BRITISH COLUMBIA | BC Parks

February 28th, 2019

Bevan Ernst
Forests, Lands and Natural Resource Operations
1259 Dalhousie drive Kamloops BC V2C 5Z5

Attention Bevan Ernst:

Re: LETTER OF AUTHORIZATION for GPS collaring of wolves in Wells Gray Provincial Park and potentially other parks in Thomson Northern Forests area

With this letter BC Parks authorizes activities to be carried out by Bevan Ernst and associated contractor "Canadian Wildlife Capture" to support the capture and GPS collaring of wolves in Wells Gray Provincial Park and other smaller parks in Adams Drainage and North Thompson Headwaters in order to gain information helping caribou recovery. This letter is valid until March 31st, 2019.

BC Parks provides its authorization with the following expectations:

1. FLNRO has a scientific basis to suggest that wolves are reducing / limiting the caribou herds, and that collaring the wolves is necessary for a better understanding of wolves movements to facilitate the caribou`s recovery.
2. You have engaged and addressed any issues related to this work with key stakeholders and First Nations.
3. You will undertake this work in a manner that considers the disturbance to and safety of park visitors.
4. You are prepared to respond to any public / media interest generated by this work.
5. You will keep BC Parks apprised of your activities and their results within the Wells Gray Provincial Park and other smaller parks in Adams Drainage and North Thompson Headwaters.

Yours truly,

Vladimira Gat

Vladimira Gat
Senior Park Ranger, Thompson Northern Forests, BC Parks

Cc:
Tod Haughton, Area Supervisor, Thomson Northern Forests
Chris Nowotny, Cariboo Section Head
Gord Jones, Clearwater Lake Tours

Ministry of Environment
BC Parks & Conservation Officer Service
Thompson-Cariboo Region
Mailing/Location Address:
1259 Dalhousie Drive
Kamloops BC V2C 5Z5
Telephone: 250 371-6200
Facsimile: 250 828-4000
www.gov.bc.ca/env

From: Nowotny, Chris ENV:EX
Sent: Wednesday, February 27, 2019 2:55 PM
To: Ernst, Bevan FLNR:EX
Cc: Haughton, Tod ENV:EX; Gat, Vladimira ENV:EX
Subject: RE: Wolff Colalring in Parks

Hi Bevan: We would authorize this under a letter of Authorization. We authorize collaring and culling in Churn Creek in this way.

Tod: Feel free to reach out to Tom for a copy of his LOA if you proceed down this path.

Thanks,

Chris

From: Ernst, Bevan FLNR:EX
Sent: Wednesday, February 27, 2019 12:35 PM
To: Nowotny, Chris ENV:EX
Cc: Haughton, Tod ENV:EX; Gat, Vladimira ENV:EX
Subject: Wolff Colalring in Parks

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Thank you for your time and consideration.

Bevan Ernst, MSc, RPBio
Regional Caribou Biologist
Thompson Okanagan Region | Ecosystems Section
Phone (250) 371-6273 | Mobile (250) 318-6929
Forests, Lands and Natural Resource Operations

From: Haughton, Tod ENV:EX
Sent: Wednesday, February 27, 2019 2:59 PM
To: Hughes, Tom ENV:EX
Cc: Gat, Vladimira ENV:EX; Nowotny, Chris ENV:EX; Ernst, Bevan FLNR:EX
Subject: RE: Wolff Colalring in Parks

Hey Tom, can I get a copy of your letter to plagiarise?

Thanks!

Tod

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From: Haughton, Tod ENV:EX
Sent: Wednesday, February 27, 2019 3:03 PM
To: Nowotny, Chris ENV:EX
Cc: Ernst, Bevan FLNR:EX
Subject: RE: Wolff Colalring in Parks

Just wondering Chris, you know what happened last time we let Bevan fly around in the park…

Bevan: no holes, no names, no photos, no geologists, no nuthin.

☺

From: Nowotny, Chris ENV:EX
Sent: Wednesday, February 27, 2019 2:55 PM
To: Ernst, Bevan FLNR:EX
Cc: Haughton, Tod ENV:EX; Gat, Vladimira ENV:EX
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Forests, Lands and Natural Resource Operations

Predator Management in support of the Itcha-Ilgachuz Caribou herd

Prepared by BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Cariboo Region

September 2018

Recommended Citation:

xxxxx. 2018. Predator Management in support of the Itcha-Ilgachuz Northern Caribou Herd. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Wildlife Section, Williams Lake, BC

Cover photo credit: Shane White

Executive Summary

Across their Canadian range, populations of woodland caribou (*Rangifer tarandus caribou*) are in decline. Factors contributing to widespread woodland caribou population declines are multi-faceted, but increased predation rates on caribou are believed to be the proximate cause of their decline. The ultimate cause of increased predator-caribou interactions is due to anthropogenic disturbances leading to habitat loss, fragmentation and land use changes, which has increased apparent competition between caribou and other ungulate species. For the Itcha-Ilgachuz caribou herd in the Chilcotin Plateau of central British Columbia, increased predation rates on caribou is considered the primary direct cause of this caribou population's recent rapid decline.

Trends in the Itcha-Ilgachuz caribou population show a continuous steady rate of decline with the most recent population estimate of 637 caribou representing a 77% decline from its population peak in 2003. Similarly calf recruitment for the Itcha-Ilgachuz caribou population has remained below population replacement levels since 2004. The most recent spring calf estimate suggests there may be no recruitment in the herd for the 2018-2019 year, although late winter surveys in 2019 are needed to confirm this. While predation is considered the primary direct cause of the Itcha-Ilgachuz caribou population decline, there is a lack of reliable information on predator abundance and distribution overlapping this caribou population. This information gap is especially relevant for wolves, the primary predator of woodland caribou in northern ecosystems. An aerial wolf survey undertaken in Management Unit 5-12 overlapping a portion of winter habitat of the Itcha-Ilgachuz herd determined a wolf density in the range of 5-7 wolves per $1000km^2$, greater than the density estimate of <3 wolves per $1000km^2$ as recommended by Environment Canada to support a caribou recovery.

In response to the current steep population decline for the Itcha-Ilgachuz caribou, as well as the lack of reliable information on wolf abundance and distribution, this predator management plan outlines possible management actions for better understanding caribou-predator dynamics in the Chilcotin Plateau. Understanding that predator management actions, such as control efforts, require science-based rationale to justify implementation, this management plan reports on existing information and future methods for acquiring new information to help inform and justify potential future control actions for predators. If control efforts are to be implemented in order to curtail the declining population trend for the Itcha-Ilgachuz caribou population, a four-phased approach is outlined to assess predator-caribou dynamics, which include;

1. GPS Radio-collaring of wolves within core caribou habitat
2. Monitoring GPS collar data to determine spatial overlap & reliably estimate wolf density
3. Implement lethal removal of wolves via aerial gunning.
4. Monitor caribou population throughout all phases to determine success of predator removal.

For predator management to be ultimately successful in curtailing or reversing the current Itcha-Ilgachuz population trend, habitat protection and restoration measures as well as alternate prey reduction are also needed to address the underlying ultimate causes of caribou decline.

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1 Background

Woodland caribou have evolved with their predators and have persisted despite millennia of predation. Throughout their Canadian distribution, however, populations of woodland caribou (*Rangifer tarandus caribou*) have been declining over the past two decades. This decline has prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess the Southern Mountain population as Special Concern, which includes the Itcha-Ilgachuz herd under the Northern Mountain Caribou Designatable Unit (DU 7) (COSEWIC 2014). The widespread decline in Woodland caribou populations has been attributed to apparent competition between caribou and other ungulate species, specifically moose and mule deer (Seip, 1992, Serrouya et al. 2017). Due to changes in vegetation from human land use practices and disturbances such as logging, as well as climate change, the conversion of old growth forests to early seral habitats has supported an increase in moose and deer densities, as well as an expansion of their distribution. Subsequently, this increase in ungulate prey populations has contributed to a strong numerical response in predators, particularly for wolves (*Canis lupus*), cougars (*Puma concolor*) and bears (*Ursus sp*). A positive numerical response for these large carnivore species, has led to increased and unsustainable predation rates on caribou (Seip, 1992; Wittmer et al. 2007; Latham et al 2011a).

Against this backdrop, population surveys for the Itcha-Ilgachuz caribou have shown a dramatic population decline since this herd's population peak in 2003 (McNay & Cichowski, 2015). The Itcha-Ilgachuz caribou population are currently designated as *Threatened* in schedule 1 of the federal *Species at Risk Act*, which was fully enacted in 2003. The Itcha-Ilgachuz caribou have been regularly monitoring since 1977 with population surveys generally occurring in June, shortly after the calving period when the majority of adult female caribou are utilizing alpine habitat in the Itcha and Ilgachuz mountain ranges. Since the first population survey for this caribou population in 1977, the number of caribou increased steadily until the herd peak in 2003, when 2800 were estimated for this population. This population peak was followed by a sharp decline until 2018 when a population estimate of 637 caribou was recorded, representing a 77% population decrease from its 2003 peak. In 1985 the Itcha-Ilgachuz population was estimated as 1300 caribou, similar to the 2014 population estimate for this herd. However, since the 2014 survey this herd has declined 47.2% in just four years. In addition, in 2018 the lowest ever recorded percentage of calves in June was observed at 10%, 16% lower than the average number of calves observed in June from 1982-2017.

While predation is the proximate cause of most Itcha-Ilgachuz adult caribou mortalities, landscape level alterations to critical caribou habitat, as well as climate change, are likely the ultimate causes responsible for this herds decline, concurrent with other woodland caribou population declines (Environment Canada, 2012). As outlined above, these landscape level changes have likely led to an increase in the primary predators of caribou, particularly wolves, overlapping the Itcha-Ilgachuz caribou range. While improving regulations for protecting caribou habitat and increasing habitat restoration efforts would greatly benefit this herd, such measures would likely not curtail this herd's current rapid decline and may take decades for a population response to be realised. As such, alternative immediate measures like predator management could benefit this herd in the short-term, and help avoid herd extirpation, especially if such actions are concurrent with habitat protection and restoration, as well as alternate prey reduction (Hervieux et al. 2014) and with specific regard to the Itcha-Ilgachuz caribou, the reduction or closure of the legal harvest.

1.1 Predator management and ungulate prey dynamics

Predator management in North America was historically implemented in response to livestock depredation conflict and as an early wildlife management tool for enhancing ungulate prey populations for human harvest (Reynolds and Trapper, 1996, Baker et al. 2008). Predator management during the early 20th Century was focused on eradicating certain species, especially wolves, from large portions of their range (Mech and Boitani 2003). Today, large scale predator eradication programs are less socially acceptable and management actions are primarily applied to stabilize and recover populations of certain threatened species currently experiencing unsustainable levels of predation (Wittmer et al. 2013, Hervieux et al. 2014, DeMars and Serrouya, 2018). While predator management is often contentious, the successful recovery of threatened species has occurred where populations of their primary predators have been reduced significantly, as documented with some threatened caribou populations where wolf removal has occurred (Hayes et al. 2003).

As a wildlife management tool, a primary objective of predator management is to stabilize and/or recover declining ungulate populations at risk of extirpation. Where sympatric predator populations have been reduced, ungulate population recovery can be measured by observed increases in juvenile recruitment rates and increased adult female survival. Both of these demographic parameters are considered to exert the greatest limiting influence on ungulate population dynamics (Gaillard et at. 2000; DeMars and Serrouya2018). In western North America, the primary predators of adult ungulate species are wolves and cougars (Mech and Peterson 2003) while the primary cause of ungulate calf mortality is often species-specific and for most caribou populations, not well understood. Aside from wolf and cougar predation, black bears (*Ursus americanus*), grizzly bears *(Ursus arctos horribilis*), wolverine (*Gulo gulo*), coyotes (*Canis latrans*), lynx (*Lynx Canadensis*) and golden eagles (*Aquila chrysaetos*) have been shown to apply strong effects on neonate ungulate survival, including for caribou (Zager and Beechman 2006, Gustine et al. 2006; Barnowe-Meyer et al. 2010, Nieminen et al. 2011). In the absence of major predators or high levels of human harvest, caribou populations in Scandinavia generally increase until their populations become regulated by density-dependent competition for food (Skogland 1985, Seip 1991).

To justify the initiation of a predator management program, a prerequisite prior to any removal action is the need to acquire scientifically defensible reasoning for implementing predator management. Obtaining reliable information on predator densities sympatric with a target recovery species' range, as well as measuring the direct impacts of this overlap, ensure that the decision making process for initiating predator management are scientifically defensible and the probability of recovery is high. From review of predator management programs undertaken throughout North America, several conclusions can help inform and guide wildlife managers considering management action to recover threatened ungulate populations. The following conclusions were reached by the Committee on Management of Wolf and Bear Populations in Alaska (National Research Council 1997) and further developed by McLaren (2016) and DeMars & Serrouya (2018) and include;

1. Active Predator management requires strong indicators that predation is a major limiting factor in the focal ungulate population.

2. Management actions will be most effective when targeted towards the predator(s) species with the largest demographic effect on ungulate population dynamics. As noted by DeMars & Serrouya (2018), in multi-predator systems, obtaining this information can be challenging as the effects of different predators may be additive or compensatory (e.g. Valkenburg et al. 2004).
3. The efficacy of predator management is multi-faceted, and depends on the intensity, duration and spatial scale of predator removals.
4. The effects of predator management have a high probability of being short-term, especially if underlying causes of high predator populations are not addressed, such as landscape level alterations and disturbances that influence predator population growth and distribution.
5. The evaluation of success for predator management requires thorough experimental design and an adaptive management approach which incorporates consistent predator and focal prey species population monitoring, as well as alternate prey monitoring. Ideally, a before-after-control impact design should be used to control for confounding factors such as annual variations in weather and prey abundances.
6. Predator management is often a contentious issue among the public. To prevent the erosion of social acceptance, predator management should not be designed as a long-term solution for recovering a focal ungulate population and the underlying causes of high predator populations need to be addressed.

2 Species specific impacts on caribou populations

While caribou predators vary regionally (wolf, grizzly bear, black bear, cougar, coyote), predation impacts on woodland caribou populations have increased primarily in response to three dominant processes: apparent competition mediated by primary prey hyperabundance (Hebblewhite et al. 2007), apparent competition facilitated by expanding primary prey distribution (Wittmer et al. 2007, DeCesare et al. 2010, Latham et al. 2011a), and enhanced predator access to woodland caribou habitat (James and Stuart-Smith 2000, Latham et al. 2011b).

2.1 Wolves

In many northern ecosystems where caribou are an important food resource for wolves (Bergerud 1983, Gauthier and Theberge 1986), wolf predation can be an important population limiting factor for caribou (Bergerud 1980, Gasaway et al 1983, Bergerud and Elliot 1996, Seip 1991, Boertje et al 1996). In trying to assess whether wolves are controlling a prey population, however, it is important to understand the extent to which wolf predation is compensatory (Errington 1967) to other mortality factors and the extent to which it is additive (Mech and Peterson 2003). While wolves can contribute to limiting the growth of their prey populations, it is also clear that they do not always hold prey populations down (Mech and Peterson 2003). Instances where prey populations have increased, despite the presence of wolves, include moose on Isle Royale (Peterson et al 1998), deer in northwestern Minnesota (Nelson and Mech, 2000) and caribou in Denali National Park (Adams and Dale 1998, Mech et al, 1998).

Nevertheless, research examining wolf-caribou dynamics in western Canada has shown that woodland caribou declines are related to a strong numerical response by wolves and subsequent increased predation rates on caribou, as a direct response to higher primary prey densities (Seip 1992, Hebblewhite et

al. 2007). Wolf management actions in Canada have included aerial shooting, trapping, poisoning and sterilising breeding pairs (Hayes et al 2003) as well as the reduction of primary prey species, such as moose (Serrouya et al 2017). A positive numerical response in ungulate prey populations has been documented after wolf control efforts have been initiated, at least in the short-term (Hayes et al 2003, Valkenburg et al 2014). For woodland caribou, to achieve the long-term recovery of this species, research has suggested that wolf management actions would be most successful when combined with effective habitat conservation and long-term planning to affect the recovery of caribou (Hervieux et al 2014). The degree to which a threatened prey species responds to wolf management also depends on the spatiotemporal scale and intensity of wolf management actions (Hervieux et al 2014, Boertje et al 2017, Serrouya et al 2017).

Wolf population size has been correlated with population growth rates of caribou (Bergerud 1996) and research examining wolf-caribou dynamics has shown wolf densities greater than 6.5 wolves/1000km^2 will lead to woodland caribou declines (Bergerud and Elliot 1986, Serrouya et al 2016). The federal recovery strategy for caribou, however, identifies < 3 wolves/1000 km^2 as a target (Environment Canada 2014). Caribou populations in northern British Columbia have been shown to decline when wolf densities ranged between 9–10 wolves/1000km^2 but increased when wolf densities were in the range of 1–4 wolves/1000km^2 (Bergerud and Elliot 1986). Wilson (2009) recommended that wolf densities for woodland caribou in the Southern Group be managed to < 1.5 wolves/1000 km^2 to generate a significant, positive response by southern mountain caribou. Similarly Hebblewhite et al. (2007) suggested that subpopulations of caribou in Jasper National Park are likely to persist when wolf densities are below 2.1-4.3 wolves/1000 km^2. In the absence of research defining a maximum density of wolves needed to enable recovery across all southern mountain woodland caribou Local Population Units (LPUs), Environment Canada has recommended a density of < 3 wolves/1000 km^2 based on a combination of Wilson (2009) and Hebblewhite et al. (2007). 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.

In British Columbia, wolves were historically managed through a regulated bounty program which led to very low numbers of wolves across the province until the bounty program was abandoned in 1955 and wolf numbers subsequently increased along with this species spatial distribution across the province (Wilson 2012). Today wolves are a widespread and abundant species in BC and management actions are primarily undertaken to reduce local wolf populations in order to curtail and reserve the decline of certain threatened prey species, especially caribou (Wilson, 2014, Hervieux et al 2014).

2.2 Cougars

In southern British Columbia, research has identified cougars as a major caribou predator (Wittmer et al. 2005), while there are only rare reports of cougar predation on caribou in northern British Columbia. In general, however, information regarding cougar-caribou dynamics is limited. One study examining how cougar populations interact with various caribou sub-populations in the Columbia Mountains of British Columbia, reported that caribou comprised only a small proportion of the cougars diet with only 3 caribou kills out of 101 total kills documented (Bird et al, 2010). The authors noted that it was difficult to make conclusive inferences on the relationship between cougars and caribou, as caribou decline and extirpation had already occurred within their study area and the sample size of monitored GPS collared cougars was

small, with only 3 cougars collared (Bird et al. 2010). The authors reported that despite the low predation rates on caribou in their study area, such predation rates could potentially be enough to negatively impact small caribou populations if primary prey populations are not reduced. Research has shown that just one specialist cougar can have significant impacts on small ungulate populations, as previously observed in mountain sheep populations once a prey search image is developed (Fest-Bianchet et al. 2006).

DeMars and Serrouya (2018) reviewed three predator management programs which included the lethal control of cougars and reported that two of the three control programs were undertaken concurrently with bear or coyote removal (White et al. 2010, Hurley et al 2011). Results from cougar control in all three reviewed studies reported increased offspring survival or juvenile recruitment in the targeted ungulate population and two of these studies also reported positive effects on adult female survival.

2.3 Bears

Both grizzly and black bears predate woodland caribou (Seip 1992) and both species are considered a primary predator of ungulate neonates that can negatively impact ungulate demographic parameters and impose substantive losses on caribou recruitment (Young and McCabe 1997, Zager and Beecham 2006, Pinard et al 2012, Brockman et al 2017). Both bear species also frequently use early-seral stage pre-forest communities for foraging, often 20-50 years post-disturbance (Zager et al. 1983, Hamer 1996, Mace et al. 1996, McLellan and Hovery, 2001). However, as omnivorous species with individual dietary variation, bears generally have less dependence on ungulate prey (Edwards et al. 2010). Due to their seasonality and/or low predation rate and dependence on caribou as food, active management to increase ungulate populations, including for caribou has not been as common as it has been for wolves. Teel et al (2002) also suggested that there may be lower social acceptance for active bear control when compared to wolf control. Increases in ungulate neonate survival and/or calf recruitment has been documented after bear control, however, but the effectiveness of bear control seems to be influenced by the intensity, duration and spatial scale of treatment (Mosnier et al. 2008, DeMars and Serrouya, 2018).

2.4 Other Predators

Other predators such as wolverine, coyote and Golden Eagle have been documented preying on caribou, especially neonates (Crete and Desrosiers, 1995, Gustine et al 2006, Nieminen et al 2011). In northern British Columbia, researchers comparing predation risk, calf survival rates and habitat characteristics among three different caribou calving areas, documented wolverines as the primary predator of caribou neonates less than 14 days old (Gustine et al 2006). In Scandinavia, wolverines are also known to prey on semi-domesticated reindeer (*Rangifer tarandus tarandus*) calves and have been documented killing adult reindeer (Landa et al. 1997, Nieminen et al 2011). Coyotes can also be an important predator on caribou calves (Crete and Desrosiers, 1995, Boisjoly et al 2010, Bastille-Rousseau, 2018), especially when combined with predation rates on adult and/or calf by other caribou predators such as wolves and bears (Wittmer et al, 2005, Pincard et al 2012, Latham et al 2013). Golden Eagles are also known to prey on caribou calves (Adams et al 1995, Nieminen et al 2011) and in rare instances, have also been documented killing adults as observed in Norway with semi-domestic reindeer (Nybakk et al 1999).

As noted by DeMars and Serrouya (2018), examples of active management for wolverines and coyotes are limited. While information on the effect of wolverine and coyote active management to support caribou calf survival is lacking, research investigating ungulate offspring survival and juvenile recruitment following coyote control efforts have had mixed results (DeMars and Serrouya 2018). Information on the lethal removal of Golden Eagles to support ungulate calf survival and juvenile recruitment is also lacking.

3 Status of the Itcha-Ilgachuz caribou herd

The Itcha-Ilgachuz caribou have been monitored regularly by regional biologists since 1977. At that time, the population estimate was 350 caribou. Since 1977 the herd steadily increased in size to its estimated population peak of 2800 caribou in 2003 (Freeman 2010, Figure 1). In 2004 population estimates for the Itcha-Ilgachuz caribou began to decline, and have continued to decline to the present day (Freeman 2010, Youds et al. 2011, Dodd 2017). The 2007 post-calving survey estimated 2100 caribou in this population, representing a 17% decrease from the 2003 survey. Poor survey conditions contributed to the low count in 2007 (Roorda and Dielman 2007). However, subsequent follow-up surveys under ideal conditions in 2009 and 2012 resulted in population estimates of 2150 and 1600 caribou, respectively. The 2007 and 2009 survey results found stable female numbers but declining calf, bull and yearling numbers relative to 2002–03. Recently, the 2018 post-calving survey estimated 637 caribou, a decline of 77% since its population peak in 2003 and the population trend over the past 3 years has been declining at an average of 17 %.

Caribou populations generally increase when annual recruitment rates exceed the 15-16% required to balance natural adult mortality and maintain population stability (Bergerud, 1992). Between 1996 and 2003, calf recruitment for the Itcha-Ilgachuz herd averaged 25.8% in June while late winter (annual) recruitment was 17.0%. During this period survey effectiveness was improved through more extensive search and having radio-collared animals. Both real population increases and more thorough surveys contributed to higher population estimates. Calf recruitment for the Itcha-Ilgachuz caribou has remained below population replacement levels since 2004. While spring calves estimates (estimated from June aerial surveys) have remained relatively high from the 1990s to 2017, a sharp reduction in late winter calf percentages from 2002-2016 suggests that a reduction in recruitment is contributing to overall population declines. The percent of spring calves in June 2018, however, dropped by 17%, from 27% to 10%. Considering that calf recruitment has been below replacement level despite high spring calf numbers between 2002-2016, the significantly lower number of spring calves in 2018 may result in reproductive failure for the herd for the 2018-2019 year (per comms Carolyn Shores, FLNRORD).

Consistent with other research examining woodland caribou mortality (Bergerud, 1992, Wittmer et al. 2013) predation is considered to be the proximate cause in the observed decline of the Itcha-Ilgachuz caribou, with wolves considered to be the primary predator responsible for herd decline (McNay and Cichowski, 2015). In 2012-14, adult female mortality was 8.7% and 33.3% in 2013–2014 (McNay and Cichowski 2015). Data on adult mortality is based on radio-collared caribou studies conducted during four study periods: mid to late 1980's, mid 1990s to early 2000s, 2011-2015 and 2018 to present. In early 2018, 50 GPS radio-collars were deployed on this herd in an attempt to better understand cause specific mortality as well as to assist with more reliable population inventory. For the Itcha-Ilgachuz caribou, the primary

known cause of mortality has been wolf predation, which makes up at least 33.3% (n=7) of known mortalities (n=21) (Table 1), and up to 42.8%, if probable wolf predations (n=2) are included. Determining known causes of mortality for this herd has been challenging, however, as "rapid response" mortality investigations were not a study priority in earlier radio-collaring studies for this herd.

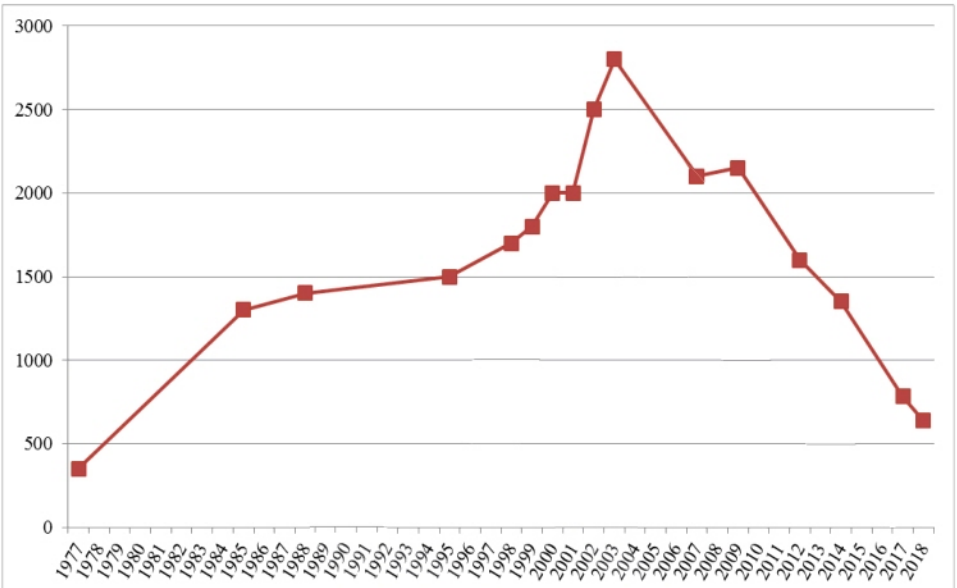

Figure 1. Sightability-corrected population estimates from 1977-2018 for the Itcha-Ilgachuz subpopulation of northern mountain caribou. Population estimates are derived from June post-calving surveys. The population estimate is calculated by applying a sightability correction factor based on the number of collared animals seen to the number of animals counted in the aerial survey.

Table 1. Causes of mortality of radio-collared Itcha-Ilgachuz caribou. Mortalities compiled from McNay and Cichowski 2015 and from mortality investigation forms done by Cariboo regional biologists from 2015-2018.

Cause of mortality	1985-88	1995-2003	2011-14	2018	Total	% of known and probable mortalities
Predation - Wolf	3	3		1	7	33.3
Predation - Cougar			1	1	2	9.5
Predation - Bear					0	0
Predation - Wolverine					0	0
Accident		1			1	4.7
Hunting		1	1		2	9.5
Poaching	1				1	4.7
Hunting or Poaching			1		1	4.7
Probable bear predation	1			1	1	4.7
Probable wolf predation				2	2	9.5
Probable poaching			1		1	4.7
Unknown - not predator-related	1	1		1	3	14.2
Unknown		8	10	1	19	NA
Total	6	14	14	7	41	NA

4 Status of predator populations in the Chilcotin Plateau

In an attempt to better understand the potential impact that predators, especially wolves, have on the Itcha-Ilgachuz caribou subpopulation, McNay and Cichowski (2015) undertook an assessment of wolf predation and management options in the Itcha-Ilgachuz caribou herd area. Existing data and reports regarding wolves, caribou, and wolf primary prey in the Itcha-Ilgachuz area were compiled and included hunter harvest data for predators and primary prey species in management unit 5-12, where the Itcha-Ilgachuz caribou range is located.

4.1 Wolves

In the Cariboo region a wolf population estimate based on combined estimates of published wolf density and range estimates, as well as prey biomass, reports between 550 - 1,250 individual wolves across the entire region (Wilson, 2014). However, reliable information on wolf populations overlapping the Itcha-Ilgachuz area is limited (McNay and Cichowski 2015). Data from both resident and non-resident harvest of wolves in MU 5-12 has not shown a general trend in wolf abundance with a very variable harvest estimate for wolves since 1975 (McNay and Cichowski, 2015). Despite a "no bag limit" for wolves introduced in 2012 for MU 5-12, estimated wolf harvest has not significantly increased, although there is no requirement to report wolf harvest in MU 5-12. In general, however, wolf harvest in the Cariboo Region is considerably higher than in regions further south, possibly due to larger wolf populations (Wilson, 2012). A poison bait program for wolves occurred in the mid to late 1990s, but data on the number of wolves killed as well as where and for how long this poisoning program lasted is lacking (McNay and Cichowski, 2015). Data from radio-collared wolves in the Chilcotin Plateau is also limited, with collars deployed on just four wolves overlapping Itcha-Ilgachuz caribou range. GPS collars were deployed on two wolves were monitored from 2012 to 2014. Movement data from these wolves showed overlap with winter habitat utilized by collared caribou in all years. VHF collars deployed on two wolves in the late 1990s also showed wolf distribution overlapping Itcha-Ilgachuz caribou habitat, including portions of their summer range in the Ilgachuz Mountains.

Density estimates for wolves and pack distribution is also lacking in MU 5-12. In January 2017, an aerial wolf survey in MU 5-12 was undertaken by Cooper Beauchesne and Associates LTD, contracted by BC Ministry of FLNRO to estimate wolf density in this area. This wolf census followed established protocols developed for surveying wolves in areas of low topographic relief with expanses of flat heavily forested terrain (Serrouya et al. 2015). Based on locating wolf tracks and subsequent track splitting, a wolf density of 5-6 – 7.6 wolves per 1000 km^2, in seven packs, was estimated over four days of flying and within a 4,231 km^2 survey area (Figure 2). While the maximum wolf density estimate of 7.6 wolves/1000km^2 is above the 6.5 wolves/1000km^2 wolf density identified as influencing caribou population decline (Bergerud and Elliot 1986), this estimate is less reliable than the minimum density estimate of 5.6 wolves /1000km^2, which is more objective. However, both density estimates are above the ECCC recommendation of <3 wolves/1000km^2 in critical caribou habitat. 24 to 32 wolves were detected in the SBPSxc subzone (Sub-Boreal Pine-Spruce; very dry cold) based on track interpretation and no visual detections of wolves were observed. The contractor defined a pack as a minimum of one animal, which is not typical for wolf studies. If the standard definition of 2 wolves to form a pack is used (Fuller 2003), then 6 wolf packs, rather than 7, were detected in the survey area. The contractors also described their survey as an "initial exploration," and recommended investing in a wolf-collaring program to validate the wolf census with sightability correction factors.

s.18

Figure 2. Wolf pack detections from the 2017 aerial wolf survey. The red polygons represent the extent of tracks detected for each group, but do not represent the much larger territory size of each pack. Number indicates pack ID.

Prior to the 2017 aerial wolf census, a winter track transect in the West Chilcotin was undertaken in the winter of 2009-10 (Davis 2009). This survey did not yield density estimates for wolves in MU 5-12. An attempted aerial survey of wolves in and around the Itcha-Ilgachuz Mountains in 1999 was also unsuccessful due to large expanses of heavily forested terrain, limited open waterways in which to track, and poor survey conditions (Roorda and Dielman 2007). The distribution of wolves in the southern part of the Itcha-Ilgachuz herd range as reported by the 2017 wolf census and GPS collar data suggests that wolves occur throughout seasonal caribou range, including in alpine caribou calving habitat during June post-calving surveys.

4.2 Cougars

Cougar densities respond positively to increased prey densities, especially deer, and cougar populations generally vary in response to habitat features and current and past exploitation (Logan and Sweanor 2001). Reliable information on cougars in the Itcha-Ilgachuz area is limited with no standardised inventory undertaken for this species in MU 5-12, or elsewhere in the Cariboo Region. Anecdotal reports of increased cougar activity in the Anahim/Nimpo Lake area has been reported by local residents in recent years (McNay and Cichowski, 2015). There is an open season for cougars in MU 5-12 with a bag limit of 2.

In the Cariboo Region, a cougar population estimate based on reported cougar kill locations and habitat capability for supporting deer estimated between 900-1200 cougars (Wilson, 2011). However, cougars are not common in the Itcha-Ilgachuz caribou subpopulation range(Spalding 1994). A recent (March 2018) mortality of a radio-collared Itcha-Ilgachuz bull caribou was confirmed as a cougar kill (Figure 3). A cougar DNA mark-recapture population estimate study near William's Lake is currently planned for the winter of 2018/19. Results from this study may help to inform the feasibility of conducting a similar cougar population or diet study on the Chilcotin plateau.

Figure 3. March 2018 radio-collared bull mortality site. Left photo: Caribou carcass partially covered in its own hair. Right photo: cougar tracks leading away from the caribou carcass (Shane White, FLNRORD).

4.3 Bears

Both grizzly bears and black bears are present in the Itcha-Ilgachuz subpopulation range. Both bear species have been shown to reduce caribou calf recruitment and contribute to adult caribou mortality (Adams et al. 1995, Wittmer et al. 2005, Bastille-Rousseau et al. 2016, Lewis et al. 2017). Although predation rates for grizzly bears have not been determined, their density in the Itcha-Ilgachuz range was estimated to be 9/1000 km^2 in 2004 and 2008 (Hamilton et al. 2004). However the 2012 estimate fell to 2.6/1000 km^2, falling to threatened status provincially (Griffiths 2012). There is no reliable information on black bear trends in the Chilcotin area, including MU 5-12 (McNay and Cichowski 2015). There is a bag limit of 2 and an open season for black bears in MU 5-12. In late 2017, the BC Government announced the closure of grizzly bear hunting by resident and non-resident hunters throughout British Columbia. Grizzly bears can still be harvested by First Nations pursuant to Aboriginal rights for food, social or ceremonial purposes or treaty rights, although the harvest in MU 5-12 is thought to be very low.

4.4 Other Predators

As with the primary predators of caribou in the Chilcotin Plateau, there is a general lack of direct information on the abundance, general trends and distribution of secondary predators of caribou, such as wolverines, coyotes and Golden Eagles in MU 5-12. Harvest for coyotes is open season with no bag limit throughout the Cariboo Region and wolverines can be legally trapped from November 1st to January 31st. Golden Eagles are also present in the Itcha-Ilgachuz caribou range and while not currently designated as a species at risk, populations in areas of Canada are declining and this species is protected under Section 34 of the Wildlife Act. Active management actions for Golden Eagle would likely be much less socially acceptable than control actions for other caribou predators. Lethal control of Golden Eagles would also be very challenging due to this species legal status, the lack of reliable information on its interactions with caribou in British Columbia and less social acceptance for management actions.

4.5 Conclusions

Consistent with other declining woodland caribou populations across western North America (Seip 1992, Hayes et al 2003, Wittmer et al. 2005) wolf predation is considered to be the primary cause of adult mortality in the Itcha-Ilgachuz caribou herd (McNay and Cichowski, 2015). While there is generally a lack of direct information regarding how wolves are interacting with caribou in the Itcha-Ilgachuz area, of the documented known mortalities for adult collared caribou in the Itcha-Ilgachuz herd (n=21), wolf predation has been confirmed as the proximate cause of death for 7 adult caribou and probable for a further 2 adult caribou. Wolf predation is currently the primary cause of known mortality for radio-collared caribou in this herd. However, it is difficult to make conclusive inferences as the sample size for confirmed wolf predation is small. Acquiring more reliable information on both the wolf density and pack distribution sympatric with the Itcha-Ilgachuz subpopulation is important to infer the potential predation effects on this herd and to support management actions such as wolf reduction. In addition, calf recruitment appears to be the driving cause of decline for this herd, and the primary cause of calf mortality is unknown. Wolves are potential caribou calf predators but other predators, disease and nutritional limitation may also be factors contributing to low calf recruitment.

For the Itcha-Ilgachuz caribou herd, potential predator management action should be intensive and occur over a large spatiotemporal scale and undertaken concurrently with other measures such as habitat protection, the reduction/closure of the legal harvest of bull caribou and continued monitoring and potential reduction of alternate prey densities, especially moose. To better understand predator-prey dynamics in the Itcha-Ilgachuz range, it will be important to monitor the wolf population size and range overlapping caribou habitat seasonally. This could be achieved by maintaining a sample of radio-collared wolves in MU 5-12 and monitoring their seasonal movements and pack size. Furthermore, to determine the effectiveness of wolf removal it is essential to maintain a sample of radio-collared adult caribou to continue to reliably estimate population trends and determine juvenile recruitment before and after potential wolf control. Percent calves in late winter surveys and population change will be used as metrics of success to determine the efficacy of wolf removal.

5 Management Recommendations

Decisions influencing the implementation of a predator management program can be complex. To aid wildlife managers in the decision making process, the development of tools such as decision matrices and prioritization tables can be of significant benefit to help inform and guide wildlife managers considering predator management in aid of caribou population recovery. In British Columbia, the Provincial Caribou Science Team, composed of government caribou biologists and managers from across the Province, met in June 2018 to develop the framework for a predator management decision matrix (Figure 4). This decision matrix includes decision points that require wildlife managers to address population parameters for a target caribou population. The first step is determining whether a caribou herd is at or below the population objectives. Once determined, questions regarding herd viability with or without predator management must be addressed, followed by the availability of reliable data to identify the primary predator limiting the population. Finally, the status of the primary predator itself and if this species is sensitive to control actions is addressed. The science committee recommended that a herd prioritization table is also developed to determine priority herds for wolf removal.

For the Itcha-Ilgachuz caribou herd, acquiring scientifically defensible information regarding predator-prey dynamics is important to support a scientifically based rationale for implementing predator management programs, especially to evaluate the third decision point in the predator management decision matrix on whether there is sufficient information to determine that predation is limiting the population. Specifically, more information on wolf density, spatial overlap between wolves and caribou, and wolf predation rates on caribou would support the decision matrix process. Also, prior to active predator management measures, due to the high intensity, multi-year wolf removal efforts required to achieve caribou herd population increases (Hayes et al 2003), the implementation of a wolf control program should only occur if adequate financial support is guaranteed over a timeframe of at least 4 years for intensive removal and the simultaneous monitoring of the Itcha-Ilgachuz caribou to evaluate the success of predator removal. Calf recruitment and sightability corrected population estimates for the herd, which will be used to determine lambda, or the rate and direction of population change, will be used as metrics of success. Population objectives for caribou herds must also be established to guide decisions around ending predator management and the ultimate cause of the herd's decline, habitat loss, must also be addressed.

Currently, following the decision matrix table, there is adequate information regarding the proximate decline of Itcha-Ilgachuz caribou to support active predator management practices such as wolf reduction, although more information on wolf caribou dynamics would be of value to address decision point three, on whether predation is limiting the population. This information to support wolf removal is the following: 1) the herd is in steep decline and calf recruitment is far below population replacement, 2) wolf predation is the leading cause of adult mortality and 3) the density of wolves in caribou critical habitat is above the ECCC recommendation of <3 wolves per/1000km^2. To address information gaps on wolf-caribou dynamics in the Chilcotin Plateau, as well as evaluate predation effects in the Itcha-Ilgachuz range, multi-faceted management actions are required. These include; determining wolf population parameters in MU 5-12, radio-collaring wolf packs with spatial overlap of the Itcha-Ilgachuz herd, maintaining a sample size of radio-collared Itcha-Ilgachuz caribou and potential lethal control of wolf populations (in the most humane method possible) in and adjacent to Itcha-Ilgachuz caribou range.

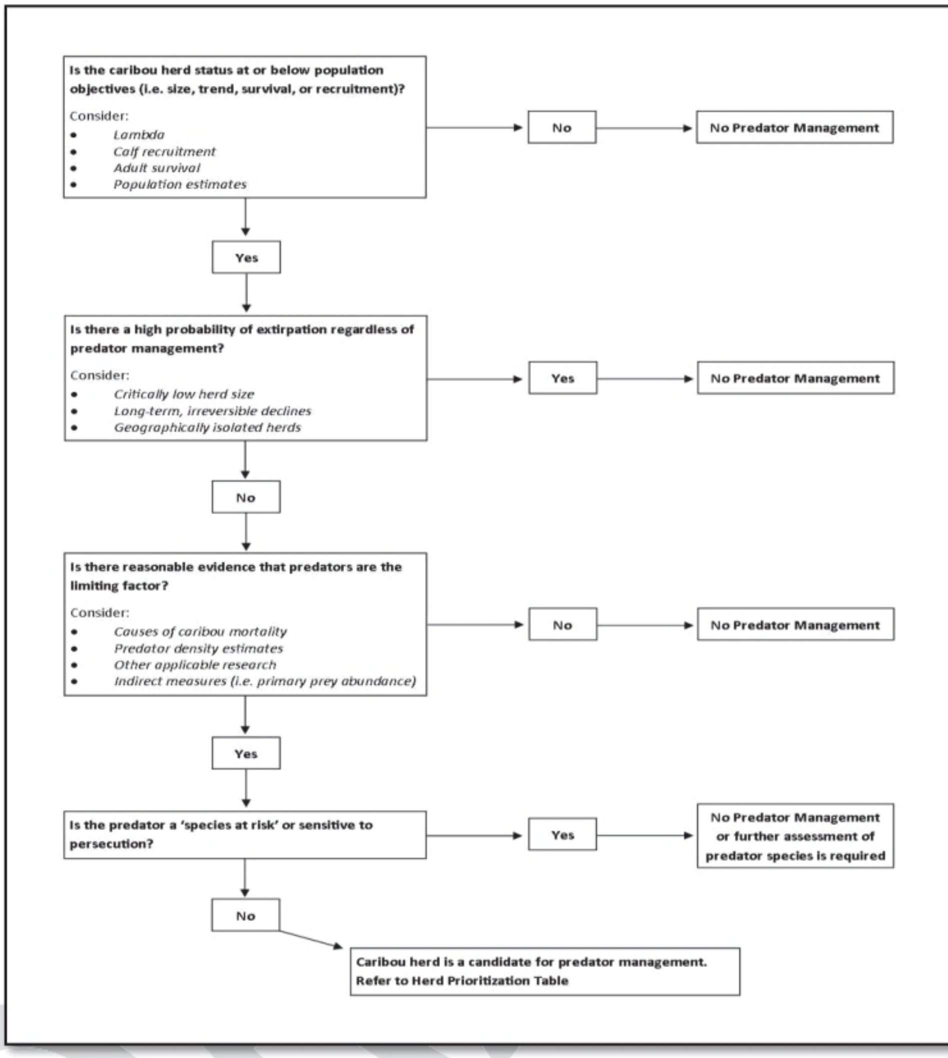

Figure 4. Predator management Decision Matrix flow chart developed by Provincial caribou biologists

5.1 Determining wolf population parameters in MU 5-12

Acquiring reliable density estimates for wolves can be especially challenging due to this species large territory size, their ability to travel extensively when hunting and their highly variable movement patterns which is dependent on pack size, availability of prey species and seasonality (Ballard et al 1987). However, in the boreal plains, winter aerial transect surveys have effectively estimated wolf populations, often in areas with dense forest cover (Serrouya et al. 2015). While a winter aerial wolf census using the survey method developed by Serrouya et al (2015) was undertaken in MU 5-12 in January 2017, this census was limited by logistical constraints such as fuel (Gill and van Oort, 2017). Furthermore, wolf density estimates are more reliable if a sample of radio-collared wolves is maintained in the population and at the time of the 2017 aerial wolf census, no GPS radio-collared wolves were present in the survey area.

To better assess wolf-caribou dynamics in MU 5-12, the initiation of an annual wolf monitoring program to determine wolf population size and distribution in the Itcha-Ilgachuz range will allow for reliable inferences to be made in assessing the potential predation effects by wolves on Itcha-Ilgachuz caribou and support potential wolf control. Aerial wolf surveys should be undertaken at least once a year starting in the winter of 2019 and continuing over the course of active predator management. Aerial wolf surveys should occur in January or February when wolf packs are more cohesive and before the breeding season in March (Packard, 2003). Wolf aerial censuses should follow existing protocols for heavily forested areas (see Serrouya et al 2015) with the survey area stratified into belt transect routes to maximize the detection of wolf tracks, relative to cost. Wolf surveys should focus primarily in the SBPS zone (sub-boreal pine-spruce), previously identified in MU 5-12 as important wolf habitat (Gill and van Oort, 2017). Aerial monitoring of wolves during the summer months, without the presence of snow to detect and follow wolf tracks, is more logistically challenging, as are ground based methods such as wolf scat and tracks surveys, which have been used elsewhere in British Columbia to infer relative abundance of wolves (Hatter 1988, Atkinson and Janz 1994). The potential use of trained field technicians/volunteers, as implemented successfully elsewhere (see http://fwp.mt.gov/fishAndWildlife/management/wolf/), could be a reliable approach for monitoring wolf populations in MU 5-12, allowing for pack distribution and pack size to be determined using camera trapping methods. Experienced volunteers could also implement ground trapping to radio-collar wolves and investigate wolf GPS location cluster sites, as well as responding to caribou mortality notifications if logistically feasible. Funding to support such a ground based volunteer wolf program would, however, need to be secured.

5.2 Radio-collaring wolves overlapping Itcha-Ilgachuz caribou range

Understanding caribou-wolf dynamics and habitat selection by wolves within and adjacent to the Itcha-Ilgachuz range will require a sample of GPS collars on both species. In their assessment of wolf management options in MU 5-12, McNay and Cichowski (2015) also recommended radio-collaring wolves to determine pack structure and range. As outlined above, maintaining a sample of radio-collared wolves will permit more precise population estimates for wolves in MU 5-12 and allow for wolves to be effectively located and removed from the population if control actions are considered necessary to curtail the current sharp decline of Itcha-Ilgachuz caribou. Evaluating wolf seasonal habitat selection will be also valuable in evaluating predation risk for Itcha-Ilgachuz caribou. At least 1-2 GPS radio-collars should be deployed on each wolf pack in the Itcha-Ilgachuz range during the Winter 2018/19. Ideally the collars should be programmed to receive at least 8 fixes a day. The newer generation of GPS radio-collars are cost effective and the number of fixes can be programmed remotely with Iridium 2-way satellite communication. Higher fix rate collars will allow wildlife managers to determine wolf pack distribution, size and home range overlap with caribou habitat as well as more effective location of collared wolf packs for removal.

5.3 Maintaining a sample of GPS radio-collared Itcha-Ilgachuz caribou

Studies have suggested that maintaining a sample size of 20-25 radio-collared caribou per year is sufficient to reliably monitor population trends and estimate survival rates (White and Garrott, 1990, Hervieux et al 2013, Serrouya et al 2017). Currently, 39 functional GPS radio-collars are deployed on female and male caribou in Itcha-Ilgachuz herd, programmed to record 1-2 GPS locations per day. These collars also transmit mortality notifications via satellite once the collar switches to mortality mode, allowing for cause of mortality to be determined and thus providing strong inferences on predation effects (DeMars and Serrouya 2018). The effectiveness of determining cause-specific mortality for radio-collared animals requires site investigations immediately following the death of a collared animal. Newer generations of GPS radio-collars are cost effective and often designed for survival studies and allow for "rapid response" mortality investigations. 50 radio-collars were initially deployed on the Itcha-Ilgachuz herd in March 2018, seven of which have already been retrieved from caribou mortality investigations and four of which are no longer transmitting location data. In maintaining a sample of radio-collared caribou, our ability to reliably monitor caribou population trends will improve (DeCesare et al 2012), and estimating important demographic parameters such as female survival and juvenile recruitment will be feasible. Continued monitoring of the Itcha-Ilgachuz herd demographics should continue for at least 5 years following wolf control.

5.4 Ethical reduction of wolf populations in MU 5-12

The reduction of wolf populations is a contentious issue and has been for decades (Cluff and Murray 1995). In Canada, wolf control programs aimed at recovering threatened caribou have attracted significant media attention with ethical and legal questions raised concerning wolf reduction actions (Brook et al 2015). Nonetheless, managing wolves to recover threatened woodland caribou is an effective science based, legal and ethical management tool (Herviuex et al 2014, Herviuex et al 2015). Direct removal of wolves using aerial gunning to recover caribou populations is currently being undertaken in British Columbia, with control actions for caribou populations being implemented in the South Selkirk, Columbia North and South Peace. In 2017/2018 151 wolves were removed from eight caribou herd areas, with a total wolf control program cost of $593,333. In the Cariboo Region, a pilot wolf reduction program was implemented to reduce wolf densities for Mountain Caribou recovery in the Quesnel Highland Planning Unit (Roorda and Wright 2012). Helicopter net-gunning combined with ground trapping was successfully used to capture, and subsequently surgically sterilize dominant wolves, in an attempt to reduce wolf recruitment while maintaining stable pack territories (Hayes et al. 2003, Roorda and Wright 2012). Wolf removals from the population also occurred, but sterilization alone was found to be sufficient in maintaining wolves at low densities (Hayes 2013). A correlation between reduced wolf densities and caribou recovery in the Quesnel Highlands was not substantiated (Hayes 2013). McNay and Cichowski reported that sterilization reduces the wolf population by about 50%, which may not reduce wolf densities to the <3 wolves/1000 km^2 needed to maintain caribou, given the 2017 wolf density estimate of 5.6 – 7 wolves/1000 km^2 in the Itcha-Ilgachuz herd's critical habitat.

The most effective and humane method of reducing wolf populations is aerial gunning (Ballard et al 1997, Hayes et al 2003, Wilson 2012), likely due to the assumption of a quick kill (McNay and Cichowski, 2015), although there are criticisms regarding this technique (Brook et al 2015). For the Itcha-Ilgachuz caribou, if evidence continues to make strong inferences as to predation effects from wolves, an aerial wolf control program should be implemented using experienced aerial gunners. Population targets for wolf densities should be less than 3 wolves/1000 km^2 a target that the federal recovery strategy for caribou has identified as eliciting a positive population response in caribou (Environment Canada 2014). Bergerud and Elliot (1998) noted that wolves quickly recolonized their study area following the conclusion of the wolf removal program in the Northern Rockies. They also noted considerable wolf recovery on an annual basis, primarily by small groups of recolonizing wolves from adjacent territories (Bergerud and Elliot, 1998). This emphasizes that wolf removal is not a sustainable long-term strategy for caribou recovery, but instead a short term recourse to prevent further population decline while long-term strategies such as habitat protection are put in place (Itcha-Ilgachuz herd recovery plan, 2018). If long-term strategies to recover the Itcha-Ilgachuz herd cannot be implemented, then serious consideration should be given as to whether to continue wolf removal. Intensive wolf removal over a period of 4-5 years is likely required to elicit a strong, positive population response in the Itcha-Ilgachuz caribou herd. Caribou calf recruitment and sightability corrected population estimates should undergo evaluation after the third winter of removal. Ongoing caribou and wolf monitoring will be necessary to determine the required frequency of wolf control. Wolf control actions implemented prior to the caribou herd reaching critically low level numbers would be most beneficial and cost-effective when considering the long-term management of this caribou herd.

Potential wolf control efforts should primarily focus within and adjacent to the Itcha-Ilgachuz caribou range (9,457 km^2; Figure 5), encompassing the Chilcotin Plateau and the Itcha-Ilgachuz Mountains in the Fraser Plateau ecoregion (Goward 2000), as well as the Dean River Corridor and low-elevation caribou winter habitat east of Anahim lake that is also used by the Itcha-Ilgachuz herd, although it is outside of their current herd boundary (Itcha-Ilgachuz caribou herd recovery plan). Based on baseline density estimates for wolves in MU 5-12 (Gill and van Oort, 2017), their findings suggest a minimum estimate of 53 wolves within or adjacent to the treatment area and a maximum estimate of 72 wolves, although further investigation into wolf population parameters in this area is warranted. Intensive aerial control of wolf populations within MU 5-12 should aim to remove a high proportion of wolves overlapping the treatment area (>80%, Hayes et al. 2003). To facilitate efficient aerial removal of wolves by experienced crew and helicopter pilots, the deployment of GPS collars on wolves will allow for quick relocation and removal and/or reduction of collared packs. Equipping a wolf pack with at least 1-2 GPS radio-collars will allow for complete pack removal later, if immediate pack removal is not feasible. The collared individuals may be removed from the pack, or left alive to facilitate wolf removal actions the following winter. Consistent with previous research (Hayes et al. 2003), to maximise the benefits of predator removal, a substantial reduction or full closure of the legal hunt of Itcha-Ilgachuz caribou should occur simultaneously with any predator control actions. Observed changes to caribou herd demographics may be evident the year following wolf control actions, but may take up to three years to have an effect.

6 Monitoring and Measures of Success

To measure the effectiveness of wolf control actions for the recovery of Itcha-Ilgachuz caribou subpopulation, maintaining population monitoring of this herd is essential to infer changes in population size and demographic trends, including juvenile recruitment and estimating adult female survival, both important demographic parameters in caribou population dynamics (DeCesare et al. 2012). Wolf control efforts must be intensive and last a minimum of 4 years, preferably 5 years. It is important to note that while wolf predation is currently likely the proximate cause of decline for the Itcha-Ilgachuz caribou herd, disturbances and loss of critical caribou habitat from timber harvesting has led to the current predator-prey system and subsequent caribou population declines. If caribou habitat degradation continues to occur, the effectiveness of wolf control will be limited (Hervieux et al 2014). Public support for wolf control to recover caribou will also likely diminish if management actions are not concurrent with habitat protection and recovery efforts. Further management actions associated with active wolf control efforts should include changing hunting regulations for alternate prey, such as moose and deer. Woodland caribou are secondary prey species for wolves (Milakovic and Parker 2011) and wolf presence, abundance and distribution will be most likely influenced by the availability of alternate prey species, especially moose (Courbin et al 2013). Moose and deer populations overlapping the Itcha-Ilgachuz range will likely increase in abundance after predator removal, which in turn will support wolf recolonization and subsequent population increases (Bergerud and Elliot, 1986). If increases in primary prey populations are not addressed, wolf control efforts will likely become increasingly difficult and cost ineffective.

In the short-term, curtailing or reversing the declining Itcha-Ilgachuz population herd will be the most appropriate measure of success, determined through ongoing population monitoring. Monitoring the wolf population before and after removal efforts will allow wildlife managers to gauge the effectiveness of the control program. The potential deployment of a camera trapping grid in the Itcha-Ilgachuz calving areas could also fill some information gaps for this caribou herd, such as the predator-caribou interactions at this important biological season. Deploying remote cameras can be a cost effective management tool, especially if such a program occurs over a large spatiotemporal scale (Steenweg et al. 2016).

s.18

Figure 5. Potential wolf treatment area based on the designated 9,457km^2 Itcha-Ilgachuz herd boundary. Purple points represent 2018 radio-collared caribou locations from collar deployment to date (March 2018 to September 2018).

7 Timeframe & Budget

Tentative predator management timeframe & budget

Develop wolf control program in core caribou habitat (9,457 km^2). A four phase plan, based on recommended management actions in the Itcha-Ilgachuz herd recovery plan, is outlined below. Ongoing caribou population monitoring is required throughout the wolf control program and for years after the end of the wolf removal program to determine its effectiveness.

- **Phase 1**: Collar wolves within ECCC core caribou habitat, focusing on areas of high caribou use in SBPS zone, winter 2018-19. Deploy 1-2 collars in each wolf pack.

- **Phase 2**: Monitor GPS collar data to determine wolf and caribou spatial overlap, map seasonal home ranges of wolf packs, and accurately estimate wolf density.

- **Phase 3**: Lethally remove wolves via aerial gunning. Due to the high intensity, multi-year wolf removal needed to achieve caribou herd population increases, only implement a wolf control program if funds are guaranteed for 1) intensive wolf removal for a minimum of 4 years and 2) to monitor calf recruitment and herd populations for 5 years. It is not recommended to begin a wolf control program if funds for the above are not guaranteed. Wolf removal over a similar size area in northeast BC cost $400,000/year.

- **Phase 4**: Ongoing caribou population monitoring to determine wolf removal effectiveness.

Determine if remote camera study is feasible for the Itcha-Ilgachuz caribou calving area:

- Potentially address information gaps regarding predator-caribou interactions during the calving season when neonate calves are most vulnerable to predation.

Apply for funding to cover laboratory work on cougar and wolf scats for:

- Diet; using prey species DNA or stable isotope analyses. Data on predator diet on the Chilcotin plateau is needed to understand the role of alternate prey (feral horses, mule deer, moose) in apparent competition dynamics with caribou
- Predator population estimation with DNA mark-recapture

The rationale for wolf removal is a steeply declining caribou population (average decline of 17% per year), mortality data for the herd showing wolf predation to be the leading cause of adult mortality (33.3%), and research that shows wolves can be responsible for >30% of caribou calf mortalities (Nieminen et al. 2013). In addition, wolf removal is most effective when done for a larger herd, so it is recommended to take this management action while the herd is still relatively large. A commitment to increasing habitat protection is necessary to go forward with predator removal. Predator removal is a temporary solution that only addresses the proximate cause of the herd's decline. For long-term recovery of this herd, habitat protection is required to addresses habitat loss, the ultimate cause of the herd's decline.

Table 2. Projected year 1 budget estimate for wolf and Itcha-Ilgachuz management

Wolf	Description	Estimate Cost
Wolf collar purchase*	s.17	$36,000 - $44,000*
Wolf Capture - Rotary		$128,000
Wolf Census		$24,000
Caribou		
Collar purchase*		$27,000
Caribou Capture		$22,400
Post-Calving Survey		$8,250
		$36,000
Late-winter Recruitment Survey		$6,600
		15,000
Equipment costs and expenses		$9000
Mortality investigations		$40,000
Total		**$352,250 – $360,250**

*Collar cost dependent on successful proponent.

Table 3. Projected annual budget estimate for year 2, 3 & 4

Wolf Removal efforts	Description	Estimate Cost
Rotary flight cost	s.17	$192,000
Fixed-wing flight cost		$16,500
Wolf collar purchase*		$10,800-$13,200
Accommodations (for three people)		$8500
Equipment costs		$1500
Total cost – wolf removal		**$229,300-$231,700**
Caribou inventory		
Caribou collars*		$27,000
Caribou capture		$22,400
Post-calving survey		$8,250
		$36,000
		$6,600
Recruitment survey		$15,000
Mortality investigations		$40,000
Total cost – Caribou monitoring		**$146,250**
Total		**$375,550-$377,950**
Additional Costs - Wolf Census Year 4		$24,000

*Collar cost dependent on successful proponent.

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Predator Management in support of the Itcha-Ilgachuz Caribou herd

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Executive Summary

Across their Canadian range, populations of woodland caribou (*Rangifer tarandus caribou*) are in decline. Factors contributing to widespread woodland caribou population declines are multi-faceted, but increased predation rates on caribou are believed to be the proximate cause of their decline. The ultimate cause of increased predator-caribou interactions is due to anthropogenic disturbances leading to habitat loss, fragmentation and land use changes, which has increased apparent competition between caribou and other ungulate species. For the Itcha-Ilgachuz caribou herd in the Chilcotin Plateau of central British Columbia, increased predation rates on caribou is considered the primary direct cause of this caribou population's recent rapid decline.

Trends in the Itcha-Ilgachuz caribou population show a continuous steady rate of decline with the most recent population estimate of 637 caribou representing a 77% decline from its population peak in 2003. Similarly calf recruitment for the Itcha-Ilgachuz caribou population has remained below population replacement levels since 2004. The most recent spring calf estimate suggests there may be no recruitment in the herd for the 2018-2019 year, although late winter surveys in 2019 are needed to confirm this. While predation is considered the primary direct cause of the Itcha-Ilgachuz caribou population decline, there is a lack of reliable information on predator abundance and distribution overlapping this caribou population. This information gap is especially relevant for wolves, the primary predator of woodland caribou in northern ecosystems. An aerial wolf survey undertaken in Management Unit 5-12 overlapping a portion of winter habitat of the Itcha-Ilgachuz herd determined a wolf density in the range of 5-7 wolves per 1000km^2, greater than the target density estimate of <3 wolves per 1000km^2 as recommended by Environment Canada to support a caribou recovery.

In response to the current steep population decline for the Itcha-Ilgachuz caribou, as well as the lack of reliable information on wolf abundance and distribution, this predator management plan outlines possible management actions for better understanding caribou-predator dynamics in the Chilcotin Plateau. Understanding that predator management actions, such as control efforts, require science-based rationale to justify implementation, this management plan reports on existing information and future methods for acquiring new information to help inform and justify potential future control actions for predators. If control efforts are to be implemented in order to curtail the declining population trend for the Itcha-Ilgachuz caribou population, a four-phased approach is outlined to assess predator-caribou dynamics, which include;

1. GPS Radio-collaring of wolves within core caribou habitat
2. Monitoring GPS collar data to determine spatial overlap & reliably estimate wolf density
3. Implement lethal removal of wolves via aerial gunning.
4. Monitor caribou population throughout all phases to determine success of predator removal.

For predator management to be ultimately successful in curtailing or reversing the current Itcha-Ilgachuz population trend, habitat protection and restoration measures as well as alternate prey reduction are also needed to address the underlying ultimate causes of caribou decline.

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1 Background

Woodland caribou have evolved with their predators and have persisted despite millennia of predation. Throughout their Canadian distribution, however, populations of woodland caribou (*Rangifer tarandus caribou*) have been declining over the past two decades. This decline has prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess the Southern Mountain population as Special Concern, which includes the Itcha-Ilgachuz herd under the Northern Mountain Caribou Designatable Unit (DU 7) (COSEWIC 2014). The widespread decline in Woodland caribou populations has been attributed to apparent competition between caribou and other ungulate species, specifically moose and mule deer (Seip, 1992, Serrouya et al. 2017). Due to changes in vegetation from human land use practices and disturbances such as logging, as well as climate change, the conversion of old growth forests to early seral habitats has supported an increase in moose and deer densities, as well as an expansion of their distribution. Subsequently, this increase in ungulate prey populations has contributed to a strong numerical response in predators, particularly for wolves (*Canis lupus*), cougars (*Puma concolor*) and bears (*Ursus sp*). A positive numerical response for these large carnivore species, has led to increased and unsustainable predation rates on caribou (Seip, 1992; Wittmer et al. 2007; Latham et al 2011a).

Against this backdrop, population surveys for the Itcha-Ilgachuz caribou have shown a dramatic population decline since this herd's population peak in 2003 (McNay & Cichowski, 2015). The Itcha-Ilgachuz caribou population are currently designated as *Threatened* in schedule 1 of the federal *Species at Risk Act*, which was fully enacted in 2003. The Itcha-Ilgachuz caribou have been regularly monitoring since 1977 with population surveys generally occurring in June, shortly after the calving period when the majority of adult female caribou are utilizing alpine habitat in the Itcha and Ilgachuz mountain ranges. Since the first population survey for this caribou population in 1977, the number of caribou increased steadily until the herd peak in 2003, when 2800 were estimated for this population. This population peak was followed by a sharp decline until 2018 when a population estimate of 637 caribou was recorded, representing a 77% population decrease from its 2003 peak. In 1985 the Itcha-Ilgachuz population was estimated as 1300 caribou, similar to the 2014 population estimate for this herd. However, since the 2014 survey this herd has declined 47.2% in just four years. In addition, in 2018 the lowest ever recorded percentage of calves in June was observed at 10%, 16% lower than the average number of calves observed in June from 1982-2017.

While predation is the proximate cause of most Itcha-Ilgachuz adult caribou mortalities, landscape level alterations to critical caribou habitat, as well as climate change, are likely the ultimate causes responsible for this herd's decline, concurrent with other woodland caribou population declines (Environment Canada, 2012). As outlined above, these landscape level changes have likely led to an increase in the primary predators of caribou, particularly wolves, overlapping the Itcha-Ilgachuz caribou range. While improving regulations for protecting caribou habitat and increasing habitat restoration efforts would greatly benefit this herd, such measures would likely not curtail this herd's current rapid decline and may take decades for a population response to be realised. As such, alternative immediate measures like predator management could benefit this herd in the short-term, and help avoid herd extirpation, especially if such actions are concurrent with habitat protection and restoration, as well as alternate prey reduction (Hervieux et al. 2014) and with specific regard to the Itcha-Ilgachuz caribou, the reduction or closure of the legal harvest.

1.1 Predator management and ungulate prey dynamics

Predator management in North America was historically implemented in response to livestock depredation conflict and as an early wildlife management tool for enhancing ungulate prey populations for human harvest (Reynolds and Trapper, 1996, Baker et al. 2008). Predator management during the early 20th Century was focused on eradicating certain species, especially wolves, from large portions of their range (Mech and Boitani 2003). Today, large scale predator eradication programs are less socially acceptable and management actions are primarily applied to stabilize and recover populations of certain threatened species currently experiencing unsustainable levels of predation (Wittmer et al. 2013, Hervieux et al. 2014, DeMars and Serrouya, 2018). While predator management is often contentious, the successful recovery of threatened species has occurred where populations of their primary predators have been reduced significantly, as documented with some threatened caribou populations where wolf removal has occurred (Hayes et al. 2003).

As a wildlife management tool, a primary objective of predator management is to stabilize and/or recover declining ungulate populations at risk of extirpation. Where sympatric predator populations have been reduced, ungulate population recovery can be measured by observed increases in juvenile recruitment rates and increased adult female survival. Both of these demographic parameters are considered to exert the greatest limiting influence on ungulate population dynamics (Gaillard et at. 2000; DeMars and Serrouya2018). In western North America, the primary predators of adult ungulate species are wolves and cougars (Mech and Peterson 2003) while the primary cause of ungulate calf mortality is often species-specific and for most caribou populations, not well understood. Aside from wolf and cougar predation, black bears (*Ursus americanus*), grizzly bears *(Ursus arctos horribilis*), wolverine (*Gulo gulo*), coyotes (*Canis latrans*), lynx (*Lynx Canadensis*) and golden eagles (*Aquila chrysaetos*) have been shown to apply strong effects on neonate ungulate survival, including for caribou (Zager and Beechman 2006, Gustine et al. 2006; Barnowe-Meyer et al. 2010, Nieminen et al. 2011). In the absence of major predators or high levels of human harvest, caribou populations in Scandinavia generally increase until their populations become regulated by density-dependent competition for food (Skogland 1985, Seip 1991).

To justify the initiation of a predator management program, a prerequisite prior to any removal action is the need to acquire scientifically defensible reasoning for implementing predator management. Obtaining reliable information on predator densities sympatric with a target recovery species' range, as well as measuring the direct impacts of this overlap, ensure that the decision making process for initiating predator management are scientifically defensible and the probability of recovery is high. From review of predator management programs undertaken throughout North America, several conclusions can help inform and guide wildlife managers considering management action to recover threatened ungulate populations. The following conclusions were reached by the Committee on Management of Wolf and Bear Populations in Alaska (National Research Council 1997) and further developed by McLaren (2016) and DeMars & Serrouya (2018) and include;

1. Active Predator management requires strong indicators that predation is a major limiting factor in the focal ungulate population.

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2. Management actions will be most effective when targeted towards the predator(s) species with the largest demographic effect on ungulate population dynamics. As noted by DeMars & Serrouya (2018), in multi-predator systems, obtaining this information can be challenging as the effects of different predators may be additive or compensatory (e.g. Valkenburg et al. 2004).
3. The efficacy of predator management is multi-faceted, and depends on the intensity, duration and spatial scale of predator removals.
4. The effects of predator management have a high probability of being short-term, especially if underlying causes of high predator populations are not addressed, such as landscape level alterations and disturbances that influence predator population growth and distribution.
5. The evaluation of success for predator management requires thorough experimental design and an adaptive management approach which incorporates consistent predator and focal prey species population monitoring, as well as alternate prey monitoring. Ideally, a before-after-control impact design should be used to control for confounding factors such as annual variations in weather and prey abundances.
6. Predator management is often a contentious issue among the public. To prevent the erosion of social acceptance, predator management should not be designed as a long-term solution for recovering a focal ungulate population and the underlying causes of high predator populations need to be addressed.

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2 Species specific impacts on caribou populations

While caribou predators vary regionally (wolf, grizzly bear, black bear, cougar, coyote), predation impacts on woodland caribou populations have increased primarily in response to three dominant processes: apparent competition mediated by primary prey hyperabundance (Hebblewhite et al. 2007), apparent competition facilitated by expanding primary prey distribution (Wittmer et al. 2007, DeCesare et al. 2010, Latham et al. 2011a), and enhanced predator access to woodland caribou habitat (James and Stuart-Smith 2000, Latham et al. 2011b).

2.1 Wolves

In many northern ecosystems where caribou are an important food resource for wolves (Bergerud 1983, Gauthier and Theberge 1986), wolf predation can be an important population limiting factor for caribou (Bergerud 1980, Gasaway et al 1983, Bergerud and Elliot 1996, Seip 1991, Boertje et al 1996). In trying to assess whether wolves are controlling a prey population, however, it is important to understand the extent to which wolf predation is compensatory (Errington 1967) to other mortality factors and the extent to which it is additive (Mech and Peterson 2003). While wolves can contribute to limiting the growth of their prey populations, it is also clear that they do not always hold prey populations down (Mech and Peterson 2003). Instances where prey populations have increased, despite the presence of wolves, include moose on Isle Royale (Peterson et al 1998), deer in northwestern Minnesota (Nelson and Mech, 2000) and caribou in Denali National Park (Adams and Dale 1998, Mech et al, 1998).

Nevertheless, research examining wolf-caribou dynamics in western Canada has shown that woodland caribou declines are related to a strong numerical response by wolves and subsequent increased predation rates on caribou, as a direct response to higher primary prey densities (Seip 1992, Hebblewhite et

al. 2007). Wolf management actions in Canada have included aerial shooting, trapping, poisoning and sterilising breeding pairs (Hayes et al 2003) as well as the reduction of primary prey species, such as moose (Serrouya et al 2017). A positive numerical response in ungulate prey populations has been documented after wolf control efforts have been initiated, at least in the short-term (Hayes et al 2003, Valkenburg et al 2014). For woodland caribou, to achieve the long-term recovery of this species, research has suggested that wolf management actions would be most successful when combined with effective habitat conservation and long-term planning to affect the recovery of caribou (Hervieux et al 2014). The degree to which a threatened prey species responds to wolf management also depends on the spatiotemporal scale and intensity of wolf management actions (Hervieux et al 2014, Boertje et al 2017, Serrouya et al 2017).

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Wolf population size has been correlated with population growth rates of caribou (Bergerud 1996) and research examining wolf-caribou dynamics has shown wolf densities greater than 6.5 wolves/1000km^2 will lead to woodland caribou declines (Bergerud and Elliot 1986, Serrouya et al 2016). The federal recovery strategy for caribou, however, identifies < 3 wolves/1000 km^2 as a target (Environment Canada 2014). Caribou populations in northern British Columbia have been shown to decline when wolf densities ranged between 9–10 wolves/1000km^2 but increased when wolf densities were in the range of 1–4 wolves/1000km^2 (Bergerud and Elliot 1986). Wilson (2009) recommended that wolf densities for woodland caribou in the Southern Group be managed to < 1.5 wolves/1000 km^2 to generate a significant, positive response by southern mountain caribou. Similarly Hebblewhite et al. (2007) suggested that subpopulations of caribou in Jasper National Park are likely to persist when wolf densities are below 2.1-4.3 wolves/1000 km^2. In the absence of research defining a maximum density of wolves needed to enable recovery across all southern mountain woodland caribou Local Population Units (LPUs), Environment Canada has recommended a density of < 3 wolves/1000 km^2 based on a combination of Wilson (2009) and Hebblewhite et al. (2007). 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.

In British Columbia, wolves were historically managed through a regulated bounty program which led to very low numbers of wolves across the province until the bounty program was abandoned in 1955 and wolf numbers subsequently increased along with this species spatial distribution across the province (Wilson 2012). Today wolves are a widespread and abundant species in BC and management actions are primarily undertaken to reduce local wolf populations in order to curtail and reserve the decline of certain threatened prey species, especially caribou (Wilson, 2014, Hervieux et al 2014).

2.2 Cougars

In southern British Columbia, research has identified cougars as a major caribou predator (Wittmer et al. 2005), while there are only rare reports of cougar predation on caribou in northern British Columbia. In general, however, information regarding cougar-caribou dynamics is limited. One study examining how cougar populations interact with various caribou sub-populations in the Columbia Mountains of British Columbia, reported that caribou comprised only a small proportion of the cougars diet with only 3 caribou kills out of 101 total kills documented (Bird et al, 2010). The authors noted that it was difficult to make conclusive inferences on the relationship between cougars and caribou, as caribou decline and extirpation had already occurred within their study area and the sample size of monitored GPS collared cougars was

small, with only 3 cougars collared (Bird et al. 2010). The authors reported that despite the low predation rates on caribou in their study area, such predation rates could potentially be enough to negatively impact small caribou populations if primary prey populations are not reduced. Research has shown that just one specialist cougar can have significant impacts on small ungulate populations, as previously observed in mountain sheep populations once a prey search image is developed (Fest-Bianchet et al. 2006).

DeMars and Serrouya (2018) reviewed three predator management programs which included the lethal control of cougars and reported that two of the three control programs were undertaken concurrently with bear or coyote removal (White et al. 2010, Hurley et al 2011). Results from cougar control in all three reviewed studies reported increased offspring survival or juvenile recruitment in the targeted ungulate population and two of these studies also reported positive effects on adult female survival.

2.3 Bears

Both grizzly and black bears predate woodland caribou (Seip 1992) and both species are considered a primary predator of ungulate neonates that can negatively impact ungulate demographic parameters and impose substantive losses on caribou recruitment (Young and McCabe 1997, Zager and Beecham 2006, Pinard et al 2012, Brockman et al 2017). Both bear species also frequently use early-seral stage pre-forest communities for foraging, often 20-50 years post-disturbance (Zager et al. 1983, Hamer 1996, Mace et al. 1996, McLellan and Hovery, 2001). However, as omnivorous species with individual dietary variation, bears generally have less dependence on ungulate prey (Edwards et al. 2010). Due to their seasonality and/or low predation rate and dependence on caribou as food, active management to increase ungulate populations, including for caribou has not been as common as it has been for wolves. Teel et al (2002) also suggested that there may be lower social acceptance for active bear control when compared to wolf control. Increases in ungulate neonate survival and/or calf recruitment has been documented after bear control, however, but the effectiveness of bear control seems to be influenced by the intensity, duration and spatial scale of treatment (Mosnier et al. 2008, DeMars and Serrouya, 2018).

2.4 Other Predators

Other predators such as wolverine, coyote and Golden Eagle have been documented preying on caribou, especially neonates (Crete and Desrosiers, 1995, Gustine et al 2006, Nieminen et al 2011). In northern British Columbia, researchers comparing predation risk, calf survival rates and habitat characteristics among three different caribou calving areas, documented wolverines as the primary predator of caribou neonates less than 14 days old (Gustine et al 2006). In Scandinavia, wolverines are also known to prey on semi-domesticated reindeer (*Rangifer tarandus tarandus*) calves and have been documented killing adult reindeer (Landa et al. 1997, Nieminen et al 2011). Coyotes can also be an important predator on caribou calves (Crete and Desrosiers, 1995, Boisjoly et al 2010, Bastille-Rousseau, 2018), especially when combined with predation rates on adult and/or calf by other caribou predators such as wolves and bears (Wittmer et al, 2005, Pincard et al 2012, Latham et al 2013). Golden Eagles are also known to prey on caribou calves (Adams et al 1995, Nieminen et al 2011) and in rare instances, have also been documented killing adults as observed in Norway with semi-domestic reindeer (Nybakk et al 1999).

As noted by DeMars and Serrouya (2018), examples of active management for wolverines and coyotes are limited. While information on the effect of wolverine and coyote active management to support caribou calf survival is lacking, research investigating ungulate offspring survival and juvenile recruitment following coyote control efforts have had mixed results (DeMars and Serrouya 2018). Information on the lethal removal of Golden Eagles to support ungulate calf survival and juvenile recruitment is also lacking.

3 Status of the Itcha-Ilgachuz caribou herd

The Itcha-Ilgachuz caribou have been monitored regularly by regional biologists since 1977. At that time, the population estimate was 350 caribou. Since 1977 the herd steadily increased in size to its estimated population peak of 2800 caribou in 2003 (Freeman 2010, Figure 1). In 2004 population estimates for the Itcha-Ilgachuz caribou began to decline, and have continued to decline to the present day (Freeman 2010, Youds et al. 2011, Dodd 2017). The 2007 post-calving survey estimated 2100 caribou in this population, representing a 17% decrease from the 2003 survey. Poor survey conditions contributed to the low count in 2007 (Roorda and Dielman 2007). However, subsequent follow-up surveys under ideal conditions in 2009 and 2012 resulted in population estimates of 2150 and 1600 caribou, respectively. The 2007 and 2009 survey results found stable female numbers but declining calf, bull and yearling numbers relative to 2002–03. Recently, the 2018 post-calving survey estimated 637 caribou, a decline of 77% since its population peak in 2003 and the population trend over the past 3 years has been declining at an average of 17 %.

Caribou populations generally increase when annual recruitment rates exceed the 15-16% required to balance natural adult mortality and maintain population stability (Bergerud, 1992). Between 1996 and 2003, calf recruitment for the Itcha-Ilgachuz herd averaged 25.8% in June while late winter (annual) recruitment was 17.0%. During this period survey effectiveness was improved through more extensive search and having radio-collared animals. Both real population increases and more thorough surveys contributed to higher population estimates. Calf recruitment for the Itcha-Ilgachuz caribou has remained below population replacement levels since 2004. While spring calves estimates (estimated from June aerial surveys) have remained relatively high from the 1990s to 2017, a sharp reduction in late winter calf percentages from 2002-2016 suggests that a reduction in recruitment is contributing to overall population declines. The percent of spring calves in June 2018, however, dropped by 17%, from 27% to 10%. Considering that calf recruitment has been below replacement level despite high spring calf numbers between 2002-2016, the significantly lower number of spring calves in 2018 may result in reproductive failure for the herd for the 2018-2019 year (per comms Carolyn Shores, FLNRORD).

Consistent with other research examining woodland caribou mortality (Bergerud, 1992, Wittmer et al. 2013) predation is considered to be the proximate cause in the observed decline of the Itcha-Ilgachuz caribou, with wolves considered to be the primary predator responsible for herd decline (McNay and Cichowski, 2015). In 2012-14, adult female mortality was 8.7% and 33.3% in 2013–2014 (McNay and Cichowski 2015). Data on adult mortality is based on radio-collared caribou studies conducted during four study periods: mid to late 1980's, mid 1990s to early 2000s, 2011-2015 and 2018 to present. In early 2018, 50 GPS radio-collars were deployed on this herd in an attempt to better understand cause specific mortality as well as to assist with more reliable population inventory. For the Itcha-Ilgachuz caribou, the primary

known cause of mortality has been wolf predation, which makes up at least 33.3% (n=7) of known mortalities (n=21) (Table 1), and up to 42.8%, if probable wolf predations (n=2) are included. Determining known causes of mortality for this herd has been challenging, however, as "rapid response" mortality investigations were not a study priority in earlier radio-collaring studies for this herd.

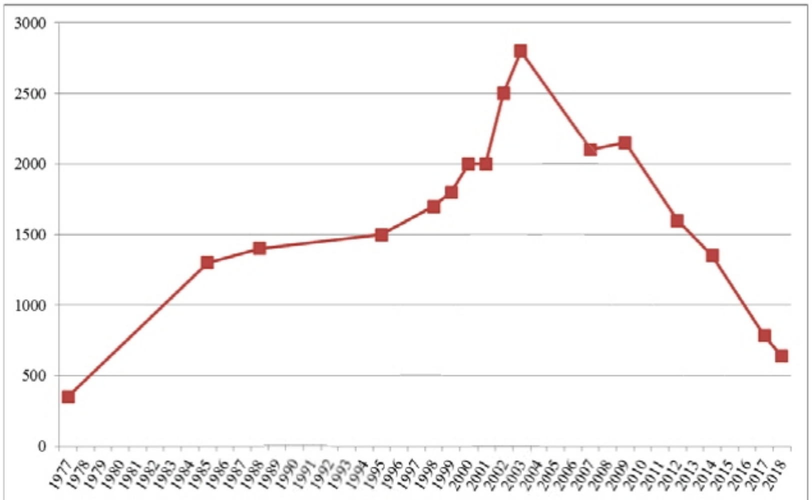

Figure 1. Sightability-corrected population estimates from 1977-2018 for the Itcha-Ilgachuz subpopulation of northern mountain caribou. Population estimates are derived from June post-calving surveys. The population estimate is calculated by applying a sightability correction factor based on the number of collared animals seen to the number of animals counted in the aerial survey.

Table 1. Causes of mortality of radio-collared Itcha-Ilgachuz caribou. Mortalities compiled from McNay and Cichowski 2015 and from mortality investigation forms done by Cariboo regional biologists from 2015-2018.

Cause of mortality	1985-88	1995-2003	2011-14	2018	Total	% of known and probable mortalities
Predation - Wolf	3	3		1	7	33.3
Predation - Cougar			1	1	2	9.5
Predation - Bear					0	0
Predation - Wolverine					0	0
Accident		1			1	4.7
Hunting		1	1		2	9.5
Poaching	1				1	4.7
Hunting or Poaching			1		1	4.7
Probable bear predation	1			1	1	4.7
Probable wolf predation				2	2	9.5
Probable poaching			1		1	4.7
Unknown - not predator-related	1	1		1	3	14.2
Unknown		8	10	1	19	NA
Total	6	14	14	7	41	NA

4 Status of predator populations in the Chilcotin Plateau

In an attempt to better understand the potential impact that predators, especially wolves, have on the Itcha-Ilgachuz caribou subpopulation, McNay and Cichowski (2015) undertook an assessment of wolf predation and management options in the Itcha-Ilgachuz caribou herd area. Existing data and reports regarding wolves, caribou, and wolf primary prey in the Itcha-Ilgachuz area were compiled and included hunter harvest data for predators and primary prey species in management unit 5-12, where the Itcha-Ilgachuz caribou range is located.

4.1 Wolves

In the Cariboo region a wolf population estimate based on combined estimates of published wolf density and range estimates, as well as prey biomass, reports between 550 - 1,250 individual wolves across the entire region (Wilson, 2014). However, reliable information on wolf populations overlapping the Itcha-Ilgachuz area is limited (McNay and Cichowski 2015). Data from both resident and non-resident harvest of wolves in MU 5-12 has not shown a general trend in wolf abundance with a very variable harvest estimate for wolves since 1975 (McNay and Cichowski, 2015). Despite a "no bag limit" for wolves introduced in 2012 for MU 5-12, estimated wolf harvest has not significantly increased, although there is no requirement to report wolf harvest in MU 5-12. In general, however, wolf harvest in the Cariboo Region is considerably higher than in regions further south, possibly due to larger wolf populations (Wilson, 2012). A poison bait program for wolves occurred in the mid to late 1990s, but data on the number of wolves killed as well as where and for how long this poisoning program lasted is lacking (McNay and Cichowski, 2015). Data from radio-collared wolves in the Chilcotin Plateau is also limited, with collars deployed on just four wolves overlapping Itcha-Ilgachuz caribou range. GPS collars ~~were~~ deployed on two wolves were monitored from 2012 to 2014. Movement data from these wolves showed overlap with winter habitat utilized by collared caribou in all years. VHF collars deployed on two wolves in the late 1990s also showed wolf distribution overlapping Itcha-Ilgachuz caribou habitat, including portions of their summer range in the Ilgachuz Mountains.

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Density estimates for wolves and pack distribution is also lacking in MU 5-12. In January 2017, an aerial wolf survey in MU 5-12 was undertaken by Cooper Beauchesne and Associates LTD, contracted by BC Ministry of FLNRO to estimate wolf density in this area. This wolf census followed established protocols developed for surveying wolves in areas of low topographic relief with expanses of flat heavily forested terrain (Serrouya et al. 2015). Based on locating wolf tracks and subsequent track splitting, a wolf density of 5-6 – 7.6 wolves per 1000 km^2, in seven packs, was estimated over four days of flying and within a 4,231 km^2 survey area (Figure 2). While the maximum wolf density estimate of 7.6 wolves/1000km^2 is above the 6.5 wolves/1000km^2 wolf density identified as influencing caribou population decline (Bergerud and Elliot 1986), this estimate is less reliable than the minimum density estimate of 5.6 wolves /1000km^2, which is more objective. However, both density estimates are above the ECCC recommendation of <3 wolves/1000km^2 in critical caribou habitat. 24 to 32 wolves were detected in the SBPSxc subzone (Sub-Boreal Pine-Spruce; very dry cold) based on track interpretation and no visual detections of wolves were observed. The contractor defined a pack as a minimum of one animal, which is not typical for wolf studies. If the standard definition of 2 wolves to form a pack is used (Fuller 2003), then 6 wolf packs, rather than 7, were detected in the survey area. The contractors also described their survey as an "initial exploration," and recommended investing in a wolf-collaring program to validate the wolf census with sightability correction factors.

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Figure 2. Wolf pack detections from the 2017 aerial wolf survey. The red polygons represent the extent of tracks detected for each group, but do not represent the much larger territory size of each pack. Number indicates pack ID.

Prior to the 2017 aerial wolf census, a winter track transect in the West Chilcotin was undertaken in the winter of 2009-10 (Davis 2009). This survey did not yield density estimates for wolves in MU 5-12. An attempted aerial survey of wolves in and around the Itcha-Ilgachuz Mountains in 1999 was also unsuccessful due to large expanses of heavily forested terrain, limited open waterways in which to track, and poor survey conditions (Roorda and Dielman 2007). The distribution of wolves in the southern part of the Itcha-Ilgachuz herd range as reported by the 2017 wolf census and GPS collar data suggests that wolves occur throughout seasonal caribou range, including in alpine caribou calving habitat during June post-calving surveys.

4.2 Cougars

Cougar densities respond positively to increased prey densities, especially deer, and cougar populations generally vary in response to habitat features and current and past exploitation (Logan and Sweanor 2001). Reliable information on cougars in the Itcha-Ilgachuz area is limited with no standardised inventory undertaken for this species in MU 5-12, or elsewhere in the Cariboo Region. Anecdotal reports of increased cougar activity in the Anahim/Nimpo Lake area has been reported by local residents in recent years (McNay and Cichowski, 2015). There is an open season for cougars in MU 5-12 with a bag limit of 2.

In the Cariboo Region, a cougar population estimate based on reported cougar kill locations and habitat capability for supporting deer estimated between 900-1200 cougars (Wilson, 2011). However, cougars are not common in the Itcha-Ilgachuz caribou subpopulation range(Spalding 1994). A recent (March 2018) mortality of a radio-collared Itcha-Ilgachuz bull caribou was confirmed as a cougar kill (Figure 3). A cougar DNA mark-recapture population estimate study near William's Lake is currently planned for the winter of 2018/19. Results from this study may help to inform the feasibility of conducting a similar cougar population or diet study on the Chilcotin plateau.

Figure 3. March 2018 radio-collared bull mortality site. Left photo: Caribou carcass partially covered in its own hair. Right photo: cougar tracks leading away from the caribou carcass (Shane White, FLNRORD).

4.3 Bears

Both grizzly bears and black bears are present in the Itcha-Ilgachuz subpopulation range. Both bear species have been shown to reduce caribou calf recruitment and contribute to adult caribou mortality (Adams et al. 1995, Wittmer et al. 2005, Bastille-Rousseau et al. 2016, Lewis et al. 2017). Although predation rates for grizzly bears have not been determined, their density in the Itcha-Ilgachuz range was estimated to be 9/1000 km^2 in 2004 and 2008 (Hamilton et al. 2004). However the 2012 estimate fell to 2.6/1000 km^2, falling to threatened status provincially (Griffiths 2012). There is no reliable information on black bear trends in the Chilcotin area, including MU 5-12 (McNay and Cichowski 2015). There is a bag limit of 2 and an open season for black bears in MU 5-12. In late 2017, the BC Government announced the closure of grizzly bear hunting by resident and non-resident hunters throughout British Columbia. Grizzly bears can still be harvested by First Nations pursuant to Aboriginal rights for food, social or ceremonial purposes or treaty rights, although the harvest in MU 5-12 is thought to be very low.

4.4 Other Predators

As with the primary predators of caribou in the Chilcotin Plateau, there is a general lack of direct information on the abundance, general trends and distribution of secondary predators of caribou, such as wolverines, coyotes and Golden Eagles in MU 5-12. Harvest for coyotes is open season with no bag limit throughout the Cariboo Region and wolverines can be legally trapped from November 1st to January 31st. Golden Eagles are also present in the Itcha-Ilgachuz caribou range and while not currently designated as a species at risk, populations in areas of Canada are declining and this species is protected under Section 34 of the Wildlife Act. Active management actions for Golden Eagle would likely be much less socially acceptable than control actions for other caribou predators. Lethal control of Golden Eagles would also be very challenging due to this species legal status, the lack of reliable information on its interactions with caribou in British Columbia and less social acceptance for management actions.

4.5 Conclusions

Consistent with other declining woodland caribou populations across western North America (Seip 1992, Hayes et al 2003, Wittmer et al. 2005) wolf predation is considered to be the primary cause of adult mortality in the Itcha-Ilgachuz caribou herd (McNay and Cichowski, 2015). While there is generally a lack of direct information regarding how wolves are interacting with caribou in the Itcha-Ilgachuz area, of the documented known mortalities for adult collared caribou in the Itcha-Ilgachuz herd (n=21), wolf predation has been confirmed as the proximate cause of death for 7 adult caribou and probable for a further 2 adult caribou. Wolf predation is currently the primary cause of known mortality for radio-collared caribou in this herd. However, it is difficult to make conclusive inferences as the sample size for confirmed wolf predation is small. Acquiring more reliable information on both the wolf density and pack distribution sympatric with the Itcha-Ilgachuz subpopulation is important to infer the potential predation effects on this herd and to support management actions such as wolf reduction. In addition, calf recruitment appears to be the driving cause of decline for this herd, and the primary cause of calf mortality is unknown. Wolves are potential caribou calf predators but other predators, disease and nutritional limitation may also be factors contributing to low calf recruitment.

For the Itcha-Ilgachuz caribou herd, potential predator management action should be intensive and occur over a large spatiotemporal scale and undertaken concurrently with other measures such as habitat protection, the reduction/closure of the legal harvest of bull caribou and continued monitoring and potential reduction of alternate prey densities, especially moose. To better understand predator-prey dynamics in the Itcha-Ilgachuz range, it will be important to monitor the wolf population size and range overlapping caribou habitat seasonally. This could be achieved by maintaining a sample of radio-collared wolves in MU 5-12 and monitoring their seasonal movements and pack size. Furthermore, to determine the effectiveness of wolf removal it is essential to maintain a sample of radio-collared adult caribou to continue to reliably estimate population trends and determine juvenile recruitment before and after potential wolf control. Percent calves in late winter surveys and population change will be used as metrics of success to determine the efficacy of wolf removal.

5 Management Recommendations

Decisions influencing the implementation of a predator management program can be complex. To aid wildlife managers in the decision making process, the development of tools such as decision matrices and prioritization tables can be of significant benefit to help inform and guide wildlife managers considering predator management in aid of caribou population recovery. In British Columbia, the Provincial Caribou Science Team, composed of government caribou biologists and managers from across the Province, met in June 2018 to develop the framework for a predator management decision matrix (Figure 4). This decision matrix includes decision points that require wildlife managers to address population parameters for a target caribou population. The first step is determining whether a caribou herd is at or below the population objectives. Once determined, questions regarding herd viability with or without predator management must be addressed, followed by the availability of reliable data to identify the primary predator limiting the population. Finally, the status of the primary predator itself and if this species is sensitive to control actions is addressed. The science committee recommended that a herd prioritization table is also developed to determine priority herds for wolf removal.

For the Itcha-Ilgachuz caribou herd, acquiring scientifically defensible information regarding predator-prey dynamics is important to support a scientifically based rationale for implementing predator management programs, especially to evaluate the third decision point in the predator management decision matrix on whether there is sufficient information to determine that predation is limiting the population. Specifically, more information on wolf density, spatial overlap between wolves and caribou, and wolf predation rates on caribou would support the decision matrix process. Also, prior to active predator management measures, due to the high intensity, multi-year wolf removal efforts required to achieve caribou herd population increases (Hayes et al 2003), the implementation of a wolf control program should only occur if adequate financial support is guaranteed over a timeframe of at least 4 years for intensive removal and the simultaneous monitoring of the Itcha-Ilgachuz caribou to evaluate the success of predator removal. Calf recruitment and sightability corrected population estimates for the herd, which will be used to determine lambda, or the rate and direction of population change, will be used as metrics of success. Population objectives for caribou herds must also be established to guide decisions around ending predator management and the ultimate cause of the herd's decline, habitat loss, must also be addressed.

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Currently, following the decision matrix table, there is adequate information regarding the proximate decline of Itcha-Ilgachuz caribou to support active predator management practices such as wolf reduction, although more information on wolf caribou dynamics would be of value to address decision point three, on whether predation is limiting the population. This information to support wolf removal is the following: 1) the herd is in steep decline and calf recruitment is far below population replacement, 2) wolf predation is the leading cause of adult mortality and 3) the density of wolves in caribou critical habitat is above the ECCC recommendation of <3 wolves per/1000km^2. To address information gaps on wolf-caribou dynamics in the Chilcotin Plateau, as well as evaluate predation effects in the Itcha-Ilgachuz range, multi-faceted management actions are required. These include; determining wolf population parameters in MU 5-12, radio-collaring wolf packs with spatial overlap of the Itcha-Ilgachuz herd, maintaining a sample size of radio-collared Itcha-Ilgachuz caribou and potential lethal control of wolf populations (in the most humane method possible) in and adjacent to Itcha-Ilgachuz caribou range.

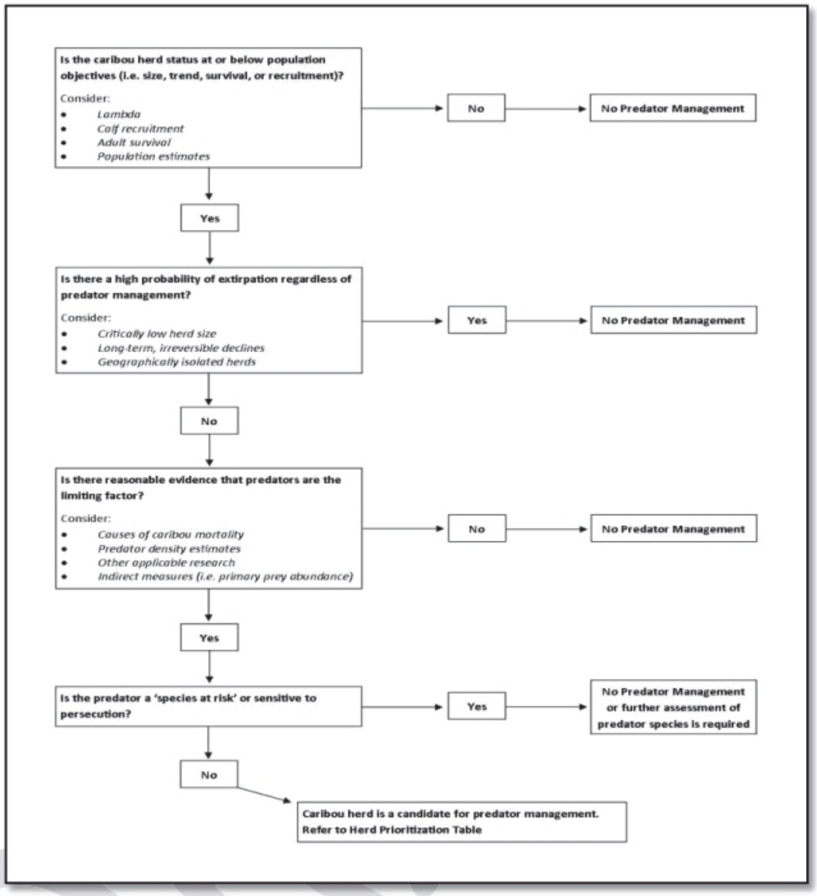

Figure 4. Predator management Decision Matrix flow chart developed by Provincial caribou biologists

5.1 Determining wolf population parameters in MU 5-12

Acquiring reliable density estimates for wolves can be especially challenging due to this species large territory size, their ability to travel extensively when hunting and their highly variable movement patterns which is dependent on pack size, availability of prey species and seasonality (Ballard et al 1987). However, in the boreal plains, winter aerial transect surveys have effectively estimated wolf populations, often in areas with dense forest cover (Serrouya et al. 2015). While a winter aerial wolf census using the survey method developed by Serrouya et al (2015) was undertaken in MU 5-12 in January 2017, this census was limited by logistical constraints such as fuel (Gill and van Oort, 2017). Furthermore, wolf density estimates are more reliable if a sample of radio-collared wolves is maintained in the population and at the time of the 2017 aerial wolf census, no GPS radio-collared wolves were present in the survey area.

To better assess wolf-caribou dynamics in MU 5-12, the initiation of an annual wolf monitoring program to determine wolf population size and distribution in the Itcha-Ilgachuz range will allow for reliable inferences to be made in assessing the potential predation effects by wolves on Itcha-Ilgachuz caribou and support potential wolf control. Aerial wolf surveys should be undertaken at least once a year starting in the winter of 2019 and continuing over the course of active predator management. Aerial wolf surveys should occur in January or February when wolf packs are more cohesive and before the breeding season in March (Packard, 2003). Wolf aerial censuses should follow existing protocols for heavily forested areas (see Serrouya et al 2015) with the survey area stratified into belt transect routes to maximize the detection of wolf tracks, relative to cost. Wolf surveys should focus primarily in the SBPS zone (sub-boreal pine-spruce), previously identified in MU 5-12 as important wolf habitat (Gill and van Oort, 2017). Aerial monitoring of wolves during the summer months, without the presence of snow to detect and follow wolf tracks, is more logistically challenging, as are ground based methods such as wolf scat and tracks surveys, which have been used elsewhere in British Columbia to infer relative abundance of wolves (Hatter 1988, Atkinson and Janz 1994). The potential use of trained field technicians/volunteers, as implemented successfully elsewhere (see http://fwp.mt.gov/fishAndWildlife/management/wolf/), could be a reliable approach for monitoring wolf populations in MU 5-12, allowing for pack distribution and pack size to be determined using camera trapping methods. Experienced volunteers could also implement ground trapping to radio-collar wolves and investigate wolf GPS location cluster sites, as well as responding to caribou mortality notifications if logistically feasible. Funding to support such a ground based volunteer wolf program would, however, need to be secured.

5.2 Radio-collaring wolves overlapping Itcha-Ilgachuz caribou range

Understanding caribou-wolf dynamics and habitat selection by wolves within and adjacent to the Itcha-Ilgachuz range will require a sample of GPS collars on both species. In their assessment of wolf management options in MU 5-12, McNay and Cichowski (2015) also recommended radio-collaring wolves to determine pack structure and range. As outlined above, maintaining a sample of radio-collared wolves will permit more precise population estimates for wolves in MU 5-12 and allow for wolves to be effectively located and removed from the population if control actions are considered necessary to curtail the current sharp decline of Itcha-Ilgachuz caribou. Evaluating wolf seasonal habitat selection will be also valuable in evaluating predation risk for Itcha-Ilgachuz caribou. At least 1-2 GPS radio-collars should be deployed on each wolf pack in the Itcha-Ilgachuz range during the Winter 2018/19. Ideally the collars should be programmed to receive at least 8 fixes a day. The newer generation of GPS radio-collars are cost effective and the number of fixes can be programmed remotely with Iridium 2-way satellite communication. Higher fix rate collars will allow wildlife managers to determine wolf pack distribution, size and home range overlap with caribou habitat as well as more effective location of collared wolf packs for removal.

5.3 Maintaining a sample of GPS radio-collared Itcha-Ilgachuz caribou

Studies have suggested that maintaining a sample size of 20-25 radio-collared caribou per year is sufficient to reliably monitor population trends and estimate survival rates (White and Garrott, 1990, Hervieux et al 2013, Serrouya et al 2017). Currently, 39 functional GPS radio-collars are deployed on female and male caribou in Itcha-Ilgachuz herd, programmed to record 1-2 GPS locations per day. These collars also transmit mortality notifications via satellite once the collar switches to mortality mode, allowing for cause of mortality to be determined and thus providing strong inferences on predation effects (DeMars and Serrouya 2018). The effectiveness of determining cause-specific mortality for radio-collared animals requires site investigations immediately following the death of a collared animal. Newer generations of GPS radio-collars are cost effective and often designed for survival studies and allow for "rapid response" mortality investigations. 50 radio-collars were initially deployed on the Itcha-Ilgachuz herd in March 2018, seven of which have already been retrieved from caribou mortality investigations and four of which are no longer transmitting location data. In maintaining a sample of radio-collared caribou, our ability to reliably monitor caribou population trends will improve (DeCesare et al 2012), and estimating important demographic parameters such as female survival and juvenile recruitment will be feasible. Continued monitoring of the Itcha-Ilgachuz herd demographics should continue for at least 5 years following wolf control.

5.4 Ethical reduction of wolf populations in MU 5-12

The reduction of wolf populations is a contentious issue and has been for decades (Cluff and Murray 1995). In Canada, wolf control programs aimed at recovering threatened caribou have attracted significant media attention with ethical and legal questions raised concerning wolf reduction actions (Brook et al 2015). Nonetheless, managing wolves to recover threatened woodland caribou is an effective science based, legal and ethical management tool (Herviuex et al 2014, Herviuex et al 2015). Direct removal of wolves using aerial gunning to recover caribou populations is currently being undertaken in British Columbia, with control actions for caribou populations being implemented in the South Selkirk, Columbia North and South Peace. In 2017/2018 151 wolves were removed from eight caribou herd areas, with a total wolf control program cost of $593,333. In the Cariboo Region, a pilot wolf reduction program was implemented to reduce wolf densities for Mountain Caribou recovery in the Quesnel Highland Planning Unit (Roorda and Wright 2012). Helicopter net-gunning combined with ground trapping was successfully used to capture, and subsequently surgically sterilize dominant wolves, in an attempt to reduce wolf recruitment while maintaining stable pack territories (Hayes et al. 2003, Roorda and Wright 2012). Wolf removals from the population also occurred, but sterilization alone was found to be sufficient in maintaining wolves at low densities (Hayes 2013). A correlation between reduced wolf densities and caribou recovery in the Quesnel Highlands was not substantiated (Hayes 2013). McNay and Cichowski reported that sterilization reduces the wolf population by about 50%, which may not reduce wolf densities to the <3 wolves/1000 km^2 needed to maintain caribou, given the 2017 wolf density estimate of 5.6 – 7 wolves/1000 km^2 in the Itcha-Ilgachuz herd's critical habitat.

The most effective and humane method of reducing wolf populations is aerial gunning (Ballard et al 1997, Hayes et al 2003, Wilson 2012), likely due to the assumption of a quick kill (McNay and Cichowski, 2015), although there are criticisms regarding this technique (Brook et al 2015). For the Itcha-Ilgachuz caribou, if evidence continues to make strong inferences as to predation effects from wolves, an aerial wolf control program should be implemented using experienced aerial gunners. Population targets for wolf densities should be less than 3 wolves/1000 km^2 a target that the federal recovery strategy for caribou has identified as eliciting a positive population response in caribou (Environment Canada 2014). Bergerud and Elliot (1998) noted that wolves quickly recolonized their study area following the conclusion of the wolf removal program in the Northern Rockies. They also noted considerable wolf recovery on an annual basis, primarily by small groups of recolonizing wolves from adjacent territories (Bergerud and Elliot, 1998). This emphasizes that wolf removal is not a sustainable long-term strategy for caribou recovery, but instead a short term recourse to prevent further population decline while long-term strategies such as habitat protection are put in place (Itcha-Ilgachuz herd recovery plan, 2018). If long-term strategies to recover the Itcha-Ilgachuz herd cannot be implemented, then serious consideration should be given as to whether to continue wolf removal. Intensive wolf removal over a period of 4-5 years is likely required to elicit a strong, positive population response in the Itcha-Ilgachuz caribou herd. Caribou calf recruitment and sightability corrected population estimates should undergo evaluation after the third winter of removal. Ongoing caribou and wolf monitoring will be necessary to determine the required frequency of wolf control. Wolf control actions implemented prior to the caribou herd reaching critically low level numbers would be most beneficial and cost-effective when considering the long-term management of this caribou herd.

Potential wolf control efforts should primarily focus within and adjacent to the Itcha-Ilgachuz caribou range (9,457 km^2; Figure 5), encompassing the Chilcotin Plateau and the Itcha-Ilgachuz Mountains in the Fraser Plateau ecoregion (Goward 2000), as well as the Dean River Corridor and low-elevation caribou winter habitat east of Anahim lake that is also used by the Itcha-Ilgachuz herd, although it is outside of their current herd boundary (Itcha-Ilgachuz caribou herd recovery plan). Based on baseline density estimates for wolves in MU 5-12 (Gill and van Oort, 2017), their findings suggest a minimum estimate of 53 wolves within or adjacent to the treatment area and a maximum estimate of 72 wolves, although further investigation into wolf population parameters in this area is warranted. Intensive aerial control of wolf populations within MU 5-12 should aim to remove a high proportion of wolves overlapping the treatment area (>80%, Hayes et al. 2003). To facilitate efficient aerial removal of wolves by experienced crew and helicopter pilots, the deployment of GPS collars on wolves will allow for quick relocation and removal and/or reduction of collared packs. Equipping a wolf pack with at least 1-2 GPS radio-collars will allow for complete pack removal later, if immediate pack removal is not feasible. The collared individuals may be removed from the pack, or left alive to facilitate wolf removal actions the following winter. Consistent with previous research (Hayes et al. 2003), to maximise the benefits of predator removal, a substantial reduction or full closure of the legal hunt of Itcha-Ilgachuz caribou should occur simultaneously with any predator control actions. Observed changes to caribou herd demographics may be evident the year following wolf control actions, but may take up to three years to have an effect.

6 Monitoring and Measures of Success

To measure the effectiveness of wolf control actions for the recovery of Itcha-Ilgachuz caribou subpopulation, maintaining population monitoring of this herd is essential to infer changes in population size and demographic trends, including juvenile recruitment and estimating adult female survival, both important demographic parameters in caribou population dynamics (DeCesare et al. 2012). Wolf control efforts must be intensive and last a minimum of 4 years, preferably 5 years. It is important to note that while wolf predation is currently likely the proximate cause of decline for the Itcha-Ilgachuz caribou herd, disturbances and loss of critical caribou habitat from timber harvesting has led to the current predator-prey system and subsequent caribou population declines. If caribou habitat degradation continues to occur, the effectiveness of wolf control will be limited (Hervieux et al 2014). Public support for wolf control to recover caribou will also likely diminish if management actions are not concurrent with habitat protection and recovery efforts. Further management actions associated with active wolf control efforts should include changing hunting regulations for alternate prey, such as moose and deer. Woodland caribou are secondary prey species for wolves (Milakovic and Parker 2011) and wolf presence, abundance and distribution will be

s.13

most likely influenced by the availability of alternate prey species, especially moose (Courbin et al 2013). Moose and deer populations overlapping the Itcha-Ilgachuz range will likely increase in abundance after predator removal, which in turn will support wolf recolonization and subsequent population increases (Bergerud and Elliot, 1986). If increases in primary prey populations are not addressed, wolf control efforts will likely become increasingly difficult and cost ineffective.

In the short-term, curtailing or reversing the declining Itcha-Ilgachuz population herd will be the most appropriate measure of success, determined through ongoing population monitoring. Monitoring the wolf population before and after removal efforts will allow wildlife managers to gauge the effectiveness of the control program. The potential deployment of a camera trapping grid in the Itcha-Ilgachuz calving areas could also fill some information gaps for this caribou herd, such as the predator-caribou interactions at this important biological season. Deploying remote cameras can be a cost effective management tool, especially if such a program occurs over a large spatiotemporal scale (Steenweg et al. 2016).

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Figure 5. Potential wolf treatment area based on the designated 9,457km^2 Itcha-Ilgachuz herd boundary. Purple points represent 2018 radio-collared caribou locations from collar deployment to date (March 2018 to September 2018).

7 Timeframe & Budget

Tentative predator management timeframe & budget

Develop wolf control program in core caribou habitat (9,457 km^2). A four phase plan, based on recommended management actions in the Itcha-Ilgachuz herd recovery plan, is outlined below. Ongoing caribou population monitoring is required throughout the wolf control program and for years after the end of the wolf removal program to determine its effectiveness.

- **Phase 1**: Collar wolves within ECCC core caribou habitat, focusing on areas of high caribou use in SBPS zone, winter 2018-19. Deploy 1-2 collars in each wolf pack.

- **Phase 2**: Monitor GPS collar data to determine wolf and caribou spatial overlap, map seasonal home ranges of wolf packs, and accurately estimate wolf density.

- **Phase 3**: Lethally remove wolves via aerial gunning. Due to the high intensity, multi-year wolf removal needed to achieve caribou herd population increases, only implement a wolf control program if funds are guaranteed for 1) intensive wolf removal for a minimum of 4 years and 2) to monitor calf recruitment and herd populations for 5 years. It is not recommended to begin a wolf control program if funds for the above are not guaranteed. Wolf removal over a similar size area in northeast BC cost $400,000/year.

- **Phase 4**: Ongoing caribou population monitoring to determine wolf removal effectiveness.

Determine if remote camera study is feasible for the Itcha-Ilgachuz caribou calving area:

- Potentially address information gaps regarding predator-caribou interactions during the calving season when neonate calves are most vulnerable to predation.

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Apply for funding to cover laboratory work on cougar and wolf scats for:

- Diet; using prey species DNA or stable isotope analyses. Data on predator diet on the Chilcotin plateau is needed to understand the role of alternate prey (feral horses, mule deer, moose) in apparent competition dynamics with caribou
- Predator population estimation with DNA mark-recapture

The rationale for wolf removal is a steeply declining caribou population (average decline of 17% per year), mortality data for the herd showing wolf predation to be the leading cause of adult mortality (33.3%), and research that shows wolves can be responsible for >30% of caribou calf mortalities (Nieminen et al. 2013). In addition, wolf removal is most effective when done for a larger herd, so it is recommended to take this management action while the herd is still relatively large. A commitment to increasing habitat protection is necessary to go forward with predator removal. Predator removal is a temporary solution that only addresses the proximate cause of the herd's decline. For long-term recovery of this herd, habitat protection is required to addresses habitat loss, the ultimate cause of the herd's decline.

BC Parks has draft policy on when predator management should occur. BC Parks provides its authorizations with the following expectations:

1) FLNRORD has a scientific basis to suggest that predators are reducing / limiting the herds referenced above, and that culling wolves is necessary to promote herd recovery;
2) The approach to heard recovery is broader than~~t~~ simply culling predators, and includes reducing other impacts, such as hunting, snowmobile activity, restoration/reclamation of industrial impacts in the identified control zones, provision of and adherence to an approved herd plan;
3) The extent of culling will balance the risk to the herds against the important role played by large predators in a natural functioning predator-prey ecosystem;
4) You have engaged and addressed any issues related to this work with key stakeholders and First Nations;
5) You will undertake this work in a manner that considers the disturbance to and safety of park visitors;
6) You are prepared to respond to any public / media interest generated by this work;
7) You will keep BC Parks apprised of and provide annual reporting for your activities and their results within the control zones.
    a. BC Parks contact (listed below in Appendix B) to be informed prior to undertaking activities within a park, or when activities may occur in a park.
    b. Annual reporting must at the least include the number:
        i. of animals destroyed by control zone, and
        ii. of animals destroyed within a park, by park, and
        iii. of animal carcasses removed by control zone, and
        iv. of animal carcasses removed from within a park, by park and
        v. location of all animals destroyed in and carcasses removed from parks, and

density of wolves by control zone.

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Table 2. Projected year 1 budget estimate for wolf and Itcha-Ilgachuz management

Wolf	Description	Estimate Cost
Wolf collar purchase*	s.17	$36,000 - $44,000*
Wolf Capture - Rotary		$128,000
Wolf Census		$24,000
Caribou		
Collar purchase*		$27,000
Caribou Capture		$22,400
Post-Calving Survey		$8,250
		$36,000
Late-winter Recruitment Survey		$6,600
		15,000
Equipment costs and expenses		$9000
Mortality investigations		$40,000
Total		**$352,250 – $360,250**

*Collar cost dependent on successful proponent.

Table 3. Projected annual budget estimate for year 2, 3 & 4

Wolf Removal efforts	Description	Estimate Cost
Rotary flight cost	s.17	$192,000
Fixed-wing flight cost		$16,500
Wolf collar purchase*		$10,800-$13,200
Accommodations (for three people)		$8500
Equipment costs		$1500
Total cost – wolf removal		**$229,300-$231,700**
Caribou inventory		
Caribou collars*		$27,000
Caribou capture		$22,400
Post-calving survey		$8,250
		$36,000
		$6,600
Recruitment survey		$15,000
Mortality investigations		$40,000
Total cost – Caribou monitoring		**$146,250**
Total		**$375,550-$377,950**
Additional Costs - Wolf Census Year 4		$24,000

*Collar cost dependent on successful proponent.

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From: Homstol, Lori ENV:EX
Sent: Monday, November 26, 2018 11:02 AM
To: White, Shane FLNR:EX
Cc: Nowotny, Chris ENV:EX; Michelfelder, Volker ENV:EX
Subject: BC Parks comments on Itcha Ilgachuz predator management proposal

Hi Shane,

s.13

Cheers,

Lori

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Predator Management in support of the Itcha-Ilgachuz Caribou herd

Prepared by BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Cariboo Region

November 2018

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Executive Summary

Across their Canadian range, populations of woodland caribou (*Rangifer tarandus caribou*) are in decline. Factors contributing to widespread woodland caribou population declines are multi-faceted, but increased predation rates on caribou are believed to be the proximate cause of their decline. The ultimate cause of increased predator-caribou interactions is anthropogenic disturbances leading to habitat loss, fragmentation and land use changes, which has increased apparent competition between caribou and other ungulate species. For the Itcha-Ilgachuz caribou herd in the Chilcotin Plateau of central British Columbia, increased predation rates on caribou is considered the primary direct cause of this caribou population's recent rapid decline.

Trends in the Itcha-Ilgachuz caribou population show a continuous steady rate of decline with the most recent population estimate of 637 caribou representing a 77% decline from its population peak in 2003. Similarly calf recruitment for the Itcha-Ilgachuz caribou population has remained below population replacement levels since 2004. The most recent spring calf estimate suggests there may be no recruitment in the herd for the 2018-2019 year, although late winter surveys in 2019 are needed to confirm this. While predation is considered the primary direct cause of the Itcha-Ilgachuz caribou population decline, there is a lack of reliable information on predator abundance and distribution overlapping this caribou population. This information gap is especially relevant for wolves, the primary predator of woodland caribou in northern ecosystems. An aerial wolf survey undertaken in Management Unit 5-12 overlapping a portion of winter habitat of the Itcha-Ilgachuz herd determined a wolf density in the range of 5-7 wolves per $1000km^2$, greater than the target density <3 wolves per $1000km^2$ recommended by Environment Canada to support a caribou recovery.

In response to the current steep population decline for the Itcha-Ilgachuz caribou, as well as the lack of reliable information on wolf abundance and distribution, this predator management plan outlines possible management actions for better understanding caribou-predator dynamics in the Chilcotin Plateau. Understanding that predator management actions, such as control efforts, require science-based rationale to justify implementation, this management plan reports on existing information and future methods for acquiring new information to help inform and justify potential future control actions for predators. If control efforts are to be implemented in order to curtail the declining population trend for the Itcha-Ilgachuz caribou population, a four-phased approach is outlined to assess predator-caribou dynamics, which include;

1. GPS Radio-collaring of wolves within core caribou habitat
2. Monitoring GPS collar data to determine spatial overlap & reliably estimate wolf density
3. Implement lethal removal of wolves via aerial gunning.
4. Monitor caribou population throughout all phases to determine success of predator removal.

For predator management to be ultimately successful in curtailing or reversing the current Itcha-Ilgachuz population trend, habitat protection and restoration measures as well as alternate prey reduction are also needed to address the underlying ultimate causes of caribou decline.

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1 Background

Woodland caribou have evolved with their predators and have persisted despite millennia of predation. Throughout their Canadian distribution, however, populations of woodland caribou (*Rangifer tarandus caribou*) have been declining over the past two decades. This decline has prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess the Southern Mountain population as Special Concern, which includes the Itcha-Ilgachuz herd under the Northern Mountain Caribou Designatable Unit (DU 7) (COSEWIC 2014). The widespread decline in Woodland caribou populations has been attributed to apparent competition between caribou and other ungulate species, specifically moose and mule deer (Seip, 1992, Serrouya et al. 2017). Due to changes in vegetation from human land use practices and disturbances such as logging, as well as climate change, the conversion of old growth forests to early seral habitats has supported an increase in moose and deer densities, as well as an expansion of their distribution. Subsequently, this increase in ungulate prey populations has contributed to a strong numerical response in predators, particularly for wolves (*Canis lupus*), cougars (*Puma concolor*) and bears (*Ursus sp*). A positive numerical response for these large carnivore species, has led to increased and unsustainable predation rates on caribou (Seip, 1992; Wittmer et al. 2007; Latham et al 2011a).

Against this backdrop, population surveys for the Itcha-Ilgachuz caribou have shown a dramatic population decline since this herd's population peak in 2003 (McNay & Cichowski, 2015). The Itcha-Ilgachuz caribou population are currently designated as *Threatened* in schedule 1 of the federal *Species at Risk Act*, which was fully enacted in 2003. The Itcha-Ilgachuz caribou have been regularly monitoring since 1977 with population surveys generally occurring in June, shortly after the calving period when the majority of adult female caribou are utilizing alpine habitat in the Itcha and Ilgachuz mountain ranges. Since the first population survey for this caribou population in 1977, the number of caribou increased steadily until the herd peak in 2003, when 2800 were estimated for this population. This population peak was followed by a sharp decline until 2018 when a population estimate of 637 caribou was recorded, representing a 77% population decrease from its 2003 peak. In 1985 the Itcha-Ilgachuz population was estimated as 1300 caribou, similar to the 2014 population estimate for this herd. However, since the 2014 survey this herd has declined 47.2% in just four years. In addition, in 2018 the lowest ever recorded percentage of calves in June was observed at 10%, 16% lower than the average number of calves observed in June from 1982-2017.

While predation is the proximate cause of most Itcha-Ilgachuz adult caribou mortalities, landscape level alterations to critical caribou habitat, as well as climate change, are likely the ultimate causes responsible for this herd's decline, concurrent with other woodland caribou population declines (Environment Canada, 2012). As outlined above, these landscape level changes have likely led to an increase in the primary predators of caribou, particularly wolves, overlapping the Itcha-Ilgachuz caribou range. While improving regulations for protecting caribou habitat and increasing habitat restoration efforts would greatly benefit this herd, such measures would likely not curtail this herd's current rapid decline and may take decades for a population response to be realised. As such, alternative immediate measures like predator management could benefit this herd in the short-term, and help avoid herd extirpation, especially if such actions are concurrent with habitat protection and restoration, as well as alternate prey reduction (Hervieux et al. 2014) and with specific regard to the Itcha-Ilgachuz caribou, the reduction or closure of the legal harvest.

1.1 Predator management and ungulate prey dynamics

Predator management in North America was historically implemented in response to livestock depredation conflict and as an early wildlife management tool for enhancing ungulate prey populations for human harvest (Reynolds and Trapper, 1996, Baker et al. 2008). Predator management during the early 20th Century was focused on eradicating certain species, especially wolves, from large portions of their range (Mech and Boitani 2003). Today, large scale predator eradication programs are less socially acceptable and management actions are primarily applied to stabilize and recover populations of certain threatened species currently experiencing unsustainable levels of predation (Wittmer et al. 2013, Hervieux et al. 2014, DeMars and Serrouya, 2018). While predator management is often contentious, the successful recovery of threatened species has occurred where populations of their primary predators have been reduced significantly, as documented with some threatened caribou populations where wolf removal has occurred (Hayes et al. 2003).

As a wildlife management tool, a primary objective of predator management is to stabilize and/or recover declining ungulate populations at risk of extirpation. Where sympatric predator populations have been reduced, ungulate population recovery can be measured by observed increases in juvenile recruitment rates and increased adult female survival. Both of these demographic parameters are considered to exert the greatest limiting influence on ungulate population dynamics (Gaillard et at. 2000; DeMars and Serrouya2018). In western North America, the primary predators of adult ungulate species are wolves and cougars (Mech and Peterson 2003) while the primary cause of ungulate calf mortality is often species-specific and for most caribou populations, not well understood. Aside from wolf and cougar predation, black bears (*Ursus americanus*), grizzly bears *(Ursus arctos horribilis*), wolverine (*Gulo gulo*), coyotes (*Canis latrans*), lynx (*Lynx Canadensis*) and golden eagles (*Aquila chrysaetos*) have been shown to apply strong effects on neonate ungulate survival, including for caribou (Zager and Beechman 2006, Gustine et al. 2006; Barnowe-Meyer et al. 2010, Nieminen et al. 2011). In the absence of major predators or high levels of human harvest, caribou populations in Scandinavia generally increase until their populations become regulated by density-dependent competition for food (Skogland 1985, Seip 1991).

To justify the initiation of a predator management program, a prerequisite prior to any removal action is the need to acquire scientifically defensible reasoning for implementing predator management. Obtaining reliable information on predator densities sympatric with a target recovery species' range, as well as measuring the direct impacts of this overlap, ensure that the decision making process for initiating predator management are scientifically defensible and the probability of recovery is high. From review of predator management programs undertaken throughout North America, several conclusions can help inform and guide wildlife managers considering management action to recover threatened ungulate populations. The following conclusions were reached by the Committee on Management of Wolf and Bear Populations in Alaska (National Research Council 1997) and further developed by McLaren (2016) and DeMars & Serrouya (2018) and include;

1. *Active Predator management requires strong indicators that predation is a major limiting factor in the focal ungulate population.*

2. *Management actions will be most effective when targeted towards the predator(s) species with the largest demographic effect on ungulate population dynamics. As noted by DeMars & Serrouya (2018), in multi-predator systems, obtaining this information can be challenging as the effects of different predators may be additive or compensatory (e.g. Valkenburg et al. 2004).*
3. *The efficacy of predator management is multi-faceted, and depends on the intensity, duration and spatial scale of predator removals.*
4. *The effects of predator management have a high probability of being short-term, especially if underlying causes of high predator populations are not addressed, such as landscape level alterations and disturbances that influence predator population growth and distribution.*
5. *The evaluation of success for predator management requires thorough experimental design and an adaptive management approach which incorporates consistent predator and focal prey species population monitoring, as well as alternate prey monitoring. Ideally, a before-after-control impact design should be used to control for confounding factors such as annual variations in weather and prey abundances.*
6. *Predator management is often a contentious issue among the public. To prevent the erosion of social acceptance, predator management should not be designed as a long-term solution for recovering a focal ungulate population and the underlying causes of high predator populations need to be addressed.*

2 Species specific impacts on caribou populations

While caribou predators vary regionally (wolf, grizzly bear, black bear, cougar, coyote), predation impacts on woodland caribou populations have increased primarily in response to three dominant processes: apparent competition mediated by primary prey hyperabundance (Hebblewhite et al. 2007), apparent competition facilitated by expanding primary prey distribution (Wittmer et al. 2007, DeCesare et al. 2010, Latham et al. 2011a), and enhanced predator access to woodland caribou habitat (James and Stuart-Smith 2000, Latham et al. 2011b).

2.1 Wolves

In many northern ecosystems where caribou are an important food resource for wolves (Bergerud 1983, Gauthier and Theberge 1986), wolf predation can be an important population limiting factor for caribou (Bergerud 1980, Gasaway et al 1983, Bergerud and Elliot 1996, Seip 1991, Boertje et al 1996). In trying to assess whether wolves are controlling a prey population, however, it is important to understand the extent to which wolf predation is compensatory (Errington 1967) to other mortality factors and the extent to which it is additive (Mech and Peterson 2003). While wolves can contribute to limiting the growth of their prey populations, it is also clear that they do not always hold prey populations down (Mech and Peterson 2003). Instances where prey populations have increased, despite the presence of wolves, include moose on Isle Royale (Peterson et al 1998), deer in northwestern Minnesota (Nelson and Mech, 2000) and caribou in Denali National Park (Adams and Dale 1998, Mech et al, 1998).

Nevertheless, research examining wolf-caribou dynamics in western Canada has shown that woodland caribou declines are related to a strong numerical response by wolves and subsequent increased predation rates on caribou, as a direct response to higher primary prey densities (Seip 1992, Hebblewhite et

al. 2007). Wolf management actions in Canada have included aerial shooting, trapping, poisoning and sterilising breeding pairs (Hayes et al 2003) as well as the reduction of primary prey species, such as moose (Serrouya et al 2017). A positive numerical response in ungulate prey populations has been documented after wolf control efforts have been initiated, at least in the short-term (Hayes et al 2003, Valkenburg et al 2014). For woodland caribou, to achieve the long-term recovery of this species, research has suggested that wolf management actions would be most successful when combined with effective habitat conservation and long-term planning to affect the recovery of caribou (Hervieux et al 2014). The degree to which a threatened prey species responds to wolf management also depends on the spatiotemporal scale and intensity of wolf management actions (Hervieux et al 2014, Boertje et al 2017, Serrouya et al 2017).

Wolf population size has been correlated with population growth rates of caribou (Bergerud 1996) and research examining wolf-caribou dynamics has shown wolf densities greater than 6.5 wolves/1000km^2 will lead to woodland caribou declines (Bergerud and Elliot 1986, Serrouya et al 2016). The federal recovery strategy for caribou, however, identifies < 3 wolves/1000 km^2 as a target (Environment Canada 2014). Caribou populations in northern British Columbia have been shown to decline when wolf densities ranged between 9–10 wolves/1000km^2 but increased when wolf densities were in the range of 1–4 wolves/1000km^2 (Bergerud and Elliot 1986). Wilson (2009) recommended that wolf densities for woodland caribou in the Southern Group be managed to < 1.5 wolves/1000 km^2 to generate a significant, positive response by southern mountain caribou. Similarly Hebblewhite et al. (2007) suggested that subpopulations of caribou in Jasper National Park are likely to persist when wolf densities are below 2.1-4.3 wolves/1000 km^2. In the absence of research defining a maximum density of wolves needed to enable recovery across all southern mountain woodland caribou Local Population Units (LPUs), Environment Canada has recommended a density of < 3 wolves/1000 km^2 based on a combination of Wilson (2009) and Hebblewhite et al. (2007). 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.

In British Columbia, wolves were historically managed through a regulated bounty program which led to very low numbers of wolves across the province until the bounty program was abandoned in 1955 and wolf numbers subsequently increased along with this species spatial distribution across the province (Wilson 2012). Today wolves are a widespread and abundant species in BC and management actions are primarily undertaken to reduce local wolf populations in order to curtail and reserve the decline of certain threatened prey species, especially caribou (Wilson, 2014, Hervieux et al 2014).

2.2 Cougars

In southern British Columbia, research has identified cougars as a major caribou predator (Wittmer et al. 2005), while there are only rare reports of cougar predation on caribou in northern British Columbia. In general, however, information regarding cougar-caribou dynamics is limited. One study examining how cougar populations interact with various caribou sub-populations in the Columbia Mountains of British Columbia, reported that caribou comprised only a small proportion of the cougars diet with only 3 caribou kills out of 101 total kills documented (Bird et al, 2010). The authors noted that it was difficult to make conclusive inferences on the relationship between cougars and caribou, as caribou decline and extirpation had already occurred within their study area and the sample size of monitored GPS collared cougars was

small, with only 3 cougars collared (Bird et al. 2010). The authors reported that despite the low predation rates on caribou in their study area, such predation rates could potentially be enough to negatively impact small caribou populations if primary prey populations are not reduced. Research has shown that just one specialist cougar can have significant impacts on small ungulate populations, as previously observed in mountain sheep populations once a prey search image is developed (Fest-Bianchet et al. 2006).

DeMars and Serrouya (2018) reviewed three predator management programs which included the lethal control of cougars and reported that two of the three control programs were undertaken concurrently with bear or coyote removal (White et al. 2010, Hurley et al 2011). Results from cougar control in all three reviewed studies reported increased offspring survival or juvenile recruitment in the targeted ungulate population and two of these studies also reported positive effects on adult female survival.

2.3 Bears

Both grizzly and black bears predate woodland caribou (Seip 1992) and both species are considered a primary predator of ungulate neonates that can negatively impact ungulate demographic parameters and impose substantive losses on caribou recruitment (Young and McCabe 1997, Zager and Beecham 2006, Pinard et al 2012, Brockman et al 2017). Both bear species also frequently use early-seral stage pre-forest communities for foraging, often 20-50 years post-disturbance (Zager et al. 1983, Hamer 1996, Mace et al. 1996, McLellan and Hovery, 2001). However, as omnivorous species with individual dietary variation, bears generally have less dependence on ungulate prey (Edwards et al. 2010). Due to their seasonality and/or low predation rate and dependence on caribou as food, active management to increase ungulate populations, including for caribou has not been as common as it has been for wolves. Teel et al (2002) also suggested that there may be lower social acceptance for active bear control when compared to wolf control. Increases in ungulate neonate survival and/or calf recruitment has been documented after bear control, however, but the effectiveness of bear control seems to be influenced by the intensity, duration and spatial scale of treatment (Mosnier et al. 2008, DeMars and Serrouya, 2018).

2.4 Other Predators

Other predators such as wolverine, coyote and Golden Eagle have been documented preying on caribou, especially neonates (Crete and Desrosiers, 1995, Gustine et al 2006, Nieminen et al 2011). In northern British Columbia, researchers comparing predation risk, calf survival rates and habitat characteristics among three different caribou calving areas, documented wolverines as the primary predator of caribou neonates less than 14 days old (Gustine et al 2006). In Scandinavia, wolverines are also known to prey on semi-domesticated reindeer (*Rangifer tarandus tarandus*) calves and have been documented killing adult reindeer (Landa et al. 1997, Nieminen et al 2011). Coyotes can also be an important predator on caribou calves (Crete and Desrosiers, 1995, Boisjoly et al 2010, Bastille-Rousseau, 2018), especially when combined with predation rates on adult and/or calf by other caribou predators such as wolves and bears (Wittmer et al, 2005, Pincard et al 2012, Latham et al 2013). Golden Eagles are also known to prey on caribou calves (Adams et al 1995, Nieminen et al 2011) and in rare instances, have also been documented killing adults as observed in Norway with semi-domestic reindeer (Nybakk et al 1999).

As noted by DeMars and Serrouya (2018), examples of active management for wolverines and coyotes are limited. While information on the effect of wolverine and coyote active management to support caribou calf survival is lacking, research investigating ungulate offspring survival and juvenile recruitment following coyote control efforts have had mixed results (DeMars and Serrouya 2018). Information on the lethal removal of Golden Eagles to support ungulate calf survival and juvenile recruitment is also lacking.

3 Status of the Itcha-Ilgachuz caribou herd

The Itcha-Ilgachuz caribou have been monitored regularly by regional biologists since 1977. At that time, the population estimate was 350 caribou. Since 1977 the herd steadily increased in size to its estimated population peak of 2800 caribou in 2003 (Freeman 2010, Figure 1). In 2004 population estimates for the Itcha-Ilgachuz caribou began to decline, and have continued to decline to the present day (Freeman 2010, Youds et al. 2011, Dodd 2017). The 2007 post-calving survey estimated 2100 caribou in this population, representing a 17% decrease from the 2003 survey. Poor survey conditions contributed to the low count in 2007 (Roorda and Dielman 2007). However, subsequent follow-up surveys under ideal conditions in 2009 and 2012 resulted in population estimates of 2150 and 1600 caribou, respectively. The 2007 and 2009 survey results found stable female numbers but declining calf, bull and yearling numbers relative to 2002–03. Recently, the 2018 post-calving survey estimated 637 caribou, a decline of 77% since its population peak in 2003 and the population trend over the past 3 years has been declining at an average of 17 %.

Caribou populations generally increase when annual recruitment rates exceed the 15-16% required to balance natural adult mortality and maintain population stability (Bergerud, 1992). Between 1996 and 2003, calf recruitment for the Itcha-Ilgachuz herd averaged 25.8% in June while late winter (annual) recruitment was 17.0%. During this period survey effectiveness was improved through more extensive search and having radio-collared animals. Both real population increases and more thorough surveys contributed to higher population estimates. Calf recruitment for the Itcha-Ilgachuz caribou has remained below population replacement levels since 2004. While spring calves estimates (estimated from June aerial surveys) have remained relatively high from the 1990s to 2017, a sharp reduction in late winter calf percentages from 2002-2016 suggests that a reduction in recruitment is contributing to overall population declines. The percent of spring calves in June 2018, however, dropped by 17%, from 27% to 10%. Considering that calf recruitment has been below replacement level despite high spring calf numbers between 2002-2016, the significantly lower number of spring calves in 2018 may result in reproductive failure for the herd for the 2018-2019 year (per comms Carolyn Shores, FLNRORD).

Consistent with other research examining woodland caribou mortality (Bergerud, 1992, Wittmer et al. 2013) predation is considered to be the proximate cause in the observed decline of the Itcha-Ilgachuz caribou, with wolves considered to be the primary predator responsible for herd decline (McNay and Cichowski, 2015). In 2012-14, adult female mortality was 8.7% and 33.3% in 2013–2014 (McNay and Cichowski 2015). Data on adult mortality is based on radio-collared caribou studies conducted during four study periods: mid to late 1980's, mid 1990s to early 2000s, 2011-2015 and 2018 to present. In early 2018, 50 GPS radio-collars were deployed on this herd in an attempt to better understand cause specific mortality as well as to assist with more reliable population inventory. For the Itcha-Ilgachuz caribou, the primary

known cause of mortality has been wolf predation, which makes up at least 33.3% (n=7) of known mortalities (n=21) (Table 1), and up to 42.8%, if probable wolf predations (n=2) are included. Determining known causes of mortality for this herd has been challenging, however, as "rapid response" mortality investigations were not a study priority in earlier radio-collaring studies for this herd.

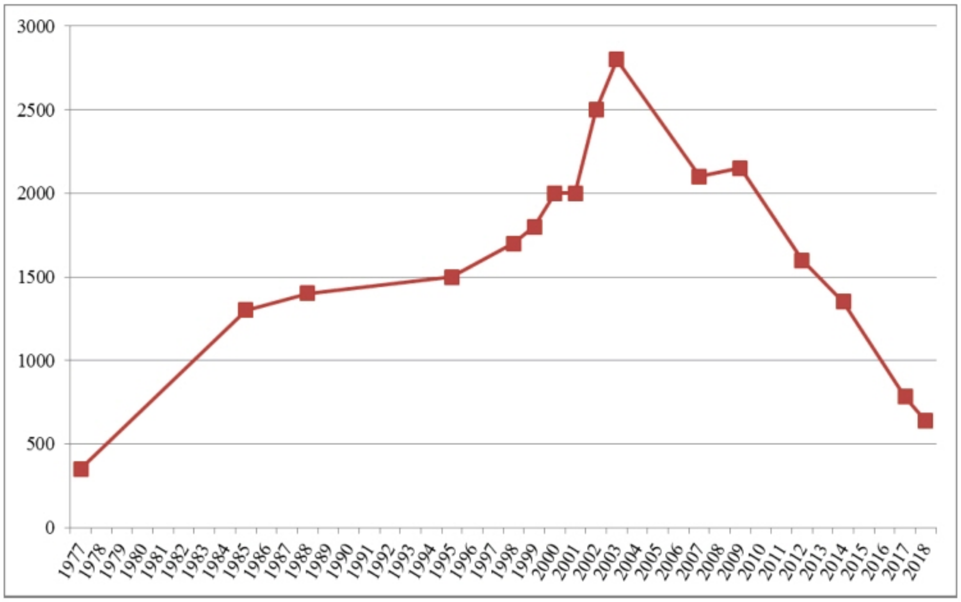

Figure 1. Sightability-corrected population estimates from 1977-2018 for the Itcha-Ilgachuz subpopulation of northern mountain caribou. Population estimates are derived from June post-calving surveys. The population estimate is calculated by applying a sightability correction factor based on the number of collared animals seen to the number of animals counted in the aerial survey.

Table 1. Causes of mortality of radio-collared Itcha-Ilgachuz caribou. Mortalities compiled from McNay and Cichowski 2015 and from mortality investigation forms done by Cariboo regional biologists from 2015-2018.

Cause of mortality	1985-88	1995-2003	2011-14	2018	Total	% of known and probable mortalities
Predation - Wolf	3	3		1	7	33.3
Predation - Cougar			1	1	2	9.5
Predation - Bear					0	0
Predation - Wolverine					0	0
Accident		1			1	4.7
Hunting		1	1		2	9.5
Poaching	1				1	4.7
Hunting or Poaching			1		1	4.7
Probable bear predation	1			1	1	4.7
Probable wolf predation				2	2	9.5
Probable poaching			1		1	4.7
Unknown - not predator-related	1	1		1	3	14.2
Unknown		8	10	1	19	NA
Total	6	14	14	7	41	NA

4 Status of predator populations in the Chilcotin Plateau

In an attempt to better understand the potential impact that predators, especially wolves, have on the Itcha-Ilgachuz caribou subpopulation, McNay and Cichowski (2015) undertook an assessment of wolf predation and management options in the Itcha-Ilgachuz caribou herd area. Existing data and reports regarding wolves, caribou, and wolf primary prey in the Itcha-Ilgachuz area were compiled and included hunter harvest data for predators and primary prey species in management unit 5-12, where the Itcha-Ilgachuz caribou range is located.

4.1 Wolves

In the Cariboo region a wolf population estimate based on combined estimates of published wolf density and range estimates, as well as prey biomass, reports between 550 - 1,250 individual wolves across the entire region (Wilson, 2014). However, reliable information on wolf populations overlapping the Itcha-Ilgachuz area is limited (McNay and Cichowski 2015). Data from both resident and non-resident harvest of wolves in MU 5-12 has not shown a general trend in wolf abundance with a very variable harvest estimate for wolves since 1975 (McNay and Cichowski, 2015). Despite a "no bag limit" for wolves introduced in 2012 for MU 5-12, estimated wolf harvest has not significantly increased, although there is no requirement to report wolf harvest in MU 5-12. In general, however, wolf harvest in the Cariboo Region is considerably higher than in regions further south, possibly due to larger wolf populations (Wilson, 2012). A poison bait program for wolves occurred in the mid to late 1990s, but data on the number of wolves killed as well as where and for how long this poisoning program lasted is lacking (McNay and Cichowski, 2015). Data from radio-collared wolves in the Chilcotin Plateau is also limited, with collars deployed on just four wolves overlapping Itcha-Ilgachuz caribou range. GPS collars deployed on two wolves were monitored from 2012 to 2014. Movement data from these wolves showed overlap with winter habitat utilized by collared caribou in all years. VHF collars deployed on two wolves in the late 1990s also showed wolf distribution overlapping Itcha-Ilgachuz caribou habitat, including portions of their summer range in the Ilgachuz Mountains.

Density estimates for wolves and pack distribution is also lacking in MU 5-12. In January 2017, an aerial wolf survey in MU 5-12 was undertaken by Cooper Beauchesne and Associates LTD, contracted by BC Ministry of FLNRO to estimate wolf density in this area. This wolf census followed established protocols developed for surveying wolves in areas of low topographic relief with expanses of flat heavily forested terrain (Serrouya et al. 2015). Based on locating wolf tracks and subsequent track splitting, a wolf density of 5-6 – 7.6 wolves per 1000 km^2, in seven packs, was estimated over four days of flying and within a 4,231 km^2 survey area (Figure 2). While the maximum wolf density estimate of 7.6 wolves/1000km^2 is above the 6.5 wolves/1000km^2 wolf density identified as influencing caribou population decline (Bergerud and Elliot 1986), this estimate is less reliable than the minimum density estimate of 5.6 wolves /1000km^2, which is more objective. However, both density estimates are above the ECCC recommendation of <3 wolves/1000km^2 in critical caribou habitat. 24 to 32 wolves were detected in the SBPSxc subzone (Sub-Boreal Pine-Spruce; very dry cold) based on track interpretation and no visual detections of wolves were observed. The contractor defined a pack as a minimum of one animal, which is not typical for wolf studies. If the standard definition of 2 wolves to form a pack is used (Fuller 2003), then 6 wolf packs, rather than 7, were detected in the survey area. The contractors also described their survey as an "initial exploration," and recommended investing in a wolf-collaring program to validate the wolf census with sightability correction factors.

s.18

Figure 2. Wolf pack detections from the 2017 aerial wolf survey. The red polygons represent the extent of tracks detected for each group, but do not represent the much larger territory size of each pack. Number indicates pack ID.

Prior to the 2017 aerial wolf census, a winter track transect in the West Chilcotin was undertaken in the winter of 2009-10 (Davis 2009). This survey did not yield density estimates for wolves in MU 5-12. An attempted aerial survey of wolves in and around the Itcha-Ilgachuz Mountains in 1999 was also unsuccessful due to large expanses of heavily forested terrain, limited open waterways in which to track, and poor survey conditions (Roorda and Dielman 2007). The distribution of wolves in the southern part of the Itcha-Ilgachuz herd range as reported by the 2017 wolf census and GPS collar data suggests that wolves occur throughout seasonal caribou range, including in alpine caribou calving habitat during June post-calving surveys.

4.2 Cougars

Cougar densities respond positively to increased prey densities, especially deer, and cougar populations generally vary in response to habitat features and current and past exploitation (Logan and Sweanor 2001). Reliable information on cougars in the Itcha-Ilgachuz area is limited with no standardised inventory undertaken for this species in MU 5-12, or elsewhere in the Cariboo Region. Anecdotal reports of increased cougar activity in the Anahim/Nimpo Lake area has been reported by local residents in recent years (McNay and Cichowski, 2015). There is an open season for cougars in MU 5-12 with a bag limit of 2.

In the Cariboo Region, a cougar population estimate based on reported cougar kill locations and habitat capability for supporting deer estimated between 900-1200 cougars (Wilson, 2011). However, cougars are not common in the Itcha-Ilgachuz caribou subpopulation range (Spalding 1994). A recent (March 2018) mortality of a radio-collared Itcha-Ilgachuz bull caribou was confirmed as a cougar kill (Figure 3). A cougar DNA mark-recapture population estimate study near William's Lake is currently planned for the winter of 2018/19. Results from this study may help to inform the feasibility of conducting a similar cougar population or diet study on the Chilcotin plateau.

Figure 3. March 2018 radio-collared bull mortality site. Left photo: Caribou carcass partially covered in its own hair. Right photo: cougar tracks leading away from the caribou carcass (Shane White, FLNRORD).

4.3 Bears

Both grizzly bears and black bears are present in the Itcha-Ilgachuz subpopulation range. Both bear species have been shown to reduce caribou calf recruitment and contribute to adult caribou mortality (Adams et al. 1995, Wittmer et al. 2005, Bastille-Rousseau et al. 2016, Lewis et al. 2017). Although predation rates for grizzly bears have not been determined, their density in the Itcha-Ilgachuz range was estimated to be 9/1000 km^2 in 2004 and 2008 (Hamilton et al. 2004). However the 2012 estimate fell to 2.6/1000 km^2, falling to threatened status provincially (Griffiths 2012). There is no reliable information on black bear trends in the Chilcotin area, including MU 5-12 (McNay and Cichowski 2015). There is a bag limit of 2 and an open season for black bears in MU 5-12. In late 2017, the BC Government announced the closure of grizzly bear hunting by resident and non-resident hunters throughout British Columbia. Grizzly bears can still be harvested by First Nations pursuant to Aboriginal rights for food, social or ceremonial purposes or treaty rights, although the harvest in MU 5-12 is thought to be very low.

4.4 Other Predators

As with the primary predators of caribou in the Chilcotin Plateau, there is a general lack of direct information on the abundance, general trends and distribution of secondary predators of caribou, such as wolverines, coyotes and Golden Eagles in MU 5-12. Harvest for coyotes is open season with no bag limit throughout the Cariboo Region and wolverines can be legally trapped from November 1st to January 31st. Golden Eagles are also present in the Itcha-Ilgachuz caribou range and while not currently designated as a species at risk, populations in areas of Canada are declining and this species is protected under Section 34 of the Wildlife Act. Active management actions for Golden Eagle would likely be much less socially acceptable than control actions for other caribou predators. Lethal control of Golden Eagles would also be very challenging due to this species legal status, the lack of reliable information on its interactions with caribou in British Columbia and less social acceptance for management actions.

4.5 Conclusions

Consistent with other declining woodland caribou populations across western North America (Seip 1992, Hayes et al 2003, Wittmer et al. 2005) wolf predation is considered to be the primary cause of adult mortality in the Itcha-Ilgachuz caribou herd (McNay and Cichowski, 2015). While there is generally a lack of direct information regarding how wolves are interacting with caribou in the Itcha-Ilgachuz area, of the documented known mortalities for adult collared caribou in the Itcha-Ilgachuz herd (n=21), wolf predation has been confirmed as the proximate cause of death for 7 adult caribou and probable for a further 2 adult caribou. Wolf predation is currently the primary cause of known mortality for radio-collared caribou in this herd. However, it is difficult to make conclusive inferences as the sample size for confirmed wolf predation is small. Acquiring more reliable information on both the wolf density and pack distribution sympatric with the Itcha-Ilgachuz subpopulation is important to infer the potential predation effects on this herd and to support management actions such as wolf reduction. In addition, calf recruitment appears to be the driving cause of decline for this herd, and the primary cause of calf mortality is unknown. Wolves are potential caribou calf predators but other predators, disease and nutritional limitation may also be factors contributing to low calf recruitment.

For the Itcha-Ilgachuz caribou herd, potential predator management action should be intensive and occur over a large spatiotemporal scale and undertaken concurrently with other measures such as habitat protection, the reduction/closure of the legal harvest of bull caribou and continued monitoring and potential reduction of alternate prey densities, especially moose. To better understand predator-prey dynamics in the Itcha-Ilgachuz range, it will be important to monitor the wolf population size and range overlapping caribou habitat seasonally. This could be achieved by maintaining a sample of radio-collared wolves in MU 5-12 and monitoring their seasonal movements and pack size. Furthermore, to determine the effectiveness of wolf removal it is essential to maintain a sample of radio-collared adult caribou to continue to reliably estimate population trends and determine juvenile recruitment before and after potential wolf control. Percent calves in late winter surveys and population change will be used as metrics of success to determine the efficacy of wolf removal.

5 Management Recommendations

Decisions influencing the implementation of a predator management program can be complex. To aid wildlife managers in the decision making process, the development of tools such as decision matrices and prioritization tables can be of significant benefit to help inform and guide wildlife managers considering predator management in aid of caribou population recovery. In British Columbia, the Provincial Caribou Science Team, composed of government caribou biologists and managers from across the Province, met in June 2018 to develop the framework for a predator management decision matrix (Figure 4). This decision matrix includes decision points that require wildlife managers to address population parameters for a target caribou population. The first step is determining whether a caribou herd is at or below the population objectives. Once determined, questions regarding herd viability with or without predator management must be addressed, followed by the availability of reliable data to identify the primary predator limiting the population. Finally, the status of the primary predator itself and if this species is sensitive to control actions is addressed. The science committee recommended that a herd prioritization table is also developed to determine priority herds for wolf removal.

For the Itcha-Ilgachuz caribou herd, acquiring scientifically defensible information regarding predator-prey dynamics is important to support a scientifically based rationale for implementing predator management programs, especially to evaluate the third decision point in the predator management decision matrix on whether there is sufficient information to determine that predation is limiting the population. Specifically, more information on wolf density, spatial overlap between wolves and caribou, and wolf predation rates on caribou would support the decision matrix process. Also, prior to active predator management measures, due to the high intensity, multi-year wolf removal efforts required to achieve caribou herd population increases (Hayes et al 2003), the implementation of a wolf control program should only occur if adequate financial support is guaranteed over a timeframe of at least 4 years for intensive removal and the simultaneous monitoring of the Itcha-Ilgachuz caribou to evaluate the success of predator removal. Calf recruitment and sightability corrected population estimates for the herd, which will be used to determine lambda, or the rate and direction of population change, will be used as metrics of success. Population objectives for caribou herds must also be established to guide decisions around ending predator management and the ultimate cause of the herd's decline, habitat loss, must also be addressed.

Currently, following the decision matrix table, there is adequate information regarding the proximate decline of Itcha-Ilgachuz caribou to support active predator management practices such as wolf reduction, although more information on wolf caribou dynamics would be of value to address decision point three, on whether predation is limiting the population. This information to support wolf removal is the following: 1) the herd is in steep decline and calf recruitment is far below population replacement, 2) wolf predation is the leading cause of adult mortality and 3) the density of wolves in caribou critical habitat is above the ECCC recommendation of <3 wolves per/1000km^2. To address information gaps on wolf-caribou dynamics in the Chilcotin Plateau, as well as evaluate predation effects in the Itcha-Ilgachuz range, multi-faceted management actions are required. These include; determining wolf population parameters in MU 5-12, radio-collaring wolf packs with spatial overlap of the Itcha-Ilgachuz herd, maintaining a sample size of radio-collared Itcha-Ilgachuz caribou and potential lethal control of wolf populations (in the most humane method possible) in and adjacent to Itcha-Ilgachuz caribou range.

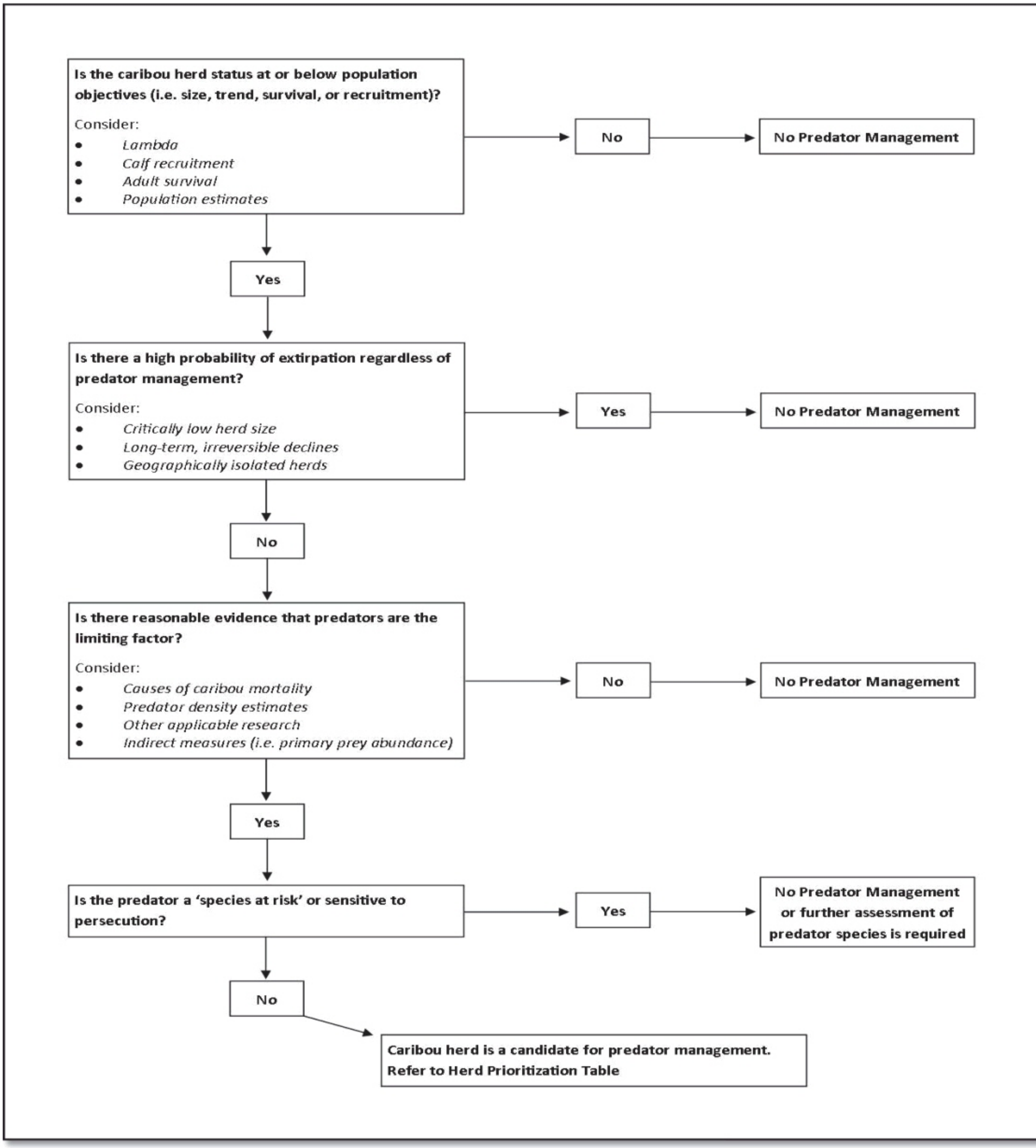

Figure 4. Predator management Decision Matrix flow chart developed by Provincial caribou biologists

5.1 Determining wolf population parameters in MU 5-12

Acquiring reliable density estimates for wolves can be especially challenging due to this species large territory size, their ability to travel extensively when hunting and their highly variable movement patterns which is dependent on pack size, availability of prey species and seasonality (Ballard et al 1987). However, in the boreal plains, winter aerial transect surveys have effectively estimated wolf populations, often in areas with dense forest cover (Serrouya et al. 2015). While a winter aerial wolf census using the survey method developed by Serrouya et al (2015) was undertaken in MU 5-12 in January 2017, this census was limited by logistical constraints such as fuel (Gill and van Oort, 2017). Furthermore, wolf density estimates are more reliable if a sample of radio-collared wolves is maintained in the population and at the time of the 2017 aerial wolf census, no GPS radio-collared wolves were present in the survey area.

To better assess wolf-caribou dynamics in MU 5-12, the initiation of an annual wolf monitoring program to determine wolf population size and distribution in the Itcha-Ilgachuz range will allow for reliable inferences to be made in assessing the potential predation effects by wolves on Itcha-Ilgachuz caribou and support potential wolf control. Aerial wolf surveys should be undertaken at least once a year starting in the winter of 2019 and continuing over the course of active predator management. Aerial wolf surveys should occur in January or February when wolf packs are more cohesive and before the breeding season in March (Packard, 2003). Wolf aerial censuses should follow existing protocols for heavily forested areas (see Serrouya et al 2015) with the survey area stratified into belt transect routes to maximize the detection of wolf tracks, relative to cost. Wolf surveys should focus primarily in the SBPS zone (sub-boreal pine-spruce), previously identified in MU 5-12 as important wolf habitat (Gill and van Oort, 2017). Aerial monitoring of wolves during the summer months, without the presence of snow to detect and follow wolf tracks, is more logistically challenging, as are ground based methods such as wolf scat and tracks surveys, which have been used elsewhere in British Columbia to infer relative abundance of wolves (Hatter 1988, Atkinson and Janz 1994). The potential use of trained field technicians/volunteers, as implemented successfully elsewhere (see http://fwp.mt.gov/fishAndWildlife/management/wolf/), could be a reliable approach for monitoring wolf populations in MU 5-12, allowing for pack distribution and pack size to be determined using camera trapping methods. Experienced volunteers could also implement ground trapping to radio-collar wolves and investigate wolf GPS location cluster sites, as well as responding to caribou mortality notifications if logistically feasible. Funding to support such a ground based volunteer wolf program would, however, need to be secured.

5.2 Radio-collaring wolves overlapping Itcha-Ilgachuz caribou range

Understanding caribou-wolf dynamics and habitat selection by wolves within and adjacent to the Itcha-Ilgachuz range will require a sample of GPS collars on both species. In their assessment of wolf management options in MU 5-12, McNay and Cichowski (2015) also recommended radio-collaring wolves to determine pack structure and range. As outlined above, maintaining a sample of radio-collared wolves will permit more precise population estimates for wolves in MU 5-12 and allow for wolves to be effectively located and removed from the population if control actions are considered necessary to curtail the current sharp decline of Itcha-Ilgachuz caribou. Evaluating wolf seasonal habitat selection will be also valuable in evaluating predation risk for Itcha-Ilgachuz caribou. At least 1-2 GPS radio-collars should be deployed on each wolf pack in the Itcha-Ilgachuz range during the Winter 2018/19. Ideally the collars should be programmed to receive at least 8 fixes a day. The newer generation of GPS radio-collars are cost effective and the number of fixes can be programmed remotely with Iridium 2-way satellite communication. Higher fix rate collars will allow wildlife managers to determine wolf pack distribution, size and home range overlap with caribou habitat as well as more effective location of collared wolf packs for removal.

5.3 Maintaining a sample of GPS radio-collared Itcha-Ilgachuz caribou

Studies have suggested that maintaining a sample size of 20-25 radio-collared caribou per year is sufficient to reliably monitor population trends and estimate survival rates (White and Garrott, 1990, Hervieux et al 2013, Serrouya et al 2017). Currently, 39 functional GPS radio-collars are deployed on female and male caribou in Itcha-Ilgachuz herd, programmed to record 1-2 GPS locations per day. These collars also transmit mortality notifications via satellite once the collar switches to mortality mode, allowing for cause of mortality to be determined and thus providing strong inferences on predation effects (DeMars and Serrouya 2018). The effectiveness of determining cause-specific mortality for radio-collared animals requires site investigations immediately following the death of a collared animal. Newer generations of GPS radio-collars are cost effective and often designed for survival studies and allow for "rapid response" mortality investigations. 50 radio-collars were initially deployed on the Itcha-Ilgachuz herd in March 2018, seven of which have already been retrieved from caribou mortality investigations and four of which are no longer transmitting location data. In maintaining a sample of radio-collared caribou, our ability to reliably monitor caribou population trends will improve (DeCesare et al 2012), and estimating important demographic parameters such as female survival and juvenile recruitment will be feasible. Continued monitoring of the Itcha-Ilgachuz herd demographics should continue for at least 5 years following wolf control.

5.4 Ethical reduction of wolf populations in MU 5-12

The reduction of wolf populations is a contentious issue and has been for decades (Cluff and Murray 1995). In Canada, wolf control programs aimed at recovering threatened caribou have attracted significant media attention with ethical and legal questions raised concerning wolf reduction actions (Brook et al 2015). Nonetheless, managing wolves to recover threatened woodland caribou is an effective science based, legal and ethical management tool (Herviuex et al 2014, Herviuex et al 2015). Direct removal of wolves using aerial gunning to recover caribou populations is currently being undertaken in British Columbia, with control actions for caribou populations being implemented in the South Selkirk, Columbia North and South Peace. In 2017/2018 151 wolves were removed from eight caribou herd areas, with a total wolf control program cost of $593,333. In the Cariboo Region, a pilot wolf reduction program was implemented to reduce wolf densities for Mountain Caribou recovery in the Quesnel Highland Planning Unit (Roorda and Wright 2012). Helicopter net-gunning combined with ground trapping was successfully used to capture, and subsequently surgically sterilize dominant wolves, in an attempt to reduce wolf recruitment while maintaining stable pack territories (Hayes et al. 2003, Roorda and Wright 2012). Wolf removals from the population also occurred, but sterilization alone was found to be sufficient in maintaining wolves at low densities (Hayes 2013). A correlation between reduced wolf densities and caribou recovery in the Quesnel Highlands was not substantiated (Hayes 2013). McNay and Cichowski reported that sterilization reduces the wolf population by about 50%, which may not reduce wolf densities to the <3 wolves/1000 km^2 needed to maintain caribou, given the 2017 wolf density estimate of 5.6 – 7 wolves/1000 km^2 in the Itcha-Ilgachuz herd's critical habitat.

The most effective and humane method of reducing wolf populations is aerial gunning (Ballard et al 1997, Hayes et al 2003, Wilson 2012), likely due to the assumption of a quick kill (McNay and Cichowski, 2015), although there are criticisms regarding this technique (Brook et al 2015). For the Itcha-Ilgachuz caribou, if evidence continues to make strong inferences as to predation effects from wolves, an aerial wolf control program should be implemented using experienced aerial gunners. Population targets for wolf densities should be less than 3 wolves/1000 km^2 a target that the federal recovery strategy for caribou has identified as eliciting a positive population response in caribou (Environment Canada 2014). Bergerud and Elliot (1998) noted that wolves quickly recolonized their study area following the conclusion of the wolf removal program in the Northern Rockies. They also noted considerable wolf recovery on an annual basis, primarily by small groups of recolonizing wolves from adjacent territories (Bergerud and Elliot, 1998). This emphasizes that wolf removal is not a sustainable long-term strategy for caribou recovery, but instead a short term recourse to prevent further population decline while long-term strategies such as habitat protection are put in place (Itcha-Ilgachuz herd recovery plan, 2018). If long-term strategies to recover the Itcha-Ilgachuz herd cannot be implemented, then serious consideration should be given as to whether to continue wolf removal. Intensive wolf removal over a period of 4-5 years is likely required to elicit a strong, positive population response in the Itcha-Ilgachuz caribou herd. Caribou calf recruitment and sightability corrected population estimates should undergo evaluation after the third winter of removal. Ongoing caribou and wolf monitoring will be necessary to determine the required frequency of wolf control. Wolf control actions implemented prior to the caribou herd reaching critically low level numbers would be most beneficial and cost-effective when considering the long-term management of this caribou herd.

Potential wolf control efforts should primarily focus within and adjacent to the Itcha-Ilgachuz caribou range (9,457 km^2; Figure 5), encompassing the Chilcotin Plateau and the Itcha-Ilgachuz Mountains in the Fraser Plateau ecoregion (Goward 2000), as well as the Dean River Corridor and low-elevation caribou winter habitat east of Anahim lake that is also used by the Itcha-Ilgachuz herd, although it is outside of their current herd boundary (Itcha-Ilgachuz caribou herd recovery plan). Based on baseline density estimates for wolves in MU 5-12 (Gill and van Oort, 2017), their findings suggest a minimum estimate of 53 wolves within or adjacent to the treatment area and a maximum estimate of 72 wolves, although further investigation into wolf population parameters in this area is warranted. Intensive aerial control of wolf populations within MU 5-12 should aim to remove a high proportion of wolves overlapping the treatment area (>80%, Hayes et al. 2003). To facilitate efficient aerial removal of wolves by experienced crew and helicopter pilots, the deployment of GPS collars on wolves will allow for quick relocation and removal and/or reduction of collared packs. Equipping a wolf pack with at least 1-2 GPS radio-collars will allow for complete pack removal later, if immediate pack removal is not feasible. The collared individuals may be removed from the pack, or left alive to facilitate wolf removal actions the following winter. Consistent with previous research (Hayes et al. 2003), to maximise the benefits of predator removal, a substantial reduction or full closure of the legal hunt of Itcha-Ilgachuz caribou should occur simultaneously with any predator control actions. Observed changes to caribou herd demographics may be evident the year following wolf control actions, but may take up to three years to have an effect.

6 Monitoring and Measures of Success

To measure the effectiveness of wolf control actions for the recovery of Itcha-Ilgachuz caribou subpopulation, maintaining population monitoring of this herd is essential to infer changes in population size and demographic trends, including juvenile recruitment and estimating adult female survival, both important demographic parameters in caribou population dynamics (DeCesare et al. 2012). Wolf control efforts must be intensive and last a minimum of 4 years, preferably 5 years. It is important to note that while wolf predation is currently likely the proximate cause of decline for the Itcha-Ilgachuz caribou herd, disturbances and loss of critical caribou habitat from timber harvesting has led to the current predator-prey system and subsequent caribou population declines. If caribou habitat degradation continues to occur, the effectiveness of wolf control will be limited (Hervieux et al 2014). Public support for wolf control to recover caribou will also likely diminish if management actions are not concurrent with habitat protection and recovery efforts. Further management actions associated with active wolf control efforts should include changing hunting regulations for alternate prey, such as moose and deer. Woodland caribou are secondary prey species for wolves (Milakovic and Parker 2011) and wolf presence, abundance and distribution will be most likely influenced by the availability of alternate prey species, especially moose (Courbin et al 2013). Moose and deer populations overlapping the Itcha-Ilgachuz range will likely increase in abundance after predator removal, which in turn will support wolf recolonization and subsequent population increases (Bergerud and Elliot, 1986). If increases in primary prey populations are not addressed, wolf control efforts will likely become increasingly difficult and cost ineffective.

In the short-term, curtailing or reversing the declining Itcha-Ilgachuz population herd will be the most appropriate measure of success, determined through ongoing population monitoring. Monitoring the wolf population before and after removal efforts will allow wildlife managers to gauge the effectiveness of the control program. The potential deployment of a camera trapping grid in the Itcha-Ilgachuz calving areas could also fill some information gaps for this caribou herd, such as the predator-caribou interactions at this important biological season. Deploying remote cameras can be a cost effective management tool, especially if such a program occurs over a large spatiotemporal scale (Steenweg et al. 2016).

s.18

Figure 5. Potential wolf treatment area based on the designated 9,457km^2 Itcha-Ilgachuz herd boundary. Purple points represent 2018 radio-collared caribou locations from collar deployment to date (March 2018 to September 2018).

7 Timeframe & Budget

Tentative predator management timeframe & budget

Develop wolf control program in core caribou habitat (9,457 km^2). A four phase plan, based on recommended management actions in the Itcha-Ilgachuz herd recovery plan, is outlined below. Ongoing caribou population monitoring is required throughout the wolf control program and for years after the end of the wolf removal program to determine its effectiveness.

- **Phase 1**: Collar wolves within ECCC core caribou habitat, focusing on areas of high caribou use in SBPS zone, winter 2018-19. Deploy 1-2 collars in each wolf pack.

- **Phase 2**: Monitor GPS collar data to determine wolf and caribou spatial overlap, map seasonal home ranges of wolf packs, and accurately estimate wolf density.

- **Phase 3**: Lethally remove wolves via aerial gunning. Due to the high intensity, multi-year wolf removal needed to achieve caribou herd population increases, only implement a wolf control program if funds are guaranteed for 1) intensive wolf removal for a minimum of 4 years and 2) to monitor calf recruitment and herd populations for 5 years.

It is not recommended to begin a wolf control program if funds for the above are not guaranteed. Wolf removal over a similar size area in northeast BC cost $400,000/year.

- **Phase 4**: Ongoing caribou population monitoring to determine wolf removal effectiveness.

Determine if remote camera study is feasible for the Itcha-Ilgachuz caribou calving area:

- Potentially address information gaps regarding predator-caribou interactions during the calving season when neonate calves are most vulnerable to predation.

Apply for funding to cover laboratory work on cougar and wolf scats for:

- Diet; using prey species DNA or stable isotope analyses. Data on predator diet on the Chilcotin plateau is needed to understand the role of alternate prey (feral horses, mule deer, moose) in apparent competition dynamics with caribou
- Predator population estimation with DNA mark-recapture

The rationale for wolf removal is a steeply declining caribou population (average decline of 17% per year), mortality data for the herd showing wolf predation to be the leading cause of adult mortality (33.3%), and research that shows wolves can be responsible for >30% of caribou calf mortalities (Nieminen et al. 2013). In addition, wolf removal is most effective when done for a larger herd, so it is recommended to take this management action while the herd is still relatively large. A commitment to increasing habitat protection is necessary to go forward with predator removal. Predator removal is a temporary solution that only addresses the proximate cause of the herd's decline. For long-term recovery of this herd, habitat protection is required to addresses habitat loss, the ultimate cause of the herd's decline.

Table 2. Projected year 1 budget estimate for wolf and Itcha-Ilgachuz management

Wolf	Description	Estimate Cost
Wolf collar purchase*	s.17	$36,000 - $44,000*
Wolf Capture - Rotary		$128,000
Wolf Census		$24,000
Caribou		
Collar purchase*		$27,000
Caribou Capture		$22,400
Post-Calving Survey		$8,250
		$36,000
Late-winter Recruitment Survey		$6,600
		15,000
Equipment costs and expenses		$9000
Mortality investigations		$40,000
Total		**$352,250 – $360,250**

*Collar cost dependent on successful proponent.

Table 3. Projected annual budget estimate for year 2, 3 & 4

Wolf Removal efforts	Description	Estimate Cost
Rotary flight cost	s.17	$192,000
Fixed-wing flight cost		$16,500
Wolf collar purchase*		$10,800-$13,200
Accommodations (for three people)		$8500
Equipment costs		$1500
Total cost – wolf removal		**$229,300-$231,700**
Caribou inventory		
Caribou collars*		$27,000
Caribou capture		$22,400
Post-calving survey		$8,250
		$36,000
		$6,600
Recruitment survey		$15,000
Mortality investigations		$40,000
Total cost – Caribou monitoring		**$146,250**
Total		**$375,550-$377,950**
Additional Costs - Wolf Census Year 4		$24,000

*Collar cost dependent on successful proponent.

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Reedman, Dave FLNR:EX

From:	White, Shane FLNR:EX
Sent:	Tuesday, October 30, 2018 10:02 AM
To:	Nowotny, Chris ENV:EX
Cc:	Lirette, Daniel FLNR:EX; Shores, Carolyn FLNR:EX; Reedman, Dave FLNR:EX
Subject:	Draft Predator Management for Itcha-Ilgachuz caribou
Attachments:	Draft_ItchaIlgachuz_PredatorMGMT.docx

Hi Chris,

I hope this email finds you well. For your reference, I have attached the draft "Predator Management in support of the Itcha-Ilgachuz Caribou herd" word document for Parks review. Please do not distribute this document outside of Parks at this time. This document outlines potential predator management actions going forward to curtail the current Itcha-Ilgachuz caribou steep population decline. In short, a 4 phased approach in assessing predator-caribou dynamics for the Itcha-Ilgachuz caribou would be initiated, which includes;

1. GPS Radio-collaring of wolves within core caribou habitat
2. Monitoring GPS collar data to determine spatial overlap & reliably estimate wolf density
3. Implement lethal removal of wolves via aerial gunning.
4. Monitor caribou population throughout all phases to determine success of predator removal

Dan Lirette, Carolyn Shores and Dave Reedman have reviewed this document and provided feedback, and I am happy to address any questions and incorporate edits that you or other relevant Parks personnel might have. If you do have questions and/or feedback for me, could you please incorporate your edits using track changes and send a copy of the management plan back to me no later than November 13th.

Thank you and I look forward to hearing from you,

Regards,
Shane

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