wolves within the Wells Gray North caribou subpopulation range have been subject to a unique sterilization project (Hayes, 2013; Roorda & Wright, 2012 ) as described above in Section 4.3.1.

### 4.8 MONITORING

Ecological, population and industrial footprint monitoring is an essential activity towards the conservation and recovery of woodland caribou. This provides the information that enables the detection of conservation threats, the effectiveness of management activities and the status of target populations. Although it cannot replace conservation action, it is an essential piece of the caribou recovery program.

Key elements of the caribou program in the Wells Gray North caribou subpopulation range include: maintenance of collared animals for population recruitment estimates, regular caribou population surveys, predator (wolf) distribution and movement, and monitoring of the natural and human disturbance footprint.

## 5 IMPLICATIONS TO OTHER WILDLIFE

Changing population trends of woodland caribou will require manipulating the environment in ways that favour caribou ecology and life history sometimes at the expense of other wildlife. More old growth forest will benefit caribou but not moose or deer. Reducing adult female and calf mortality may require lethal wolf control. Maternity penning makes calves, common spring prey for black and grizzly bears, less vulnerable to these predators. None of these management actions can or will imperil other wildlife species, but will precipitate changes to their population density and/or distribution.

Conserving caribou could also 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

The recovery and protection of woodland caribou populations will affect a range of human values and activities across caribou range (Scarfe, 2006). These include recreational / commercial activities such as camping, snowmobiling and backcountry skiing, commercial resource extraction activities such as forestry, mining and oil and gas development as well as non-commercial resource uses such as hunting. Research shows that none of these activities will have to be halted to protect woodland caribou (Kruse, et al., 1998; Hebblewhite, 2017; Hebblewhite, et al., 2007). However, changes to operations, seasonal restrictions and area closures will be required, locally affecting some recreational and commercial activities (Government of Alberta, 2016).

## 7 PARTNERS / NEIGHBOURS

Partners are existing or potential groups that can contribute to woodland caribou management with expertise, funding, in-kind or moral support. Neighbours are groups within in the caribou subpopulation area that are currently not participating in caribou management but that could be affected by caribou management. Neighbours include local governments, industry tenure holders, and recreation groups. Neighbours could potentially become future partners.

Below is a list of communities in and adjacent to Wells Gray North caribou subpopulation range, organizations that have a clear interest in how this area is managed and businesses that have a commercial interest in the area. This may not be a complete list, particularly of distant organization with an inherent interest.

Communities: **First Nations:** Lheidli-T'enneh First Nation, ?Esdilagh First Nation (Alexandria Indian Band), T'exelc First Nation (Williams Lake Indian Band), Carrier Chilcotin Tribal Council (Red Bluff Indian Band (Lhtako Dene), Lhoosk'uz Dene' Government Administration) , Cariboo Tribal Council

**Local:** Quesnel, Dunkley, Wells, Sugarcane

**Regional:** Prince George (and outlying communities), Williams Lake

**Organizations:** **Recreation:** British Columbia Snowmobile Federation (Wells Snowmobile Club, Prince George Snowmobile Club, Williams Lake Powder Kings Snowmobile Club, Quesnel Snowmobile Club), Land Conservancy of British Columbia, Outdoor Recreation Council of British Columbia, Quad Riders Association of British Columbia, Prince George ATV Club, Quesnel Cross Country Motorcycle Association, Caledonia Ramblers Hiking Club, Prince George Horse Society, Prince George Off-Road Motorcycle Association, Williams Lake Off Road Motorcycle Association, Prince George Snowmobile Club, Northwest Brigade Canoe Club, Hickory Wing Ski Touring Club, Silvertip Heli-ski

**Protection:** Western Canada Wilderness Committee, BC Spaces for Nature, Yellowstone to Yukon Initiative

## 8 RECOMMENDED ACTIONS

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

#### 8.1.1 HABITAT PROTECTION

- Begin discussions on methods to increase no harvest protection of core habitat as mapped by Environment and Climate Change Canada (ECCC) to 100%.
- Begin discussions on converting the target of a wolf density of 3 per 1000 km<sup>2</sup> in matrix habitat to a system tangible to the forest industry, potentially a cap on the amount of early seral forest stages.
- Initiate Land Act Reserves over remaining untenured areas of core habitat for major industrial uses including metal mining, placer mining, and natural gas.

#### 8.1.2 ALTERNATE PREY MANAGEMENT

- Move towards management of moose populations to densities of < 0.3 / km<sup>2</sup> in all core and matrix caribou habitat.
- Review if changes are required to white tail deer hunting management to facilitate lower predator populations.

#### 8.1.3 PREDATOR MANAGEMENT

- Resume the wolf research program to improve current knowledge of wolf densities, movements and populations.
- Review compulsory inspection data and anecdotal reports for cougar to determine prevalence.

#### 8.1.4 RESTORATION

- Initiate discussions with the forestry sector on decommissioning and rehabilitating roads to reduce predator travel efficiency and to limit recreational access.
- Initiate discussions with the forestry sector 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.

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### 8.1.5 RECREATION

- Assess if current snowmobile restrictions are adequate to prevent the displacement of caribou from preferred habitat.
- In conjunction with the Conservation Officer Service, continue compliance monitoring and enforcement of current snowmobile restrictions.
- Update heliski industry best management practices. Experience in other mountain caribou areas suggest that the 500 meter flight and skier avoidance guideline is inadequate; suggest updating to 3 km skier and flight avoidance and / or ensure area closures are in key locations.

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

### 8.2.1 HABITAT PROTECTION

- Increase no harvest protection of core habitat as mapped by Environment and Climate Change Canada (ECCC) to 100%.
- Convert the target of a wolf density of 3 per 1000 km<sup>2</sup> in matrix habitat to a system tangible to the forest industry, potentially a cap on the amount of early seral forest stages.

### 8.2.2 ALTERNATE PREY MANAGEMENT

- Continue management of moose populations to densities of  $< 0.3 / \text{km}^2$  in all core and matrix caribou habitat.
- Manage white tail deer populations to lower predator populations if necessary.

### 8.2.3 PREDATOR MANAGEMENT

- Reintroduce a wolf cull if densities are greater than 3 wolves / 1000 km<sup>2</sup>

### 8.2.4 RESTORATION

- Rehabilitate forestry road segments to inhibit predator movement and prevent mechanized access.
- Initiate silviculture and forestry management options and prescriptions which will increase the speed at which early seral forests mature.

### 8.2.5 RECREATION

- Improve on current snowmobile restrictions to prevent the displacement of caribou from preferred habitat if necessary.
- In conjunction with the Conservation Officer Service, continue compliance monitoring and enforcement of current snowmobile restrictions.

### 8.2.6 POPULATION MONITORING

- Continue caribou population monitoring through annual or bi-annual aerial censuses.

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

### 8.3.1 HABITAT PROTECTION

- Monitor whether the introduction of a cap on the amount of early seral forest is producing the desired result.

### 8.3.2 ALTERNATE PREY MANAGEMENT

- Continue management of moose populations to densities of  $< 0.3 / \text{km}^2$  in all core and matrix caribou habitat.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Continue management of white tail deer populations if necessary.

### 8.3.3 PREDATOR MANAGEMENT

- Continue the wolf cull if densities are greater than 3 wolves / 1000 km<sup>2</sup>

### 8.3.4 RESTORATION

- Continue to rehabilitate forestry road segments to inhibit predator movement and prevent mechanized access.
- Continue with silviculture and forestry management options and prescriptions which will increase the speed at which early seral forests mature.

### 8.3.5 RECREATION

- In conjunction with the Conservation Officer Service, continue compliance monitoring and enforcement of current snowmobile restrictions

### 8.3.6 POPULATION MONITORING

- Continue caribou population monitoring through annual or bi-annual aerial censuses.

### 8.3.7 OUTREACH

- Continue with a regional outreach program to foster support for management that will promote ongoing growth of the Wells Gray North caribou program.

## 9 LITERATURE CITED

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

Antoniuk, T., Dzus, E. & Nishi, J., 2015. *A methodological framework for caribou action planning in support of the Canadian Boreal Forest Agreement*, s.l.: s.n.

Apps, C. & Dodd, N., 2017. *Caribou habitat modeling and evaluation of forest disturbance influences across landscape scales in west-central British Columbia*, Williams Lake, BC: Ministry of Forests, Lands and Natural Resource Operations.

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., McLellan, B., Kinley, T. & Flaa, J., 2001. Scale-dependent habitat selection by mountain caribou, Columbia Mountains, British Columbia. *Journal of Wildlife Management*, Volume 65, pp. 65-77.

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.

BC Government, 1986. *Wells Gray Park Master Plan*, Victoria, BC: Ministry of Lands, Parks, and Housing, Parks and Outdoor Recreation Division.

BC Government, 2014. *Memorandum of understanding regarding management of helicopter and snow cat skiing in mountain caribou habitats*. Victoria, BC: s.n.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- 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, 2017a. *Caribou*. In: *Species & Ecosystems at Risk*. British Columbia Ministry of Environment, Victoria, BC.. [Online]  
Available at: <https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/caribou>  
[Accessed 11 11 2017].
- BC Government, 2018. *Provincial Data Warehouse*, Victoria, BC: s.n.
- BC MFLNRO, 2017. *Mountain caribou survey results and population trends*, Nelson, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- 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.
- BC Parks, 2002. *Management Plan for Bowron Lake, Cariboo Mountains, and Cariboo River Provincial Parks*, Williams Lake BC: BC Parks Cariboo District.
- Bergerud, A. & Elliot, J., 1986. Dynamics of caribou and wolves in northern British Columbia. *Canadian Journal of Zoology*, Volume 64, pp. 1515-1529.
- Bergerud, A. T., 1988. Caribou, wolves, and man. *Trends in Ecology and Evolution* 3, pp. 68-72.
- 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 alrge Mammals in North America*. New Jersey: Prentice Hall.
- Bergman, E. J., Doherty, P. F., White, G. C. & Holland, A. A., 2015. Density dependence in mule deer: a review of evidence. *Wildlife Biology*, Volume 21, p. 18-29.
- 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.
- Boutin, S. et al., 2012. Why are caribou declining in the oil sands?. *Frontiers in Ecology and the Environment*, Volume 10, pp. 65-67.
- Boutin, S. & Merrill, E., 2016. *A review of population-based management of southern mountain caribou in BC.*, Revelstoke, BC.: Columbia Mountains Institute.



## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Bowden, G., 1985. *Wildlife damage on private agricultural land in the east Kootenay*, Vancouver, BC: Ministry of Environment.
- Bradshaw, C., Boutin, S. & Hebert, D., 1998. Energetic implications of disturbance caused by petroleum exploration to woodland caribou. *Canadian Journal of Zoology*, Volume 76, pp. 1319-1324.
- Brown, G., Landriault, L., Sleep, D. & Mallory, F., 2007. Comment arising from a paper by Wittmer et al.: hypothesis testing for top-down and bottom-up effects in woodland caribou population dynamics. *Oecologia*, Volume 154, pp. 485-492.
- Brown, T. L. et al., 2000. The future of hunting as a mechanism to control white-tailed deer populations. *Wildlife Society Bulletin*, Volume 28, p. 797–807.
- Butler, E., Jensen, W., Johnson, R. & Scott, J., 2008. Grain overload and secondary effects as potential mortality factors of moose in North Dakota. *Alces*, Volume 44, pp. 73-79.
- Card, A., 2015. *Kamloops TSA TSR Data Package*, Victoria, BC: British Columbia Ministry of Forests, Lands and Natural Resource Operations.
- Caughley, G., 1994. Directions in conservation biology. *The Journal of Animal Ecology*, Volume 63, pp. 215-244.
- CCLUP, 2000. *Cariboo - Chilcotin land use plan - Mountain caribou strategy*, s.l.: Cariboo Mid-Coast Interagency Management Committee.
- CCLUP, 2007. *Caribou Chilcotin Land Use Plan. Mountain caribou strategy - update #1*, s.l.: Cariboo Manager Committee.
- CCRIG, 2005. *Recovery implementation plan for threatened woodland caribou in the Hart and Cariboo mountains recovery area, British Columbia*, s.l.: BC Ministry of Environment.
- Chubbs, T., Keith, L., Mahoney, S. & McGrath, M., 1993. Responses of woodland caribou (*Rangifer tarandus* caribou) to clear-cutting in east-central Newfoundland. *Canadian Journal of Zoology*, Volume 71, pp. 487-493.
- Cichowski, D. B., 1989. *Seasonal movements, habitat use, and winter feeding ecology of woodland caribou in west-central British Columbia*, s.l.: s.n.
- 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. B., 1996. Managing woodland caribou in west-central British Columbia. *Rangifer*, Volume 16, p. 119–126.
- Cichowski, D. B. & Williston, P., 2005. Mountain pine beetles and emerging issues in the management of woodland caribou in west-central British Columbia. *Rangifer*, Volume 16, p. 97–103.
- Compton, B. B., Zager, P. & Servheen, G., 1995. Survival and mortality of translocated woodland caribou. *Wildlife Society Bulletin*, Volume 23, p. 490–496.

- Cornwall, W., 2016. To save caribou, Alberta wants to fence them in. *Science*, Volume 353, p. 333–333.
- 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.
- Cote, S. et al., 2004. Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics*, Volume 35, pp. 113-147.
- Courtois, R. et al., 2007. Effects of forest disturbance on density, space use, and mortality of woodland caribou. *Ecoscience*, Volume 14, pp. 491-498.
- Cringan, A. T., 1956. *Some aspects of the biology of caribou and a study of the woodland caribou range of the Slate Islands, Lake Superior, Ontario*, s.l.: s.n.
- Cumming, H., 1992. Woodland caribou: Facts for forest managers. *The Forestry Chronicle*, Volume 68, pp. 481-491.
- Curatolo, J. A. & Murphy, S. M., 1986. The effects of pipelines, roads, and traffic on the movements of caribou, Rangifer tarandus. *Canadian Field-Naturalist*, Volume 100, p. 218–224.
- 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.
- Dawson, R., Werner, A. T. & Murdock, T. Q., 2008. *Preliminary analysis of climate change in the Cariboo-Chilcotin Area of British Columbia*, s.l.: s.n.
- 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., Hebblewhite, M., Robinson, H. & Musiani, M., 2010b. Endangered, apparently: the role of apparent competition in endangered species conservation. *Animal Conservation*, Volume 13, pp. 353-362.
- DeCesare, N. J. et al., 2010c. The role of translocation in recovery of woodland caribou populations. *Conservation Biology*, Volume 25, p. 365–373.
- DeCesare, N. et al., 2010a. *Evaluating the reintroduction of southern mountain woodland caribou to restore small populations*, s.l.: s.n.
- 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*.
- Denryter, K., Cook, R., Cook, J. & Parker, K., 2017. Straight from the caribou's (Rangifer tarandus) mouth: detailed observations of tame caribou reveal new insights into summer–autumn diets. *Canadian Journal of Zoology*, Volume 95, pp. 81-94.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Dickie, M. et al., 2017. Evaluating functional recovery of habitat for threatened woodland caribou. *Ecosphere*.
- Dodd, N., 2017. *Mountain caribou population status for the Wells Gray North, Barkerville and North Cariboo Mountains-Bowron sub-populations, Cariboo region, 2015-2016*, Victoria, BC: British Columbia Ministry of Environment.
- Dolman, P. M., Collar, N. J., Scotland, K. M. & Burnside, R. J., 2015. Ark or park: the need to predict relative effectiveness of ex situ and in situ conservation before attempting captive breeding. *Journal of Applied Ecology*, Volume 52, p. 841–850.
- Dumont, A. et al., 2000. Population dynamics of northern white-tailed deer during mild winters: evidence of regulation by food competition. *Canadian Journal of Zoology*, Volume 78, p. 764–776.
- Dussault, C. et al., 2012. Avoidance of roads and selection for recent cutovers by threatened caribou: fitness-rewarding or maladaptive behaviour?. *Proceedings of the Royal Society B: Biological Sciences*, Volume 279, p. 4481.
- Dyer, S. J., O'Neill, J. P., Wasel, S. M. & Boutin, S., 2002. Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. *Canadian Journal of Zoology*, Volume 80, p. 839–845.
- Dyer, S., O'Neill, P., Wasel, S. & Boutin, S., 2001. Avoidance of industrial development by woodland caribou. *Journal of Wildlife Management*, Volume 65, pp. 531-542.
- 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.
- Eclipsol Energy Inc., n.d. *Eclipsol Energy Inc.* [Online]  
Available at: <http://www.eclipsol.com/hen/>  
[Accessed 18 07 2018].
- 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.
- Edwards, R. Y., 1954. Fire and the decline of a mountain caribou herd. *The Journal of Wildlife Management*, Volume 18, pp. 521-526.
- Environment Canada, 2012a. *Management Plan for the Northern Mountain Population of Woodland Caribou (Rangifer tarandus caribou) in Canada*. Page vii + 79 pp in *E. Canada, editor.*, Ottawa, Canada: s.n.
- Environment Canada, 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.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Environment Canada, 2014. *Recovery Strategy for the Woodland Caribou, Southern Mountain Population (Rangifer tarandus caribou) in Canada*, s.l.: Species at Risk Act Recovery Strategy Series.
- 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.
- Forrester, T. D. & Wittmer, H. U., 2013. A review of the population dynamics of mule deer and black-tailed deer *Odocoileus hemionus* in North America. *Mammal Review*, Volume 43, p. 292–308.
- Freddy, D., 1974. *Status and management of the Selkirk caribou herd 1973*, Masters Thesis, Moscow, Idaho: University of Idaho Graduate School.
- Freeman, N., 2008. *Motorized backcountry recreation and stress response in mountain caribou (Rangifer tarandus caribou)*. M.Sc. thesis, Vancouver, BC: University of British Columbia.
- Fryxell, J. M., Jussell, D. J. T., Lambert, A. B. & Smith, P. C., 1991. Time lags and population fluctuations in white-tailed deer. *Journal of Wildlife Management*, Volume 55, p. 377–385.
- Gillett, N. P., Weaver, A. J., Zwiers, F. W. & Flannigan, M. D., 2004. Detecting the effect of climate change on Canadian forest fires. *Geophysical Research Letters*, Volume 31, p. n/a–n/a.
- Glover, G. J., Swendrowski, M. & Cawthorn, R. J., 1990. An epizootic of Besnoitiosis in captive caribou (*Rangifer tarandus caribou*), reindeer (*Rangifer tarandus tarandus*) and mule deer (*Odocoileus hemionus*). *Journal of Wildlife Diseases*, Volume 26, p. 186–195.
- Google Earth, 2017. Mountain View, California: Google Incorporated.
- Government of Alberta, 2016. *Little Smoky and A La Pêche Caribou Range Plan*, Edmonton, Canada: Ministry of Environment and Parks.
- Government of BC, 2017b. *Environmental Violations Database (EVD)*. Ministry of Environment, Victoria, BC.. [Online]  
Available at: <https://a100.gov.bc.ca/pub/ocers/searchApproved.do?submitType=menu>  
[Accessed 8 11 2017].
- Griesbauer, H. P. & Green, D. S., 2010. Regional and ecological patterns in interior Douglas-fir climate–growth relationships in British Columbia, Canada. *Canadian Journal of Forest Research*, Volume 40, p. 308–321.
- Gustine, D. et al., 2006. Interpreting resource selection at different scales for woodland caribou in winter. *Journal of Wildlife Management*, Volume 70, p. 1601–1614.
- Harding, L. E. & McCullum, E., 1997. Ecosystem response to climate change in British Columbia and Yukon: threats and opportunities for biodiversity. In: E. Taylor & B. Taylor, eds. *Responding to global climate change in British Columbia and Yukon*. Vancouver(BC): Environment Canada, p. 1–22.
- Hatter, I., Dielman, P. & Kuzyk, G., 2017. An integrated modeling approach for assessing management objectives for mule deer in central British Columbia. *Wildlife Society Bulletin*, Volume 41, pp. 508-515.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- 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*, s.l.: s.n.
- Hayes, B., 2013. *Quesnel Highland wolf sterilization pilot assessment 2012. An independent evaluation of the response of mountain caribou*, Smithers, BC: s.n.
- HCRIG, 2005. *Recovery implementation plan for threatened woodland caribou in the Hart and Cariboo mountains recovery area, British Columbia*, s.l.: BC Ministry of Environment.
- Heard, D., 2016. *Helicopter and snowcat skiing operations in relation to mountain caribou, 2014-2015. Final Report*, Victoria, BC: Ministry of Forests, Lands and Natural Resource Operations.
- Heard, D., Gillingham, M., Steenweg, R. & Cadsand, B., 2013. *Promotion of mountain caribou recovery through alternative prey management*, Prince George, BC: Peace / Williston Fish and Wildlife Compensation Program.
- Heard, D., Klaczek, M., Marshall, S. & Batho, A., 2015. *Parsnip caribou herd census, April 2015*, Prince George, BC: BC MFLNRO.
- Heard, D. & Zimmerman, K., 2017. *Supplemental feeding of Kennedy Siding caribou, September 2016 to January 2017*, Vancouver, BC.: Peace Northern Caribou Program.
- Hebblewhite, M., 2017. Billion dollar boreal woodland caribou and the biodiversity impacts of the global oil and gas industry. *Biological Conservation*, Volume 206, p. 102–111.
- 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. et al., 2010a. *Linear features, forestry and wolf predation of caribou and other prey in west central Alberta*, s.l.: s.n.
- Hebblewhite, M., White, C. & Musiani, M., 2010b. Revisiting Extinction in National Parks: Mountain Caribou in Banff. *Conservation Biology*, Volume 24, p. 341–344.
- Hebda, R. J., 1997. Impact of climate change on biogeoclimatic zones of British Columbia and Yukon. In: E. Taylor & B. Taylor, eds. *Responding to global climate change in British Columbia and Yukon*. Victoria(BC): British Columbia Ministry of Environment, Lands and Parks, p. 31–1 – 13–15.
- 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].
- Herbison, B., 1996. *Central Selkirks caribou, historic to present times: apparent trends and emerging priorities*, Argenta, BC: s.n.
- Hervieux, D. et al., 2013. Widespread declines in woodland caribou (*Rangifer tarandus caribou*) continue in Alberta. *Canadian Journal of Zoology*, Volume 91, pp. 872-882.

- 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.
- Holmes, K., Nelson, T., Coops, N. & Wulder, M., 2013. Biodiversity indicators show climate change will alter vegetation in parks and protected areas. *Diversity*, Volume 5, p. 352.
- Holt, R. D., 1977. Predation, apparent competition, and the structure of prey communities. *Theoretical Population Biology*, Volume 12, p. 197–229.
- Houghton, J. T. et al., 2001. *Climate change 2001: The scientific basis*. New(York): Cambridge University Press.
- IUCN, 2012. *IUCN Species Survival Commission. IUCN Guidelines for Reintroductions and Other Conservation Translocations*. Page 16 pp., , Gland, Switzerland: International Union of Conserving Nations.
- James, A. R. C., Boutin, S., Hebert, D. M. & Rippin, A. B., 2004. Spatial separation of caribou from moose and its relation to predation by wolves. *Journal of Wildlife Management*, Volume 68, p. 799–809.
- 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.
- Johnson, C., Parker, K. & Heard, D., 2000. Feeding site selection by woodland caribou in north-central British Columbia. *Rangifer*, Volume 20, pp. 158-172.
- Johnson, C., Parker, K., Heard, D. & Seip, D., 2004. Movements, foraging habits, and habitat use strategies of northern woodland caribou during winter: Implications for forest practices in British Columbia. *BC Journal of Ecosystems and Management*.
- Johnson, D. R., 1985. Man-caused deaths of mountain caribou, *Rangifer tarandus* in southeastern British Columbia. *Canadian Field-Naturalist*, Volume 99, p. 542–544.
- Johnson, D. R. & Todd, M. C., 1977. Summer use of a highway crossing by mountain caribou. *Canadian Field-Naturalist*, Volume 91, p. 312–314.
- Jones, S., 2014. *Facts about Brucellosis In: Brucellosis Disease Information, ed. Animal and Plant Health Inspection Service. United States Department of Agriculture, Washington, DC..* [Online]  
Available at: [https://www.aphis.usda.gov/animal\\_health/animal\\_diseases/brucellosis/downloads/bruc-facts.pdf](https://www.aphis.usda.gov/animal_health/animal_diseases/brucellosis/downloads/bruc-facts.pdf)  
[Accessed 18 09 2017].
- Kinley, T., 2003. *Snowmobile–mountain caribou interactions: a summary of perceptions and an analysis of trends in caribou distribution*, Victoria, BC: British Columbia Ministry of Water, Land and Air Protection.
- Kruse, J. et al., 1998. Co-management of natural resources: A comparison of two caribou management systems. *Human Organization*, Volume 57, p. 447–458.

- Latham, A., Latham, M. & Boyce, M., 2011a. Habitat selection and spatial relationships of black bears (*Ursus americanus*) with woodland caribou (*Rangifer tarandus caribou*) in northeastern Alberta. *Canadian Journal of Zoology*, Volume 89, pp. 267-277.
- Latham, A., Latham, M., Boyce, M. & Boutin, S., 2011b. 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.
- Latham, A., Latham, M., McCutchen, N. & Boutin, S., 2011c. 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.
- Lessard, R. et al., 2005. Should ecosystem management involve active control of species abundances?. *Ecology and Society*, Volume 10, p. 1:online.
- MacNearney, D. et al., 2016. Towards stable caribou populations in Alberta: Considering resource selection by wolves, grizzly bears, and caribou to prioritize restoration of legacy seismic lines. *PeerJ Preprints*, Volume 4, p. e1972v1.
- Mahoney, S. et al., 2001. Caribou reactions to provocation by snowmachines in Newfoundland. *Rangifer*, Volume 21, pp. 35-43.
- Mahood, C., 2018. *Protections in Critical Habitat by LPU 20180210*. Williams Lake, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- McKay, T., 2007. *Woodland caribou response to encounters with people in Jasper National Park*, Victoria, BC: Royal Roads University.
- 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.
- 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., 1991. The significance of limiting and regulating factors on the demography of moose and white-tailed deer. *Journal of Animal Ecology*, Volume 60, p. 377–393.
- Messier, F., 1994. Ungulate population models with predation: a case study with the North American moose. *Ecology*, Volume 75, p. 478–488.
- Messier, F. & Joly, D. O., 2000. Comment: Regulation of moose populations by wolf predation. *Canadian Journal of Zoology*, Volume 78, p. 506–510.



- 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.
- Miller, F. L., Barry, S. J., Calvert, W. A. & Zittlau, K. A., 2007. Rethinking the basic conservation unit and associated protocol for augmentation of an 'endangered' caribou population: An opinion. *Rangifer*, Volume Special Issue No. 17, p. 13–24.
- Miller, M., Dawson, R. & Schwantje, H., 2014a. *Besnoitiosis*. In: *Manual of Common Diseases and Parasites of Wildlife in Northern British Columbia*. University of Northern British Columbia, Prince George, BC. [Online] Available at: <http://wildlifedisease.unbc.ca/besnoit> [Accessed 18 09 2017].
- Miller, M. J. R., Dawson, R. D. & Schwantje, H., 2014b. *Manual of Common Diseases and Parasites of Wildlife in Northern British Columbia*, s.l.: s.n.
- Neiland, K. A., King, J. A., Huntley, B. E. & Skoog, R. O., 1968. The diseases and parasites of Alaskan wildlife populations, part i. Some observations on brucellosis in caribou. *Bulletin of the Wildlife Disease Association*, Volume 4, p. 27–36.
- Neiland, K., King, J., Huntley, B. & Skoog, R., 1968. The diseases and parasites of Alaskan wildlife populations, part i. Some observations on brucellosis in caribou. *Bulletin of the Wildlife Disease Association*, Volume 4, pp. 27-36.
- Nellemann, C. et al., 2003. Progressive impact of piecemeal infrastructure development on wild reindeer. *Biological Conservation*, Volume 113, pp. 307-317.
- Nitschke, C., 2008. The cumulative effects of resource development on biodiversity and ecological integrity in the Peace-Moberly region of Northeast British Columbia, Canada. *Biodiversity and Conservation*, Volume 17, pp. 1715-1740.
- Oberg, P. R., 2001. *Responses of mountain caribou to linear features in a west-central Alberta landscape*, s.l.: s.n.
- O'Brien, D., Manseau, M., Fall, A. & Fortin, M., 2006. Testing the importance of spatial configuration of winter habitat for woodland caribou: An application of graph theory. *Biological Conservation*, Volume 130, pp. 70-83.
- Parker, K., Barboza, P. & Stephenson, T., 2005. Protein conservation in female caribou (*Rangifer tarandus*): Effects of decreasing diet quality during winter. *Journal of Mammalogy*, Volume 86, pp. 610-622.
- Parker, K. L., Barboza, P. S. & Gillingham, M. P., 2009. Nutrition integrates environmental responses of ungulates. *Functional Ecology*, Volume 23, p. 57–69.
- Pasztor, C., 2013. *Pasztor, C. 2013. Mountain caribou compliance monitoring: interactions between mountain caribou and helicopter and snowcat skiing operations*, Victoria, BC: BC Ministry of Environment.
- Pierce, B. M., Bleich, V. C., Monteith, K. L. & Bowyer, R. T., 2012. Top-down versus bottom-up forcing: evidence from mountain lions and mule deer. *Journal of Mammalogy*, Volume 93, p. 977–988.

- Pigeon, K. E. et al., 2016. Toward the restoration of caribou habitat: Understanding factors associated with human motorized use of legacy seismic lines. *Environmental Management*, Volume 58, p. 821–832.
- Plummer, D. A. et al., 2006. Climate and climate change over north america as simulated by the Canadian RCM. *Journal of Climate*, Volume 19, p. 3112–3132.
- Polfus, J., 2010. *Assessing cumulative human impacts on northern woodland caribou with traditional ecological knowledge and resource selection functions*. Dissertation, Missoula, MT: The University of Montana.
- 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.
- Poole, K., Heard, D. & Mowat, G., 2000. Habitat use by woodland caribou near Takla Lake in central British Columbia. *Canadian Journal of Zoology*, Volume 78, p. 1552–1561.
- Proulx, G. & Brook, R., 2017. Fencing large predator-free and competitor-free landscapes for the recovery of woodland caribou in western Alberta: An ineffective conservation option. *Animals*, Volume 7, p. 2.
- Racey, G. D., 2005. Climate change and woodland caribou in Northwestern Ontario: a risk analysis. *Rangifer*, Volume 25, p. 123–136.
- Ray, J. C. et al., 2015. Conservation status of caribou in the western mountains of Canada: Protections under the Species At Risk Act, 2002-2014. *Rangifer*, Volume 35, p. 49–80.
- Robinson, H. S. et al., 2012. The effect of fire on spatial separation between wolves and caribou. *Rangifer*, Volume 32, p. 277–294.
- Robinson, H. S., Wielgus, R. B. & Gwilliam, J. C., 2002. Cougar predation and population growth of sympatric mule deer and white-tailed deer. *Canadian Journal of Zoology*, Volume 80, p. 556–568.
- Roorda, L. & Wright, R., 2012 . *Caribou recovery in the Quesnel Highlands: Predator management progress report - March 31, 2012*, Williams Lake, BC: BC Ministry of Forests, Lands, and Natural Resource Operations.
- Rytwinski, T. & Fahrig, L., 2012. Do species life history traits explain population responses to roads? A meta-analysis. *Biological Conservation*, Volume 147, p. 87–98.
- Scarfe, B. L., 2006. *Socio-economic and environmental impact assessment for the Peace Moberly Tract: The base case*, s.l.: s.n.
- 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.
- Schwantje, H., 2015. *Chronic Wasting Disease*. In: *Wildlife Diseases*. Government of British Columbia, Victoria, BC. [Online]  
Available at: . <http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-health/wildlife-diseases/chronic-wasting-disease>  
[Accessed 18 09 2017].

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- 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., 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. *Canadian Journal of Zoology*, Volume 70, pp. 1494-1503.
- Seip, D. & Cichowski, D., 1996. Population ecology of caribou in British Columbia. *Rangifer* 16:73–80.. *Rangifer*, Volume 16, pp. 73-80.
- Seip, D. et al., 2002. *Ecological relationships between threatened caribou herds and their habitat in the Central Rocky Mountains Ecoregion*, Prince George, BC: FRBC Research Project #OPR02001-01.
- 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., 1998. Ecosystem management and the conservation of caribou habitat in British Columbia. *Rangifer*, Volume 18, p. 203–211.
- Seip, D. R., 2008. Mountain caribou interactions with wolves and moose in central British Columbia. *Alces*, Volume 44, p. 1–5.
- 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.
- Sielecki, L. E., 2010. *Wildlife accident monitoring and mitigation in British Columbia* , s.l.: s.n.
- Sifton, E., 2001. *Disease risk assessment for an experimental captive breeding program of Mountain Caribou in British Columbia. final*, Nelson, BC: Wildlife Branch BC Ministry of Environment, Lands and Parks.
- 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. & Terry, E., 2000. *Impacts of backcountry recreation activities on mountain caribou. Wildlife Working Report No. WR-99*, Victoria, BC: Ministry of Environment, Lands 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.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Smith, K. et al., 2000. Winter distribution of woodland caribou in relation to clear-cut logging in west-central Alberta. *Canadian Journal of Zoology*, Volume 78, pp. 1433-1440.
- 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., 1990. Managing second-growth forests as caribou habitat. *Rangifer*, Volume Special Issue No. 3, p. 139–144.
- Stevenson, S. K., 1991. Forestry and caribou in British Columbia. *Rangifer*, Volume 11, pp. 124-129.
- Stronen, V. et al., 2007. Translocation and recovery efforts of the Telkwa caribou, *Rangifer Tarandus caribou*, herd in westcentral British Columbia 1997-2005. *Canadian Field Naturalist*, Volume 121(2), pp. 155-163.
- Swift, K. & Ran, S., 2012. Successional responses to natural disturbance, forest management and climate change in British Columbia forests. 2012, Volume 13.
- Trainer, D., 1973. Caribou mortality due to the meningeal worm. *Journal of Wildlife Diseases*, Volume 9, pp. 376-378.
- van Oort, H., McLellan, B. N. & Serrouya, R., 2010. Fragmentation, dispersal and metapopulation function in remnant populations of endangered mountain caribou. *Animal Conservation*, Volume 14, pp. 215-224.
- 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.
- Walden, H. S. et al., 2014. Chapter 60 - Miscellaneous Parasitic Diseases. In: *Equine Infectious Diseases (Second Edition)*. St. Louis: W.B. Saunders, p. 505–514.
- White, G., 1996. Population estimation from mark-resighting surveys  
<http://www.cnr.colostate.edu/~gwhite/software.html>. *Wildlife Society Bulletin*, Volume 24, pp. 50-52.
- 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.
- Wilkinson, C. J. A., 2010. An analysis of government actions for the protection and recovery of forest-dwelling woodland caribou (*Rangifer tarandus caribou*) in Ontario, Canada. *Rangifer*, Volume 30, p. 67–77.
- Wilmshurst, J. & Gordon, S., 2016. *Mountain Caribou Compliance Monitoring: Interactions between Mountain Caribou and Helicopter and Snowcat Skiing Operations during the 2015-16 Skiing Season. draft report*, Victoria, BC: BC MFLNRO.

## Woodland Caribou Plan for the Wells Gray North Subpopulation

- Wilson, S., 2010. *Analysis of mountain caribou sighting data collected by heli-ski and snow-cat skiing operators in 2009-10. final report*, Victoria, BC: BC Ministry of Environment.
- Wilson, S. & Hamilton, D., 2003. *Cumulative effects of habitat change and backcountry recreation on mountain caribou in the Central Selkirk mountains Final Report*, s.l.: BC Ministry of Sustainable Resource Management, Nelson, Canadian Mountain Holidays, Banff AB, Pope & Talbot Ltd., Nakusp BC .
- Wilson, S. & Nyberg, J., 2009. *A proposed monitoring and adaptive management strategy for mountain caribou recovery implementation*, Victoria, BC: Ecosystems Branch, BC Ministry of Environment.
- 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., Ahrens, R. N. M. & McLellan, B. N., 2010. Viability of mountain caribou in British Columbia, Canada: Effects of habitat change and population density. *Biological Conservation*, Volume 143, p. 86-93.
- 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.
- Wobeser, G., 1976. Besnoitiosis in a woodland caribou. *Journal of Wildlife Diseases*, Volume 12, pp. 566-571.
- Wolfe , S., Griffith, B. & Wolfe, C., 2000. Response of reindeer and caribou to human activities. *Polar Research*, Volume 19, pp. 63-73.
- Young, J. & Freeman, N., 2001. *Summary of mountain caribou surveys within the Quesnel Highland and Cariboo Mountains, Cariboo Region, up to and including 2001*, Prince George, BC: Wildlife Branch Cariboo Region, Ministry of Water, Land and Air Protection.
- Young, J. & Freeman, N., 2002. *Towards integrated management solutions: The Quesnel Highland caribou project radio-telemetry final report 1993-2000*, Williams Lake, BC: BC Ministry of Water, Land, and Air Protection.
- Young, J. & Freeman, N., 2003. *Summary of mountain caribou surveys within the Quesnel Highland and Cariboo Mountains, Cariboo Region, up to and including 2002*, Williams Lake, BC: Ministry of Water, Land and Air Protection.