Yukon Conservation Society

Current levels of accumulated surface disturbance in the range of a Yukon caribou herd are reaching critical levels

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Abstract

The progress of industrialization across the boreal forests of Canada has come at the expense of caribou (*Rangifer tarandus*). Northern Mountain Woodland Caribou herds in the Yukon are mostly stable, but pressures from disturbances resulting from expanding industrial activity are rising. We calculated the area of permitted industrial disturbances in the range of the Clear Creek Caribou Herd in central Yukon using the Yukon Environmental and Socio-Economic Assessment Boards online registry. We found that cumulative disturbances from industrial activities have potentially reached the point of jeopardizing the future of the herd. More detailed and current spatial data is required to accurately estimate the current levels of disturbance before more disturbances can be permitted.

Introduction

Caribou (*Rangifer tarandus*) are an iconic species, deeply rooted in the cultural and ecological fabric of the North. The Yukon is home to three caribou ecotypes: barren-ground (*R. t. grantii*), boreal woodland (*R. t. caribou*), and northern mountain woodland (*R. t. caribou*) (Hegel and Russel 2013). Woodland caribou (boreal and northern mountain) are often considered an environmental indicator species because they are sensitive to disturbances and their health is considered to reflect that of the overall ecosystem (Environment and Climate Change Canada 2018). Woodland caribou are also an umbrella species as they have specific habitat requirements and their conservation has cascading effects, supporting populations of a variety of other species that depend on the same ecosystem (Environment and Climate Change Canada 2018).

In northern regions, surface disturbances associated with mining and mineral exploration make up the bulk of disturbances within caribou ranges. This is counter to patterns in southern regions where the main disturbance to caribou habitat is clear cut logging, a large but relatively concentrated disturbance (Lockhead et al. 2021). Surface disturbances alter habitat via changes to the successional stage of the landscape and a reduction in the availability of caribou forage (COSEWIC 2014). Surface disturbances also alter caribou behaviour, including increased rates of predation and decreased ability to tolerate other stresses (Environment Canada 2012). The effects of habitat alterations and disturbances are exacerbated when combined with other stressors such as climate change (Johnson et al. 2020).

While disturbances throughout the entire habitat-disturbance complex are of concern, it is especially important to understand disturbance in two types of areas due to their disproportionate influence on caribou activity. First, caribou behaviour is altered in zones of influences (ZOIs), the area surrounding the direct footprint of the surface disturbances. These altered behaviours can include things such as being more alert, feeding less, or avoiding the area altogether (Boulanger et al. 2021). Second, Wildlife Key Areas (WKAs) facilitate critical seasonal and life functions (Environment Canada 2012) and have disproportionate value to the caribou (Department of Environment 2014). In the Yukon, publicly available WKAs are classified in three different levels: 1) points from wildlife surveys; 2) polygons reflecting animal locations; and 3) generalized ranges (Department of Environment 2014). Level 2 and 3 WKAs are further separated based on the life functions that they support. In the case of Northern Mountain Woodland Caribou (NMWC), these are a herd's winter and rutting ranges. Caribou's avoidance of disturbances changes with seasons and life stages (Polfus et al. 2011; Francis and Nishi 2016). Understanding the distribution of human-caused disturbances within WKAs is therefore critical in order to better evaluate threats that caribou face.

Disturbance Thresholds

Disturbances to caribou habitat arise from two means: natural disturbances such as wildfires and anthropogenic or industrial disturbances such as mining. Natural and anthropogenic disturbances are partially cumulative. Throughout Canada, thresholds of caribou's tolerance to disturbance have been identified using two metrics. For woodland and southern mountain caribou, official recovery strategies indicate that if 65% of habitat is undisturbed, populations have a 60% chance of persisting and being self-sustaining (Environment Canada 2014; Government of Canada 2018). Boreal caribou herds in Saskatchewan were identified to be self-sustaining if only 40% of the habitat remained undisturbed (Johnson et al. 2020). We focus here on industrial disturbances.

The density of linear surface disturbances within a herds' range can also be used as a marker of population stability. For the À La Pêche herd in Alberta (a Southern Mountain Woodland Caribou herd), increases in cutblock or road densities by 0.07 km^2/km^2 or 120 m/km^2 respectively, are projected to result in a decline of the herd by at least 20% (COSEWIC 2014). Similarly, the density of barren-ground populations near Prudhoe Bay, Alaska, are demonstrated to decline with increasing road density. Road densities up to 0.3 km/km^2 reduced caribou density by 63%, while road densities ranging from 0.6 - 0.9

km/ km^2 reduced caribou density by 86% (Nelleman and Cameron 1998). There are currently no established linear disturbance thresholds for NMWC populations in the Yukon.

Study location and rationale

The Yukon has 25 NMWC herds, including the Clear Creek Caribou Herd (CCCH; Figure 1). The CCCH annual range is within the traditional territories of the Tr'ondëk Hwëch'in and Na-Cho Nyak Dun First Nations and lies east of Dawson City, and northwest of Mayo (Figure 2). The two most recent herd surveys (2001 and 2018) indicate that the herd is either stable or slowly declining (O'Donoghue et al. 2001; Russel 2019). There is no official recovery strategy or disturbance threshold for NMWC (listed as *Special Concern* under SARA).

Caribou population concerns are typically addressed through recovery programs rather than pro-active or precautionary programs which seek to prevent the initial decline. This project was undertaken to investigate existing disturbances and to provide a rationale for taking preventative measures in protecting this herd **before** dramatic and costly recovery programs are warranted. This is a preliminary study that assessed only publicly listed projects within the Territorial environmental assessment registry, and used publicly available spatial data. The purpose of the study is to raise awareness of the ongoing threats to a caribou herd whose range has likely already been influenced by the significant mining and exploration activity in the area. We hypothesized that disturbances within the annual, rutting, and winter range of the CCCH have already surpassed sustainable levels, signifying population-wide threats to this herd.

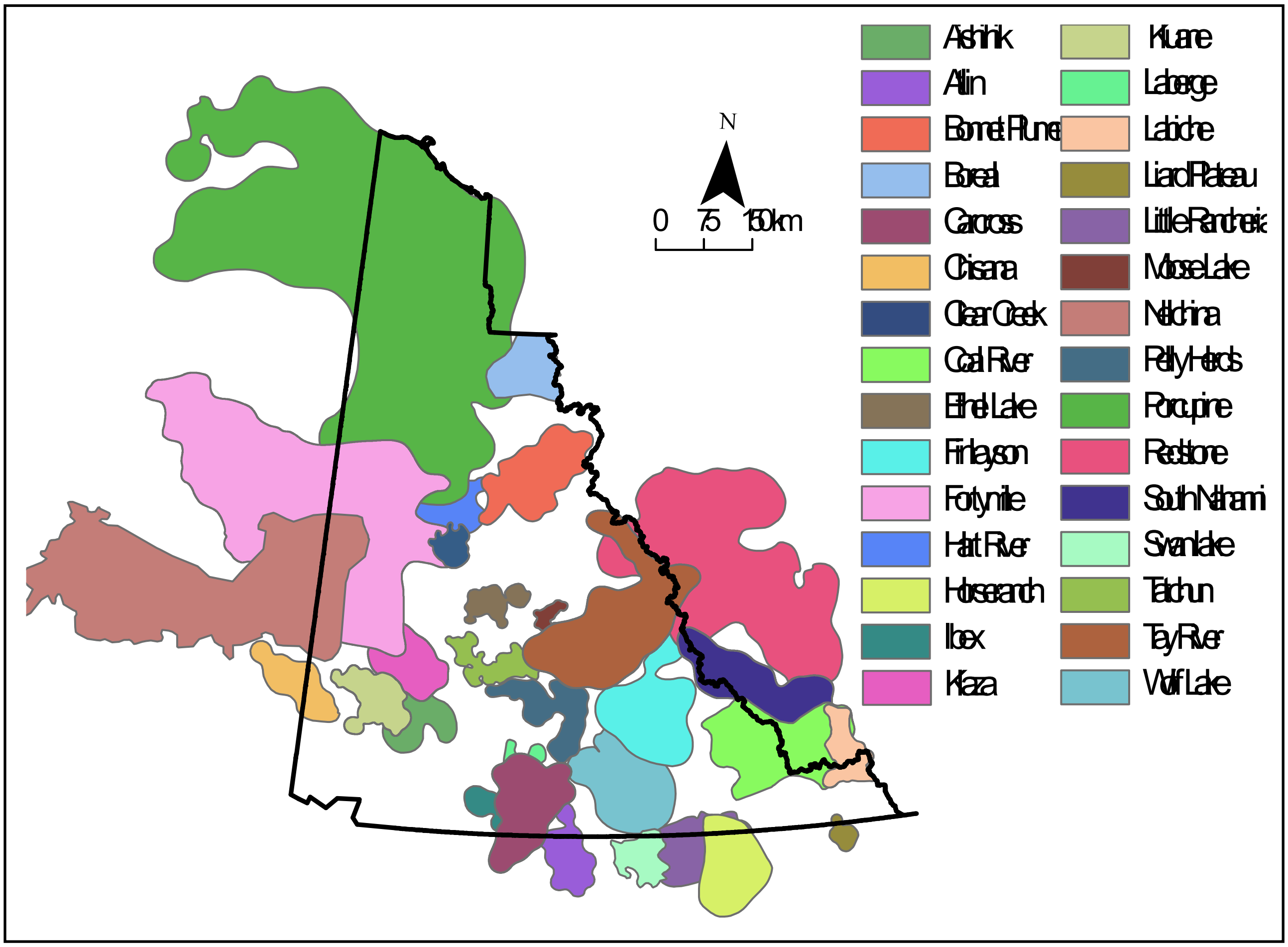

Figure 1 Ranges of caribou herds in Yukon. Data source: Department of Environment, Yukon Government

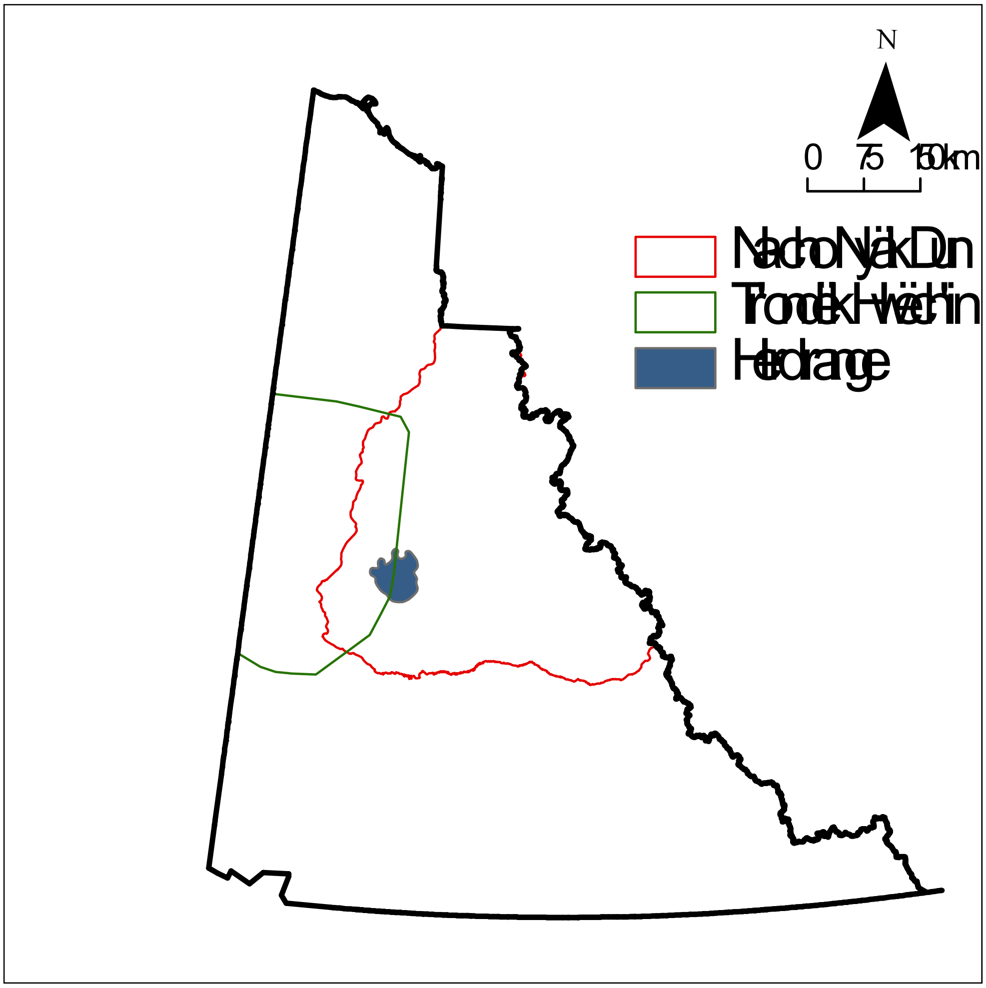

Figure 2 Range of the Clear Creek Caribou Herd (CCCH) in central Yukon. The CCCH range is within the traditional territories of the Tr’ondëk Hwëch’in (west, green) and Na-Cho Nyak Dun First Nations (east, organge).

Methods

Due to limited available data, we took a two-step approach for this project, using different yet complementary datasets for each step. Our two steps were: 1) calculate the area of permitted surface disturbance and 2) calculate the area of the range that has currently been staked for mining activity. We recognize that this is not ideal, however we think that it provides a broad estimate of the threats faced by the CCCH and provides rationale for future, more detailed assessments of these threats.

To assess the herd range, we used Environment Yukon's delineation of the CCCH annual range. From the Government of Yukon's WKA data, we used Level 2 WKAs (rutting and winter ranges), as they are more specific than the generalized Level 3 WKAs (Department of Environment 2014). The area of the herd range is 2,904 km^2; the area of the rutting range WKA is 337 km^2; the area of the winter range WKA is 467 km^2 (Figure 3).

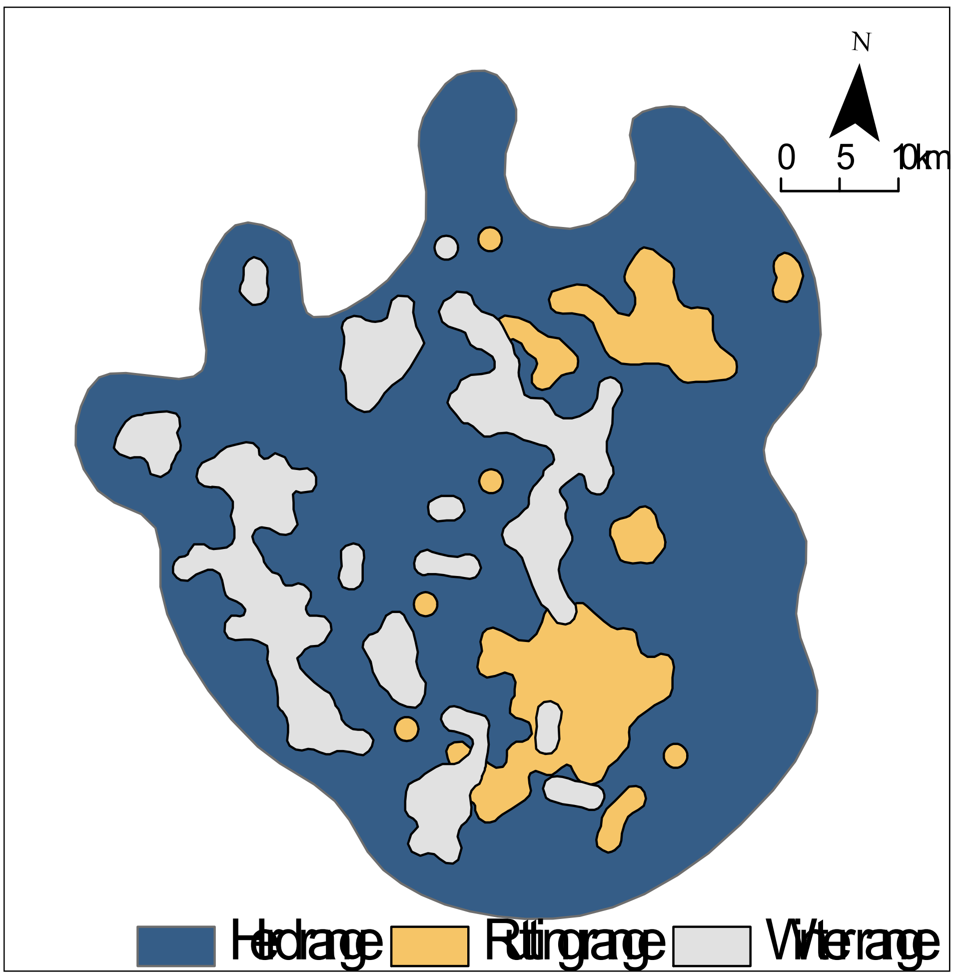

Figure 3 Level 2 Wildlife Key Areas (WKAs) within the Clear Creek Caribou Herd annual range (blue; 2904 km^2). Grey polygons represent winter range (467 km^2) and yellow polygons represent the rutting range WKA (337 km^2). Breakdown of the area of each polygon is in Appendix 1.

1. Calculate the area of permitted surface disturbances

To calculate area of permitted surface disturbances within the CCCH range, we used the online registry of the Yukon Environmental and Socio-Economic Assessment Board (YESAB, 2021). Using the data from the YESAB land use projects we considered all projects within the herd range and summarized the details of the proposed disturbances for each project including roads (built and refurbished), trenches built, cut lines, helicopter pads, clearings, etc. (Appendix 2). Projects were treated in a binary fashion: they were either inside or outside of the CCCH annual range and WKAs, based on the point of origin coordinates in their YESAB project.

We aimed to calculate habitat loss as a result of (i) direct loss of footprints of human disturbances and (ii) indirect habitat loss from ZOIs. Direct habitat loss was calculated using data directly from YESAB projects (*Direct habitat loss* = ∑ *area of individual disturbances in each application*). For Quartz mining, *direct* disturbance was calculated as the sum of the footprints for each disturbance (i.e., YESAB project). Placer mining applications tended to be less complete (e.g., rarely included the dimensions of the area used/disturbed, the roads built, previously existing roads, area of overburden removal and storage, etc.,), likely as a result of lower standards of thoroughness in placer mining land use applications. We therefore assumed, based on personal observations and informal inquiries that 75% of the area of each claim would be developed (i.e., disturbed).

Indirect habitat loss involves far more variables; this preliminary investigation therefore had to make some assumptions to simplify the calculation of the amount of habitat effectively lost to caribou as a result of avoidance of disturbances. The evidence is unequivocal that caribou respond negatively to the zones around disturbances (avoidance behaviour), but the exact amount varies drastically depending on a number of variables. We therefore decided it was appropriate to work with a range of ZOIs, that is, a range of areas around the linear disturbances that caribou may avoid. Using values from literature and local range assessments (Francis and Nishi 2016) as our guide, we employed a lower ZOI bound of 0.25 km and a higher ZOI bound of 4 km. The higher ZOI is less than the maximum ZOI observed in the Klaza

Caribou Herd Range Assessment (Francis and Nishi 2016), Alberta (James and Stuart-Smith 2000), and the Northwest Territories (Boulanger et al. 2021). However, given that not all YESAB projects are active and most have seasonal closures, we determined that this reduced ZOI was appropriate. Therefore, we consider our estimations of ZOI to be conservative. For each disturbance type, *indirect* disturbance was calculated using the measurements proposed linear disturbances in the YESAB application (length and width); to incorporate the ZOIs, we increased the width of the disturbance by both the lower ZOI and the upper ZOI. This resulted in lower and upper bounds of percent of area disturbed in the annual range and each WKA (rutting and winter ranges). Total disturbed area (km^2) was calculated as the sum of direct and indirect disturbances from quartz mining, placer mining, and transportation corridors, divided by total area of the annual range or WKA (Table 1). These were further separated based on type of disturbance (Quartz and Placer mining; Table 2).

We calculated the linear density of disturbances (km/km^2) by dividing the sum of linear disturbances in YESAB projects by the total area of the annual range or WKA. We used a conservative estimate of 0.1 km/km^2 as the maximum linear density threshold before the herd begins to avoid an area. We assessed our disturbance values relative to thresholds published for other populations of caribou. That is, we assumed that the CCCH required at least 65% of their range to remain undisturbed for them to persist unassisted.

2. Calculate the area of the range that has currently been staked for mining

We overlaid spatial data of pending and approved mining claims on top of the herds range and WKAs (Government of Yukon 2021). Each WKA is composed of a number of polygons. We calculated the area of each polygon as well as the area of mining claims that overlapped with WKAs. We calculated the degree of overlap between individual WKAs and combination of mining category (quartz, placer, active, pending) and summed these as the total percent of WKAs staked.

Results

We found that 13 - 112% of the CCCH annual range was directly or indirectly disturbed (Table 1). Linear feature density in the annual range was 0.27 km/km^2. Disturbance in the rutting and winter WKAs were 147 - 754% and 144 - 493% respectively, with corresponding linear densities of 1.62 km/km^2 and 0.93 km/km^2, respectively (Table 1). Separated by disturbance type, placer mining disturbed less of the annual, rutting and winter ranges than quartz mining. Breakdown of disturbances in the annual range and the WKAs are found in Table 2.

Spatial data showed that there is variation in the overlap between WKA polygons and active and pending mine claims. For the rutting range, 58% has been staked for active quartz mining, 10% has been staked for active placer mining. A further 6% is pending for quartz mining; there is no pending placer mining in this WKA. For the winter range, 22% has been staked for active quartz mining and 4% for active placer mining; a further 10% is pending for quartz mining. Breakdown by individual WKA polygons is in Appendix 1.

Table 1. Lower and higher estimates of the percent area disturbed and linear density in the annual, rutting, and winter range of the Clear Creek Caribou Herd (CCCH), calculated using the Yukon Environmental and Socio-Economic Assessment Board (YESAB) online registry. Lower (0.25km) and upper (4km) bounds of Zones of Influence (ZOI) were applied to linear features reported in YESAB projects. See Appendix 2 for calculations; results have been rounded to the nearest whole percent or one tenth of a kilometer.

CCCH Range	Percent Area Disturbed (Lower bound)	Percent Area Disturbed (Higher bound)	Linear Density (km/km^2)
Annual Range (2904 km^2)	13%	112%	0.27
Rutting Range (337 km^2)	147%	754%	1.62
Winter Range (467 km^2)	144%	493%	0.93

Table 2. Breakdown of area disturbed and linear density by quartz and placer mining applications from the Yukon Environmental and Socio-Economic Assessment Board online registry in the herd, rutting, and winter range of the Clear Creek Caribou Herd. See Appendix 2 for calculations; results have been rounded to the nearest whole percent or one tenth of a kilometer.

CCCH Range	Mining Sector	Percent Area Disturbed (Lower bound)	Percent Area Disturbed (Higher bound)	Linear Density (km/km^2)
Annual Range	Quartz	5%	81%	0.20
	Placer	7%[1]	29%	0.06
Rutting Range	Quartz	139%	671%	1.42
	Placer	8%	66%	0.15
Winter Range	Quartz	116%	433%	0.84
	Placer	28%	60%	0.09

Table 3. Summary of overlap between rutting range WKA polygons and quartz mining claims (active and pending). Each WKA has multiple polygons (breakdown in Appendix 1); the total area (WKA Area) and total area of overlap (Overlap Area) are presented here. The percentage of WKA staked represents the area of the WKA that has already been staked according to GeoYukon (Overlap Area/WKA Area).

Mining	**WKA**	**Status**	**WKA Area (km^2)**	**Overlap Area (km^2)**	**% of WKA staked**
Quartz	Rutting	Active	337.16	196.26	58%
		Pending	337.16	20.31	6%
Quartz	Winter	Active	465.73	101.17	22%
		Pending	465.73	47.78	10%
Placer	Rutting	Active	337.16	10.12	3%
		Pending	337.16	0	0
Placer	Winter	Active	465.73	17.24	4%
		Pending	465.73	0	0

[1] Quartz and placer disturbances in Table 2 appear to be inconsistent with total disturbance in Table 1 because placer and quartz projects sometimes overlap and Table 1 includes Transportation corridors.

Discussion

The objective of this project was to test the hypothesis that disturbances in the Clear Creek Caribou Herd (CCCH) annual range and Wildlife Key Areas (WKAs) have already exceeded disturbance thresholds outlined by various regional caribou recovery strategies and those identified in the literature. We used lower and upper bounds of Zones of Influence (ZOI) to reflect the variability in caribou behaviour of avoidance. Our findings indicate that the upper bound ZOI significantly exceeded disturbance thresholds, especially in the WKAs. This suggests that current alterations to habitat via human-caused disturbances likely lead to significant avoidance of these features and further alterations to caribou behaviours. These results are especially concerning because the ZOIs employed here are likely conservative estimates.

The calculations of the upper bound of the ZOI resulted in large areas of the WKAs being permitted for disturbance (754% and 493% for the rutting and winter WKAs respectively). These numbers are a mathematical artifact that arise because in some WKA polygons, so much disturbance has been approved that when we apply a standard ZOI to each approved disturbance, it adds up to 7.5 times the area of the WKA. While these numbers highlight the degree of potential disturbance that has been approved, they make it difficult to understand in a practical sense how much disturbance has actually occurred in the WKAs.

We were able to tease this apart using spatial data and calculating the overlap between the mining claims and the WKAs. The mining data used here is not exactly the same as the data used for the YESAB calculations as those projects are not required to submit spatial data. Instead, these data are from the Yukon Government and represent the best estimate of active and pending mining claims in the region (and throughout the Yukon). In general, these data are considered quite reliable and for our purposes, present a broad understanding of the overlap between mining activity and WKAs. From these calculations, we determined that the variation in claims amongst different WKA polygons was high (range 0 – 100%). However, in total, mining claims already cover over 60% of the rutting range and over 25% of the winter range.

These data highlight that a significant amount of development and disturbance is in varying stages of approval for these important areas of caribou habitat. We lack the detailed spatial data to definitively say how much of the herds range and WKAs have already been developed but we can say that a not insignificant portion has been approved for development. We can also see that the mining activity has focused on the southern portion of the CCCH range, rendering many of the polygons in that area almost completely disturbed (Figure 3).

The most recent population estimate for the CCCH in 2018 indicated that the herd was either stable or slowly decreasing (Russell 2019). Given that our results surpassed the suggested disturbance threshold prior to herd decline, our findings corroborate this speculated pattern of decline. From the preliminary results presented here, we think that any further development anywhere within the CCCH range must be paused until accurate calculations of disturbance within the herd range can be made. If the estimates here are accurate and over 60% of the herd's rutting range has already been permitted for development, then the threshold of undisturbed habitat to ensure herd survival has been well surpassed for the rutting range WKA and is fast approaching the threshold within the winter range. Furthermore, some of the pending quartz claims will result in WKA polygons that are currently not staked or only partially staked to become completely staked (e.g., Rutting Range WKA 2792, Winter Range WKA 2805; Table A1). These pending claims are likely to have a significant cumulative effect on the herds WKAs. Further approval of mineral claims should consider environmental factors as well as mining process and financial factors.

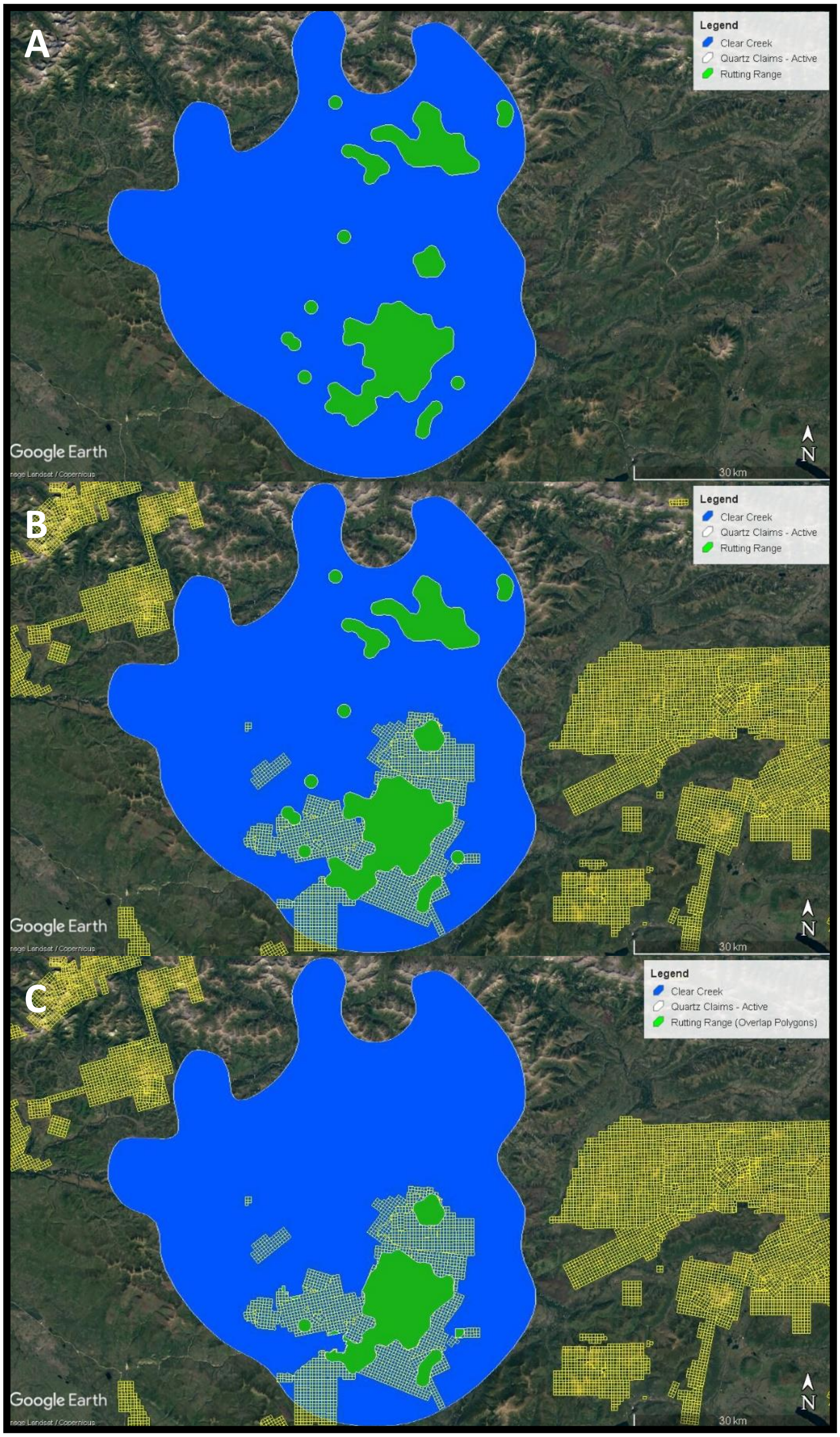

Figure 4 Example of the overlaps between WKA polygons and mining claims. A) Rutting range WKA polygons (green) inside the CCCH herd range (blue); B) All staked active quartz mining claims in the CCCH range; C) Only the WKA polygons (or portions of polygons) that overlap with the active quartz mining claims.

Limitation in data collection

Due to the preliminary nature of this study, there were some logistical limitations that we could not avoid. However, we acknowledge them and urge that where possible, they be addressed in future studies.

1. By relying on projects in the YESAB database, we must assume that all applications are accurate. Many applications were missing dimensions for common features such as camps, helicopter pads, or off-claim features such as access roads. We also could not account for linear features that are not required to be included in YESAB applications (e.g., trails and cutlines <1.5 m wide); trails such as these can provide increased access to caribou for predators and therefore may be crucial in accurately predicting the health of the population. Due to the lack of publicly accessible inspection reports on permit compliance, there may be significantly more (or less) development than that considered here.
2. We only accounted for disturbances proposed since the inception of the YESAB Online Registry in 2005. Human activity and habitat alterations have almost certainly taken place prior to 2005. Our data must therefore be seen as a conservative estimate, especially since many projects since 2005 state that they are expanding on existing features which were not included in the footprints reported in the YESAB projects.
3. We applied ZOIs to listed linear disturbances (dimensions provided in YESAB projects) but not to footprints of area disturbances because there were no dimensions provided. This likely means that ZOIs were under-accounted for and that our calculations underestimate the area influenced.

Follow-Up Studies

Following from our results and the data limitations discussed above, we have identified the following research or knowledge gaps which, if filled, would significantly further our understanding of the relationship between caribou populations and human disturbances in the Yukon.

1. Compare area measurements extrapolated from YESAB projects to existing satellite imagery or detailed spatial datasets to investigate the validity of applications and to further verify methods used here.
2. Use existing satellite collar data for caribou to map their movements relative to existing disturbances to identify which features are being avoided more or less regularly. This knowledge can be useful for planning disturbances with a goal of avoiding certain features or WKAs.
3. Similar studies should be conducted for other caribou herds, specifically those without recent population censuses or those facing new or increased human disturbances. We propose the Finlayson and Klaza herds as initial candidates given the pressures these herds face from planned large mines and their associated exploration.

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