Behavioral and demographic effects of open-pit mining on Central Mountain Caribou in British Columbia – Plain Language Summary

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Introduction

Caribou (*Rangifer tarandus caribou*) of the Central Group of Southern Mountain Caribou in British Columbia (BC) are listed as Threatened on Schedule 1 of the federal Species at Risk Act (SARA) (Environment Canada 2014). They were more recently assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014) and are assigned to the provincial red list by the BC Conservation Data Centre (BCCDC 2017). Quintette caribou, a local population unit within the Central Group, have declined in number from 173-218 in 2008 to a low of 62 individuals in 2016, but now number 110 after having responded positively to recent recovery measures (Seip and Jones 2008, Seip and Jones 2016).

An application for an Environmental Assessment Certificate (EAC) for the proposed Sukunka Coal Mine (the Application) was first submitted to the BC Environmental Assessment Office (EAO) in 2015. The proposed mine is located within the range of the Quintette herd. The federal government has identified critical habitat required for the recovery and sustainability of threatened populations such as the Quintette herd (Environment Canada 2014). Critical habitat provides the necessary attributes for forage and security, which includes summer and winter habitats at both high (typically alpine) and low elevations (typically productive mature forest). Seasonal ranges may show some degree of overlap. Another critical habitat type is matrix range, which is typically forested habitat that provides cover to facilitate movements between seasonal ranges and is important to minimize the risk of predation. As of August 2022, the proposed Sukunka project is estimated to cause the direct loss (e.g., habitat clearing) of 125 ha of High Elevation Summer Range (HESR) (including 8 ha of overlapping High Elevation Winter Range (HEWR)), as well as 44 ha of HEWR, 4 ha of Low Elevation Winter Range (LEWR) and 2,276 ha of Matrix range. Mining activity can also cause caribou to avoid or potentially abandon critical habitat due to sensory impacts, such as noise, odors, and dust. This potential avoidance is characterized as an indirect effect. The Sukunka project may indirectly affect up to a further 5,885 ha of HEWR and 6,403 ha of HESR and at least 121 ha of LEWR and 3512 ha of Matrix (EAO 2022). A draft Assessment Report from the EAO indicates that, even after a proposed suite of mitigation, monitoring, and offsets are applied, the combination of direct and indirect impacts from the proposed Sukunka project is likely to result in significant adverse and cumulative effects on Quintette caribou (EAO 2022).

Subject matter experts (SMEs) have been working with West Moberly First Nations, Saulteau First Nations, Doig River First Nation, and the McLeod Lake Indian Band to jointly review the Application. During this review, it was determined by the SMEs and the First Nations that additional scientific analyses on the potential impacts to Quintette caribou was required to better understand the impacts of mining on caribou. To support decision-making, it is necessary to 1) demonstrate impacts, and 2) understand the various ways those impacts might cause changes in caribou populations. This brief summarizes the results of these additional analyses. Details are provided in the full Technical Report: *Behavioral and demographic effects of open-pit mining on Central Mountain Caribou in British Columbia* (McNay et al. 2022a).

Study Area

The Quintette caribou range is an area of ~6,000 km^2 along the eastern slopes of the Rocky Mountains characterized by mountains and rolling hills where elevations span 600 m to 2,400 m above sea level (asl). The range is bounded by the continental divide on the southwest, the Sukunka River on the northwest, the Murray River on the northeast and Kinuseo Creek on the southeast (BCMOE 2014). The town of Tumbler Ridge and provincial Highways 29 and 52 are located on the northeast side of the range. Forest cover is predominately lodgepole pine (*Pinus contorta*) and hybrid white-spruce (*Picea glauca x engelmannii*) at lower elevations, and subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) forest at higher elevations. The study focuses on two of the three primary ridges of HEWR that run in parallel to the Sukunka, Wolverine, and Murray Rivers (Figure 1). Several mining complexes were in various states of operation during the study time period.

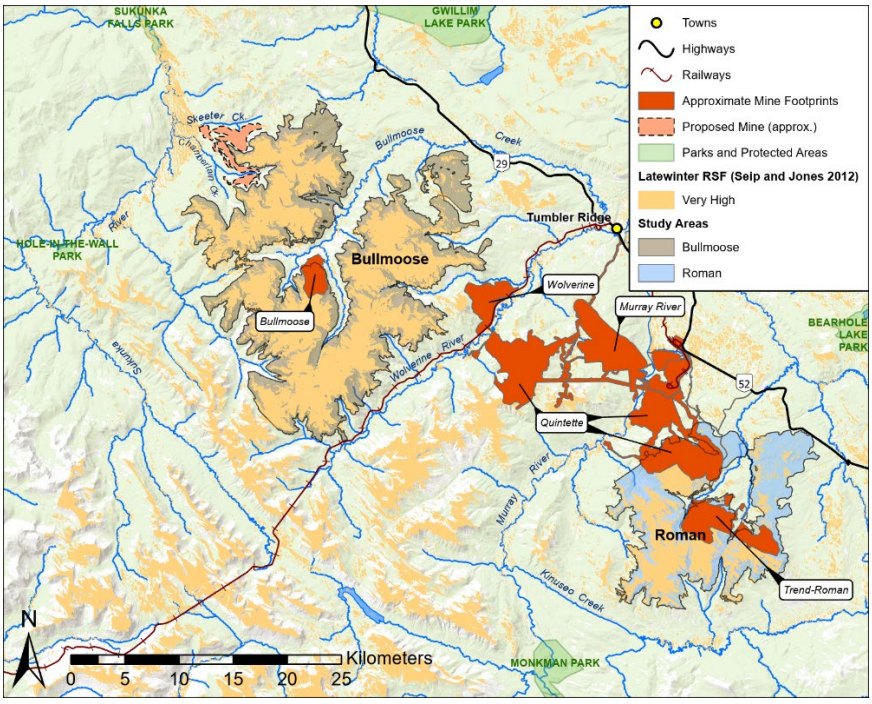

Figure 1. The location of open-pit coal mines (Bullmoose, Wolverine, Quintette, and Trend-Roman), a proposed underground coal mine (Murray River), a proposed new coal mine (Sukunka), and two independent study areas (Control - Bullmoose and Treatment - Roman) relative to high-valued high-elevation winter range for Quintette caribou of the Central Group of Southern Mountain Caribou in northern British Columbia.

Methods

In studies of wildlife populations, a lot of information can be obtained by comparing populations with the same habitat requirements but exposed to different habitat conditions. In this study, a Control (Bullmoose) area is identified that approaches more optimal conditions for caribou, and a Treatment (Roman) area is identified where industrial disturbance may have created more sub-optimal conditions. Our goal is to use caribou data collected over a period of 20 years to isolate the effects of mining on caribou behavior (habitat use and movements) and demographics (survival rates of adults and calves, and abundance) by comparing caribou using HEWR in which active mining sites have occurred (Treatment or Roman area) and in HEWR without active mining (Control or Bullmoose area). We focus here on HEWR because winter range is particularly important to caribou as it provides important forage (for example, lichen) and separation from predators at lower elevations.

Adult female caribou from the Quintette population have been captured and collared with tracking devices since 2002 providing a rich source of behavior data. Population surveys have also been conducted with sufficient regularity to reveal patterns in vital rates and population structure and size. We defined before-after periods to be pre-mining (2002-2005) and post-mining (2006-2022) for each area.

We used several analytical models supported by the scientific literature to test six predictions about the effects of mines upon the behavior and demographics of caribou. These predictions are:

- Behavioral Effects:
    - Prediction 1 (potential for displacement) – Compared to caribou in the Control area, (1) caribou in the Treatment area will use more range outside of HEWR during winter and (2) the proportion of individual caribou in the Treatment area that spend >50% of locations outside HEWR will increase over time.
    - Prediction 2 (energetic consequences of displacement) – Compared to caribou in the Control area, movements of caribou in the Treatment area will be more dynamic in (1) use of larger areas and (2) travelling longer distances between core areas of use.
    - Prediction 3 (habitat consequences of displacement) – Compared to caribou in the Control area, caribou in the Treatment area progressively use (1) more habitat in lower elevations and (2) habitats that are more disturbed.

- Demographic Effects:
    - Prediction 4 (vital rates) – Compared to caribou in the Control area, and compared to a period before mining, caribou in the Treatment area post-mining will have (1) poorer survival and more mortalities in riskier habitats and (2) poorer recruitment of 9–10-month-old calves.
    - Prediction 5 (abundance and rate of increase) – The abundance of caribou in the Treatment area will decline at a rate faster than observed in the Control area.
    - Prediction 6 (response to removal of wolves) – Regardless of study area (Control or Treatment), instantaneous rate of growth will respond positively to the removal of wolves during the post-mining period.

Results and Discussion

Over the period 2002-2021, a total of 97,159 telemetry locations for 74 individual caribou were obtained for the two areas (Bullmoose [Control]: 49 caribou, 59,615 locations; Roman [Treatment]: 25 caribou, 37,544 locations (Figure 2). Across both areas and years, 51.8% of the locations were obtained during winter (n=50,375) and the remainder in summer (48.2%; n=46,784). Figures 2-11 at the end this summary provide illustrations of the results described below.

Over the 20-year period of this study, we found that caribou associated with the Treatment area (Roman) began to differ both behaviorally and demographically from caribou associated with the Control area (Bullmoose) once mining began in the Treatment area. Caribou in the Treatment area spent proportionately more time away from HEWR relative to caribou in the Control area and proportionally more Treatment caribou did so over time. This apparent displacement due to operational mining activity led to cascading effects beginning with a tendency for Treatment caribou to use larger amounts of range, moving more, and therefore expending more time and energy (Hudson and White 1985) to fulfill life requisites compared to caribou in the Control area. While away from HEWR, caribou in both Control and Treatment areas used habitats other than HEWR even though other HEWR options existed. Treatment caribou gradually began using proportionally more range below 1,350 m over time, the sizes of core winter areas increased and became more variable across years, and they proportionally spent more time in range modified by humans. The cascading events manifested in Treatment caribou having lower survival rates than the Control group with a large portion of the mortalities, mostly by predation, occurring outside HEWR. These effects eventually led to a local Treatment population abundance that declined to zero by the end of the study.

There was a gradual shift in the proportional use of elevations <1,350 m which did not reach its peak difference until 7-11 years after the start of mining. This meant mining had progressed for several years before behavioral effects could potentially be detected. Environment Canada (2008) estimated that caribou populations may take up to several decades to respond to landscape changes. A pillar of the mitigation plan for the Sukunka project is a plan for adapting operations when or if negative effects on caribou behavior or demographics is detected[1]. Our results here demonstrate that the expected lag in detection for these responses essentially voids any opportunity for successfully adapting mining operations as a mitigation measure.

The Treatment area (Roman) initially had the relatively larger abundance of caribou hence the larger proportion of the overwintering Quintette population. However, the population density at the Control area (Bullmoose) remained relatively stable until wolf removal began in 2016 and, with the positive increase in population growth rate, has become the HEWR complex with the relatively higher abundance and hence the larger proportion of the Quintette caribou population. The importance of the Control area has, in recent years become paramount to the recovery of Quintette caribou.

Although our comparison is only one example, the results demonstrate the high likelihood that open-pit mining operations have potential to displace caribou away from critical

range, positioning them in habitats that lead to higher rates of mortality, and leading to declining local population abundance, and eventual abandonment of range.

Increasing negative pressure on caribou demographics, especially in the vicinity of the Bullmoose HEWR given its current importance to the Quintette population, increases the likelihood of eventual extirpation of the Quintette population. Based on our findings, we predict that the level of cumulative disturbance of additional mining throughout the Quintette range will place the Quintette herd in a demographic condition that would require implementation of continuous and costly recovery measures to avoid extirpation. Recovery measures implemented to date in a neighboring population (the Klinse-Za caribou population), including maternity penning, wolf removal, and habitat restoration (McNay et al. 2022b), exceed $2-3 million/year (Unpubl. Data, Wildlife Infometrics Inc., Mackenzie, BC). Similar cost can be expected for management of the Quintette population and implementation would last as long or longer than the mine lives. In this case, the EAO requirement for Glencore to enter a financial agreement for a contribution of ~$4,800,000 over the life of the proposed Sukunka mine pales in comparison to the actual funding required to offset the cost of the necessary recovery measures. Additionally, placing Quintette caribou in a state of precarious extirpation by advancing coal mine operations is counter to BC's Declaration on the Rights of Indigenous Peoples Act[1] and the promises made to First Nations in Treaty 8[2] for their rights to continue hunting caribou.

The risk of repeating the negative consequence of open-pit mining that occurred at Roman is contrary to the Federal and Provincial commitments to the goal of recovering the Central Group population of caribou and is contrary to the shared recovery objective of the Partnership Agreement (Intergovernmental Partners 2020) and its statutes that promises to achieve the recovery goal. We argue that the evidence provided here substantially reduces uncertainty about the significance of long-term effects of open-pit mining on caribou, the potential magnitude of the outcomes on Quintette caribou demographics, and provides well-informed guidance to regulators, statutory decision makers, and others responsible for planning the careful conservation and recovery of Quintette caribou.

While this summary is focused on caribou, the proposed Sukunka coal mine will have other consequences. Saulteau First Nations (SFN), West Moberly First Nations (WMFN), Doig River First Nation (DRFN), and the McLeod Lake Indian Band (MLIB) (collectively the Impacted Nations) collaborated on the review of the EAC Application for the proposed Sukunka coal mine. Members from these Impacted Nations use the area of the proposed Sukunka project for traditional activities including fishing, camping, berry picking, hunting, teaching youth, canoeing, and traversing game and other trails to access traditional use sites. The ability of the Impacted Nations to engage in these traditional activities has already been impacted by the cumulative effects of industrial development throughout their traditional territories. The addition of the proposed Sukunka coal mine would further infringe on these activities, which will have consequences for food security and the overall health and wellness of the communities. As a result, these Nations are of the view that the Ministers ought to deny Glencore's Application for an environmental assessment certificate due to impacts to the critically endangered Quintette

[1] https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/19044 (accessed 220831)
[2] http://treaty8.bc.ca/wp-content/uploads/2015/07/Treaty-No-8-Easy-Read-Version.pdf (accessed 220831)

caribou herd, and several other key issues related to cumulative impacts on Treaty and Aboriginal Rights and Interests that were not addressed or resolved by Glencore. For further information, we encourage a review of the letters submitted by each Impacted Nation that outlines their evaluation of the assessment methodology and conclusions, and summarizes the impacts to their Treaty and Aboriginal Rights and Interests.

Summary

Using behavioral and demographic information collected between 2002-2021 from the Quintette population of Central Mountain caribou (*Rangifer tarandus*), we tested the effects of mining operations in a Treatment area relative to a Control area without operational mining. Both areas are in separate, independent units of High Elevation Winter Range, a critical habitat type for these caribou. We found that caribou associated with the Treatment (Roman) area responded differently than did caribou associated with the Control (Bullmoose) area on several metrics characterizing a cascading of events, beginning with maladaptive behavioral responses and leading to negative demographic outcomes for Roman caribou. Specifically, we found that, after the start of mining, Roman caribou were likely to spend proportionately more of their time away from HEWR relative to Bullmoose caribou and that, over time, more Roman caribou spent more than 50% of their time away from HEWR. The apparent displacement of Roman caribou from HEWR resulted in larger areas of use, longer movements away from core areas of use, and when away from the study area HEWR, Roman caribou chose habitat at locations likely to have higher risk of predation. These behavioral responses manifested in caribou having lower vital rates (adult survival and juvenile recruitment) in the Treatment area, compared to the Control, and to lower rates of instantaneous increase creating a population abundance that steadily decreased to zero in the Treatment area by the end of the study. An increased likelihood is reported on each ecological metric that is linked to consequences of open-pit mining operations, specifically in HEWR. We also noted a time lag between the initiation of operational mining in the Treatment area and the ability to detect behavioural effects on caribou, meaning that operational mine life was substantially underway before the full impacts on caribou became apparent. Once apparent, these impacts include displacement of caribou away from critical range that positions them in more dangerous habitat where mortality rates increase and population abundance decreases. We present multiple lines of evidence from behavioural to demographic effects and responses pointing to a cause of the eventual abandonment of critical habitat that is either compromised or irreparably harmed by mining disturbance. Based on these results and their extrapolation to other historic, current, and proposed mines in the range of Quintette caribou, future extirpation of the population appears likely and could only be avoided through intensive and continuous implementation of recovery measures at a cost that cannot currently be met through proposed mitigation measures.

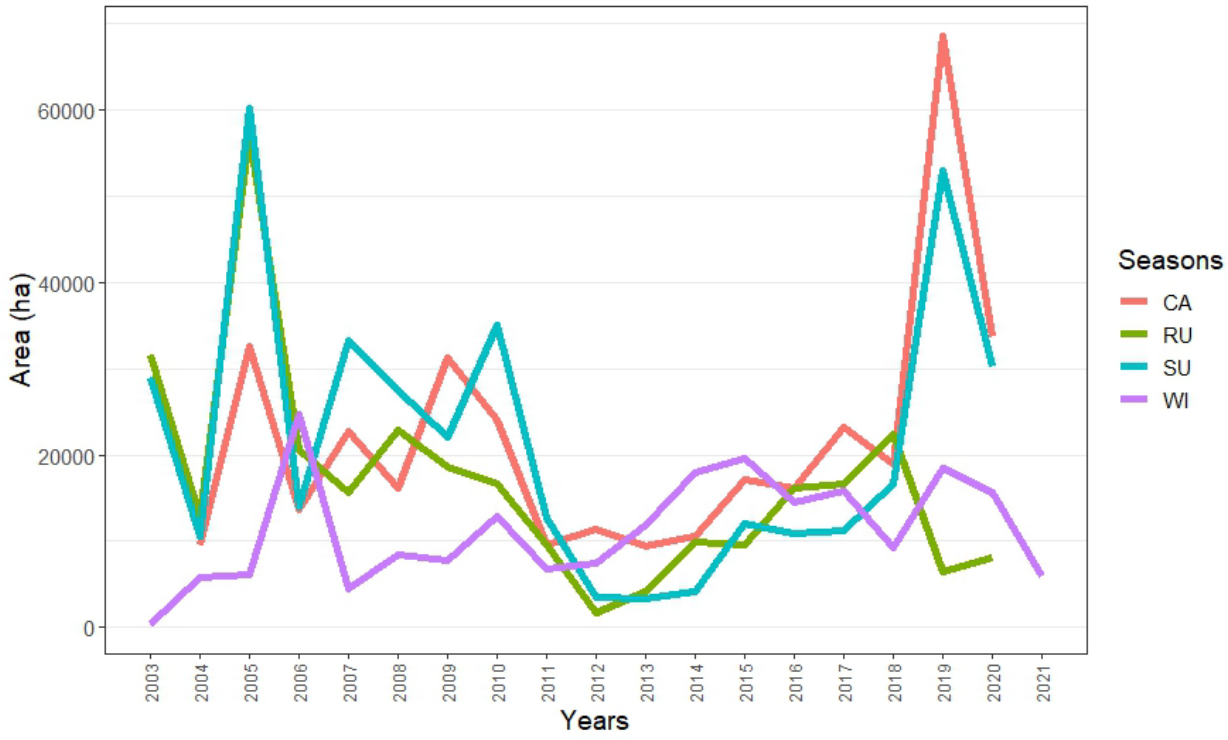

Figure 2. Spatial area used by caribou for four seasons in the Control area (WI = winter, CA = calving, RU = rut, SU = summer). These areas represent core habitat.

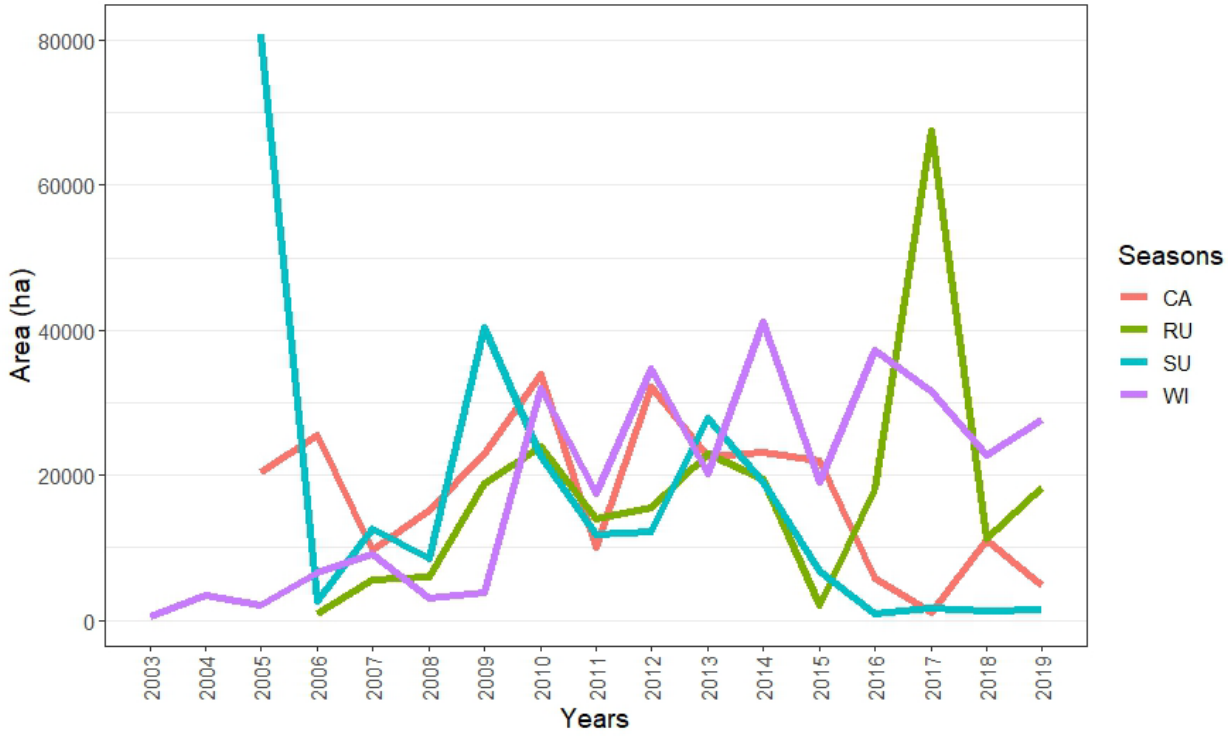

Figure 3. Spatial area used by caribou for four seasons in the Treatment area (WI = winter, CA = calving, RU = rut, SU = summer). These areas represent core habitat.

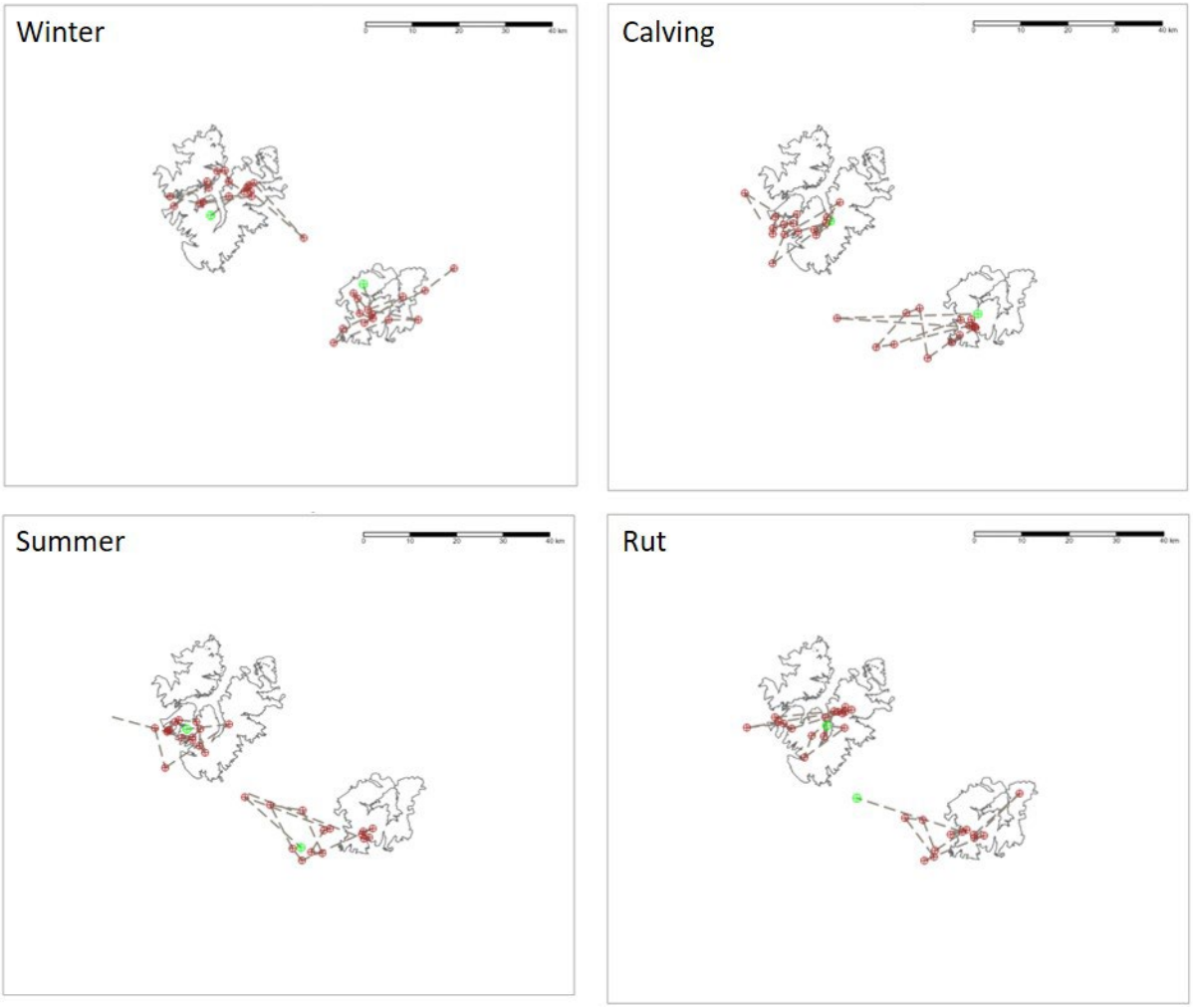

Figure 4. Shifts in the location of the centroids within core areas used by caribou at the Control area (left study area in each panel) and Treatment area (right study area in each panel). The first year of analysis is represented by the green marker. Distances are corrected for topography. Monitoring the locations of centroids may provide some insights into habitat condition. More disturbance may lead to higher movement rates as caribou need to venture further to obtain resources, resulting in variability in the size of the areas that caribou use and larger distances between centroids.

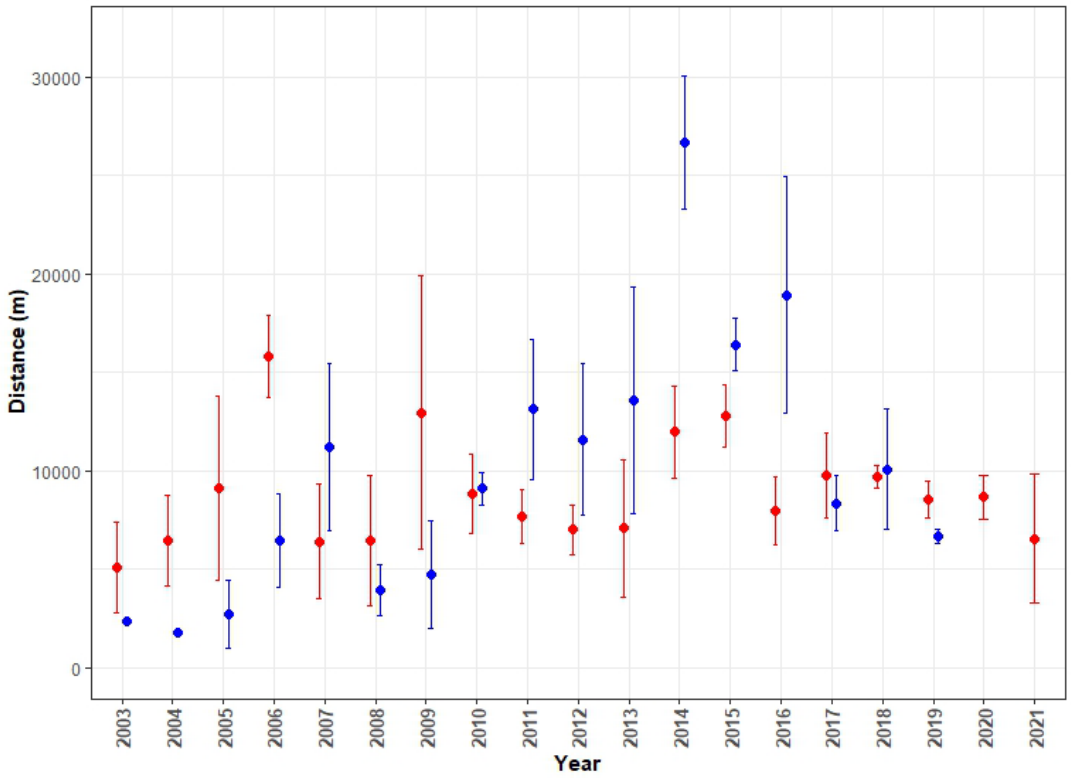

Figure 5. Average distance measured from individual centroids to the overall group centroid during winter at Control (red) and Treatment (blue). The dots represent the average, and the lines represent the overall range in values. Generally, as mining progressed there is a trend towards larger distances (dots with higher values) between centroids in the Treatment compared to the control, and higher variability (longer lines) in the Treatment area.

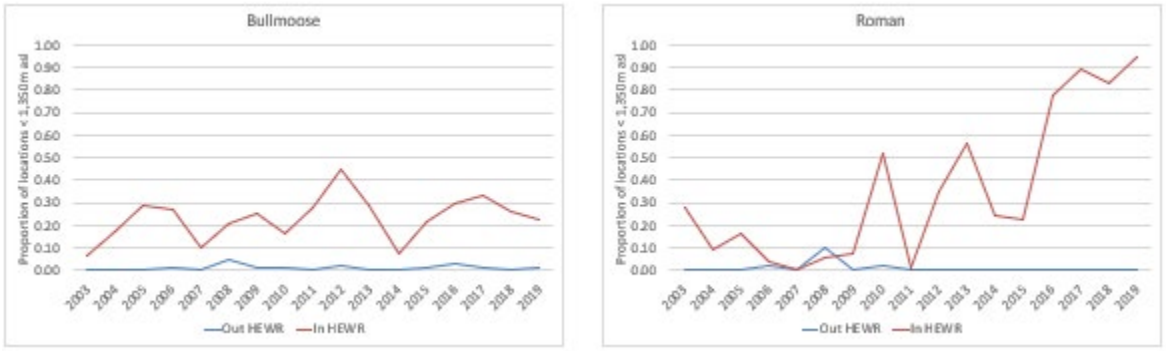

Figure 6. Proportion of radio-collared caribou locations below 1,300 m where proportions were derived from observations pooled annually across seasons and individuals and for areas inside our outside High-elevation Winter Range (HEWR) within two study areas (Roman and Bullmoose). The difference in proportions was calculated as Roman – Bullmoose.

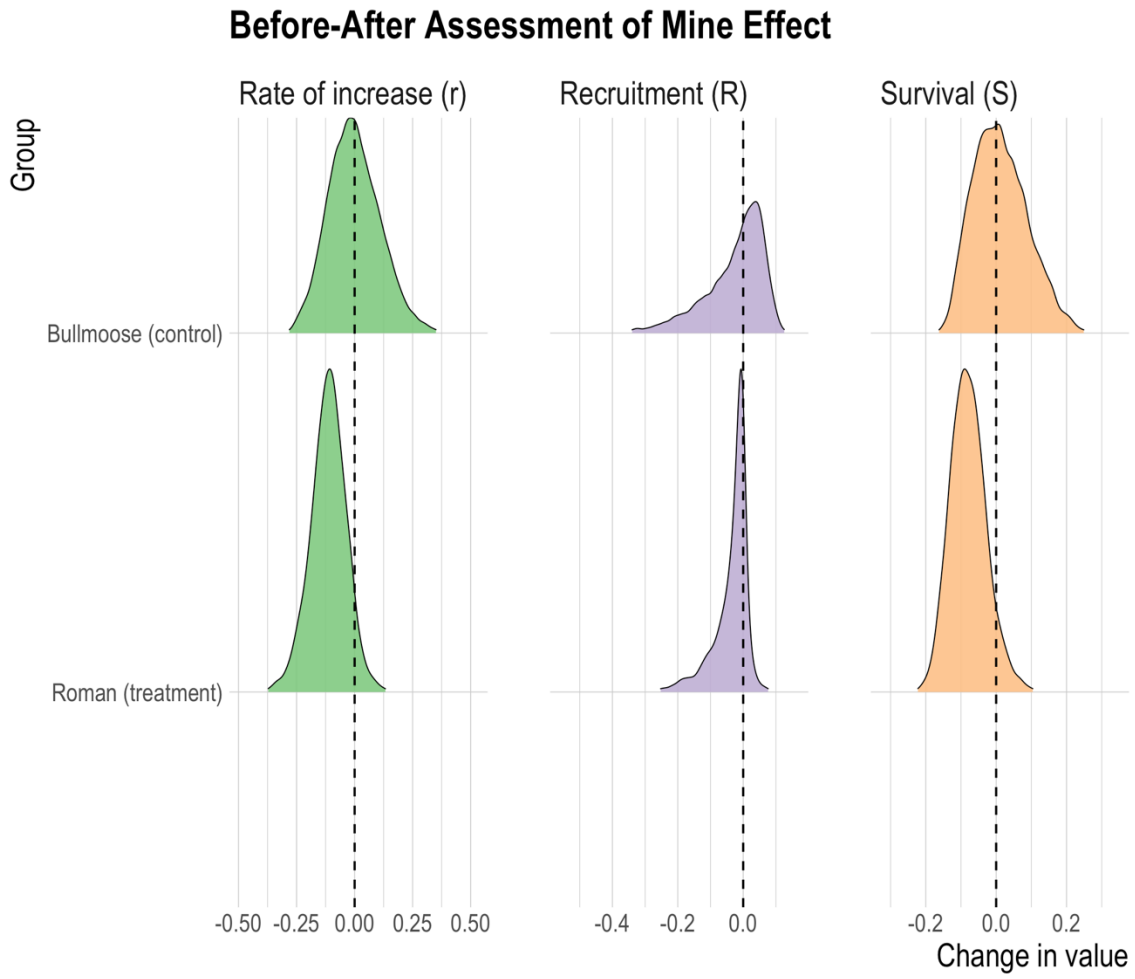

Figure 7. Estimates of changes in the population growth rate, recruitment of new calves to the population, and adult for the Treatment and Control areas following mine development. Change is estimated by subtracting the rates in the after period (2006-2015) from the before period (2002-2005). Values at or to the right (positive values) of the dotted line typically indicate stable or increasing populations. Values to the left of the dotted line typically indicate conditions that often lead to population decline. In every case, the Roman area has a net negative result in all three metrics relative to the Bullmoose area after the onset of mining. This has ultimately lead to extirpation of caribou from the Roman area.

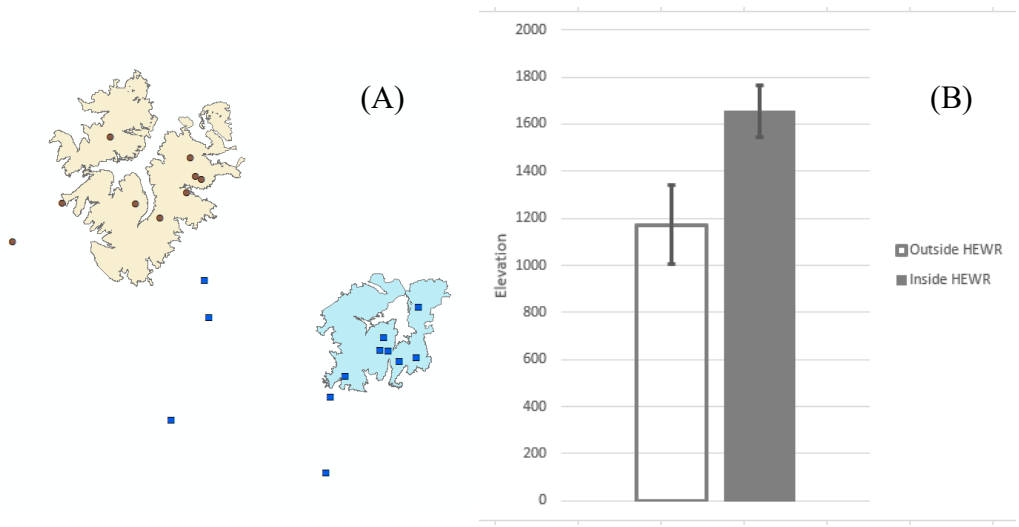

Figure 8. (A) Location of radio-collared caribou mortalities (brown circles and blue squares) in relation to high-elevation winter range (HEWR) study areas (Bullmoose – cream and Roman – blue) and (B) average elevations (histograms) of the mortalities outside and inside the HEWR areas. The vertical bars represent the range around the average values. This figure indicates that relatively more caribou died in the Roman area, and a higher proportion of these mortalities occurred at lower elevations. Caribou that leave HEWR tend to be exposed to risker habitats at lower elevations due to higher levels of disturbance and higher densities of predators that can move more easily through fragmented landscapes.

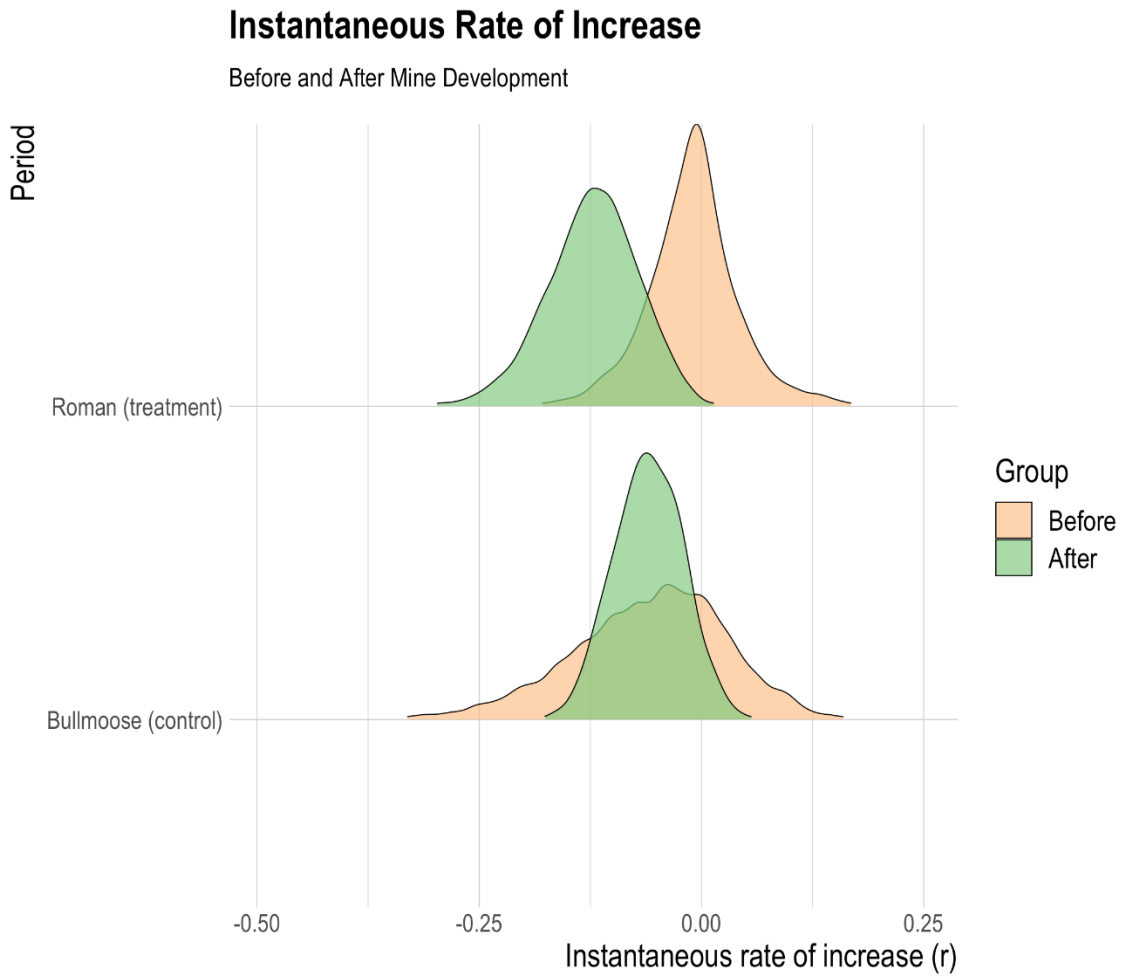

Figure 9. Estimates of population growth rates for the Treatment and Control areas before (2002-2005; brown) and after (2006-2015; green) mine development. Values at or to the right of 0 are indicative of stable or increasing populations. Values to the left of 0 are indicative of declining populations. Growth rates for Roman caribou declined substantially after the onset of mining, ultimately leading to their extirpation from the area. It is interesting to note that growth rates at Bullmoose, while higher than Roman, are still less than 0, suggesting that this population can be vulnerable to disturbance.

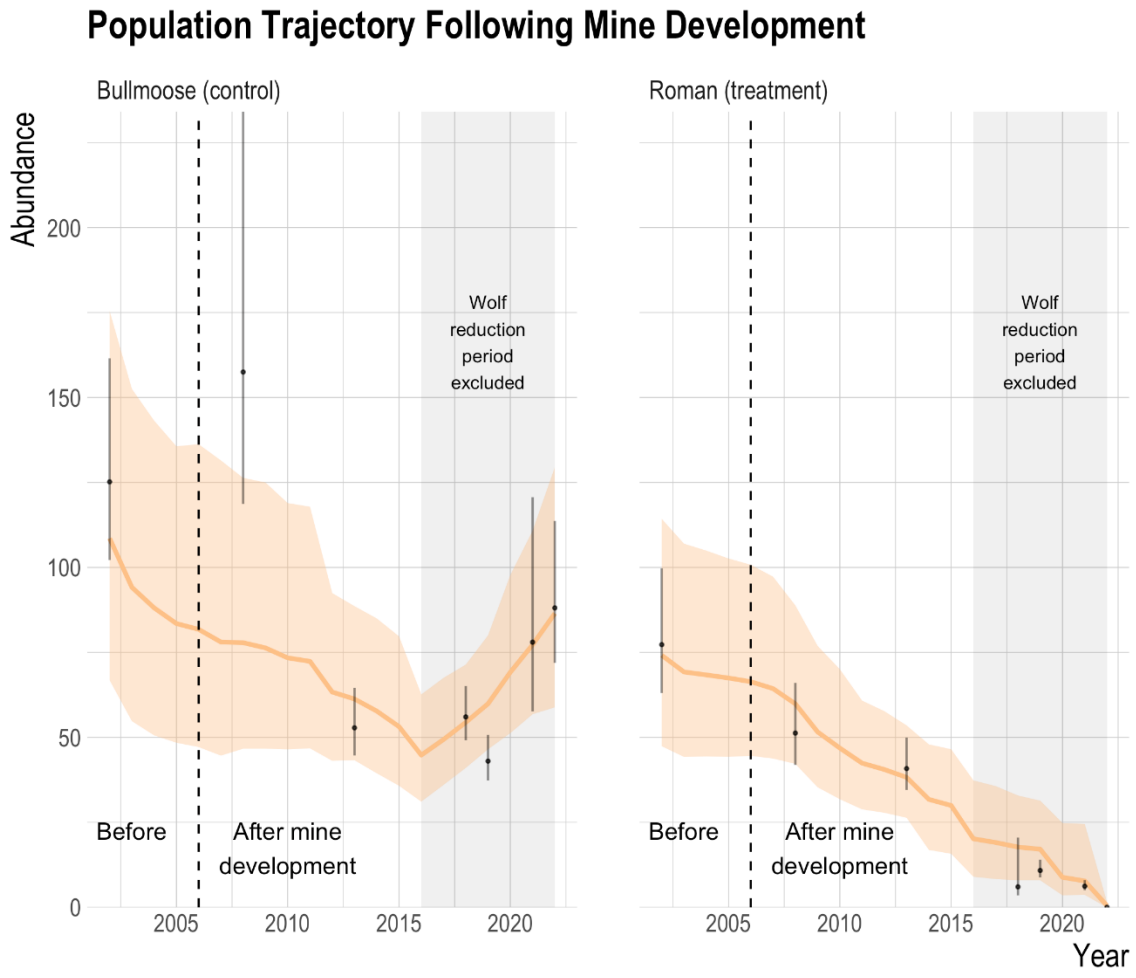

Figure 10. Abundance of caribou using the Bullmoose (Control) and Roman (Treatment) study areas within the Quintette caribou population between 2002-2022. Orange line represents the median estimates and the shaded area represents the range. Points show observed abundance from aerial surveys and their precision. Development of the Roman mine began in 2006 and effective wolf reductions began in 2016. We exclude the wolf reduction period 2016-2022 from future analyses measuring the effects of mining. We show that excluding this period provides a conservative approach to measuring the effects of mining. This figure shows that caribou abandoned the Roman area and that caribou numbers increased in recent years in the Bullmoose area. These graphs illustrate the increasing importance of the Bullmoose area, and that additional disturbance may negate recovery efforts.

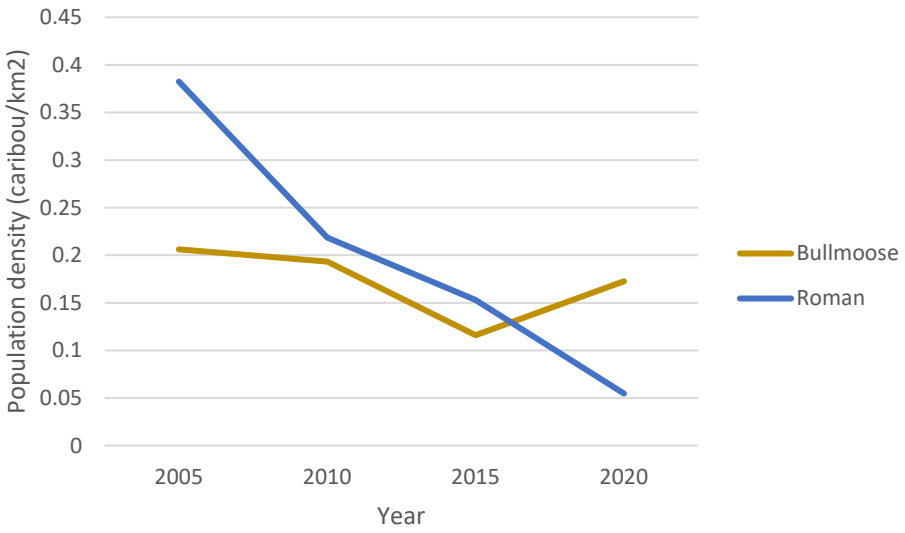

Figure 11. Caribou population density in two study areas (Bullmoose and Roman) within the Quintette caribou population of the Central Group of Southern Mountain Caribou in British Columbia. Density in the Roman (Treatment) area was much higher (almost double) than the Bullmoose (Control) area prior to mining (Pre-2006). In subsequent years, densities decreased in both areas, albeit less steeply in the Bullmoose area. More recently, density approaches 0 at Roman and has been increasing at Bullmoose. These graphs illustrate the increasing importance of the Bullmoose area, and that additional disturbance may negate recovery efforts.

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