

State of Southern Mountain Caribou Habitat in BC: Exceeding Disturbance Limits



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Contents

1. Introduction.....	1	9. Results.....	13
2. Habitat and biological needs	3	9.1. LPU habitat disturbance	13
3. Status.....	3	9.1.1. Northern group.....	14
4. Population	4	9.1.2. Central group	14
4.1. Caribou population trends	4	9.1.3. Southern group	15
4.1.1. LPUs in the northern group.....	4	10. Discussion	16
4.1.2. LPUs in the central group.....	4	10.1. Summary of results	16
4.1.3. LPUs in the southern group.....	4	10.2. Importance of results	16
4.2. Locally extinct subpopulations	4	10.3. Data Gaps	17
5. Critical habitat	5	10.3.1. Partially identified habitat	17
6. Threats	6	10.3.2. Recovery strategy thresholds	
6.1. Habitat alteration causing predation	6	set a low bar	17
6.2. Loss of habitat	6	10.3.3. Wolf density is unusable	17
6.3. Roads and linear features	6	10.3.4. Recovery strategy habitat categories	
6.4. Recreational activities	6	don't align with map	17
6.5. Other threats	6	10.4. Solutions and future direction	17
7. Habitat protection and legal requirements	7	10.4.1. First Nations collaboration.....	17
7.1. Government of Canada.....	7	10.4.2. Complete critical habitat mapping.....	18
7.2. Government of British Columbia	7	10.4.3. Stronger, clearer habitat	
8. Methods.....	8	protection targets	18
8.1. Scope of study	8	10.4.4. Habitat protection must be	
8.1.1. Local population units	8	top priority	18
8.1.2. Disturbance mapping.....	8	10.4.5. Habitat restoration to	
8.1.2.1. Buffers.....	8	block access	18
8.1.2.2. Timescale	8	10.4.6. High impact recreation	19
8.2. Setting numerical recovery thresholds	8	11. Conclusion	20
8.2.1. Defining "minimal disturbance"	8	12. References.....	21
8.2.2. Wolf density thresholds	9	13. Appendix I	23
8.3. Creating comparable critical		14. Appendix II	24
habitat categories	9		
8.4. Recovery thresholds for each group	10		
8.4.1. Northern group	10		
8.4.2. Central group.....	10		
8.4.3. Southern group	11		
8.5. Disturbance mapping within caribou			
habitat categories	12		

Introduction

Woodland caribou, southern mountain population (*Rangifer tarandus caribou*), herein referred to as southern mountain caribou, are endemic to Canada. They occur throughout the lower two-thirds of BC and west-central Alberta. Previously their range extended into Idaho and Washington in the US but this subpopulation became locally extinct in 2018. Southern mountain caribou subpopulations (individual herds) and their ranges have been defined and mapped by the Canadian government. Subpopulations are grouped into local population units (LPUs). Some LPUs contain multiple subpopulations. LPUs reflect the historical larger subpopulations which have since declined and fragmented into the now distinct subpopulations (Environment Canada, 2014). Southern mountain caribou are divided into three ecological and evolutionarily distinct groups: the northern group, the central group and the southern group (Figure 1). These three groups occupy different areas of BC and have diverse habitat requirements.

Southern mountain caribou are a species at risk in BC and Canada. They were listed as a threatened wildlife species on Schedule 1 of the federal Species at Risk Act (SARA) in 2003 (Government of Canada, 2018). Southern mountain caribou have experienced an overall range loss of about 30% since the early 1990s (COSEWIC, 2014). At least six LPUs of southern mountain caribou have now become locally extinct.

Despite knowing about the threats and decline of southern mountain caribou for over three decades, the abundance and distribution of caribou has been greatly reduced and little has been done to effectively halt habitat fragmentation (Wittmer et al., 2005). Numerous studies have concluded habitat destruction and alteration is the ultimate or leading cause of decline and will need to be addressed for long-term recovery (Festa-Bianchet, Ray, Boutin, Côté, & Gunn, 2011; Ray et al., 2015; Serrouya et al., 2019a). Regardless, most effort in BC has focused

on short-term, temporary solutions such as predator control, maternity penning and captive breeding to protect caribou (Parr & Paquet, 2017; Ray et al., 2015). In 2007 the BC government announced habitat protection measures in the form of ungulate winter ranges and wildlife habitat areas (Ray et al., 2015). Yet, on the ground monitoring has proved that these designations do not necessarily exclude harmful activities to caribou. The Wilderness Committee and Wildlife Defence League found extensive logging occurring in ungulate winter ranges designated for the protection of the Wells Gray-Thompson LPU (Cox, 2019b). Increased habitat protection for most southern mountain caribou subpopulations across BC is not being considered, regardless of their dwindling populations. The provincial forestry minister announced in

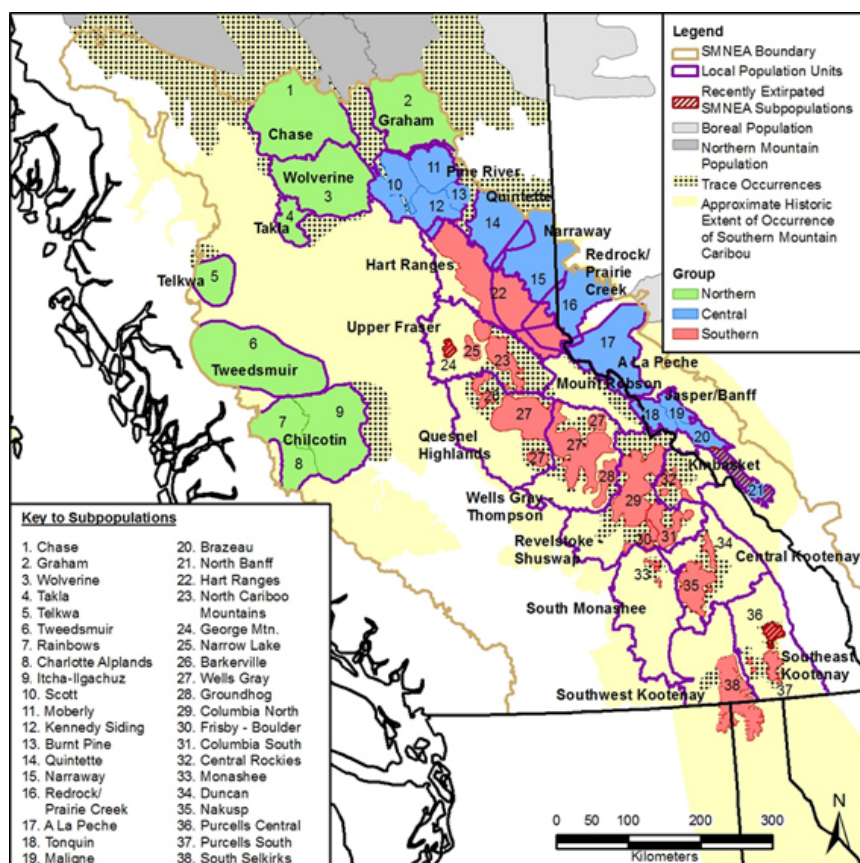


Figure 1. Groups and Local Population Units of Woodland Caribou, Southern Mountain population (from Environment Canada 2014).



Recently logged caribou old-growth habitat, east of Clearwater Valley (Joe Foy/ WC Files)

September 2019 that the government is reluctant to increase protection of southern mountain caribou critical habitat except for the subpopulations located in the Peace Valley region (Fletcher, 2019), although it is essential for the long-term recovery (Species at Risk Act Recovery Strategy Series, 2014). The decline of southern mountain caribou in BC is a result of ongoing mismanagement of a species at risk and their habitat by past provincial and federal governments, which have responsibilities to protect the species under SARA (Nixon & French, 2018). The current BC government has inherited a difficult task of recovering caribou in the face of decades of habitat mismanagement. Although more money and effort has been dedicated to southern mountain caribou recently, critical habitat protection for the majority of LPUs remains off the table (Dawe, 2019b; Fletcher, 2019). In 2014 the federal government published the report: *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada*. The recovery strategy was published seven years late, as it was supposed to be released by 2007. This recovery strategy is required under SARA and must also identify critical habitat to the extent possible. Critical habitat is the habitat necessary to achieve population and distribution objectives for the recovery and survival of southern mountain caribou. We refer to the 2014 recovery strategy and the critical habitat identified in it throughout the rest of this report. In the 2014 recovery strategy the critical habitat is partially identified and mapped. Yet, as we have found, southern mountain caribou critical habitat continues to be disturbed from activities like logging, road building, oil and gas activities, and mining (Cox, 2019a; Dawe, 2019a).

Although previous analysis has been done to identify the destruction of caribou habitat by varying industries (Serrouya et al., 2019b), there has not been a recent analysis calculating the footprint of all destructive activities occurring within critical habitat while considering time needed for habitat to become suitable again for caribou. The federal recovery strategy defined critical habitat for all three groups and assigned thresholds for the maximum amount of disturbance that can occur within each category of critical habitat. If destruction exceeds the thresholds then population and distribution objectives for the recovery and survival of southern mountain caribou will likely not be met (Environment Canada, 2014).

The objective of this analysis is to determine which, if any, LPUs have exceeded the federal recovery strategy critical habitat thresholds necessary to achieve caribou recovery and survival. To do this we included all disturbance types harmful to caribou within a time range that qualifies the habitat as disturbed. Destructive activities include all cutblocks, roads, utility right-of-ways, pipelines, seismic lines, and gas wells that have occurred throughout the past 80 years. These activities have been identified in the recovery strategy as harmful to caribou.



Caribou habitat near Wells Gray Provincial Park (Joe Foy/WC Files)

Habitat and biological needs

The following information has been taken from the *Species at Risk Act Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* 2014, unless otherwise stated.

Southern mountain caribou occupy diverse topography and terrain as well as varying environmental conditions. In order to separate themselves, horizontally and by elevation, from predators and other prey species, they need large areas of relatively undisturbed and connected habitat. A large range of intact habitat is needed so they can modify their use of habitat in response to natural and human caused disturbance and activities, and to access preferred food sources. In the winter they need large patches of mature and old forests with abundant lichen. Most southern mountain caribou require high elevation habitat to birth their calves. Because many caribou subpopulations traverse from different seasonal ranges, southern mountain caribou require connected lands to facilitate these movements, called matrix range. matrix range must provide forage, security from human

disturbance and have a low risk of predation.

The northern group (west-central and north-central BC) and the central group (east-central BC and west-central Alberta) spend their time in low snowpack areas. During the winter they will use low elevation mature coniferous forests or alpine slopes to find terrestrial lichens, which they primarily rely on. They will also use low elevation forests, forested wetlands and subalpine habitats to find arboreal lichen (lichen growing on trees), which they also forage on. Certain subpopulations of central and northern groups can travel long distances between winter and summer ranges. Other subpopulations remain year-round in a general area. Both central and northern groups require intact matrix habitat for a low predation rate. The southern group (in southeastern BC) spends the winter in high elevation mature and old forests and subalpine areas with deep snowpack to forage on arboreal lichens. During the spring and early winter, they use low elevation mature and old forests. To ensure a low predation rate, the southern group also requires intact matrix habitat.

Status

Southern mountain caribou were listed as a threatened wildlife species on Schedule 1 of SARA in 2003. The federal recovery strategy was posted eleven years later on June 3, 2014. In 2014 an assessment and status report for southern mountain caribou concluded the condition of many subpopulations in all three groups had deteriorated (Ray et al., 2015). The central group and southern group were observed to have small and declining populations and are now recognized as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The northern group is now recognized as special concern (COSEWIC, 2014). BC's conservation data center (CDC) ranks the three groups individually as well. CDC lists the central and southern groups as red-listed (extirpated, endangered or threatened) and the northern group as blue-listed (special concern) ("BC Species and Ecosystem Explorer," 2020).

In May 2018, the federal Minister of Environment and Climate Change (ECCC) Catherine McKenna determined that woodland caribou, southern mountain population, faces imminent threats to its recovery. The Central Kootenay, Southwest Kootenay, Southeast Kootenay, Kinbasket, South Monashee, Quintette, Narraway, Jasper-Banff, Redrock-Prairie Creek, and Telkwa LPUs were noted of particular concern. Minister McKenna stated that although population management has had some positive short-term effects, these measurements are not being sufficiently complemented by significant habitat protection or restoration measures, which are required to improve the likelihood of long-term recovery (Government of Canada, 2018). Under section 80(2) of SARA, once a species is found to face imminent threats to its recovery, the federal minister of ECCC is required to recommend that Cabinet make an emergency order to protect the species and its habitat (Species at Risk Act, 2002). To date the public has not been notified if the minister has recommended an emergency order and whether Cabinet has determined to issue one or not.

Population

4.1 Caribou population trends

The following population trend information was taken from the *Conservation status of caribou in the western mountains of Canada: Protections under the species at risk act, 2002-2014*.

4.1.1 LPUs in the northern group

The nine subpopulations that make up the northern group of southern mountain caribou in BC have experienced an overall decline of 34% since 2002, from 4,030 to 2,673 mature individuals. Recent surveys indicate that three LPUs in west-central BC (Telkwa, Tweedsmuir and Chilcotin) are currently declining.

4.1.2 LPUs in the central group

The estimated overall decline in the central group was at least 64% during the last three generations. The 2014 estimate for the central group of southern mountain caribou within BC is 247 mature individuals. All five extant subpopulations in BC belonging to the central group contain fewer than 100 mature individuals, and three among them had fewer than 50.

4.1.3 LPUs in the southern group

The estimated overall decline in the southern group was at least 46% over the last three generations. The 2014 estimate for the southern group is 1,354 mature individuals. Only two subpopulations had more than 250 mature individuals, nine numbered fewer than 50, and six of these fewer than 15.

4.2 Locally extinct subpopulations

Below is a list of known subpopulations that have become locally extinct:

- Purcells Central – belonged to the Southeast Kootenay LPU of the southern group (Shore, 2018).
- Monashee subpopulation – belonged to the South Monashee LPU of the southern group (Government of British Columbia & Government of Canada, 2017).
- George Mountain – belonged to the Upper Fraser LPU of the southern group (Government of British Columbia & Government of Canada, 2017).
- South Purcells – belonged to the Southeast Kootenay LPU of the southern group (Shore, 2018).
- South Selkirks – belonged to the Southwest Kootenay LPU of the southern group (Shore, 2018).
- Burnt Pine – belonged to the Pine River LPU of the central group (Government of British Columbia & Government of Canada, 2017).

Table 1. Central, northern, southern group local population units in BC and studied in this report.

Central Group LPUs
Narraway
Pine River
Quintette

Northern Group LPUs
Chase
Chilcotin
Graham
Takla
Telkwa
Tweedsmuir
Wolverine

Southern Group LPUs
Central Kootenay
Hart Ranges
Mount Robson
Quesnel Highlands
Revelstoke-Shuswap
South Monashee
Southeast Kootenay
Southwest Kootenay
Upper Fraser
Wells Gray-Thompson
Kinbasket

Critical habitat

Critical habitat is defined in SARA subsection 2(1) as, “the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species” (Species at Risk Act, 2002). The recovery strategy defines critical habitat for southern mountain caribou as the ranges within each LPU that contain the biophysical attributes required to carry out their life processes. The following habitat disturbance thresholds for recovery apply for categories of critical habitat (Environment Canada, 2014):

- All of the area of high elevation winter and/or summer range.
- Within the northern and central groups that contain low elevation winter range, a state of a minimum 65% undisturbed habitat (or inversely maximum 35% disturbed). This is required for an overall ecological condition that will allow for an ongoing recruitment and retirement cycle of habitat. This threshold was based on a 60% probability that a boreal caribou population would be self-sustaining at this 65% level of disturbance (Environment Canada, 2012). No such analysis has been done for southern mountain caribou. Yet, since boreal caribou ranges and the northern and central groups' low elevation winter ranges consist of fire-adapted ecosystems, the recovery strategy applies this same threshold.
- Matrix range that provides an overall ecological condition that will allow for low predation risk is defined as wolf population densities less than 3 wolves/1000 km².

The above information has been summarized in Table 2. This table, produced in the 2017 Protection Study, clearly explains the six range types of critical habitat for the northern, central and southern group as identified in the recovery strategy. This is the most in-depth explanation of southern mountain caribou critical habitat and the varying recovery thresholds. Recovery thresholds are the amount of critical habitat range that must remain intact, defined as a percentage or a wolf density. The six critical habitat range types are: high elevation winter and summer range, low elevation winter range, low elevation summer range, low elevation early winter and/or spring range, Type 1 matrix, and Type 2 matrix. Each range type has an identified recovery threshold necessary to achieve the survival or recovery of southern mountain caribou. Recovery thresholds will be referred to throughout this report.

Range Types	Northern Group Recovery Thresholds	Central Group Recovery Thresholds	Southern Group Recovery Thresholds
High elevation winter range*	Minimal disturbance		
High elevation summer range*	Minimal disturbance		
Low elevation winter range	Minimum 65% undisturbed		N/A
Low elevation summer range	Minimal disturbance	N/A	N/A
Low elevation early winter and/or spring range	N/A	N/A	Minimal disturbance
Type 1 matrix range	Minimum 65% undisturbed		Wolf density of < 3/1000 km ²
Type 2 matrix range	Wolf density of < 3/1000 km ²		

Table 2. Critical habitat range types and recovery thresholds for each group of southern mountain caribou, defined in the 2014 federal recovery strategy (Government of British Columbia & Government of Canada, 2017).

*The recovery strategy combines these range types into one of the six critical habitat types.

Threats

The following information has been taken from the *Species at Risk Act Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* 2014, unless otherwise stated.

6.1 Habitat alteration causing predation

The most significant, immediate threat to all three groups of southern mountain caribou is increased predation resulting from habitat alteration due to industrial activities. Industrial activities like logging, mining, and fossil fuel exploration and development remove and alter habitat. This creates a forest favoured by prey species like moose and deer. The result can be:

- A change in predator-prey dynamics. In ranges with habitat alteration providing favorable conditions for other prey species, predators such as wolves can increase in number and significantly reduce or even eliminate southern mountain caribou subpopulations.
- Increased predation of caribou due to disturbances reducing the spatial separation between caribou and other prey or predators.

6.2 Loss of habitat

There are impacts beyond changes in predator-prey dynamics from loss of habitat. These impacts include:

- Permanent habitat changes resulting in loss of habitat from industrial infrastructure or agriculture. Reduced habitat quality and quantity may lead to a reduction in the size of the range and potentially result in the extirpation of a subpopulation.
- Industrial activities can also affect caribou directly through impacts on forage lichens resulting in a loss of food resources.
- Temporary habitat changes such as forest harvesting can take 60-80 years for fire-adapted forests and over 100 years for high elevation subalpine habitat or low elevation cedar-hemlock forests to become suitable habitat for southern mountain caribou. Disturbed habitat will be unsuitable for the next 80-100 years.

- Habitat alteration resulting from industrial activities has been linked to reduced range occupancy, population declines and reduced adult caribou survival.

6.3 Roads and linear features

Pipelines, seismic lines, off highway vehicle trails and hydro transmission lines can impact southern mountain caribou indirectly by:

- Causing forest fragmentation. Southern mountain caribou avoid roads and other linear features.
- Improving access and efficiency of movement of predators. In the central group, encounter rates between wolves and caribou increased with proximity to linear features. In the southern group, wolf predation on caribou occurs in association with roads at the fine scale.

6.4 Recreational activities

In addition to providing access for predators, recreational activities such as off highway vehicles, heli-skiing and snowmobiling cause other impacts such as:

- Displacing caribou into areas where mortality risk is higher.
- Causing increased levels of stress. Increased levels of stress hormones have been found in caribou up to 10 km away from winter recreational activities. Continued stress could lead to poor body condition and lower survival and reproductive rates.

6.5 Other threats

Other threats to caribou include habitat disturbance caused by fire and forest insects, hunting, climate change, avalanches, parasites, disease, noise and light disturbance.

Habitat protection and legal requirements

Southern mountain caribou were listed as a threatened wildlife species on Schedule 1 of SARA in 2003. Both the provincial and federal government have different responsibilities and have undergone different initiatives to protect southern mountain caribou.

7.1 Government of Canada

For species at risk located on federal land, there are general prohibitions in order to protect the species under SARA. The general prohibitions include protection from: killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals of endangered, threatened and extirpated species listed in Schedule 1. The act also contains a prohibition against the damage or destruction of their residences (e.g. nest or den) (Government of Canada, 2019). These prohibitions automatically apply to all species located on federal lands throughout provinces and territories under the authority of the federal minister of ECCC or the Parks Canada Agency (Environment Canada, 2007).

For southern mountain caribou on provincial land or private land, SARA first looks to the provinces or territories to provide protection of individuals of species at risk and their habitat (except for migratory birds and aquatic species) (Government of British Columbia & Government of Canada, 2017). The provinces and territories have a responsibility to effectively protect critical habitat of threatened and endangered land-based species on non-federal land. If the provinces and territories fail to do this, the federal minister of ECCC must recommend an order be made which would provide effective protection for a portion or all of a species critical habitat (Environment Canada, 2007). The government of Canada has obligations under SARA to ensure critical habitat of southern mountain caribou is being effectively protected by the BC government, even when the habitat is located on provincial or private land.

7.2 Government of British Columbia

The government of British Columbia is responsible for protecting critical habitat of southern mountain caribou found on non-federal lands (Government of British Columbia & Government of Canada, 2017). The

province is required to develop laws/policies which would effectively protect critical habitat found throughout BC on non-federal land, which makes up 99% of BC's land base ("Working on the Land Base - Province of British Columbia," n.d.). In order for the government of BC to effectively protect critical habitat and avoid an order from the federal government, they must provide recovery outcomes similar to SARA subsection 61(1) (where no person shall destroy any part of the critical habitat of a listed endangered species or a listed threatened species) (Environment and Climate Change Canada, 2016). The BC government is under increasing pressure to protect critical habitat since the announcement was made in May 2018 that determined southern mountain caribou are facing imminent threats to their recovery. Under section 80 of SARA, when such a finding occurs the federal minister of ECCC must recommend to governor in council that an emergency order be made (Government of Canada, 2015). If the government of BC wants to avoid this order, they must finally implement laws and policies that achieve the level of critical habitat protection described in the 2014 federal recovery strategy.



Southern mountain caribou herd, near Selkirk (David Moskowitz)

Methods

8.1 Scope of study

8.1.1 Local population units

In this study we included the LPUs found only in BC that have federally mapped critical habitat, downloaded from the Environment and Climate Change Canada website. This map data is still incomplete and some LPUs have critical habitat partially mapped. Type 2 matrix range is located outside of southern mountain caribou LPUs annual range (Environment Canada, 2014). Matrix Type 2 range is not included in federal critical habitat mapping and therefore exists outside of our study area (our study area is restricted to within LPU boundaries). The LPUs from the northern group included in this analysis are Chase, Chilcotin, Graham, Takla, Telkwa, Tweedsmuir and Wolverine. The central group LPUs in this study are Pine River, Quintette and Narraway. The southern group LPUs in this analysis are Hart Ranges, Upper Fraser, Quesnel Highlands, Wells Gray-Thompson, Revelstoke-Shuswap, Kinbasket, South Monashee, Central Kootenay, Southeast Kootenay, Southwest Kootenay and Mount Robson (Table 1).

8.1.2 Disturbance mapping

We mapped the disturbance of all cut blocks, roads, utility right-of-ways, pipelines, seismic lines and gas wells. All the listed activities impact caribou. All anthropogenic disturbance mapping data was downloaded from the BC government data catalogue as GIS shapefiles.

8.1.2.1 Buffers

We added a 500 metre buffer to each disturbance. The buffer was chosen because disturbance is defined in the recovery strategy as the area affected by human-caused disturbance, including a 500 metre buffer around the area to account for avoidance by caribou (Environment Canada, 2014). Further, ECCC demonstrated that the 500 metre buffer best represents the combined effects of increased predation and avoidance on caribou population trends at the national scale (Environment Canada, 2011).

8.1.2.2 Timescale

All the above listed disturbances within the past 80 years were included in the analysis. The exact date range of disturbances included in the analysis is 1939-2019. Any disturbance occurring before 1939 was not included in total disturbance. We chose an 80-year disturbance timescale because fire adapted forests can take 60-80 years to become suitable again for caribou after habitat alteration, and subalpine habitat or low elevation cedar-hemlock forests can take 100 years (Environment Canada, 2014). The federal critical habitat map does not delineate between fire-adapted forests and high elevation subalpine habitat or low elevation cedar-hemlock forests. For this reason, we were unable to separate the forest types by regeneration time for caribou suitability. We chose a single threshold of 80 years because it represented the median recovery time from the range of 60-100 years required for forests to become suitable again for caribou.

8.2 Setting numerical recovery thresholds

Two recovery thresholds are measured in non-numerical values, minimal disturbance and wolf densities. Both thresholds were addressed in order to complete our analysis.

8.2.1 Defining "minimal disturbance"

The recovery strategy sets recovery thresholds for certain high and low elevation range types as "minimal disturbance," a non-numerical value. In order to do the analysis, we assigned a numerical value to range types which would accurately represent "minimal disturbance." We interpreted "minimal disturbance" to be approximately 0% because the federal recovery strategy defines critical habitat as all the area of high and low elevation (Environment Canada, 2014). Therefore, any disturbance throughout either high or low elevation range is considered the destruction of critical habitat. The "minimal disturbance" range types that we've applied a recovery threshold of approximately 0% disturbance are: high

Range Types	Northern Group Recovery Thresholds	Central Group Recovery Thresholds	Southern Group Recovery Thresholds
High elevation winter range	≈ 0% disturbance		
High elevation summer range	≈ 0% disturbance		
Low elevation winter range	< 35% disturbance		N/A
Low elevation summer range	≈ 0% disturbance	N/A	N/A
Low elevation early winter and/or spring range	N/A	N/A	≈ 0% disturbance
Type 1 matrix range	< 35% disturbance		N/S

Table 3. Critical habitat range types and numerical recovery thresholds for each group of southern mountain caribou. A value of ≈ 0% disturbances has been applied to all recovery thresholds with “minimal disturbance.” For matrix Type 1, the recovery threshold given in wolf density cannot be and is not included in our analysis. Since wolf density does equate to a threshold of allowed habitat disturbance it is labeled N/S for “not set.”

Recovery thresholds that were defined as minimum undisturbed values were changed to represent maximum disturbance values. For example, the recovery strategy requires a minimum of 65% undisturbed matrix habitat, which means a maximum disturbance of 35%.

elevation winter and summer range (for all groups), low elevation summer range (for the northern group) and low elevation early winter and/or spring range (for southern group) (Table 3).

8.2.2 Wolf density thresholds

The recovery strategy defines Type 1 matrix habitat for the southern group as the habitat needed to provide for an overall ecological condition that will allow for low predation risk, resulting in a wolf density of less than 3 wolves/1000 km². No numerical value for habitat disturbance was given which would result in a density of <3 wolves/1000 km² and no research has been done to indicate what level of habitat protection is needed to achieve a specified wolf density. Therefore, we were unable to extrapolate an actual number of allowable habitat disturbance which would result in <3 wolves/1000 km². As a result, the habitat recovery thresholds for matrix Type 1 of the southern group cannot be analyzed in our study. We labelled matrix habitat measured in wolf densities as “not set” or N/S (Table 3).

8.3 Creating comparable critical habitat categories

The federal habitat GIS mapping data shapefiles do not separate critical habitat into the same six range types outlined in the recovery strategy. Instead, the mapping data only separates critical habitat into two broad range categories: high and low elevation range and matrix range. In order to figure out if disturbance was crossing recovery thresholds within critical habitat, we needed to create the same two critical habitat categories from the range types and their corresponding recovery thresholds. We combined

the habitat range types outlined in the recovery strategy that included any high and low elevation range to create a single category. This category will henceforth be addressed as total high and low elevation habitat, or Category 1. In order to get a single recovery threshold value for Category 1, we added the recovery thresholds together for all range types included in Category 1 (Table 4). The federal map separates matrix habitat within LPU as its own category. Therefore Type 1 matrix range will be left as its own Category and will be referred to as total matrix habitat or Category 2 (Table 4).



Proposed Imperial Metals mine in caribou habitat near Blue River (Joe Foy/WC Files)

Range Types	Northern Group Recovery Thresholds	Central Group Recovery Thresholds	Southern Group Recovery Thresholds
High elevation winter range	≈ 0% disturbance		
High elevation summer range	≈ 0% disturbance		
Low elevation winter range	< 35% disturbance		N/A
Low elevation summer range	≈ 0% disturbance	N/A	N/A
Low elevation early winter and/or spring range	N/A	N/A	≈ 0% disturbance
Total high and low elevation habitat (Category 1)	< 35% disturbance	< 35% disturbance	≈ 0% disturbance
Type 1 matrix range	< 35% disturbance		N/S
Total matrix habitat (Category 2)	< 35% disturbance	< 35% disturbance	N/A

Table 4. Updated critical habitat categories used in this analysis including the total recovery threshold values. Category 1 recovery thresholds were created by adding the recovery threshold values together for all range types. Category 2 recovery thresholds are simply the thresholds given for Type 1 matrix range. Not all range types are required by the different groups of southern mountain caribou, indicated by N/A. All matrix recovery thresholds measured in wolf density are labelled N/S for “not set.”

8.4 Recovery thresholds for each group

8.4.1 Northern group

The Category 1 recovery threshold is less than 35% disturbed habitat. Three of the four range types have a recovery threshold of ≈ 0% and the low elevation winter range has a recovery threshold of less than 35% disturbance. Therefore, if Category 1 disturbance exceeds 35% then we know disturbance has exceeded the recovery threshold in at least one of the four range types making up Category 1. It should be noted that the recovery strategy set the low elevation recovery threshold of less than 35% disturbance based on a 60% probability that populations will be self-sustaining. The Category 2 recovery threshold for the northern group is less than 35% disturbed habitat. If disturbed habitat in the matrix habitat exceeds 35% it can be concluded that disturbance exceeds recovery thresholds (Table 5).

8.4.2 Central group

The Category 1 recovery threshold is less than 35% disturbed habitat. Two of the three range types have recovery thresholds of ≈ 0% disturbance and low elevation winter range of less than 35% disturbance. Therefore, if Category 1 disturbance exceeds 35% then we know disturbance exceeds the recommended amount in at least one of the three range types making up Category 1. The low elevation recovery threshold of less than 35% disturbance for the central group was also based on a 60% probability that populations will be self-sustaining. The Category 2 recovery threshold for the central group is less than 35% disturbed habitat. If disturbance in the matrix habitat exceeds 35% it can be concluded that disturbance exceeds recovery thresholds (Table 5).

8.4.3 Southern group

The Category 1 recovery threshold is $\approx 0\%$ disturbance. All three of the range types have recovery thresholds of approximately 0% disturbance. If Category 1 disturbance exceeds $\approx 0\%$, then we know disturbance has exceeded the recommended amount in at least one of the three range types making up Category 1. A recovery threshold for Category 2 for the southern group has not been set. Therefore, we were unable to compare the matrix habitat current disturbance level to a specified recovery threshold and determine if disturbance exceeds recommended amounts (Table 5).

Category	Northern Group Recovery Thresholds	Central Group Recovery Thresholds	Southern Group Recovery Thresholds
1: Total high and low elevation habitat	< 35% disturbance	< 35% disturbance	$\approx 0\%$ disturbance
2: Total matrix habitat	< 35% disturbance	< 35% disturbance	N/S

Table 5. Summary of the critical habitat categories and recovery thresholds that are used in this analysis. N/S indicates there is no habitat recovery threshold set for matrix habitat of the southern group.



Quintette caribou herd near Peace Valley region (Isabelle Groc)

8.5 Disturbance mapping within caribou habitat categories

We overlaid all shapefiles of cut blocks, roads, utility rights-of-way, pipelines, seismic lines and gas wells including a 500 metre buffer within the last 80 years with the federal critical habitat shapefile for each LPU of southern mountain caribou (Figure 2). This allowed us to see the current disturbance levels in federally mapped high and low elevation range and matrix range. We were able to determine the percent of habitat disturbance within both high and low elevation range and matrix range. We compared this number to the critical habitat recovery thresholds we assigned for Category 1 and Category 2, which are based on the federal recovery strategy. If the level of disturbance exceeded the Category 1 and 2 recovery thresholds, then we concluded that for those LPUs critical habitat is not being effectively protected.

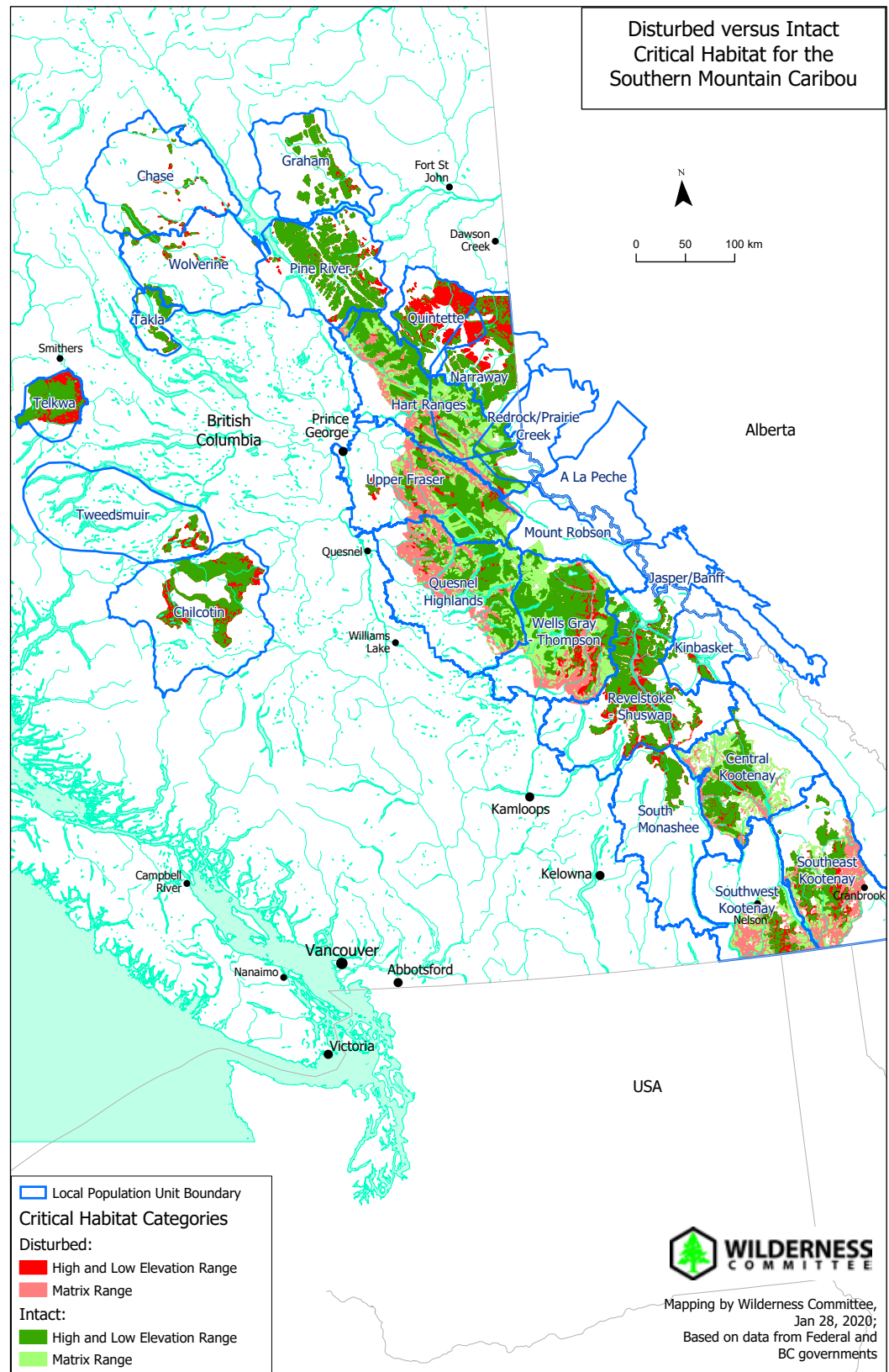


Figure 2. Map of all southern mountain caribou LPU boundaries which shows disturbance within the high or low elevation habitat and matrix habitat as well as the intact high or low elevation and matrix habitat.

Results

9.1 LPU habitat disturbance

All three groups of southern mountain caribou contain LPUs whose habitat disturbance levels exceed either the Category 1 or Category 2 recovery thresholds, Table 6. Only 4 LPUs have disturbance levels below the recovery thresholds: Chase, Wolverine, Graham and Takla LPUs.

Every LPU in the southern and central groups of southern mountain caribou have disturbance levels that exceed recovery thresholds. These two groups, containing 14 LPUs, are in the worst shape when it comes to habitat disturbance. Our results indicate that 17 LPUs have

disturbance levels throughout Category 1 or 2 that exceed the recovery thresholds suggested in the 2014 federal recovery strategy (Table 7). The northern group does not have matrix habitat mapped and so we were unable to compare the disturbance levels to the Category 2 recovery threshold. The central group's matrix habitat has been partially identified and mapped and we were unable to fully determine if disturbance levels exceed Category 2 recovery thresholds.

Northern Group LPUs	Disturbed high and low elevation habitat (%)	Disturbed matrix habitat (%)	Is disturbance exceeding 35% (Category 1)	Is disturbance exceeding 35% (Category 2)
Chase	27	N/A	no	N/A
Chilcotin	37	N/A	yes	N/A
Graham	17	N/A	no	N/A
Takla	10	N/A	no	N/A
Telkwa	43	N/A	yes	N/A
Tweedsmuir	53	N/A	yes	N/A
Wolverine	33	N/A	no	N/A

Central Group LPUs	Disturbed high and low elevation habitat (%)	Disturbed matrix habitat (%)	Is disturbance exceeding 35% (Category 1)	Is disturbance exceeding 35% (Category 2)
Narraway	52	N/A	yes	N/A
Pine River	12	68	no	yes
Quintette	76	0	yes	no

Southern Group LPUs	Disturbed high and low elevation habitat (%)	Disturbed matrix habitat (%)	Is disturbance exceeding = 0% (Category 1)	Is disturbance exceeding threshold for < 3 wolves/1000km ²
Central Kootenay	27	56	yes	N/A
Hart Ranges	11	59	yes	N/A
Mount Robson	33	40	yes	N/A
Quesnel Highlands	19	72	yes	N/A
Revelstoke-Shuswap	29	85	yes	N/A
South Monashee	23	N/A	yes	N/A
Southeast Kootenay	38	88	yes	N/A
Southwest Kootenay	53	74	yes	N/A
Upper Fraser	24	67	yes	N/A
Wells Gray-Thompson	27	48	yes	N/A
Kinbasket	44	N/A	yes	N/A

Table 6. Summary of current disturbance levels within each habitat Category and whether recovery thresholds have been exceeded for each LPU. All LPUs without matrix critical habitat mapped are represented by N/A. For those LPUs, it is impossible to determine whether matrix habitat disturbance has surpassed the recommended threshold. All LPUs that have habitat disturbance exceeding either Category 1 or 2 recovery thresholds are labeled "yes" in the respective columns, or "no" if disturbance has not exceeded recovery thresholds.

LPUs that have exceeded the federal habitat recovery thresholds	
Central Kootenay	Southern Group
Hart Ranges	Southern Group
Mount Robson	Southern Group
Quesnel Highlands	Southern Group
Revelstoke-Shuswap	Southern Group
South Monashee	Southern Group
Southeast Kootenay	Southern Group
Southwest Kootenay	Southern Group
Upper Fraser	Southern Group
Wells Gray-Thompson	Southern Group
Kinbasket	Southern Group
Narraway	Central Group
Quintette	Central Group
Pine River	Central Group
Chilcotin	Northern Group
Telkwa	Northern Group
Tweedsmuir	Northern Group

Table 7. A list of all LPUs with habitat disturbance that has exceeded either total high and low elevation (Category 1) or total matrix habitat (Category 2) recovery thresholds.

9.1.1 Northern group

The recommended recovery thresholds for both Category 1 and 2 in the northern group is less than 35% disturbance. The low elevation recovery threshold (included in Category 1) was based on a 60% chance the population will become self-sustaining. Therefore, when interpreting results for Category 1 disturbance levels it's important to be aware that abiding by the recovery thresholds would not guarantee recovery. By the same token, LPUs that are below the recommended disturbance levels, may still have up to a 40% probability of not becoming self-sustaining.

Three of the seven northern LPUs have current disturbance levels exceeding Category 1 thresholds: Chilcotin, Telkwa and Tweedsmuir, which have disturbance levels of 37%, 43% and 53% respectively (Figure 3). Other LPUs have disturbance levels extremely close to the 35% threshold such as the Chase and Wolverine LPUs whose disturbance levels are 27% and 33% respectively. Since the Chase and Wolverine LPUs are just below the recovery

thresholds, they may still have up to a 40% probability of not becoming self-sustaining. The matrix habitat for the northern group has not been mapped. Therefore, we were unable to determine whether the matrix habitat disturbance level is beyond the recovery threshold.

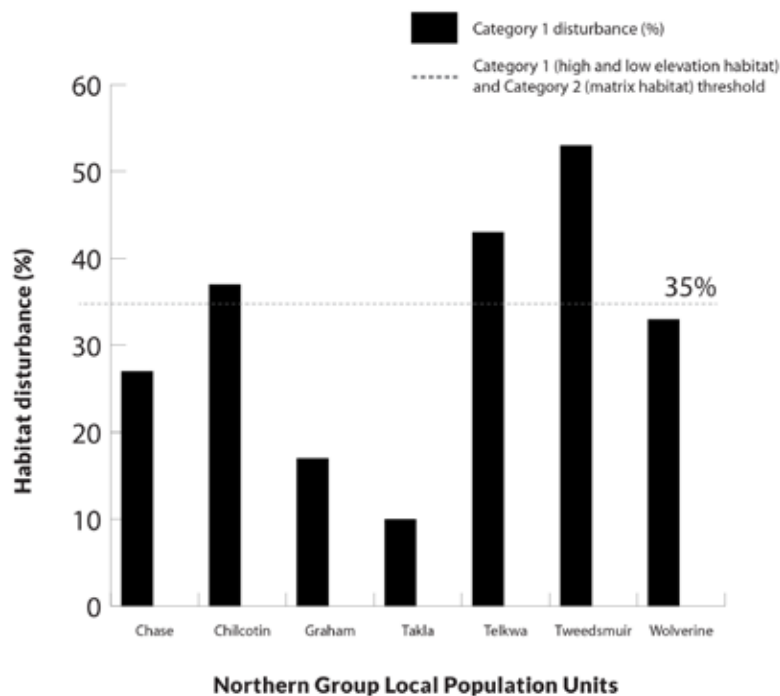


Figure 3. Habitat disturbance percentage throughout Category 1 habitat for the seven LPUs of the northern group. If habitat disturbance surpasses the dotted line representing the recovery thresholds for Category 1, those LPUs have exceeded the recommended amount of habitat disturbance.

9.1.2 Central group

The recovery threshold for both Category 1 and 2 is less than 35% disturbance. The low elevation recovery threshold (included in Category 1) was based on a 60% probability the population will become self-sustaining. Therefore, LPUs below the recovery threshold for Category 1 may still have up to a 40% chance they will not become self-sustaining. All three LPUs in the central group have current disturbance levels exceeding the recovery thresholds in either Category 1 or Category 2 (Figure 4). Narraway and Quintette LPUs have disturbance levels in Category 1 that exceed the 35% threshold, with levels of 52% and 76% disturbance respectively. The Pine River LPU's total Category 1 disturbance level is 12%, which is below the 35% recovery threshold. Yet, Category 2 disturbance within the Pine River LPU is 68%, which surpasses the recovery threshold of 35% disturbance.

Narraway has not had any matrix habitat mapped so we were unable to determine if disturbance levels in the matrix range have exceeded recovery thresholds. The Quintette LPU has matrix habitat only partially identified which is the reason it is noted to have no disturbance in the matrix range.

with certainty if this level of disturbance would create an environment that exceeds the threshold of 3 wolves/1000 km², but since habitat disturbance is the ultimate cause of decline, it is likely that this level of disturbance has negative impacts on the southern group LPUs.

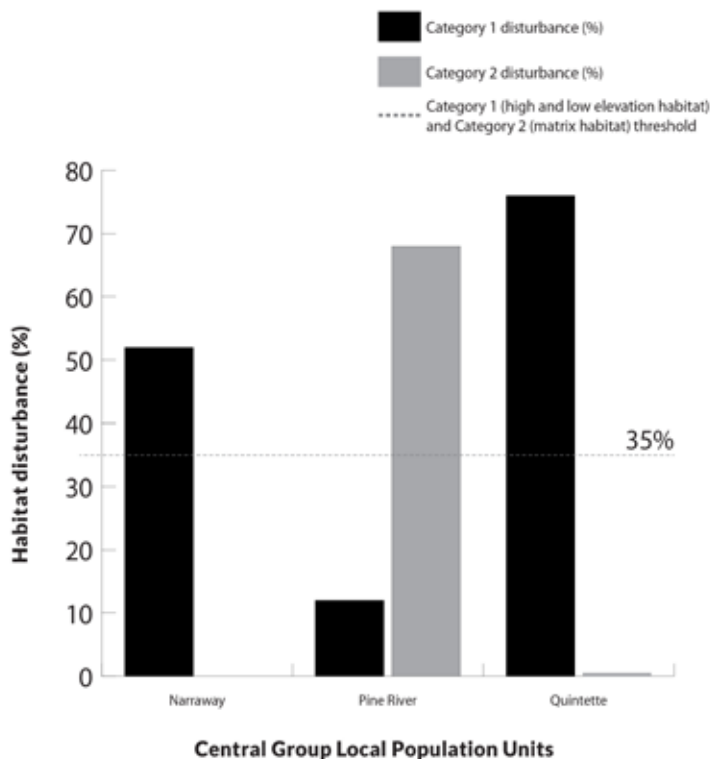


Figure 4. Habitat disturbance percentage for the three LPUs of the central group. If habitat disturbance surpasses the dotted line representing the recovery thresholds for Category 1 and 2 habitats, those LPUs have exceeded the recommended amount of habitat disturbance.

9.1.3 Southern group

All 11 LPUs in the southern group exceeded the Category 1 recovery threshold of $\approx 0\%$ (Figure 5). The highest disturbance level was in the Southwest Kootenay range where 53% of Category 1 habitat is disturbed. We were unable to conclude if Category 2 disturbance exceeds recovery thresholds because it is measured in wolves/1000 km². However, because matrix habitat has been identified and mapped for LPUs in the southern group (except for South Monashee and Kinbasket), we were able to determine matrix range disturbance levels for most LPUs in the southern group. Disturbance levels in the matrix range are extremely high, ranging from the lowest of 40% disturbed (Mount Robson) to the highest of 88% disturbed (Southeast Kootenay) (Figure 5). We cannot say

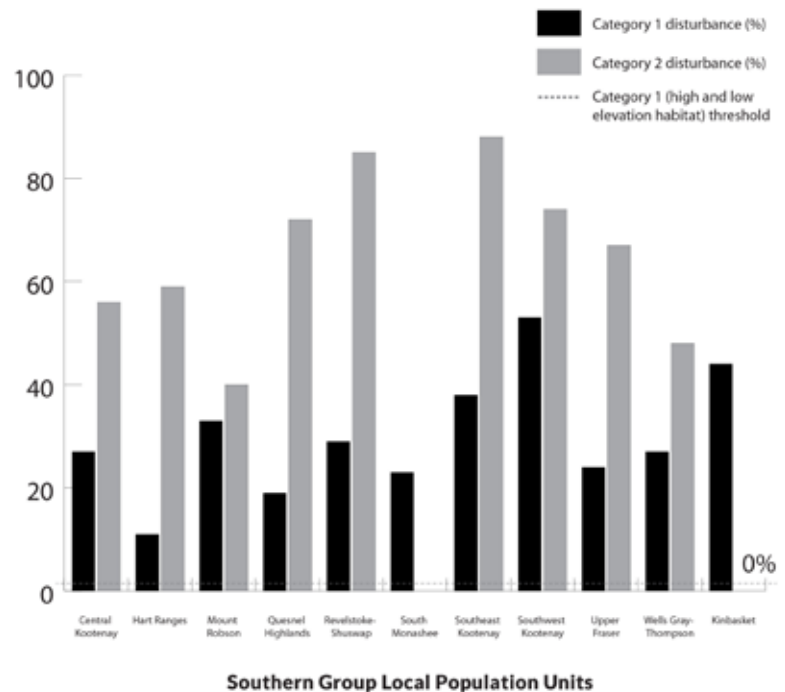


Figure 5. Habitat disturbance percentage for the 11 LPUs of the southern group. If Category 1 habitat disturbance surpasses the dotted line representing the recovery thresholds for Category 1 habitat, those LPUs have exceeded the recommended amount of habitat disturbance. Category 2 recovery thresholds have not been set in a way that can be compared with habitat disturbance. Therefore, it cannot be determined if the matrix habitat disturbance throughout the southern group LPUs have exceed recommended levels therein.

Discussion

10.1 Summary of results

This analysis is up to date as of 2019 and provides insight into all impacts over a timescale that accurately represents caribou use and requirements of habitat. The results are clear: habitat disturbance greatly exceeds recommended levels for 81% of the southern mountain caribou LPUs in BC (17 out of 21 LPUs). Our results align with prior research that links habitat destruction to caribou decline. Industrial projects contribute to habitat loss, shifting predator-prey dynamics, reduced separation from predators and caribou, and the reduction of habitat quality and quantity (Environment Canada, 2014). The results help answer the question of why southern mountain caribou populations across BC are declining.

The 17 out of 21 LPUs for which current critical habitat disturbance exceeds recovery thresholds are: Central Kootenay, Hart Ranges, Mount Robson, Quesnel Highlands, Revelstoke-Shuswap, South Monashee, Southeast Kootenay, Southwest Kootenay, Upper Fraser, Wells Gray-Thompson, Kinbasket, Pine River, Narraway, Quintette, Chilcotin, Telkwa, and Tweedsmuir. These LPUs currently do not have enough intact habitat necessary to achieve recovery of caribou therein.

Literature shows that anthropogenic habitat alteration is the ultimate cause of caribou decline (Serrouya et al., 2019a). Five out of the six extirpated caribou populations in BC existed in the southern group, which is also where every LPU has crossed the recovery threshold for high and low elevation habitat. The other extirpated population (Burnt Pine) was in the central group, where every LPU has also exceeded habitat recovery thresholds in either matrix or high and low elevation habitat. With a staggering 81% of LPUs throughout BC having critical habitat disturbance over the recommended thresholds, habitat destruction has been a huge factor in declining populations.

10.2 Importance of results

Nature is declining globally at unprecedented rates. Research indicates around one million animal and plant species are threatened with extinction (Diaz, Settele, & Brondízio, 2019). This indicates that business as usual must not and cannot continue if we want to save biodiversity on Earth. Globally, management efforts to protect and recover

species at risk are failing. In BC, there are as many as 1900 species and subspecies that are at risk, a clear flag that BC is contributing to those one million at risk species globally (Pope, 2018). Provincial, territorial and federal governments must re-think how to manage species at risk in Canada, starting with southern mountain caribou. The results of this study are specifically important given the current direction of BC's Ministry of Forests. BC Forest Minister Doug Donaldson recently told reporter Tom Fletcher that for all caribou subpopulations west of the Rocky Mountains except the Peace region subpopulations (the central group of caribou), no additional habitat protection is required (Fletcher, 2019). This statement indicates that further critical habitat destruction can be expected for LPUs in the northern and southern groups. Our analysis disproves Doug Donaldson's statement that no more habitat protection is required. The current level of intact caribou habitat is insufficient to sustain all LPUs in the southern group and three LPUs in the northern group, let alone undergo further destruction.

The reason the government is willing to protect more habitat for the central group is due to a partnership agreement that's been in the works since the spring of 2019. West Moberly and Sauteau First Nations have negotiated a plan that would protect a significant area of critical habitat, restore habitat and continue the maternity pen, among other efforts. Although both the federal and provincial governments insist the plan is happening, it has yet to be confirmed and implemented. Results from this study provide important evidence that without the plan, current habitat destruction levels throughout the central group are not compatible with recovery.

The results of this study also show that the provincial and federal governments are not fulfilling commitments under SARA. The province is not effectively protecting habitat as they are required to do. Effective protection is achieved by providing recovery outcomes similar to SARA subsection 61(1), where no destruction of any part of the critical habitat is allowed. Given that 81% of southern mountain caribou LPUs in BC have critical habitat disturbance beyond the recommended levels, it can be concluded that the province is failing on their responsibilities under SARA to effectively protect

habitat. This failure of the province requires the federal government to step in and issue habitat protection orders. To date, the federal government has not issued an order that would provide effective protection for critical habitat on provincial land. Our results are important because they provide clarity on the failure of both the federal and provincial government to fulfill obligations under SARA.

10.3 Data Gaps

10.3.1 Partially identified habitat

The federal recovery strategy states that in order to meet the recovery goal for southern mountain caribou, additional critical habitat will need to be identified for many LPUs. A schedule of studies in the recovery strategy outlines research needed to identify the critical habitat required to meet population and distribution objectives. The deadline to complete the schedule of studies was 2014. Yet, this additional mapping has not been completed. The partially identified critical habitat resulted in data gaps in our analysis; some data gaps are obvious and others not. The data that have explicitly been missing from the federal critical habitat map and therefore not included in our analysis are the matrix range for all LPUs in the northern group, the matrix range for the Narraway LPU in the central group and the matrix range for South Monashee and Kinbasket LPUs in the southern group.

Other LPUs may have some portion of their critical habitat mapped but this mapping may not be complete. This resulted in gaps in our analysis that are less obvious. For example, our analysis showed that the Quintette LPU has 0% disturbance in the matrix range. However, the total amount of matrix habitat identified in the federal map is only 42 hectares. It is highly likely more matrix range exists and this section of critical habitat has only been partially identified. Therefore, the result of 0% disturbance in matrix range is likely due to the federal map only partially identifying matrix range habitat for the Quintette LPU. Not having a fully completed critical habitat map may have impacted our analysis by underrepresenting the full scope of critical habitat required for recovery. The implications of this can vary but could lead to our results underrepresenting the level of habitat and habitat disturbance throughout the LPUs.

10.3.2 Recovery strategy thresholds set a low bar

The central and northern groups' low elevation habitat recovery thresholds in the federal recovery strategy were based on the goal of achieving a 60% probability that populations will be self-sustaining. This means

that LPUs with habitat disturbance levels below the recovery threshold, may still only have a 60% chance (or greater) at becoming self-sustaining. Choosing recovery thresholds that allows only a 60% probability of becoming self-sustaining is not setting the populations up for the greatest chance at survival. Therefore, the results of this study would have been more useful for ensuring caribou survival in the long-term if recovery thresholds were set in a way that provided the LPUs a much higher chance at becoming self-sustaining.

10.3.3 Wolf density is unusable

The recovery strategy sets disturbance limits for matrix habitat as the habitat needed to provide for an overall ecological condition that will result in a wolf density of less than 3 wolves/1000 km². The lack of supporting information regarding how much intact habitat is required in order to produce this wolf density results in the inability to determine if habitat disturbance is surpassing threshold recommendations. Because there was not a habitat disturbance number provided by the federal government, we were unable to conclude in our study if certain matrix habitat recovery thresholds were passed.

10.3.4 Recovery strategy habitat categories don't align with map

This study would be stronger if the federal government mapped the same critical habitat categories outlined in their recovery strategy. This way, we could delineate disturbance levels occurring in each of the six critical habitat range types and it would have provided a more in-depth look at habitat disturbance throughout the varying range types. For example, we would have been able to determine the disturbance levels in low elevation winter range or low elevation summer range and compare disturbance levels with the specific recovery thresholds identified for those range types.

10.4 Solutions and future direction

10.4.1 First Nations collaboration

First Nations in BC lead the way when it comes to caribou recovery. After years of inaction by colonial governments to protect caribou, West Moberly and Sauteau First Nations began their own plan to recover caribou in the Peace region and their efforts are working for some subpopulations (Kurjata, 2019). West Moberly and Sauteau First Nations have been instrumental in negotiating the Partnership Agreement, which will protect and restore habitat. The agreement is a type of conservation agreement. Under SARA, the federal

minister of ECCC can enter into conservation agreements with First Nations (and other governments) in order to benefit the species and enhance survival in the wild. The governments of BC and Canada must collaborate with other interested First Nations to develop caribou conservation agreements.

10.4.2 Complete critical habitat mapping

In order to fully understand the needs of southern mountain caribou all critical habitat must be fully mapped immediately. A full identification of critical habitat is required for a scientific baseline on habitat that can be used to measure BC's efforts to recover southern mountain caribou. The BC government is required by SARA to effectively protect critical habitat and the federal government is responsible for ensuring this happens. Without critical habitat identified and mapped it undercuts responsibilities of both the provincial and the federal governments. The federal government has missed the deadline to fully identify critical habitat by five years. The result has undermined several sections of SARA, including the duty to report on whether all portions of critical habitat are protected (s. 63), the duty to monitor all portions of critical habitat on provincial land and ensure the province is providing effective protection (s. 61), and creating conservation agreements that protect areas identified as critical habitat (s.11). Without fully mapped habitat, SARA cannot be used and implemented in the way it was meant to be (Nixon, 2019). The failure of subsequent federal ministers of ECCC to fulfill requirements under SARA has resulted in ineffective protection for southern mountain caribou (Neave, Stahl, & Andrews, 2018). In order to resolve this issue, the federal government must finally fully identify and map all critical habitat for all southern mountain caribou LPU's.

10.4.3 Stronger, clearer habitat protection targets

Southern mountain caribou populations are in severe decline and the impacts of habitat disturbance will only become worse with the growing effects of climate change. Providing subpopulations with habitat thresholds that result in a 60% probability of becoming self-sustaining may not be enough. The habitat thresholds that allow for a 60% probability of becoming self-sustaining were selected by Environment Canada in 2011. They indicated that it should be considered a minimum threshold because it allows for a significant risk (40%) that an LPU will not be self-sustaining (Environment Canada, 2012). Southern mountain caribou populations have since declined. Therefore, thresholds that allow for a 60% probability of becoming self-sustaining are out of date and do not align with the severity of the current extinction crisis. Habitat recovery thresholds must be changed to provide southern

mountain caribou LPU's a much higher chance at becoming self-sustaining. The federal government should provide clear, numerical habitat disturbance thresholds in place of habitat thresholds measured in wolves/1000 km².

10.4.4 Habitat protection must be top priority

The recovery strategy sets out the critical habitat required for long-term survival and recovery, and in order to achieve this, all identified critical habitat must be protected (Environment Canada, 2014). Killing prey and predators, particularly wolves, has been the strategy most used in BC to recover caribou, while critical habitat disturbance continues (Vancouver Sun, 2019). Over-reliance on killing predators and prey without protecting habitat will not only lead to the long-term extirpation of caribou but also countless dead wolves, cougars and prey species as collateral damage. Our analysis further supports the need for critical habitat protection for caribou populations to recover and this must be the primary strategy going forward. Government must address the ultimate cause of decline, habitat destruction, first and foremost.

All destructive activities should be halted within identified critical habitat and future critical habitat that will be revealed once full mapping is completed. The province can achieve this by protecting identified habitat and complying with SARA to ensure habitat is being effectively protected. Given the province's ongoing failure to do this, it is likely it will continue to destroy critical habitat. Therefore, the federal government must fulfill obligations under SARA and step in to provide effective protection for southern mountain caribou on non-federal lands in BC.

10.4.5 Habitat restoration to block access

It can take decades for vegetation to recover throughout disturbed areas, which must be left undisturbed in order to recover (Bentham & Coupal, 2015). It is essential that while habitat recovers, action is taken to block predator, prey and human uses of linear disturbances that allow access into caribou habitat. Research shows that spreading logs, felling trees, or roughing the soil surface of linear disturbances like roads and seismic lines can successfully prevent further disturbance and predation in the critical habitat of at-risk caribou (Keim, 2019). These strategies must be widely implemented throughout caribou critical habitat in BC.

Government must ensure that fossil fuel, logging and mining industries take responsibility for blocking access throughout previous project areas that overlap with caribou critical habitat. Different kinds of blocking should

be applied to each region based on the problematic prey or predator species and vegetation type in that area. Companies should employ different techniques to block access such as mounding and/or ripping, spreading woody material and tree felling/tree bending. The companies responsible for destroying and fragmenting habitat, leaving caribou vulnerable, must be held accountable for the cost of restoration. It is unfair for the public to pay for the cleanup or witness extinction while companies walk away from projects with full pockets, taking no responsibility for restoring habitat in a way that mitigates impacts to caribou. Government should make companies legally responsible for undergoing long-term habitat restoration and short-term access-blocking measures to mitigate impacts on caribou.

10.4.6 High impact recreation

Recreation throughout caribou critical habitat can displace caribou and increase opportunities for predation (Environment Canada, 2014). Research shows that moving snowmobiling trails away from caribou habitat may help draw wolves away from caribou (Keim, 2019). Further, the ability for disturbed caribou habitat to regenerate is affected by human use and restoration efforts are negated when humans destroy or damage seedlings (Bentham & Coupal, 2015). A comprehensive plan should be developed to determine which areas should be off limits to motorized vehicle use. Activities in caribou habitat that contribute to the extinction of the species must be prohibited, including snowmobiling, heli-skiing and other off highway vehicles. With one million species facing extinction, compromises have to be made such as forgoing certain areas for motorized recreation.



Caribou from the central group of southern mountain caribou (Isabelle Groc)

Conclusion

Habitat disturbance levels exceed recovery thresholds for 17 out of 21 (or 81%) of southern mountain caribou subpopulations throughout BC. In 2003, southern mountain caribou were first listed as at risk under SARA. Since then, BC has not provided the effective protection they are legally required to. The federal government has also not fulfilled their obligations under SARA to step in and provide habitat protection on non-federal lands while also failing to complete critical habitat mapping. We entreat the federal government to complete habitat mapping and issue an emergency protection order under s. 80 of SARA for all LPUs surpassing recovery thresholds: all LPUs in the southern group and the Chlicotin, Telkwa and Tweedsmuir LPUs in the northern group. The emergency order should be extended to the central group if the province fails to implement the Partnership Agreement in full by the spring of 2020. Once all remaining intact critical habitat is protected, other measures to help address short-term decline can be explored in collaboration with First Nations, such as habitat restoration, blocking access and maternity pens.



Southern mountain caribou in logged forest (John E. Marriott)

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Appendix I

GIS Mapping Data Sources

Anthropogenic Disturbances

All anthropogenic disturbance mapping data was downloaded from the BC government data catalogue as GIS shapefiles.

1. Forest Tenure Cutblock Polygons (FTA 4.0) - downloaded Sep 12, 2019:
<https://catalogue.data.gov.bc.ca/dataset/forest-tenure-cutblock-polygons-fta-4-0>
2. Harvested Areas of BC (Consolidated Cutblocks) - downloaded May 3, 2019:
<https://catalogue.data.gov.bc.ca/dataset/harvested-areas-of-bc-consolidated-cutblocks->
3. Digital Road Atlas (DRA) - Demographic Partially-Attributed Roads - downloaded Oct 10, 2019:
<https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-demographic-partially-attributed-roads>
4. TANTALIS - Surveyed Right-of-way Parcels - downloaded Apr 6, 2017:
<https://catalogue.data.gov.bc.ca/dataset/tantalis-surveyed-right-of-way-parcels>
5. Oil and Gas Commission Pipeline Right of Way Permits - downloaded Nov 15, 2019:
<https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-right-of-way-permits>
6. Oil and Gas Commission Pipeline Segment Permits - downloaded Nov 15, 2019:
<https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-pipeline-segment-permits>
7. Oil and Gas Commission Geophysical Program Permits (seismic lines) - downloaded May 9, 2019:
<https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-geophysical-program-permits>
8. Oil and Gas Commission Well/Facility Area Permits - downloaded May 9, 2019:
<https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-well-facility-area-permits>
9. Oil and Gas Commission Facility Location Permits - downloaded May 9, 2019:
<https://catalogue.data.gov.bc.ca/dataset/oil-and-gas-commission-facility-location-permits>

Southern Mountain Caribou Critical Habitat

Southern mountain caribou critical habitat was federally mapped for BC and downloaded from Environment and Climate Change Canada.

10. Critical Habitat for Species at Risk, British Columbia - Woodland Caribou, Southern Mountain pop. (*Rangifer tarandus caribou*) - downloaded Feb 20, 2019:
<http://donnees.ec.gc.ca/data/species/developplans/critical-habitat-for-species-at-risk-british-columbia/critical-habitat-for-species-at-risk-british-columbia-woodland-caribou-southern-mountain-pop.-rangifer-tarandus-caribou/?lang=en>

Appendix II

GIS / Mapping Analysis Methodology

1. Data Preparation / Isolation:

From the “Forest Tenure Cutblock Polygons (FTA 4.0)” dataset I selected the cutblocks that had block status code of approved, logging complete and silviculture (logged and planted with trees) since the year 1939, thus polygons with BLK_ST_CD = HB, LC, S.

From the “Harvested Areas of BC (Consolidated Cutblocks)” dataset I selected cutblocks since the year 1939, thus polygons with HARVEST_YR >= 1939.

From “Digital Road Atlas (DRA) - Demographic Partially-Attributed Roads” dataset I selected all roads and excluded trails and ferry routes, thus lines with TRANSPORT_LINE_TYPE_CODE not equal to T* or F*.

From “Oil and Gas Commission Pipeline Right of Way Permits” and “Oil and Gas Commission Well/Facility Area Permits” datasets I selected only those pipeline rights of ways and gas wells / facilities that have been constructed, thus polygons with CONSTRUC_1 = Constructed.

From “Oil and Gas Commission Geophysical Program Permits” dataset I selected all geophysical line “cut types”, except for “Gravity / Aeromagnetic” types (as these have no physical disturbance on landscape); this lines with CUT_TYPE_D not equal to Gravity / Aeromagnetic.

The three remaining disturbance datasets “TANTALIS - Surveyed Right-of-way Parcels, Oil and Gas Commission Pipeline Segment Permits and Oil and Gas Commission Facility Location Permits” were not manipulated in anyway.

In addition, the Southern mountain caribou critical habitat dataset was also not manipulated in anyway. Note that the critical habitat dataset already had fields that separated habitat polygons by variant “Matrix” versus “High or Low Elevation Range” and also by Local Population Unit (LPU).

2. Buffer All Disturbance Datasets by 500 metres

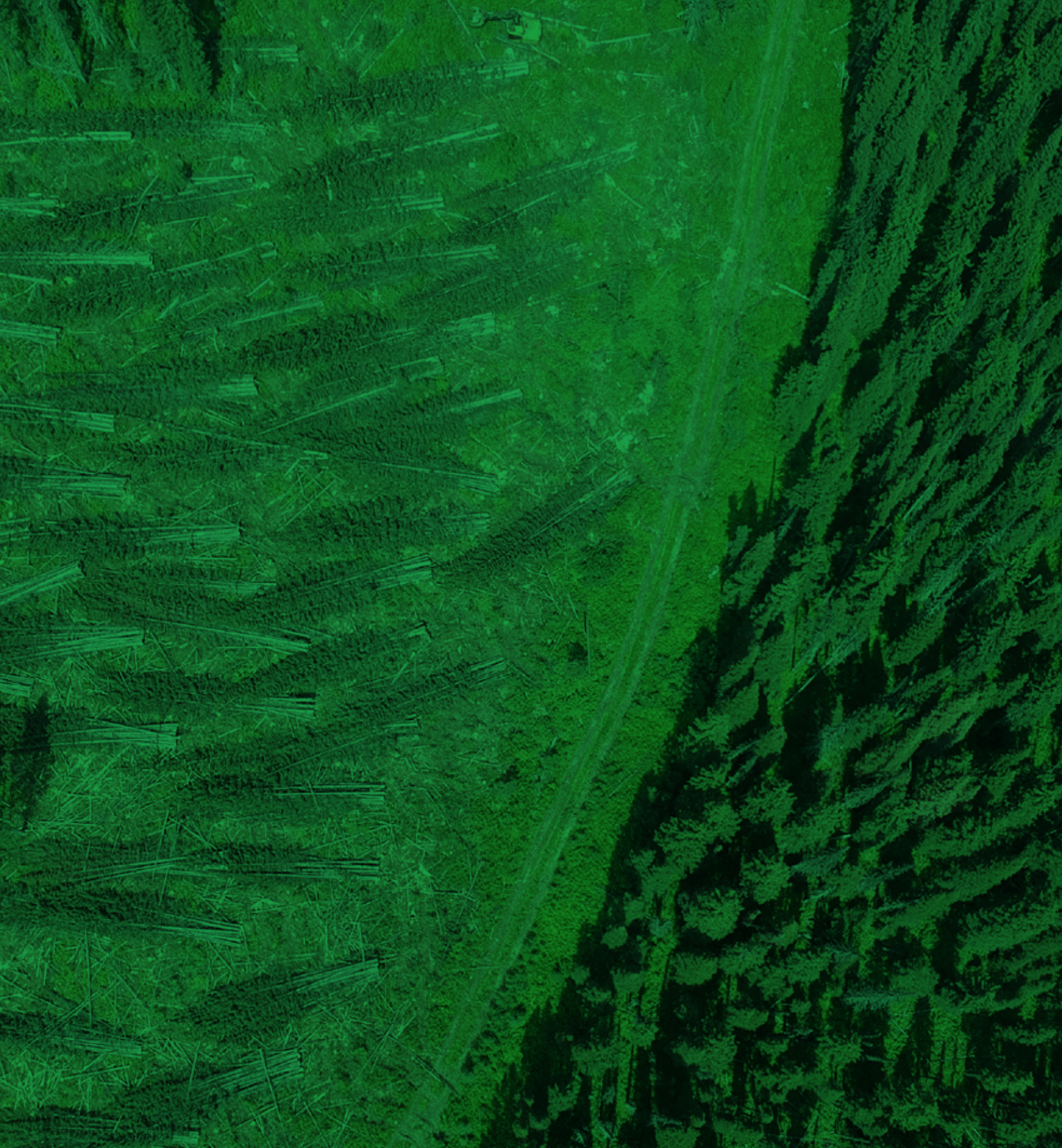
I then applied a 500 metre buffer on all prepared disturbance datasets using GIS software.

3. Erase Critical Habitat with All Buffered Disturbance Datasets

I then applied an “Erase” overlay function on the critical habitat dataset with all the 500 metre buffered disturbance datasets, which essentially erases or deletes any of the critical habitat polygons that are overlapped by one or more of the buffered disturbance polygon datasets.

4. Calculate Areas in Hectares of Original and Remaining Critical Habitat

The final analysis step was to calculate the area in hectares of both the original critical habitat polygons dataset and the remaining erased with disturbance critical habitat polygons dataset using the “calculate geometry” function in the GIS software. Then area statistics were queried by LPU and by habitat variant, and were put into a spreadsheet from both the original critical habitat dataset and the erased critical habitat datasets for comparison.



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