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

Liard Plateau
Subpopulation

Northern Mountain Population

BRITISH COLUMBIA

Recommended Citation:

EXECUTIVE SUMMARY

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1 BACKGROUND

1.1 INTRODUCTION TO THE PROGRAM

2 POPULATION DESCRIPTION

Liard Plateau caribou are a subpopulation of northern mountain (NM) caribou, an ecotype of woodland caribou that is listed as *Special Concern* by the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC 2014). NM caribou currently occur in 45 subpopulations that are distributed across the northwestern section of British Columbia, the southwestern part of the Northwest Territories and the southern two-thirds of the Yukon Territory with one Yukon subpopulation being trans-boundary with Alaska (COSEWIC 2014). Within COSEWIC's (2011) Designatable Units classification system, which reflects evolutionary and ecological distinctions among caribou groups, NM caribou are considered part of Designatable Unit 7. In British Columbia, mountain-living caribou are classified into "northern" and "southern mountain" ecotypes, which reflect differences in feeding ecology during winter (Stevenson and Hatler 1985). The northern ecotype, which includes all NM caribou subpopulations, occurs in mountainous areas receiving relatively low annual snowfall and primarily forages on terrestrial lichens within mature conifer forests or wind-swept alpine slopes (Seip and McLellan 2008). The southern mountain ecotype, in contrast, inhabits the interior, deep-snow mountains and forages on arboreal lichens during winter as terrestrial foods are generally unavailable. Within British Columbia, NM caribou are currently *Blue-listed* with a conservation status of S2/S3 due to sustained declines in some subpopulations, uncertainty in the population trend of others, and high threats from predation and anthropogenic disturbance (BC Conservation Data Centre 2017).

2.1 DISTRIBUTION

The range of the Liard Plateau subpopulation lies north of the Liard River in the northeastern portion of the province and is trans-boundary with the Yukon Territory (Fig. 1). The BC portion of the range encompasses 5,069 km^2 and consists of rolling terrain (300 – 750 m) with gently sloped alpine areas (up to ~1450 m in elevation) and lower elevation boreal forests (Spruce-Willow-Birch and Boreal White and Black Spruce biogeoclimatic zones; Powell 2006, McNay 2011). Spatial data from radio-collared female caribou suggests that the BC portion of the range is larger than the Yukon portion (Powell 2006). These data and those from aerial surveys suggest that caribou use is centered upon the Caribou Range, which is an isolated alpine area separating the boreal plains from higher elevation mountain ranges further west (McNay et al. 2014). The range is bordered to the east by the boreal forests of the Taiga Plains ecoprovince and to the west by the Coal River drainage. To the south, the Liard River corridor separates the Liard Plateau range from the Muskwa and Rabbit caribou ranges. The range encompasses Grayling Hot Springs Ecological Reserve and borders the Smith River Ecological Reserve.

2.2 HABITAT AND BEHAVIOUR

NM caribou undergo seasonal range shifts in response to snowfall conditions affecting forage availability (Bergerud 1978, Heard and Vagt 1998). These shifts vary among subpopulations, being affected by such factors as topography, predation risk, and snow characteristics (Seip and McLellan 2008). The centre of activity for Liard Plateau caribou appears to be the alpine areas of the Caribou Range. Powell (2006) broadly described habitat use of three females monitored by GPS radio-collars from 2002 – 2004 and the majority of GPS locations for all three animals were situated in alpine areas on the Caribou Range with the remaining locations occurring in the adjacent subalpine forests. Interestingly, all three females appeared to have calved in forested areas. In 2011, habitat selection analyses incorporating data from an additional 15 GPS radio-collars supported the year-round importance of the Caribou Range alpine areas but also showed that lower elevation conifer forests were used during early winter (McNay et al. 2014).

Further studies are necessary to make stronger conclusions on range use and behaviour of Liard Plateau caribou. Such caution is particularly warranted given that caribou in adjacent herds (e.g. Muskwa and Pink Mountain) show significant individual variation in seasonal habitat use and behaviour. For example, in late winter, many Pink Mountain caribou use wind-swept alpine ridges whereas other individuals remain below treeline in the conifer forests of the eastern foothills (Wood 1996, Gustine and Parker 2008). Spatial strategies may also differ during calving, which generally occurs from mid-May to mid-June, with many females using high elevation sites above treeline while others calve in subalpine conifer forests prior to moving to higher elevation summer ranges (Gustine and Parker 2008).

2.3 Population Size and Trend

Over the past four decades, the Liard Plateau subpopulation has had relatively few surveys to estimate population size (Table 1). In 1975, expert opinion suggested the population was 325 – 475 caribou. A helicopter-based survey three years later estimated a population size of 125 (Bergerud 1978). From this survey until the early 2000s, estimates of population size (~ 150 caribou) relied on expert opinion. In the winter of 2005, an aerial survey recorded a minimum number alive of 141 (Powell 2006). Subsequent aerial surveys to estimate herd composition and record minimum counts were conducted in 2010, 2011 (Thiessen 2010*a*, McNay et al. 2014) and 2017 (BC Ministry of Forest, Lands and Natural Resource Operations, unpublished data). The 2010 and 2011 surveys were completed multiple times per year (spring, fall and late winter) and minimum counts ranged from 81 to 173 caribou. The 2017 survey yielded a minimum count of 87. With few surveys conducted overall and all relying on minimum counts, discerning population trend based on changes in abundance is difficult for the Liard Plateau subpopulation.

Determining population trend using other demographic parameters is also difficult due to a paucity of such data. Juvenile recruitment, defined as the percentage of calves in the population when calves are approximately nine months old, has only been recorded in four years (1978, 2010, 2011 and 2017) since 1975 (Table 2). Estimated percentages for these four years have been < 10%, below percentages associated with stable populations (e.g. 10-15%; Bergerud 1996, Environment Canada 2008), which may suggest a declining population during these years. Adult female survival, the other parameter with high influence on caribou population dynamics (DeCesare et al. 2012*a*), was estimated to be 94% over a 22-month period from 2010 to 2011 using data from 35 radio-collared animals (McNay et al. 2014). This survival rate is relatively high (Seip and Cichowski 1996, COSEWIC 2014) though may still be insufficient to prevent population decline if juvenile recruitment remains very low (e.g. calves < 5% of the population). Because of the few yet consistently low rates of juvenile recruitment, COSEWIC (2014) considers the Liard Plateau subpopulation to be in decline.

In hunted populations of ungulates such as the Liard Plateau subpopulation, harvest indices such as catch-per-unit-effort and hunter success rate can give an indication of population trend. Between 1976 and 2016, harvest indices have been highly variable in Wildlife Management Unit 7-53, which encompasses the Liard Plateau range (Fig. 2; see also Duncan 2009). However, since 2000 catch-per-unit-effort and hunter success rate have shown a decreasing trend and both indices are generally lower than peaks occurring in the late 1980s to early 1990s. These indices suggest a declining population but should be corroborated with more reliable estimates of population size and/or continued monitoring of demographic parameters (i.e. adult female survival and juvenile recruitment) to calculate annual estimates of population growth rates (e.g. using the R/M equation; Hatter and Bergerud 1991, DeCesare et al. 2012).

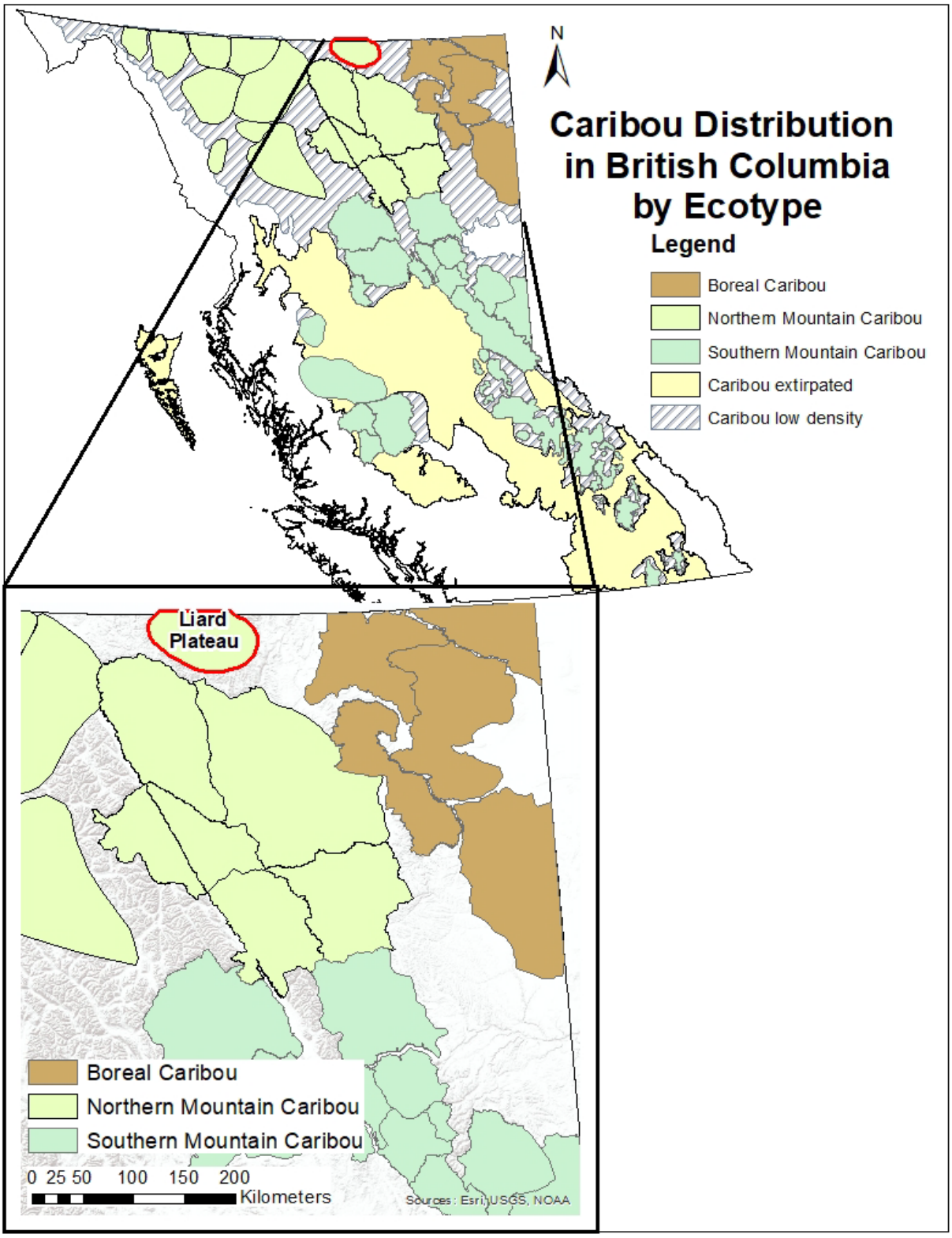
N
Caribou Distribution in British Columbia by Ecotype
Legend
Boreal Caribou
Northern Mountain Caribou
Southern Mountain Caribou
Caribou extirpated
Caribou low density
Liard Plateau
Boreal Caribou
Northern Mountain Caribou
Southern Mountain Caribou
0 25 50 100 150 200
Kilometers
Sources: Esri, USGS, NOAA

Figure 1: The geographical location of the Liard Plateau subpopulation of northern mountain caribou. The 5,069 km^2 range (inset: red outline) is situated within the Northern Rocky Mountains of northeastern British Columbia.

Table 1: Estimates of population size by year for the Liard Plateau subpopulation of northern mountain caribou in northeastern British Columbia.

Year	Estimate	Method	Survey Timing	Reference
1975	325	expert opinion	NA	Bergerud 1978
1975	425	expert opinion	NA	McNay et al. 2014
1978	125	survey estimate	winter	Bergerud 1978
1996	150	expert opinion	NA	Heard and Vagt 1998
2000	150	unknown	unknown	COSEWIC 2002
2002	<200	expert opinion	February	Powell 2006
2005	141	minimum count	winter	Powell 2006
2008	>160	expert opinion	NA	McNay et al. 2014
2010	81	minimum count	winter	Thiessen 2010
2010	94	minimum count	calving	McNay et al. 2014
2010	173	minimum count	rut	McNay et al. 2014
2011	159	minimum count	winter	McNay et al. 2014
2011	117	minimum count	calving	McNay et al. 2014
2011	120	minimum count	rut	McNay et al. 2014
2017	87	minimum count	winter	BC MFLNRO, *unpublished data*

Table 2: Estimates of the percentage of calves in the Liard Plateau subpopulation of northern mountain caribou in northeastern British Columbia. Estimates were derived from aerial surveys. Percentages between 10-15% in late winter (February – March) are generally associated with stable populations (Bergerud 1996).

Year	% Calves	Survey Timing	Reference
1977	9.3	October	Bergerud 1978
1978	10.3	February	Bergerud 1978
2005	13.5	September	Powell 2006
2010	4	February	Thiessen 2010
2010	12	June	McNay et al. 2014
2010	7	October	McNay et al. 2014
2011	7	March	McNay et al. 2014
2011	17	July	McNay et al. 2014
2011	5	October	McNay et al. 2014
2017	8	March	BC MFLNRO, *unpublished data*

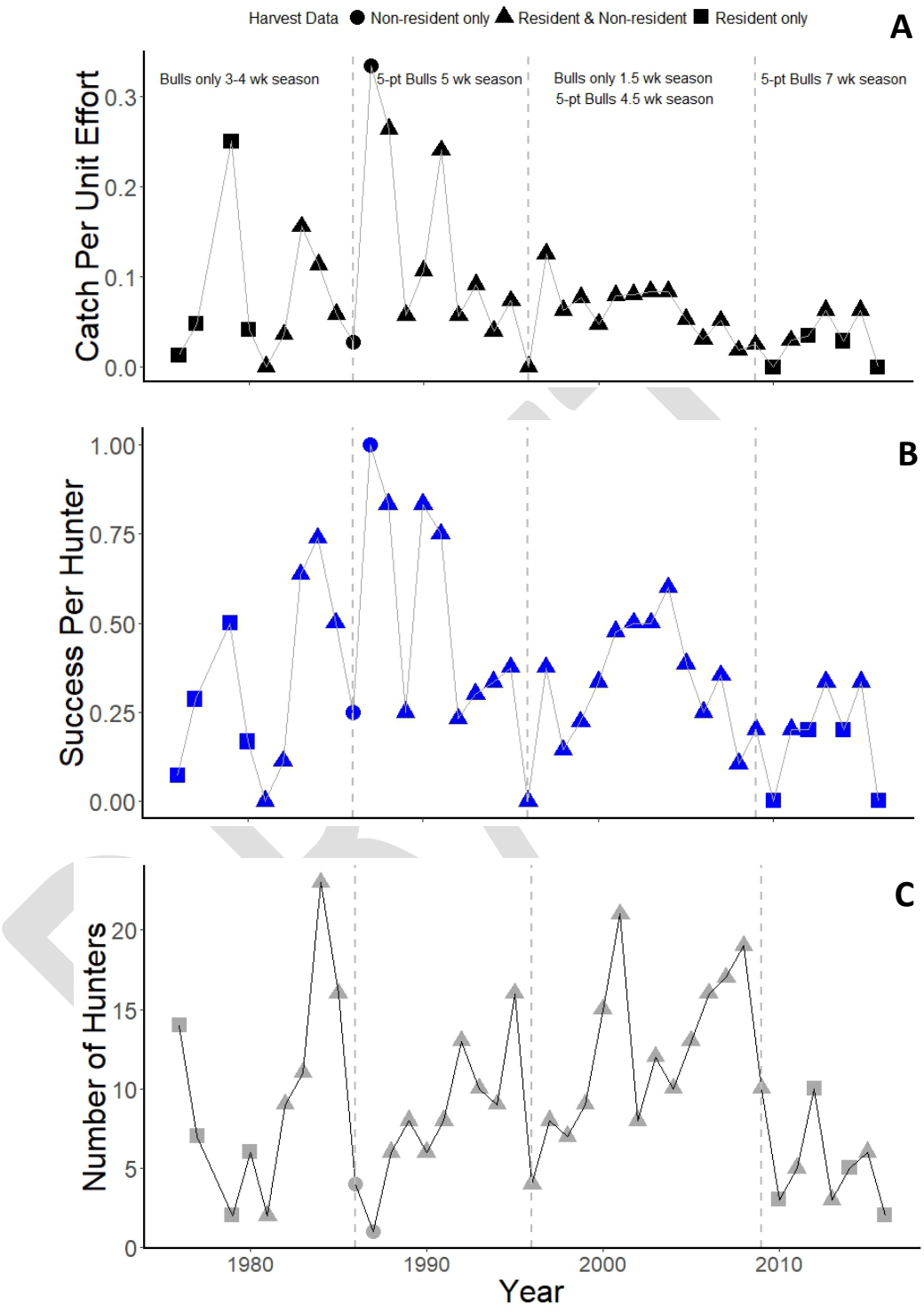

Figure 2: Harvest indices for the Liard Plateau subpopulation of northern mountain caribou in northeastern British Columbia from 1976 to 2016. Catch per unit effort (A) is the total kills divided by the total number of hunter-days. Success per hunter (B) is the total kills divided the total number of hunters. The total number of hunters (C) represents both resident and non-resident hunters. Hunting regulations prior to 2006 are from Duncan (2009).

3 THREATS AND LIMITING FACTORS

Populations of NM caribou face a variety of threats and limiting factors that may compromise their stability now and in the future. Current declines in many woodland caribou populations have been ultimately attributed to direct and indirect effects of human activities and climate change (Vors and Boyce 2009, Festa-Bianchet et al. 2011, Environment Canada 2014). These effects have resulted in lowered rates of adult female survival and/or juvenile recruitment, two demographic rates that have high influence on caribou population dynamics (DeCesare et al. 2012*b*). For most populations, effects of human activities and climate change have led to unsustainable rates of predation (McLoughlin et al. 2003, Wittmer et al. 2005*b*, Apps et al. 2013). Compared to other ungulates, caribou are particularly vulnerable to increasing predation because they have low reproductive rates (Bergerud 2000). To reduce predation risk, caribou generally occur at low densities and have evolved to live in low productivity habitats that spatially separates 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 *Management Plan* for NM caribou (Environment Canada 2012*a*) and the recent status report by COSEWIC (2014) identified a number of threats potentially affecting NM caribou subpopulations and their habitat. These threats included: predation, industrial activities, roads and other linear features, recreational activities, natural disturbances (e.g. fire), hunting, climate change and parasites and diseases. This section discusses these threats – and others – and the order of discussion does not reflect their relative importance to a specific subpopulation. 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). Overall, the NM caribou population was recently assigned a threat impact rating of High by COSWEIC (2014).

3.1 PREDATION

Woodland caribou populations are naturally limited by predation, which results in caribou occurring at relatively low but stable densities within their range (Fuller and Keith 1981, Bergerud 1996, Bergerud and Elliott 1998). Because caribou have low rates of reproduction, their populations are sensitive to changes in predation rates. Indeed, increasing predation is the primary proximate cause of population decline in most woodland caribou herds (McLoughlin et al. 2003, Wittmer et al. 2005*b*, Apps et al. 2013). Increasing predation in these populations has been ultimately linked to human-mediated landscape disturbance and climate change, both of which alter the abundances and distributions of predators and alternate prey (Seip 1992, Latham et al. 2011*b*, Apps et al. 2013, DeMars and Boutin 2018). Hypothesized mechanisms relating increased predation to landscape alteration and climate change are detailed under *Section 3.3 Human Activities* and *Section 3.6 Climate Change*.

The effect of predation on the population dynamics of Liard Plateau caribou is not well understood. Bergerud (1978) reported that the range supports many large predators including grizzly bears and wolves. During the recent radio-collaring study from 2010-2012 (22 months monitored; $n = 35$), four females died, all from predation (three from wolves, one from bear; McNay et al. 2014). Recent surveys have reported low rates of juvenile recruitment, which can be indicative of a high predation environment

given that predation is generally the dominant cause of calf mortality (Adams et al. 1995, Gustine et al. 2006). To date, however, there has been no evidence collected to support the predation hypothesis for explaining these low recruitment rates.

3.2 Food Limitation

Spatiotemporal changes in the quality and quantity of food resources can influence the dynamics of caribou populations by directly affecting survival and reproductive rates (Parker et al. 2009). Woodland caribou are generally associated with old-growth habitats and food limitation may occur if such habitats are converted to early seral habitats (i.e. younger forest), which are avoided because of increased predation risk (Fortin et al. 2013, Serrouya et al. 2017*b*). Such avoidance behaviours may also result in caribou restricting their annual movements, leading to over-grazing of seasonal areas (Heard and Zimmerman 2017). Climate change may further affect food availability and quality; for example, an increase in rain-on-snow events may limit forage availability by increasing the probability of icing (Hansen et al. 2011).

For mountain-dwelling caribou in British Columbia, evidence to date suggests that food limitation is not a primary factor in recent declines in many populations (Wittmer et al. 2005*b*, McLellan et al. 2012). Such evidence, however, does not preclude any food limitation effect. For example, risk-sensitive foraging in highly altered landscapes may increase predation risk for caribou if such behaviour causes them to become more predictable in time and space or more clumped in their distribution (Fortin et al. 2013, DeMars et al. 2016). Food limitations may also result in smaller calves, which could have increased predation risk (Adams et al. 1995). Determining the magnitude of such food limitation effects, however, is difficult if predation rates are high because predation may occur before effects on body condition become evident (Cook and Cook 2015, Boutin and Merrill 2016). To date, there have been no studies explicitly assessing the nutritional condition of Liard Plateau caribou.

3.3 Human Activities

Human activities within and adjacent to caribou range are believed to be a primary driver of current declines in woodland caribou populations (Wittmer et al. 2007, Environment Canada 2008, Sorensen et al. 2008, Johnson et al. 2015) . Such activities can impact caribou populations through multiple mechanisms including direct habitat loss, displacement from preferred habitats (Seip et al. 2007) and indirectly increasing predation (Apps et al. 2013, DeMars and Boutin 2018). This section focuses on impacts associated with industrial activities, recreational activities and other activities such as agriculture and roads.

3.3.1 Industrial

Industrial activities include forestry, mining, oil & gas development and clean energy.

3.3.1.1 Forestry

Woodland caribou are an old-growth forest dependent species (Bergerud 2000) and are therefore affected by forestry practices. Logging of old-growth forests can result in direct habitat loss and an increase in the extent of early seral (or young) forest, which can increase the abundance and alter the distribution of other ungulates (e.g. moose) and their predators, potentially leading to increased caribou predation (Serrouya et al. 2011, 2015). Cutblocks can further increase predation risk for caribou if behavioural avoidance of these areas causes caribou to become more clumped in their distribution (Schaefer and Mahoney 2007, Fortin et al. 2013).

The Liard Plateau subpopulation has had no impacts from forestry operations as GIS data up to 2015 shows no cutblocks situated within or adjacent (e.g. < 10 km) to the subpopulation's range.

3.3.1.2 MINING

Impacts from mining primarily relate to direct habitat loss. The effective amount of habitat loss, however, can extend well beyond its physical footprint due to behavioural avoidance of areas surrounding mine infrastructure (Polfus et al. 2011, Johnson et al. 2015). As noted previously, impacts that limit the spatial distribution of caribou can potentially lead to increased predation risk (Fortin et al. 2013, DeMars et al. 2016). Related infrastructure such as roads may further increase predation risk by increasing predator hunting efficiency and facilitating predator movement into caribou habitat (Latham et al. 2011*a*, DeMars and Boutin 2018).

There are currently no impacts from mining within the Liard Plateau caribou range. In 2010 – 2011, an application was prepared by Stikine Energy Corp. to develop an open pit mine for accessing sand to support hydraulic fracturing within the Horn River Basin, an area of active natural gas development ~ 150-200 km to the east in the boreal plains (Thiessen 2010*a*, McNay et al. 2014). This mine, however, did not proceed to development (S. NcNay, *personal communication*).

3.3.1.3 OIL AND GAS

Landscape alteration from oil and gas exploration and extraction can affect caribou populations through direct habitat loss and by indirectly increasing predation. As with other industrial impacts, avoidance behaviours by caribou can increase the effective extent of habitat loss (Dyer et al. 2001, Vistnes and Nellemann 2008) and limit the spatial distribution of caribou, potentially increasing predation risk (Fortin et al. 2013, DeMars et al. 2016). Oil and gas impacts may further increase predation risk by facilitating the expansion of alternate prey (e.g. white-tailed deer) into caribou range (Dawe and Boutin 2016). Linear features associated with oil and gas development may also increase predation risk by enhancing predator hunting efficiency and facilitating predator movement into caribou range (Dickie et al. 2017, DeMars and Boutin 2018; see also *Section 3.3.3.3 Linear Features* below).

Impacts from oil and gas exploration and extraction constitute the most ubiquitous form of human disturbance in northeastern British Columbia (Thiessen 2009, DeMars and Boutin 2018). The Liard Plateau range, however, has been minimally impacted compared to other neighboring ranges in the boreal plains. GIS data available from the BC Oil and Gas Commission up to 2016 shows only one abandoned well site (authorization date 1964) in the southwest portion of the range. Linear features are the most widespread form of disturbance accompanying oil and gas dvelepments and their impacts are further discussed in *Section 3.3.3.3 Linear Features* below.

3.3.1.4 CLEAN ENERGY

Infrastructure related to clean energy production (e.g. hydroelectric facilities, wind power) can impact caribou populations through mechanisms similar to other industrial developments. Caribou may avoid such infrastructure with the degree of avoidance dependent on the degree of human activity (Mahoney and Schaefer 2002, Colman et al. 2013). Such avoidance can alter seasonal migration patterns (Mahoney and Schaefer 2002), which can result in negative demographic impacts (Bolger et al. 2008). Power lines associated with energy development can also increase predation risk for caribou because these features create relatively permanent early seral habitat that is favorable to other ungulates (e.g.

moose, white-tailed deer) and provide movement corridors for predators (Latham et al. 2011*a*, Dickie et al. 2017*b*).

There are no wind power or other clean energy developments within the Liard Plateau range.

3.3.1.5 Other

There are currently no other major forms of industrial development within the Liard Plateau caribou range.

3.3.2 Recreation

Recreational activities conducted within caribou range can impact caribou populations by displacing individuals into sub-optimal habitats (Seip et al. 2007), increasing stress levels (Freeman 2008) and / or facilitating predator movement into caribou habitat (Whittington et al. 2011). This section considers impacts related to snowmobiling and backcountry skiing as well as other activities such as hiking and mountain biking.

3.3.2.1 Snowmobile

Among winter recreational activities, snowmobiling appears to have the highest impact on caribou, in part because the preferred areas for this activity often overlap with the preferred winter habitat of caribou (Simpson and Terry 2000). Snowmobiling has been shown to displace caribou from preferred areas and the intensity of displacement – both in space and time – can depend on the intensity of snowmobile use (Simpson and Terry 2000, Seip et al. 2007). Snowmobiling may further induce physiological stress, potentially affecting individual fitness and population dynamics (Freeman 2008). Compacted trails from snowmobiles may also facilitate movement of predators into winter habitats of caribou, thereby increasing predation risk (Droghini and Boutin 2017).

Because of the remoteness of the Liard Plateau range and the lack of major roads accessing the area, snowmobile impacts are expected to be minimal to non-existent.

3.3.2.2 Heli-ski / Cat-ski

Heli- and cat-skiing can have similar mechanistic effects on caribou populations as snowmobiling though the degree of impacts is considered to be lower, primarily because skiing generally occurs on slopes steeper than those preferred by caribou (Simpson and Terry 2000). Also, best management practices such as skiing at least 500-m away from observed caribou may reduce caribou-skier encounters (Huebel 2012) although the lack of compliance with these practices remains an issue (L. DeGroot, *personal communication*).

There are no heli-skiing or cat-skiing companies operating within the Liard Plateau range.

3.3.2.3 Summer Recreation

Recreational activities in the snow-free seasons can also impact caribou populations. Trails associated with off-road vehicles, hiking, mountain biking and horseback riding may facilitate predator movements into summer habitats used by caribou, potentially increasing predation risk (Whittington et al. 2011). Human presence on hiking trails may also induce physiological stress, though this response may attenuate if humans are not perceived as a predation threat (Lesmerises et al. 2017).
Impacts from summer recreation activities are minimal to non-existent in the Liard Plateau range due to its remoteness and difficult access.

3.3.2.4 Other

There are no other recreational activities currently impacting the Liard Plateau caribou subpopulation.

3.3.3 Other

This section considers other forms of human activity potentially impacting caribou populations, including agriculture, major highways linear features and hunting.

3.3.3.1 Agriculture

Agriculture can impact caribou populations through a number of mechanisms. First, conversion of forested areas to agriculture can result in direct habitat loss and avoidance behaviours by caribou may increase the extent of loss beyond the physical footprint (Vistnes and Nellemann 2008). Second, agricultural areas are generally favourable to alternate prey (e.g. deer and elk), potentially increasing their populations and those of predators, which ultimately may increase predation rates of caribou. Third, agriculture could increase the likelihood of disease and parasite transmission among domesticated animals, alternate prey and caribou although such links have not been established within British Columbia caribou herds (Vors and Boyce 2009, Martin et al. 2011).

There are no agricultural impacts within or adjacent to the Liard Plateau caribou.

3.3.3.2 Major Highway Corridors

Major highways can constitute a direct source of mortality (i.e. road kill) for caribou and may further alter or impede caribou movements (Leblond et al. 2013). Although road kill of caribou is generally rare, it can become an increasingly important mortality source for small populations (Kinley and Apps 2001). With respect to movement impacts, the relative permeability of highways to caribou movement is inversely related to traffic volumes (Leblond et al. 2013) and, as such, major highways with high traffic may lead to population fragmentation (Apps and McLellan 2006).

There no major highways accessing the Liard Plateau caribou range. The range is remotely located and access by motorized vehicle is difficult.

3.3.3.3 Linear Features

Industrial activities within forested systems are often accompanied by the creation of linear features such as roads, railways, power lines, pipe lines and seismic lines. Such features are thought to increase predation of caribou by increasing predator hunting efficiency (McKenzie et al. 2012, Dickie et al. 2017*b*) and facilitating predator movement into caribou range (Whittington et al. 2011, DeMars and Boutin 2018). Linear features may further contribute to caribou-predator spatial overlap if such features facilitate the movement of alternate prey into caribou range (Dawe and Boutin 2016, Fisher et al. 2017). With natural resource exploration increasing in NM caribou ranges, the creation of new linear features is becoming an increasingly important management concern as such features may result in increased harvest by allowing easier human access to caribou habitat (Seip and McLellan 2008, Hegel and Russell 2013).

Linear features are the most ubiquitous form of human-caused disturbance within northeastern British Columbia, including the Liard Plateau range (Fig. 3). Compared to neighboring caribou ranges, particularly those in the boreal plains, the density of linear features is relatively low within the Liard Plateau range, with the majority occurring in the eastern one-third of the range. The vast majority of these features are situated in the foothills of the eastern portion of the range. Note that the age, width

and state of regeneration on linear features within the Liard Plateau range are largely unknown and that these attributes likely play a significant role in determining predator use of – and movement efficiency on – a given linear feature (Dickie et al. 2017*a*).

3.3.3.4 HUNTING

Historical records indicate that NM caribou have long been hunted by First Nations in BC (Spalding 2000). Liard Plateau caribou also have a long history of being hunted following Euro-American settlement of the region though hunting pressure is assumed to have been light. Bergerud (1978) estimated that 10-15 caribou per year were harvested from the range during the 1970s. Between 2000 and 2016, an average of 3.4 bulls were harvested in the range with most animals taken by non-resident hunters (Thiessen 2010; BC MFLNRO, *unpublished data*). Although the population dynamics of this herd are not well known, Thiessen (2010) recommended that no more than three bulls be harvested per year. Currently, a general open season for licensed hunting of caribou is still allowed within Wildlife Management Unit 7-53, which encompasses the Liard Plateau range. Harvest is restricted to 5-point bulls with a bag limit of one though there is no quota on the number of hunters or animals taken. Within British Columbia, all licensed harvest of caribou has been tracked since 1976 by compulsory inspection or hunter surveys. For a review of harvest statistics within the Liard Plateau range, see *Section 2.3 Population Size and Trend* and Figure 2 above.

3.3.3.5 POACHING

The impact of illegal hunting (i.e. poaching) is unknown but is likely small (Environment Canada 2014).

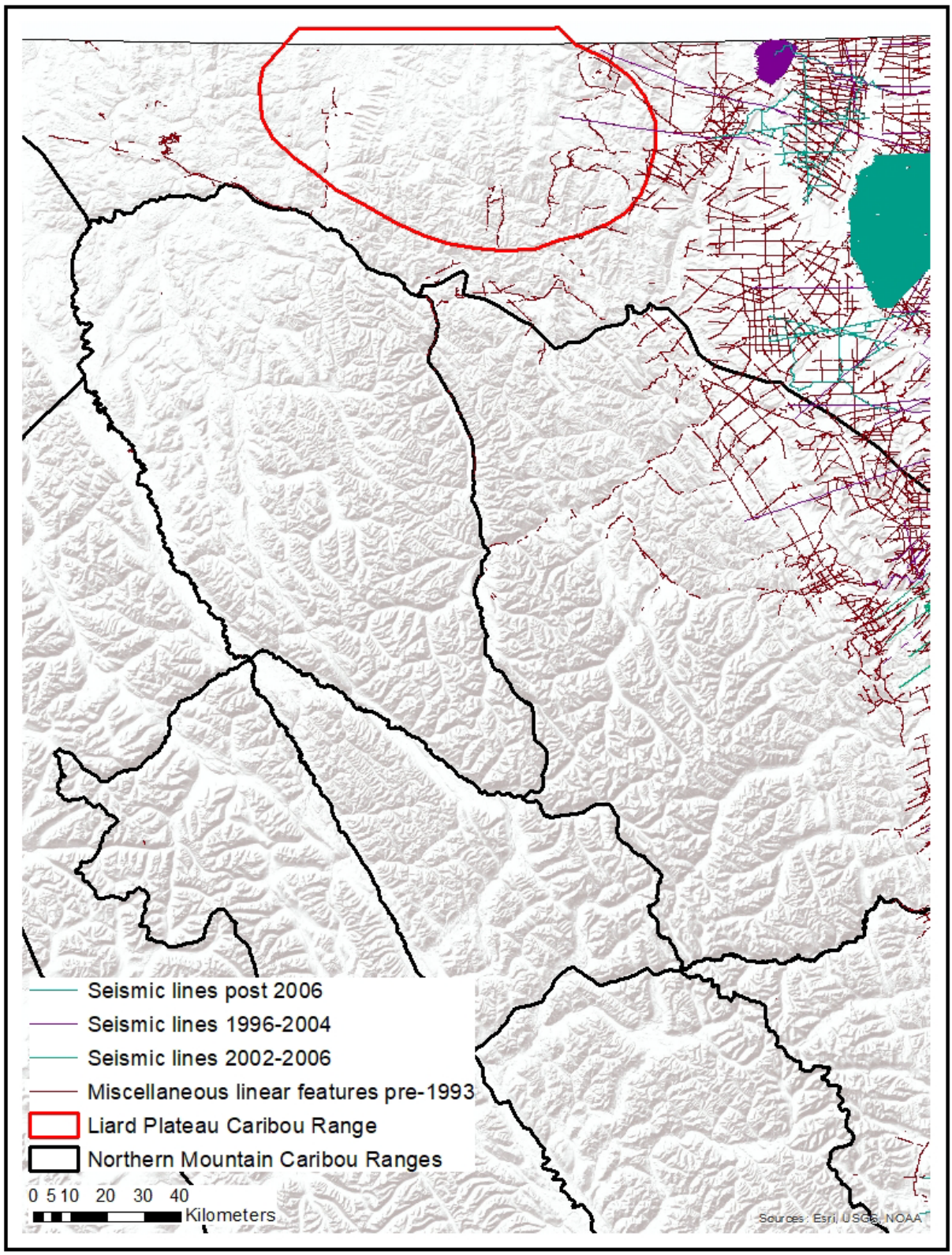

Figure 3: The distribution of seismic lines within the range of the Liard Plateau subpopulation of northern mountain caribou.

3.4 Natural Disturbance

Caribou populations are subject to impacts from a number of natural disturbances. Being dependent on old-growth forests, caribou are impacted by forest fires. Areas burned by fire may be avoided for up to 50 years (Dalerum et al. 2007) and the early seral habitat created post-fire may facilitate population increases in predators and alternate prey. Although caribou are likely adapted to the natural forest fire regime within and adjacent to their ranges, effects of forest fire may act cumulatively with human-mediated disturbances to negatively impact caribou demography (Sorensen et al. 2008). Caribou may also be affected by insect or disease outbreaks that affect forest stand condition. For example, mountain pine beetle outbreaks can highly impact old-growth pine stands, affecting lichen availability (Cichowski and Haeussler 2015, Apps and Dodd 2017) – a primary forage resource for caribou – and increasing the likelihood of fire (Lynch et al. 2006). For mountain-dwelling caribou, avalanches constitute another type of natural disturbance that can potentially impact demography, though under normal conditions their importance as a mortality should be small unless population sizes are small (Seip and Cichowski 1996, Hebblewhite et al. 2010).

Within the boreal forests of northeastern British Columbia, the median return interval for forest fires is ~ 100 years (Johnstone et al. 2010). Using forest fire data available to 2015, the extent of areas burned < 50 years ago constitutes ~ 21% of the Liard Plateau range. Within this time frame, the largest fire occurred in 1971 (43,738 ha burned) and was situated in the southern part of the range.

The Liard Plateau range has been minimally affected by the mountain pine beetle though projections into the year 2020 suggest that infestations may begin to appear in the southern part of the range (https://www.for.gov.bc.ca/hre/bcmpb/year13.htm).

3.5 Parasites and Diseases

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

Impacts from parasites and disease on the population dynamics of Liard Plateau caribou are not well studied. In nearby ranges of boreal caribou, a three-year study documented a number of potential disease and pathogenic threats to these subpopulations, including the pathogenic bacterium *Erysipelothrix rhusiopathiae*, the protozoan parasite *Neospora caninum*, and high winter tick (*Dermacentor albipictus*) loads (Schwantje et al. 2014). Winter tick in particular was identified as an emerging threat to caribou in the region as moderate to severe infestations were observed in all ranges, although its prevalence in NM caribou has not been explicitly assessed. In the federal *Management Plan* for NM caribou, determining the role of disease and parasites in limiting caribou populations was identified as a priority for future research (Environment Canada 2012*a*).

3.6 Climate Change

Climate change can potentially exert numerous effects on caribou population dynamics. Warmer winters may impact forage availability by increasing icing events and / or causing poor snow conditions that limit the ability of SM caribou to access arboreal lichens (Kinley et al. 2007, Hansen et al. 2011). A warming climate may also change the abundances and distribution of alternate prey and their generalist predators, potentially increasing rates of caribou predation (Latham et al. 2011*b*, Dawe and Boutin 2016). Climate change may alter the spatial and temporal distribution of insects, diseases and parasites, potentially affecting individual fitness and population dynamics (Bradley et al. 2005). Changes to the natural disturbance regime (e.g. fire interval, fire intensity, avalanche frequency) may further impact caribou through mechanisms outlined in *Section 3.4*.

Impacts of climate change on the Liard Plateau range have not been well studied. The negative impacts of the northward expansion white-tailed deer have been documented in ranges of boreal caribou (Latham et al. 2011*b*, Dawe and Boutin 2016) but whether white-tailed deer have impacted NM caribou ranges is unclear. Recent analyses using demographic data from boreal caribou subpopulations in northeast British Columbia have suggested that woodland caribou may be impacted from effects of climate change other than those related to alterations in predator-prey communities. Specifically, juvenile recruitment was negatively affected by increasing mean winter temperatures while adult female survival was positively associated with the timing of spring (i.e., later onset of spring growing conditions equated to increased survival; DeMars et al. 2017). Collectively, these relationships suggest that warmer winter temperatures and lowered snowfall may have a negative effect on caribou population dynamics. It is unknown whether the Liard Plateau subpopulation has been specifically impacted by these predicted effects of climate change.

3.7 Small Population Size Effects

Caribou subpopulations that are small and isolated may be subject to negative demographic effects that can occur as a result of their small size (Caughley 1994). Such effects include inbreeding depression, genetic isolation from population fragmentation (Serrouya et al. 2012), demographic stochasticity (e.g. all offspring produced are of one sex), environmental stochasticity (e.g. the population is extirpated by a random natural disturbance such as an avalanche; Hebblewhite et al. 2010), and Allee effects (e.g. lowered demographic performance with decreasing population size; Courchamp et al. 1999). For group-living ungulates such as caribou, McLellan et al. (2010) documented a predation-mediated Allee effect where the predation rate may increase with declining population size because group size declines at a faster rate than the number of groups in the population and the number of groups dictates the rate of caribou-predator encounters.

Historically, the size of the Liard Plateau subpopulation has been relatively small compared to neighboring NM subpopulations (e.g. Muskwa; Bergerud 1978). With the latest minimum count recording < 100 individuals, this subpopulation may be subject to small population size effects in the near future if abundances continue to decline (Environment Canada 2012*a*). Because of its small size and relative isolation, both Powell (2006) and Thiessen (2010) have recommended that annual harvest be limited to ≤ 3 bulls.

4 MANAGEMENT HISTORY

Many subpopulations of NM caribou have a limited history of active management, which in part may be due to the remoteness of their ranges and a lack of baseline information. In its initial assessment of NM caribou, COSEWIC (2002) suggested that most subpopulations were stable because their habitat was remote and relatively intact. Only two subpopulations were thought to be at risk with the primary threats being altered predator-prey dynamics and increased human access. Twelve years later, a reassessment of NM caribou found two subpopulations to be increasing, seven were stable, nine were decreasing, and the statuses of the remaining 27 subpopulations were unknown due to data deficiencies (COSEWIC 2014). For subpopulations within British Columbia, one subpopulation was thought to be stable, seven were decreasing and the population trends for the remaining 15 were uncertain.

In 2012, the federal *Management Plan* for NM caribou was developed to prevent further population declines and avoid their potential listing as threatened or endangered. The *Plan* recommended a series of management actions to address the uncertainties surrounding the status of many subpopulations and to outline recovery measures for those in decline (Environment Canada 2012*a*). These actions were similar to those recommended for recovering Boreal and Southern Mountain caribou (Environment Canada 2012*b*, 2014), and broadly included the following key components:

i. Managing and protecting of sufficient habitat for caribou to carry out life history processes and reduce predation risk thereby ensuring long-term population persistence. Habitat protection generally has included access management.

ii. Managing the populations of other ungulate species.

iii. Managing of predator populations.

As a fourth key component, the *Management Plan* also recommended that NM caribou be managed for a sustainable harvest, which is unique to this population as Boreal and Southern Mountain caribou are no longer hunted.

This section reviews management actions undertaken for the Liard Plateau subpopulation under five broad categories: habitat management, recreation and access management, predator management, alternate prey management, and population reinforcement. For a review of this subpopulation's harvest history and management, see Sections *2.3 Population Size and Trend* and 3.3.3.4 *Hunting*.

4.1 HABITAT

Protecting and restoring sufficient habitat for caribou to carry out essential life processes and reduce predation risk is fundamental to achieving self-sustaining populations (Environment Canada 2014, Ray et al. 2015). NM caribou require large tracts of undisturbed habitat and have evolved to inhabit alpine areas and old-growth forests, which separates them – both in terms of elevation and horizontal space – from other ungulates and their generalist predators (Bergerud et al. 1984, Bergerud and Page 1987, Seip 1992). In winter, NM caribou use mature forests and wind-swept alpine areas to access lichen (Johnson et al. 2004). Summer ranges are typified by alpine birch-sedge meadows (Oosenbrug and Theberge 1980, Denryter et al. 2017). Spatial requirements for NM caribou also extend beyond seasonal areas of high use (i.e. habitat cores) and can include "matrix" habitat, areas of relatively low use that may be used during migration (Environment Canada 2012*a*).

The 2012 federal *Management Plan* for NM caribou suggests that effective habitat management for each subpopulation requires delineating and protecting habitats with high influence on population dynamics (e.g. calving areas, rutting ranges, winter ranges, movement corridors). Because natural and anthropogenic disturbances are known to negatively impact habitat quality (Wittmer et al. 2007, Sorensen et al. 2008), active restoration may be required for those subpopulations residing in highly disturbed landscapes.

4.1.1 Protection

To date, the only protected area within the Liard Plateau caribou range is the Grayling River Hot Springs Ecological Reserve. There has been no explicit protection of caribou habitat although thus far the range has been minimally impacted by development. Because caribou use appears to be highly concentrated within the alpine areas of the Caribou Range, protection of these areas from development has been suggested (Thiessen 2010*a*, Environment Canada 2012*a*).

4.1.2 Enhancement and Restoration

There has been no management actions to enhance or restore caribou habitat within the Liard Plateau range.

4.2 Recreation and Access Management

The Liard Plateau caribou range is generally remote and see much lower recreational activity than caribou ranges situated in mountainous areas of southern British Columbia. Consequently, there are minimal limitations on recreational activities within the Liard Plateau range.

4.2.1 Snowmobile

Motorized vehicles are not permitted within the Grayling Hot Springs Ecological Reserve. Outside of this protected area, there are currently no restrictions on snowmobiling within the Liard Plateau range.

4.2.2 Heli-ski / Cat-ski

The Liard Plateau range is situated in areas not conducive to heli- or cat-skiing and thus is not subjected to impacts from these activities.

4.2.3 Summer Recreation

Motorized vehicles are not permitted within the Grayling Hot Springs Ecological Reserve. Outside of this protected area, there are currently no restrictions on summer activities (e.g. off-road vehicles, hiking, mountain biking) within the Liard Plateau range.

4.2.4 Other

There are no other restrictions on access and recreation within the Liard Plateau range.

4.3 Predators

Actions aimed at managing predators may include liberalizing hunting and trapping quotas (Cluff and Murray 1995), diversionary feeding (Lewis et al. 2017), managing alternate prey (Serrouya et al. 2017*c*), and lethal control (Hervieux et al. 2014). Note that actions such as lethal control are controversial (Boertje et al. 2010, Lute and Attari 2017) and are generally considered short-term strategies used to sustain small and rapidly declining populations until the effects of habitat restoration and protection are realized (Wittmer et al. 2010, Hervieux et al. 2014).

4.3.1 Wolf Management

Within British Columbia, active management of wolves began in the early 1900s with the introduction of a bounty program, which lasted until 1955 (BC Ministry of Forests, Lands and Natural Resource Operations 2014). Predator control programs were also initiated during the 1940s and the combined effect of these initiatives resulted in wolf populations declining to their lowest estimated numbers provincially in the late 1950s. The suppression of wolf numbers resulted in population peaks of caribou in northeastern British Columbia during the 1960s (Bergerud 1978, Spalding 2000) though the specific effects of wolf control on the Liard Plateau subpopulation is unknown.

Wolves are present within the Liard Plateau range and a pack of seven wolves was observed in the alpine areas of the Caribou Range during a 2010 survey (Thiessen 2010*a*). Over the last four decades, there has been no active management of wolves in the context of caribou conservation within the Liard Plateau range. Currently, there is an eight month general hunting season for wolves with a bag limit of three in Wildlife Management Units within and adjacent to the Liard Plateau range. In 2016, the removal of the bag limit was being considered (https://www2.gov.bc.ca/assets/gov/sports-recreation-arts-and-culture/outdoor-recreation/fishing-and-hunting/hunting/regulations/2016-2018/hunting-trapping-synopsis-2016-2018-region7b.pdf).

4.3.2 Cougar Management

Cougars are considered to be rare or absent in the Liard Plateau range and therefore have not been subject to management actions in the context of caribou conservation. The 2017 bag limit for cougars in Wildlife Management Units within and adjacent to the Liard Plateau range is one.

4.3.3 Other

There have been no management actions targeted toward other predators (e.g. bears and wolverine) within the Liard Plateau range.

4.4 Alternate Prey

Declines in many populations of woodland caribou have been attributed to apparent competition, an indirect interaction between two or more prey species and a shared predator (Holt 1977, DeCesare et al. 2010, Hebblewhite 2017). In this process, increased abundances of other ungulate species – stemming from an increase in favourable habitat following landscape alteration – has led to higher populations of predators, resulting in unsustainable predation of caribou. Because of these linkages, recommended strategies for recovering caribou populations includes reducing the abundances of primary prey (Wittmer et al. 2013, Serrouya et al. 2015, Boutin and Merrill 2016).

4.4.1 Moose Management

The most recent survey to estimate moose abundance within the Liard Plateau range or Wildlife Management Unit 7-53, which encompasses the range, was conducted in 1996-1997 (Poole and DeMars 2015). This survey estimated a moose density of 0.09 moose / km^2, which is relatively low and within thresholds conductive to caribou population persistence (e.g. 0.2 – 0.3 / km^2; Bergerud 1996). During the 2010 aerial survey to determine composition of the Liard Plateau caribou subpopulation, no observations of moose were recorded, although survey effort was focused on the alpine areas of the Caribou Range (Thiessen 2010*a*). Within the lower elevation foothills, moose are likely present as they are the most abundant ungulate species within the adjacent boreal plains (Thiessen 2010*b*). Poole and DeMars (2015) calculated moose density estimates by extrapolating from habitat capability modelling and estimated a moose density of 0.3 moose / km^2 for Wildlife Management Unit 7-53.

To date, there has been no active management of moose in the context of caribou conservation within the Liard Plateau range. Licensed hunting for moose is restricted to bulls with a bag limit of one. The impact of First Nations hunting on moose populations is unknown.

4.4.2 Deer Management

White-tailed deer and mule deer are likely rare or absent with the Liard Plateau caribou range although the northern distribution and abundance of white-tailed are likely increasing (Latham et al. 2011*b*, Dawe and Boutin 2016). Within Wildlife Management Unit 7-53, there is currently no hunting season for either species. To date, there have been no management actions targeted toward deer in the context of caribou conservation in the Liard Plateau caribou range.

4.4.3 Other

Elk (*Cervus elaphus*) are present within and adjacent to the Liard Plateau caribou range. Within Wildlife Management Unit 7-53, there is a general hunting season for six-point bulls only. Wood bison (*Bison bison athabascae*) have also been introduced within the Liard River Corridor but their space use does not appear to overlap significantly with the Liard Plateau caribou range (Leverkus 2011). Neither species has been subject to management actions in the context of caribou conservation.

4.5 Population Reinforcement

To bolster small populations, management actions may include population reinforcement. Such measures include maternal penning, captive breeding, and translocation. Population reinforcement techniques are generally considered to be highly invasive, logistically difficult and expensive (Hayek et al. 2016).

4.5.1 Maternal Penning

Maternal penning is a captive-rearing technique where wild female caribou are captured in late-winter and confined to a predator-proof pen within their range to give birth (Hayek et al. 2016). Females and calves are retained in the pen for at least four weeks post-parturition. The main objective of maternal penning is to increase calf survival during the neonate period when predation rates are generally highest (Adams et al. 1995, Pinard et al. 2012). To effectively improve caribou population dynamics, the success of maternal penning depends on the proportion of the female population penned, the survival of penned females and calves post-release, and the survival of wild females and calves.
To date, maternal penning has not been used to reinforce the Liard Plateau subpopulation.

4.5.2 Captive Breeding

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

There have been no captive breeding efforts undertaken for the Liard Plateau subpopulation.

4.5.3 Translocation

Translocation refers to the movement of individuals from one population (or subpopulation) to another (Hayek et al. 2016). Numerous translocation efforts for caribou have taken place across South America and are reviewed in Bergerud and Mercer (1989) and Hayek et al. (2016).

There have been no translocations of other caribou into the Liard Plateau subpopulation.

4.5.4 OTHER

There have been no other forms of population reinforcement implemented for the Liard Plateau subpopulation.

4.6 STEWARDSHIP/OUTREACH

[NO IDEA WHAT TO PUT HERE....]

4.7 RESEARCH

Most subpopulations of NM caribou are relatively little studied, perhaps because they are a lower management priority due to being less threatened than populations of boreal and southern mountain caribou (Environment Canada 2012*a*). Within British Columbia, the first research efforts aimed at evaluating NM caribou ecology and behaviour began in the late 1970s with Bergerud's (1978) surveys of various subpopulations to estimate size, juvenile recruitment and population trend. Since then, numerous studies have been conducted within NM caribou ranges, with research focusing on predator-prey dynamics (Bergerud and Elliot 1986, Bergerud and Elliott 1998, Gustine et al. 2006), estimating vital rates (Parker and Gustine 2007, McNay et al. 2014), spatial behaviours (Bergerud et al. 1984, Bergerud and Page 1987), habitat selection (Gustine and Parker 2008, Polfus et al. 2014), responses to disturbance impacts (Polfus et al. 2011), pregnancy rates (McNay et al. 2014), diet (Denryter et al. 2017) and nutritional condition (Parker and Gustine 2007). While these studies have collectively informed the broad management strategies outlined in the federal *Management Plan* for NM caribou, further herd-specific research will likely be necessary to develop effective strategies for individual subpopulations (Environment Canada 2012*a*).

Beyond infrequent surveys to estimate minimum population size and herd composition, research evaluating the behaviour and ecology of Liard Plateau caribou has been limited to two studies. The first study occurred in 2002 when GPS radio-collars were deployed on three adult females (Powell 2006). The second study, occurring from 2010 – 2012, was more extensive with both VHF (n =20) and GPS (n = 20) radio-collars deployed on 35 females. This study provided assessments of habitat selection, seasonal movements, home range sizes, minimum population sizes, pregnancy and parturition rates, survival rates and mortality causes (McNay et al. 2014). Since the completion of this study, there have no further surveys or studies of the Liard Plateau subpopulation.

4.8 MONITORING

Over the last 50 years, the Liard Plateau subpopulation has received little formal monitoring. In the mid- to late-1970s, periodic surveys were conducted to estimate the minimum size and composition of the herd (Bergerud 1978). The subpopulation did not receive another survey until the mid-2000s and was primarily monitored by harvest records during this intervening period (Environment Canada 2012*a*). In 2002, the Yukon Government deployed GPS radio-collars on three females to monitor seasonal space use (Powell 2006). This effort was followed by a rut survey in 2005 to record the subpopulation's minimum size and composition. Five years later, Thiessen (2010*a*) conducted a late winter survey to estimate minimum size, composition, and juvenile recruitment. The most intensive monitoring period occurred from 2010 – 2012 when radio-collars were deployed on 35 females and the subpopulation received multiple surveys per year to estimate herd size, composition, survival rates and

mortality causes (McNay et al. 2014). Since the termination of this study in 2012, the Liard Plateau range has not been re-surveyed and is monitored by harvest records.

5 IMPLICATIONS TO OTHER WILDLIFE

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

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

6 IMPLICATIONS TO OTHER VALUES

Enacting measures to conserve caribou will likely have impacts on social, political and economic values. Most woodland caribou populations occur in working landscapes managed for natural resource extraction. Conserving caribou in these landscapes will require limits on these activities, which will invoke socioeconomic costs (Schneider et al. 2011). Limiting recreational activities such as snowmobiling and skiing within caribou range will likely create further socioeconomic costs. To effectively mitigate these impacts while conserving caribou in multi-use landscapes, conservation planning will need to incorporate both economic costs and the biological needs of caribou in a spatially-explicit modelling framework (Schneider et al. 2011, 2012).

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

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

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

7 PARTNERS / NEIGHBOURS

[LEAVING THIS FOR THE RELEVANT GOV FOLKS....]

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

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

8 RECOMMENDED ACTIONS

In 2012, the federal *Management Plan* for NM caribou was released to outline objectives and strategies for recovering and managing subpopulations of NM caribou (Environment Canada 2012*a*). The primary goal of the *Management Plan* was to facilitate cooperative management of NM caribou to prevent the population from becoming threatened or endangered. Inherent to the latter part of this goal is that subpopulations are maintained within their natural range of variability. To achieve this goal, the *Management Plan* outlined a number of objectives, including:

i. Evaluating and monitoring population size and trend
ii. Managing harvest for sustainable use
iii. Identifying and protecting demographically important habitats
iv. Understanding and managing predator-prey dynamics
v. Assessing health risks (e.g. parasites and disease) to caribou
vi. Evaluating disturbance impacts in a cumulative affects framework
vii. Foster multi-stakeholder stewardship and develop knowledge sharing programs

The relative importance and order of implementation of the above objectives will vary by subpopulation and will depend on such factors as current population size, population trend (stable, increasing or decreasing) and known threats. To assess progress toward management objectives, the *Management Plan* recommended that population size and trend, habitat conservation and the reduction of threats be used as performance measures.

Below, recommended management actions are outlined for the Liard Plateau subpopulation. Following the framework of the federal Management Plan, actions are grouped under three headings: Population Management, Habitat Management, and Communication and Involvement.

Recommended Actions for the Liard Plateau Subpopulation

1. *Population Management*

    a. *Develop a consistent monitoring program to track population size and trend*

    The Liard Plateau has been surveyed infrequently over the last 30 years and each survey has varied in design and search intensity, which confounds the comparison of estimates over time to evaluate trend. Going forward, population size should be estimated using a consistent survey design (see Wittmer et al. 2005*a* and Serrouya et al. 2014, 2017*a* for examples and discussion). In the absence of annual estimates of population size, trend can be monitored indirectly using Hatter and Bergerud's (1991) “R/M” equation, which

estimates the population growth rate (λ) by relating annual adult female survival (S) to juvenile recruitment (R) ($\lambda = S / (1 - R)$; DeCesare et al. 2012*b*, Serrouya et al. 2017*a*). This indirect approach requires a sample of radio-collared females to estimate S and late-winter composition surveys to estimate R. An advantage to the indirect approach is that by maintaining a sample of radio-collared animals, information on mortality causes can also be collected, which can provide insights into mechanisms influencing population declines. Regardless of the method used, Environment Canada (2012*a*) recommends annual monitoring of trend for subpopulations like Liard Plateau where population sizes are < 200 caribou.

b. Manage harvest for sustainable use

Current hunting regulations allow for a general season on 5-point bulls within the Liard Plateau range with no quota on the number of animals harvested. In the early 2000s, Thiessen (2010*a*) estimated an average annual harvest rate of 3.7% assuming a population of 150 animals. This rate exceeded the 2% harvest rate recommended for NM caribou populations by Hayes et al. (2003) and Powell (2006) further noted that NM caribou populations < 200 animals are closed to hunting in the Yukon. While hunting pressure is currently light in the Liard Plateau range (see Fig. 2) and the total number of kills has averaged 1.9 bulls per year for the last decade, a quota system should be considered to ensure that harvest rates are sustainable, particularly given that the most recent survey (2017) of the Liard Plateau subpopulation recorded < 100 animals.

c. Identify limiting factors contributing to suspected population decline

For the past decade, decreasing minimum counts, low rates of juvenile recruitment, and decreasing harvest indices all suggest that the Liard Plateau subpopulation is in decline. Understanding the factors driving this decline should be given a high priority, particularly given that the most recent survey (2017) observed < 100 animals.

2. Habitat Management

a. Ensure protection of core habitat areas

All studies conducted within the Liard Plateau range have recognized the importance of the alpine areas of the Caribou Range to this subpopulation (Bergerud 1978, Powell 2006, Thiessen 2010*a*, McNay et al. 2014). Thiessen (2010*a*) recommended that these areas be protected from development. This action should extend to prohibiting the development of new roads or trails that would increase access to the area. McNay et al. (2014) also identified low-elevation old-growth conifer forests as being important during the early winter.

b. Maintain a spatial inventory of natural and anthropogenic disturbances within caribou range

Substantial evidence from boreal and southern mountain caribou populations demonstrates a negative relationship between caribou population growth rates and the amount of disturbance within caribou range (Environment Canada 2008, 2014). Analyses from these populations suggest that the spatial extent of buffered (500-m) disturbances should not exceed 35% of caribou range.

3. *Communication and Involvement*

    a. *Facilitate shared stewardship with all relevant stakeholders, including guide outfitters and First Nations*

    The Liard Plateau range has a long history of use by First Nations and incorporating traditional knowledge and perspectives should be integral to any management plan. The Liard Plateau range is also an important area for guided hunting and local outfitters (e.g. http://liardriveroutfitters.com/) should be consulted and included in management planning.

8.1 Short Term (Within 6-12 Months)

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8.2 Medium Term (Within 12-24 Months)

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8.3 Long Term (Within 24-48 Months)

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