The impact of habitat destruction and predator-prey relationships on the survival of Mountain caribou in the Southern Interior of British Columbia.

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Contents

Abstract

Mountain caribou, *Rangifer tarandus*, in Southern British Columbia are an at risk species which face many different stressors on their overall survival and recovery. Caribou habitat has been extremely degraded, making it more difficult for them to meet their survival habitat requirements. Habitat degradation allows predator's easier access to their summer and winter habitat, and introduces primary prey species into caribou range. In BC, habitat protection, moose reduction, wolf reduction, and caribou maternity pens have been used to help increase population growth rates, or lambda (λ), which has aided in their population recovery in areas where these management strategies are practiced. Human disturbance is the original key issue at hand. The production of linear features (logging roads and infrastructure, and ski operations), has allowed for predators to access caribou populations which would have otherwise been isolated due to the steep and remote topography of the landscapes which they generally reside within. For years, habitat has been severely degraded in Mountain caribou range, wolf numbers were unmonitored, and their population has expanded greatly across British Columbia. Mountain caribou are heavily preyed upon by wolves, bears, and cougars. When moose and deer are also present, predator competition can occur which reduces caribou numbers. Moose and deer populations support much higher wolf densities, which in turn reduces Mountain caribou populations, as they are an easier target for wolves. When moose and deer numbers are reduced, wolf numbers also decrease as a result, and caribou populations experience reduced predation. We are now seeing the full effect of our habitat destruction, and when paired with high predator numbers, the caribou are now in a state of desperation.

1.0 Introduction

1.1 The status of Mountain caribou in the Southern Interior of British Columbia

Mountain caribou, are a sub-group in Southern Interior British Columbia wet belt, to the Woodland caribou, *Rangifer tarandus,* and are considered 'endangered' in BC (Wittmer 2004). All sub-populations of caribou globally share the name of *Rangifer tarandus.* Northern Idaho marks the southern-most boundary of Mountain caribou range (Wittmer 2004). Province wide, caribou have declined from around 40,000 individuals, to around 15,000 in the last century. Many populations of Mountain caribou in BC are at risk of extirpation, such as the Columbia South herd which overlaps Glacier and Mount Revelstoke National parks, whose numbers went from 120 animals in 1994 to 4 animals in 2016 (Serrouya et al. 2016). Mountain caribou populations are located all across BC, each herd of varying conservation status and concern. Mountain caribou are an extremely unique species in British Columbia. They utilize specific high elevation habitats which deter other ungulates, and survive on a diet of mainly lichen, willow, Dwarf birch, and other woody browse, particularly during winter months (Apps and McLellan 2006). These features that caribou require are found in old growth forests of the interior wet belt of BC. They function well at lower densities compared to other ungulates, but as their populations reach extreme lows in most areas, they truly require special attention and adaptive management strategies to aid in their recovery (Guide Outfitters Association of British Columbia 2018). I will analyze and discuss issues pertaining to alternate prey theory and habitat, as that is the core underlying problem in Mountain caribou declines in most areas.

1.2 Alternate prey theory

Alternate prey theory arises from increases in certain species populations, and how their associated predators increase in numbers, and spread to new areas, therefore consuming other species as a by-catch. In the case of Mountain caribou, if populations of ungulates such as moose and deer increase, which are the primary prey of wolves, cougars, and bears, predator numbers will increase in response to more available prey. As predator numbers increase, there is a higher likelihood of them spatially distributing themselves on the landscape, and Mountain caribou can be predated upon, as secondary prey (Wittmer et al. 2005). Species of primary prey in BC are the Canadian moose (*Alces alces)*, Elk (*Cervus canadensis)* and both Mule deer (*Odocoileus hemionus)* and Whitetail deer (*Odocoileus virginianus)*. The main predators of Mountain caribou in BC are the Grey Wolf (*Canis lupis)*, Cougars (*Felis concolor)*, and bears, both Black bears (*Ursus americanus)*, and Grizzlies (*Ursus arctos)* (Serrouya, Wittmann, et al. 2015). Cougars are more common in southern areas of BC, whereas wolves, Black bears, and Grizzlies can be found province wide (Wittmer et al. 2005). Predator numbers generally increase in response to environmental changes which favor the novel primary prey. Generally, human caused factors are the main determining factor in environmental change, however, natural shifts in environment such as fires, weather patterns, and shifts in habitat vegetation can occur, and manipulate numbers of both primary prey and their associated predators (Serrouya et al. 2016).

1.3 Caribou critical habitat

Mountain caribou as of 1999 have a population distribution of approximately 58,500km^2, from the BC/Idaho border, north east to Prince George, 55°N (Wittmer et al. 2005). Their habitat lies within the

interior wet belt of BC (Figure 2). High precipitation, which is delivered primarily as snow, creates low fire frequencies. Therefore, mature forests dominate the landscape, which Mountain caribou have adapted to thrive in (Wittmer et al. 2005). Four main biogeoclimatic zones make up their niche, which include the Interior Cedar Hemlock zone (ICH), the Sub-Boreal Spruce zone (SBS), Engelmann Spruce Subalpine Fir zone (ESSF), and the Alpine Tundra zone (AT) (Wittmer et al. 2005). The caribou will utilize each of these habitat types according to snowpack, seasonal migration to summer and winter ranges, and based on forage availability. Mountain caribou will spend the winter months foraging for arboreal lichen in deep snow pack, often exceeding 2 meters, which they walk upon with their wide and splayed hooves (Wittmer et al. 2005). Caribou spend the majority of the summer in the AT and ESSF zones feeding on herbs, grasses, sedges, lichens, and bryophytes (Wittmer 2004). The protection of caribou winter range is especially critical, as this is when caribou face the toughest conditions for survival and often enter the spring months in very poor body condition, as do most species of ungulates due to harder to access forage in deep snowpack as well as increased calories burned while migrating and maneuvering through snow (Wittmer 2004). Mountain caribou require old growth forests for their survival (Serrouya et al. 2016). Old growth forests provide the lichens in which they feed on during winter months (Apps and McLellan 2006). Areas which contain the key components of caribou habitat can be grouped and recognized as caribou critical habitat, and require specific attention and protection from predation and destruction. Caribou critical habitat should not support the growth or expansion of moose or deer to provide prey for predator species. (Serrouya et al. 2016).

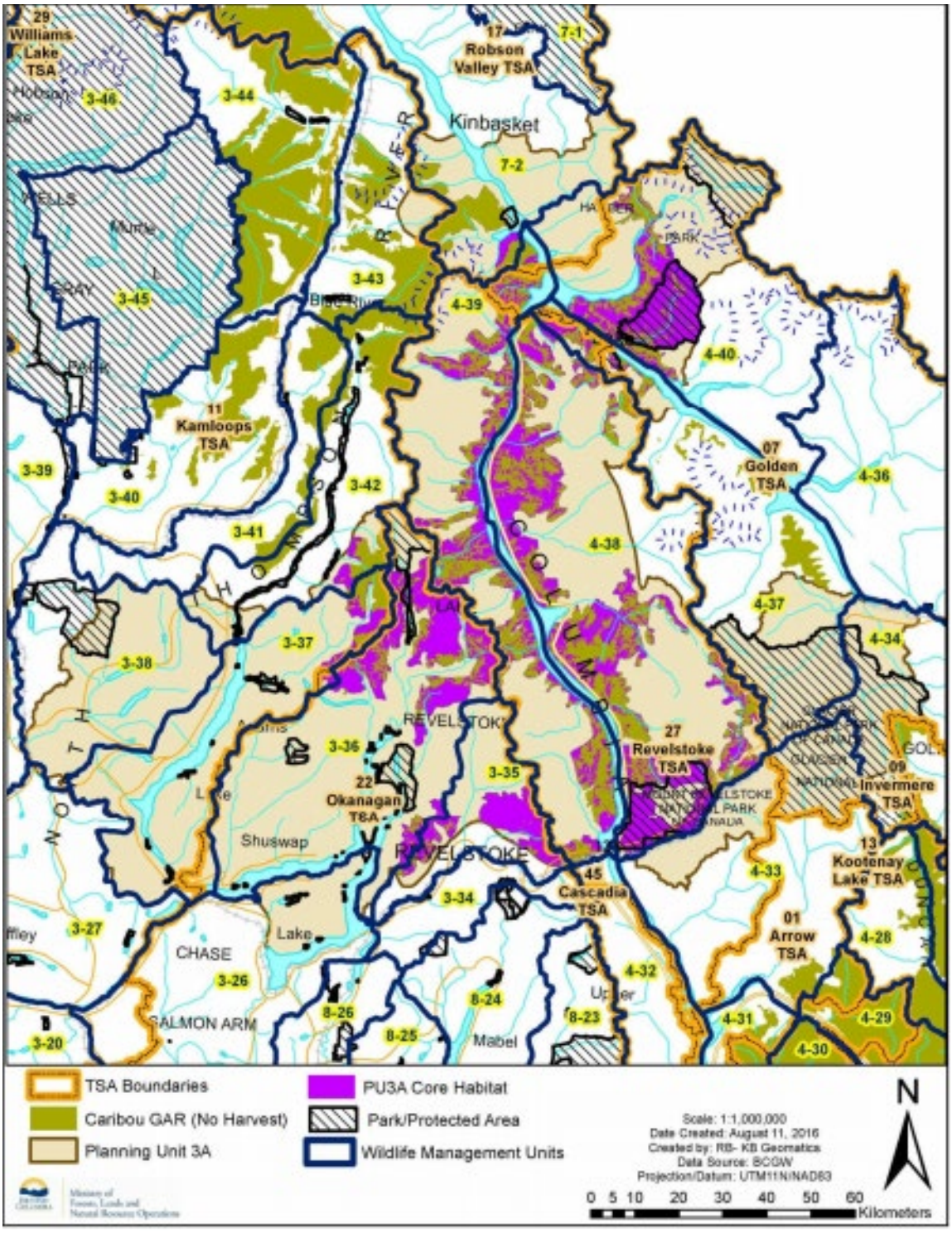

Figure 1. Caribou critical habitat, protected areas, and timber supply areas in the Columbia Shuswap and Revelstoke area. Retrieved from Next steps for Southern Mountain Caribou recovery in planning Unit 3A, the Revelstoke Shuswap Region (Serrouya et al. 2016).

This literature review will analyze how anthropogenic changes to caribou habitat have created a series of direct and indirect issues effecting caribou predation and the overall decline of their populations. The purpose of this literature review is to determine 1) habitat alterations through linear features, 2) caribou predation, 3) the current state of caribou habitat, 4) the effects of maternity penning, and 5) the impacts of motorized vehicles in backcountry areas.

2.0 Methods

For my research, I have collected reference papers through contacting various wildlife biologists throughout British Columbia and Alberta. These papers were published by both provincial governments and academic institutions. I will be analyzing data from multiple different studies, many of which draw very conclusive evidence, and will help lead to management recommendations for Mountain caribou. These papers contain information which I will be referring to in order to provide elaboration and support for my findings. For the purpose of this literature review, my study area will be herds within the Southern Interior of BC, which are divided into 18 separate herds. These herds extend from the Hart range north east of Prince George, to the South Selkirk mountain range on the BC-Idaho border.

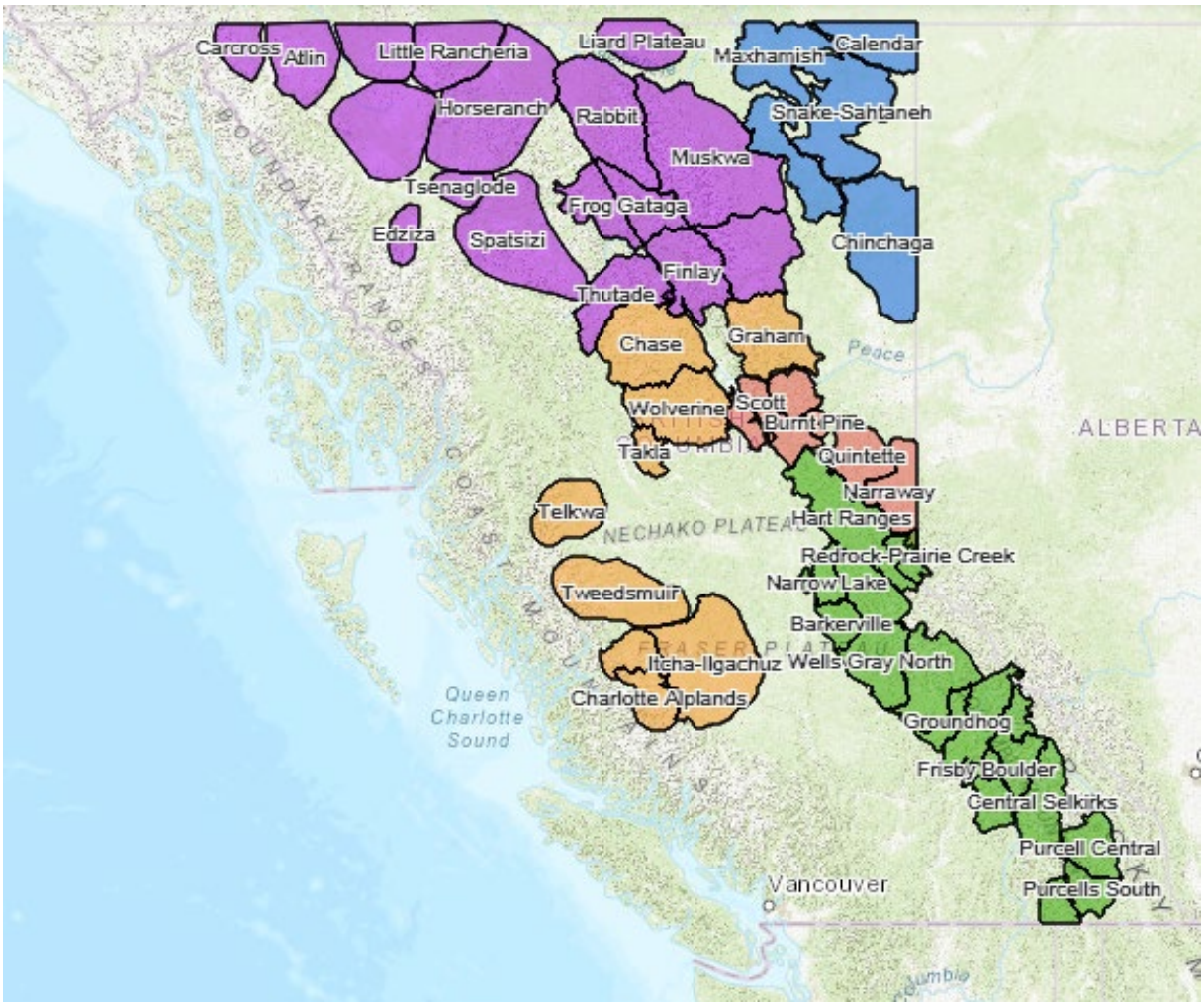

Figure 2. Mountain caribou sub-populations in British Columbia. For the purpose of this paper I will be focusing on the Southern Interior populations, indicated by the green polygons.

3.0 Results and Discussion

3.1 Roads and other linear features

As humans expand and exploit resources across western North America, the landscape left behind is scarred with the capillary-like framework of the industrialization of the natural environment. These

features can be seen as roads, pipelines, or any form of disturbance which creates linear access into what was once inaccessible otherwise (DeMars et al. 2017). Linear features adversely affect predator and prey relationships, as predators can utilize linear features to gain access to prey refugia at a must faster rate (DeMars et al. 2017). Serrouya et al (2016) reported that human disturbance was directly linked to positive effects on wolf population growth rates, when compared to areas completely unaffected by human disturbance, in 6 different areas (4000-5000 km^2) in the North West Territories. (Serrouya et al. 2016). The heterogeneity of a landscape is what allows for the coexistence of predator and prey species, as it is what affects the likelihood of encounter with one another, and the probability of death of the prey (Serrouya et al. 2016). This occurs due to the variation in topography which may favor the prey and effect the success of the predator, which acts as a regulating affect which will create a long term balanced system (DeMars et al. 2017). Anthropogenic forces will create overlap in the spatial and topographical ranges of Mountain caribou and their associated predators, favoring the movement and expansion of predators, and increase the odds of encounters (DeMars et al. 2017).

3.2 Caribou Predation

3.2.1 Moose reduction in Caribou areas

Wolf predation of caribou has been linked to human created disturbances which has increased populations of other ungulates, such as moose. A management strategy developed to decrease wolf densities in areas where caribou populations are in decline, has been to reduce moose densities to historic levels before human disturbance (Serrouya et al. 2016). Moose reduction is a method that has been practiced in the Lake Revelstoke area with some degree of success (Serrouya et al. 2016). Moose

densities are decreased by altering general open season regulations and increasing the number of tags for cow and calf moose through limited entry hunting (LEH), by licensed and non-licensed hunters (First Nation hunters). In most ecosystems across BC, wolf population levels are limited by moose densities (Serrouya et al. 2017). The Lake Revelstoke area has seen a reduction in wolf densities from around 30/1000km^2 in 2007, to around 11/1000km^2 recently (Serrouya et al. 2016). Moose reduction could likely be a viable option to help lower predation rates on Mountain caribou, however primary prey management is opposed by many stakeholder groups. The Guide Outfitters Association of British Columbia, who claim that manipulating prey levels of the trophic balance of an ecosystem is risky, and could simply lead to population crashes of moose and deer instead, while not doing much to help Mountain caribou herds. No scientific evidence is available to support the claim, as this statement is being made by guide outfitters, which hunt moose and deer, and not Mountain caribou.

3.2.2 Wolf reduction in caribou areas

The Grey Wolf has been identified as one the main predators for Mountain caribou in British Columbia, along with Black bears (DeMars et al. 2017). Wolf densities limit caribou abundance (Serrouya et al. 2017). Wolves have always been natural predators of Mountain caribou, however, human related disturbances tend to favor moose and deer propagation, therefore also greatly increasing populations of wolves and other predators. Deer and moose are considered primary prey species for wolves, cougars, Black bears, and Grizzlies (Guide Outfitters Association of British Columbia 2018). Currently there is not sufficient amounts of literature on bear predation of caribou, and further research is required. Through apparent competition, Mountain caribou become secondary prey in areas where wolf populations are high, therefore creating a link between human caused disturbances, and declines of Mountain caribou

herds across BC (Serrouya, van Oort, et al. 2015).The goal of the wolf reduction program is to remove entire packs or problem individuals from areas where Mountain caribou populations are suffering due to predation. The goal is not to exterminate wolves from BC, it is to help bring back trophic balance to ecosystems, where Mountain caribou risk extirpation. Wolf populations prior to 1950 were below historical levels due to intensive poisoning and trapping across BC, however wolf numbers have recovered dramatically since then and are above historical levels (B.C. Ministry of Forests, Lands 2014). Currently wolves in BC are stable or increasing (B.C. Ministry of Forests, Lands 2014). Wolves in BC are considered as an iconic species by many, as well as a threat to game populations and livestock, and their management should reflect all needs of British Columbians. There is no scientific peer reviewed literature available on why wolves in BC should not be managed. No one wants to see an animal die, however, wolf reduction has been proven as a very effective means to provide instant relief and recover to caribou herds which are struggling to survive (Serrouya et al. 2016). Wolves in British Columbia are designated as Not at Risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2004). The distribution of wolves in BC is wide spread, and number around 8500 individuals (B.C. Ministry of Forests, Lands 2014). Wolves in BC are removed in areas where Mountain caribou are observed in extremely low abundance, through aerial removal with no risk of by-catch. Currently, no wolves have been removed from the Lake Revelstoke area, however wolf reduction has occurred in the Thompson Region. Wolf reduction has seen fantastic results from herds around the province, when coupled with other strategies such as maternity penning. The Klinse-Za herd in Northern British Columbia has since been doubled since wolf reduction tactics began (Serrouya et al. 2016). Tremendous increases in caribou population size are extremely critical when herds are at extreme lows. In the 2016 study by Robert Serrouya in 6 different study areas in the Northwest Territories, caribou lambda was determined by monitoring caribou birth rates, and linked directly to wolf densities (Serrouya et al. 2016).

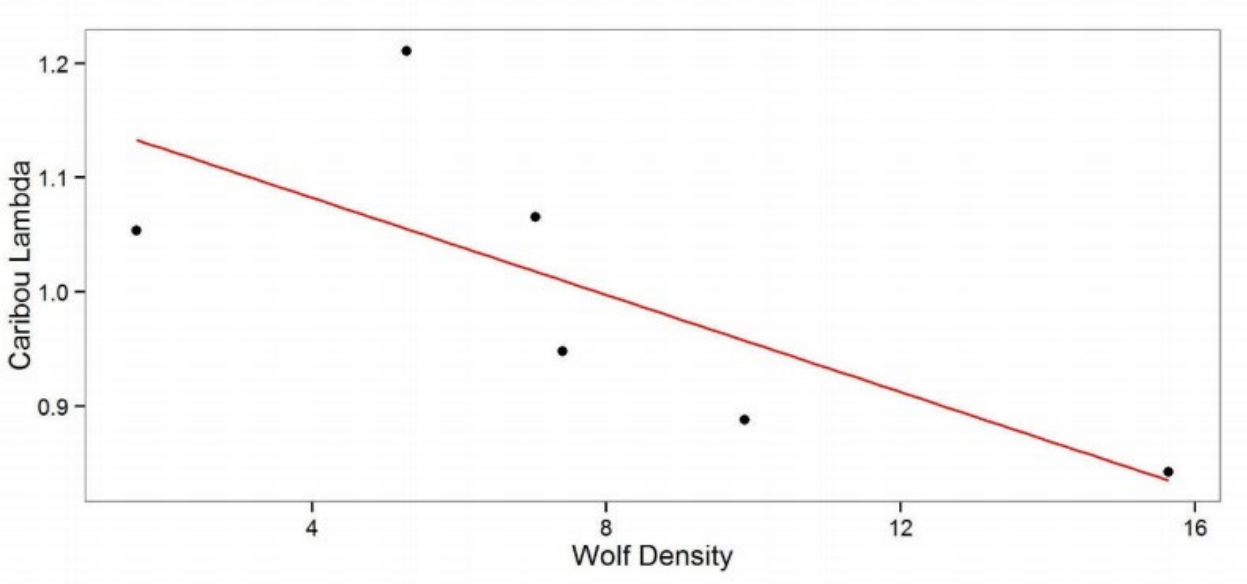

Figure 3. Relationship between caribou lambda and wolf densities in 6 different areas of the Northwest Territories (Serrouya et al. 2016).

3.2.3 Cougar predation

The decline of Mountain caribou in BC can be linked to predator densities (wolves), increased by apparent competition with moose. However, the effect of cougar predation on Mountain caribou was unknown. Bird et al (2010) began to address knowledge gaps on how cougars interact with Mountain caribou in the Lake Revelstoke area. In the 2010 study, researchers were able to capture and GPS collar 3 cougars of various ages, named “MG”, “Dennis”, and “Penelope”. From the collar data, researchers we able to track their movements in order to find kill locations. From data they gathered from kill sites they were able to determine major prey items of cougars and the percentage of total kills. In this study, only 1 of the 3 cougars was found to consume Mountain caribou (Figure 4), however the home range of all 3 cougars overlapped with Mountain caribou critical habitat. Kill sites were recognized through GPS “multiple cluster point sites” which means locations where the specific cougar spent enough time to

leave a cluster of data points. In this study, 634 multiple cluster points were identified, and 200 were visited. Of the 200 sites visited, 101 had evidence of a kill (Bird et al. 2010). Due to topography, and the expense of the helicopter to reach these multiple cluster points, not nearly enough sites could be visited out of the 634 that were identified. Ideally, all 634 data sites would be visited, however this is unrealistic, but a target for at least 50% of the data sites should be made for future research, and a greater sample size for cougars in the area. This data is important to identifying if cougars are in fact a key predator of Mountain caribou, however more research is needed to provide a more sufficient sample size of cougar kill sites, as it is highly possible that many more Mountain caribou were killed and not accounted for from the 634 confirmed multiple cluster point locations. The main prey consumed by cougars was deer, followed by moose, elk and beaver (Bird et al. 2010).

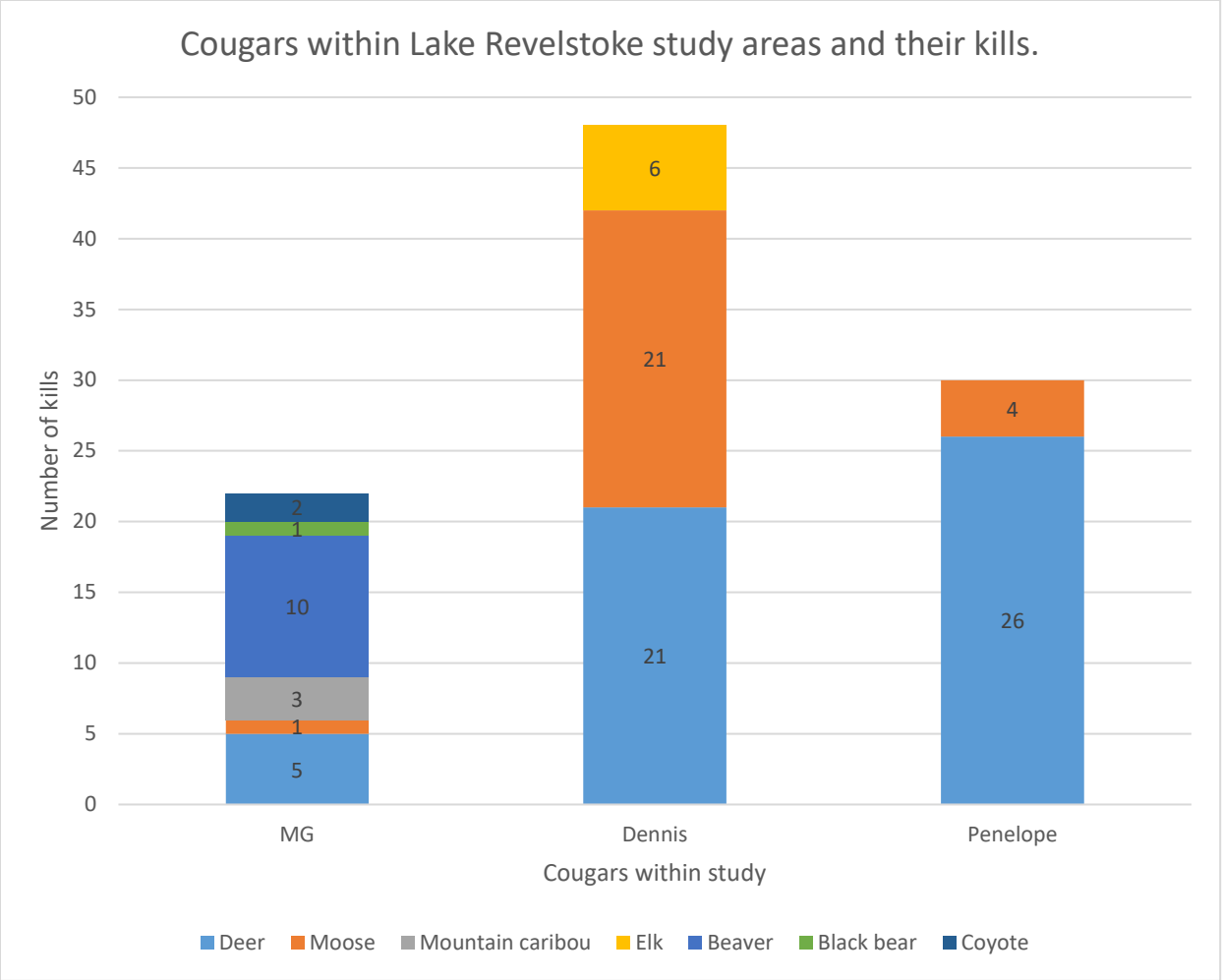

Figure 4. Cougars collared within the Lake Revelstoke study area and their associated kills, both numerical values and species (Bird et al. 2010).

3.3 State of current caribou habitat

Caribou depend on old growth forests for their survival. However, the old growth timber which provides Mountain caribou with the essentials for their survival, also hold the most value for forestry companies across BC. As for most industries, the desire for profit turns a blind eye to the direct and indirect suffering to the sensitive ecosystems of our province. Clear cuts are a common sight throughout the

landscape of BC, and it is no surprise that timber harvest is the main activity which persists within Mountain caribou habitat (Wittmer 2004). Currently, in certain management jurisdictions, caribou critical habitat is recognized and practically 100% protected from forestry activities and disruptive backcountry use such as snowmobiling and heli-skiing (Serrouya et al. 2016). However, in most locations experiencing declines in Mountain caribou, these protective measures are far too late, and forestry practices have destroyed high volumes of critical old growth timber and facilitated high levels of predation through the expansion of linear features such as roads. Apparent competition from moose and deer has occurred, as forestry practices create new growth which triggers population increases of other ungulate species (Wittmer 2004).

3.4 Caribou Maternity Penning

One strategy that has been implemented in some regions, is caribou maternity penning. Caribou maternity penning works by capturing pregnant females, and keeping them in an enclosed area a few acres in size. The caribou will be kept in the enclosed area until they have given birth, and calves are allowed to reach a certain size and health before being released. The idea behind it, is that calves are most vulnerable immediately after being born, and for the next few weeks afterwards. The pen will keep predators out, and allow more calves to reach a larger size where they will be able to fend for themselves better once they are released. However, the cost of penning is extremely high, and the process is very labor intensive (Serrouya et al. 2016). It is recommended that if maternity penning is to be utilized, it should involve capturing 30%-40% of female caribou within the population, and couple the penning with aerial and ground removal of wolves, in order to achieve maximum success of the project (Serrouya et al. 2016). Referring to a project performed on the Klinse-Za herd, which is located north of

the lake Revelstoke area, intensive wolf removal and penning of almost every female resulted in an increase of about 30 units of lambda (λ) for the herd, and shows the effectiveness which this program can have on a subpopulation (Serrouya et al. 2016). It is not recommended that maternity penning is used as a means to restore caribou numbers, unless it is used with wolf removal (Serrouya et al. 2016). In the Columbia North subpopulation, radio collars, and survey flights are used to analyze herd numbers and determine calf survival, typically in March, after winter conditions. Calf recruitment rates in the early 1990's were around 19%, and at the time this rate was increasing caribou population size. 2015 survey flights analyzed caribou recruitment rates and they were found to be about 11.5% (Serrouya, Furk, et al. 2015). If caribou numbers are to increase within the Columbia North subpopulation, I recommend that calf recruitment levels should stay above 19%, and more preferably range from 20%-30% in order to see immediate effects on population size, basing my recommendations on the previous calf recruitment rate of 19%, which promoted population growth.

3.5 Snowmobile and Backcountry Usage

Another key issue in declines of Mountain caribou is backcountry usage, particularly by heli-ski operations and snowmobiling. Snowmobiling often occurs within critical caribou winter habitat, and poses direct and indirect issues to caribou survival (Fletcher and Hamilton 2007). The use of snowmobiles will displace caribou from their preferred habitat, as caribou avoid the noise and human associated smells, and force them to move into less suitable areas to avoid snowmobiles (Fletcher and Hamilton 2007). A more indirect effect snowmobiles have is that they create linear features in the form of hard packed trails. This allows predators to travel with greater ease into caribou habitat. This is a direct observation which I have witnessed, however further research is required to solidify this

evidence. Many access management areas and motorized vehicle closed areas have been put in place across British Columbia to reduce the impact of backcountry usage on Mountain caribou, primarily in Region 4. Typically, caribou will not use habitats where snowmobiles are used, which can limit their access to forage in critical areas (Serrouya et al. 2016).

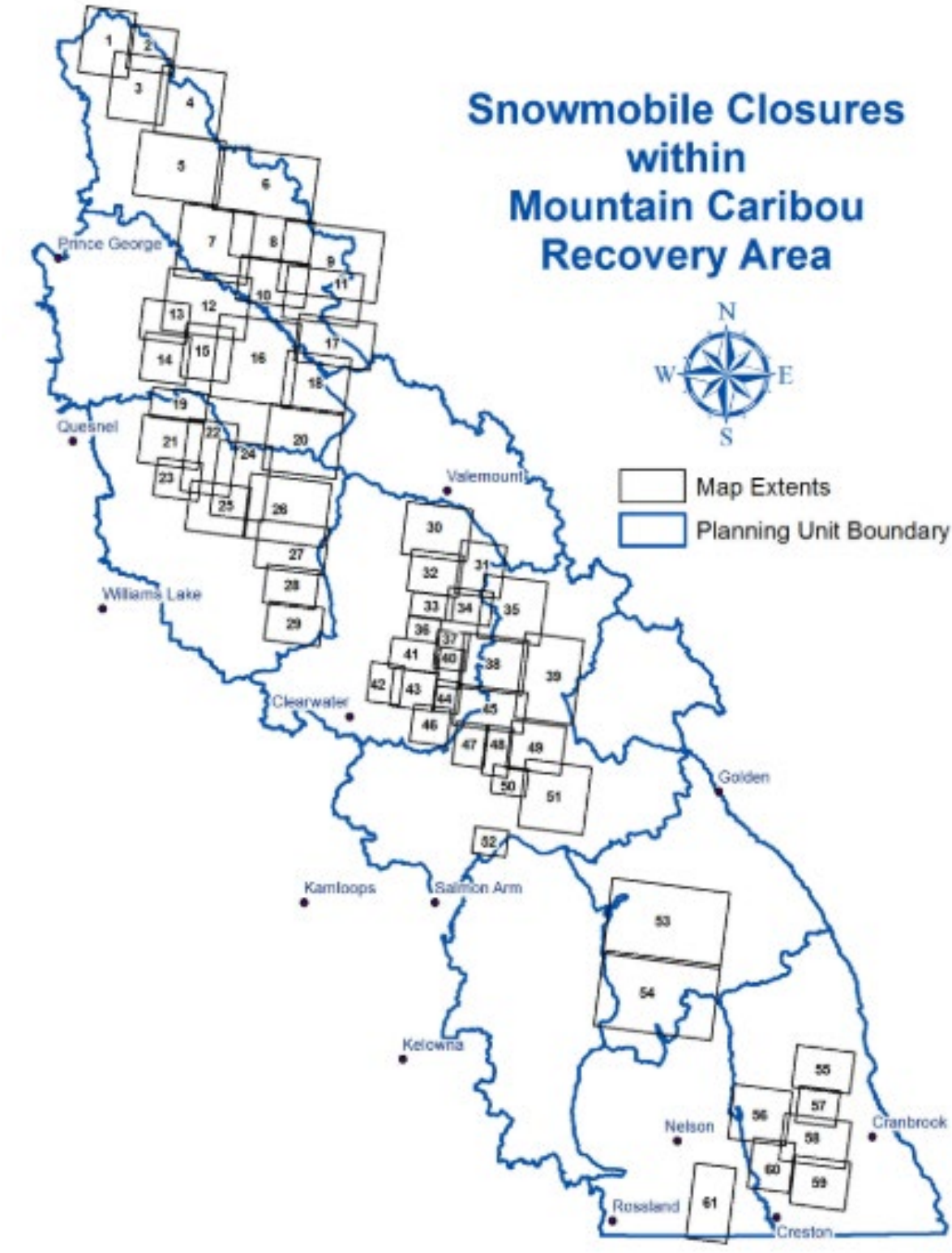

Figure 5. Snowmobile closure areas in Mountain caribou range. Map retrieved from Ministry of Forests, Lands, and Natural Resource Operations.

BC Conservation Officer Service routinely patrols motorized vehicle closure areas to ensure no one is illegally accessing caribou critical areas However, their patrols are done with use of snowmobiles, essentially making the access restriction on snowmobiles useless in the first place. Through the use of motorized vehicle closure areas, disturbance of Mountain caribou in their critical winter range is reduced. Caribou displacement by heli-skiing operations is low, as flight paths are spatially limited, and short in duration (Huebel 2012). Although the risk of displacement is low, it cannot be completely discounted. Stress hormones are higher in Mountain caribou in area which receive pressure from heli-ski operations, and there is still risk of direct harassment to caribou if skiers and caribou cross paths (Serrouya et al. 2016).

4.0 Conclusion

Mountain caribou are faced with a plethora of issues in BC. Habitat alterations and damage are general the key problem for most species of wildlife, and can trigger a devastating train of events. As for Mountain caribou, the predominant issues are habitat damage, wolf expansion and predation due to habitat damage, and primary prey interactions with moose, and deer, both Mule deer and Whitetail deer. Logging removes vast quantities of timber from the landscape, and thousands of kilometers of new roads infiltrate once what was untouched. With increased roads and sightlines, predators reap the benefits, and use these features to their advantage for finding and killing prey, allowing them to travel into harder to access areas with ease. As timber is removed from the landscape, it allows space for many species of forbs and grasses, which provide excellent forage for ungulate species. This creates higher populations of deer and moose, which coupled with easy road access for predators, greatly increases the populations of predatory species in BC such as wolves, cougars, and bears. As a result, Mountain

caribou are indirectly impacted, and this situation is referred to as apparent competition (Serrouya 2016). The quickly become secondary prey, and are consumed by predators as what could be called a "by-catch", caught in the crossfire as predators cover new areas of the landscape as moose and deer become more scarce due to their increased presence. Linear features continue to develop at an alarming rate in BC, despite the known negative impacts which they have. Management protocols have been put into place across BC, such as habitat protection, moose reduction, wolf reduction, and maternity penning, all with various levels of effectiveness. In many areas, habitat has been degraded to a point where there is not much hope for protection or restoration, and has led to increases in populations of wolves and other predators, making lethal removal the most effective option. Maternity penning has seen fantastic results in certain areas, but must also be coupled with predator reduction, in order to maximize effectiveness. Caribou winter range is currently protected in most areas across BC from motorized vehicle use, which should continue. Ideally, critical habitat areas for caribou would see complete protection within their entire range, linear features within caribou critical habitat would be none existent or reduced, and in areas where wolves overlap Mountain caribou range see targeted removal. In areas where apparent competition takes place in Mountain caribou range, and where moose and deer numbers are increasing, sport hunting should be used as an effective means to reduce populations of moose and deer to directly decrease predator densities. Mountain caribou are a unique species within British Columbia. They inhabit niche environments and occupy a wide native range. Human footprint on Mountain caribou habitat has created a plethora of issues which have drastically reduced caribou populations across the province. Some areas of BC have seen complete extirpation of caribou, while others are nearing that point. I have heard the argument made by some that at what point is it no longer worth it to put money and resources into caribou recovery, in areas where populations are extremely low. I believe it is our duty as stewards of the land and as scientists and researchers to continue to strive for the protection and recovery of all caribou herds and

subpopulations, as human caused disturbance can be directly linked to their demise in the first place (Serrouya et al. 2016).

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Appendix

Table 1. Species and frequency killed by Cougar "MG"

Species	Age Class	Number of Kills	Percentage of Total (%)
Beaver	Unknown Age	10	45
Deer	Unknown Age	5	23
Coyote	Unknown Age	2	9
Black Bear	6-18 months	1	5
Caribou	Unknown Age	3	15
Moose	6-18 months	1	5
Total		**22**	**100**

Table 2. Species and frequency killed by Cougar "Dennis"

Species	Age Class	Number of Kills	Percentage of Total (%)
Beaver	Unknown Age	1	2
Deer	<6 months	3	6
	6-18 months	6	12
	>18 months	9	18
	Unknown Age	3	6
	Subtotal	**21**	**43**
Elk	6-18 months	3	6
	>18 months	2	4
	Unknown Age	1	2
	Subtotal	**6**	**12**
Moose	<6 months	6	12
	6-18 months	6	12
	>18 months	6	12
	Unknown Age	3	6
	Subtotal	**21**	**42**
Total		**49**	**100**

Table 3. Species and frequency killed by Cougar “Penelope”

Species	**Age**	**Number of Kills**	**Percentage of Total (%)**
Deer	<6 months	1	3
	6-18 months	8	27
	>18 months	7	23
	Unknown Age	10	33
	Subtotal	**26**	**87**
Moose	<6 months	3	10
	>18 months	1	3
	Subtotal	**4**	**13**
Total		**30**	**100**