Ministry of Forests, Lands and Natural Resource Operations

Survey history and status of Northern Mountain Caribou populations in the Northeast region of BC 2016-2021

Agnès Pelletier, Ph.D, R.P.Bio

Kevin Watt, M.Sc., R.P.Bio

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

Caribou Recovery Program

February 2022

Suggested citation: Pelletier, A. and Watt, K. 2022. Survey history and status of Northern Mountain Caribou populations in the Northeast region of BC 2016-2021. *BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, p39, Fort St. John, BC, Canada.*

Contents

List of Figures

List of Tables

Executive Summary

This report is a review of historical and current population data for all COSEWIC DU 7 (Northern Mountain Designatable Unit) caribou populations located in the Northeast region of British Columbia (BC). The information presented shows that most of these populations have received inconsistent monitoring over the past decades, although the Graham and Pink Mountain populations are now more consistently monitored because of an ongoing wolf control program. Data from the 1960s to the late 1980s were mostly based on reconnaissance surveys with no statistical foundation to provide strong population estimates, while data from the early 2000s to 2020 were mainly based on recruitment surveys conducted following the collaring of adult females. Based on this review, we propose that a more consistent inventory schedule that includes mark-resight surveys where population sizes can be estimated is implemented. We also suggest that herd boundaries are reviewed in areas of known caribou trace occurrence to potentially update herd delineations. Finally, we propose the implementation of additional recovery programs to improve survival.

Introduction

In BC, 25 woodland caribou (*Rangifer tarandus caribou*) populations belong to the Northern Mountain Designatable Unit (DU 7), with 7 located in the Northeast region (Committee on the Status of Endangered Wildlife in Canada, 2014; Figure 1). Although these populations are federally designated as "Special Concern" and "Blue-Listed" provincially, they have been monitored inconsistently from 2016 to 2021 (Anderson, 2020). In southern and central BC, pressures posed by habitat loss and predation over the past decades on Southern Mountain (DU 9) and Central Mountain (DU 8) caribou have led to declining populations and local extirpations (Reid & DeGroot, 2018b, 2018a; Seip & Jones, 2013; Figure 2).

The Northeast Region is located on Treaty 8 territory, where caribou have an invaluable cultural importance for local Indigenous communities. As a response to these local extirpations, several First Nations have implemented voluntary moratoriums on caribou hunting until populations recover (Government of Canada, 2020).

Under the context of the rapid decline of Southern Mountain and Central Mountain caribou, the Government of BC has decided to use a more proactive approach to prevent the uplisting of Northern Mountain caribou populations. This objective requires more consistent monitoring of distribution and key population metrics such as annual female survival and calf recruitment.

The goal of this report is to present a 5-year overview of survey results for each of the Northern Mountain caribou populations located in the Northeast region of BC prior to the increased monitoring effort, and to provide specific recommendations and next steps to monitor these populations effectively for the next 10 years.

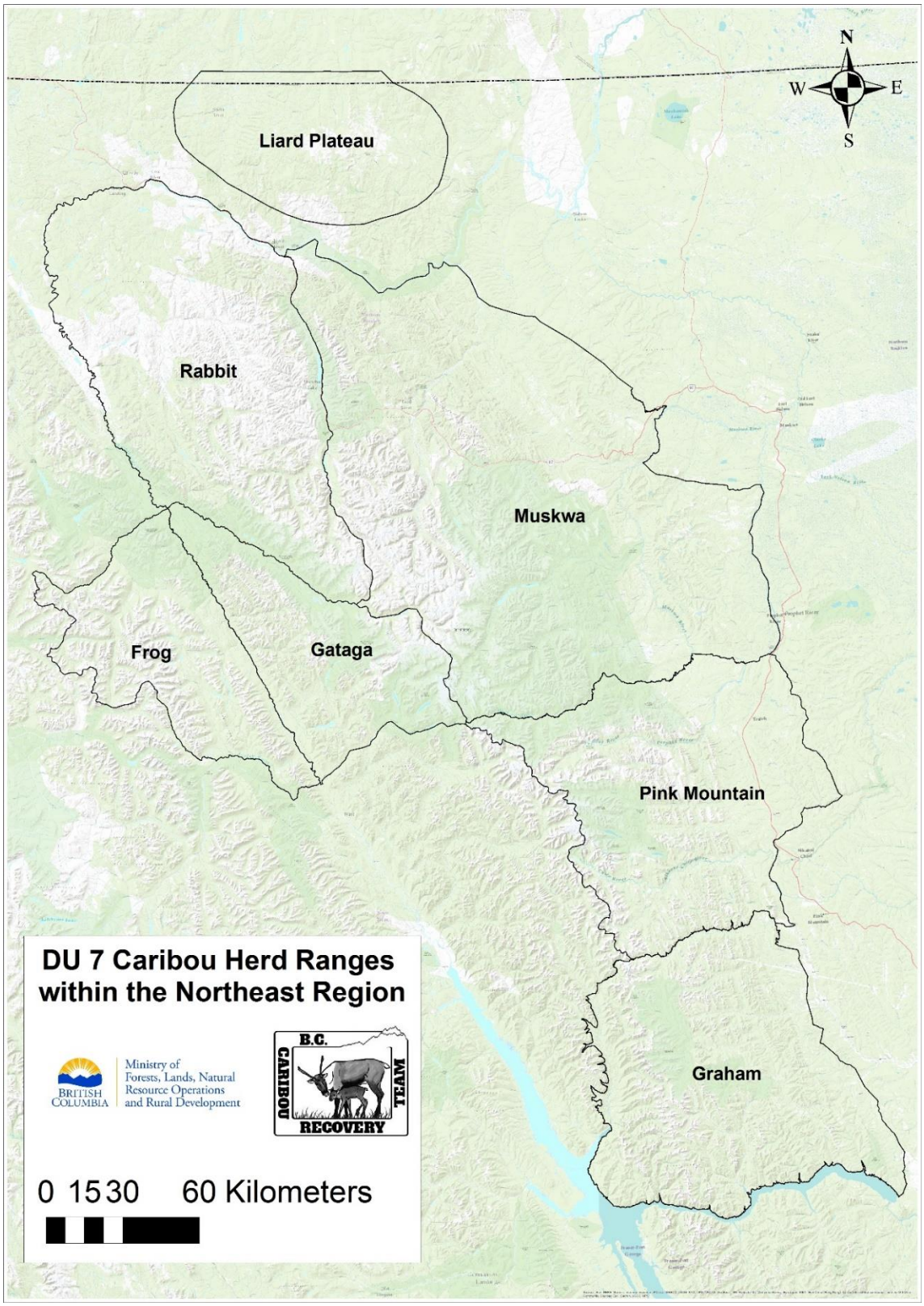

Figure 1. Map of DU 7 Caribou herd ranges in Northeast BC

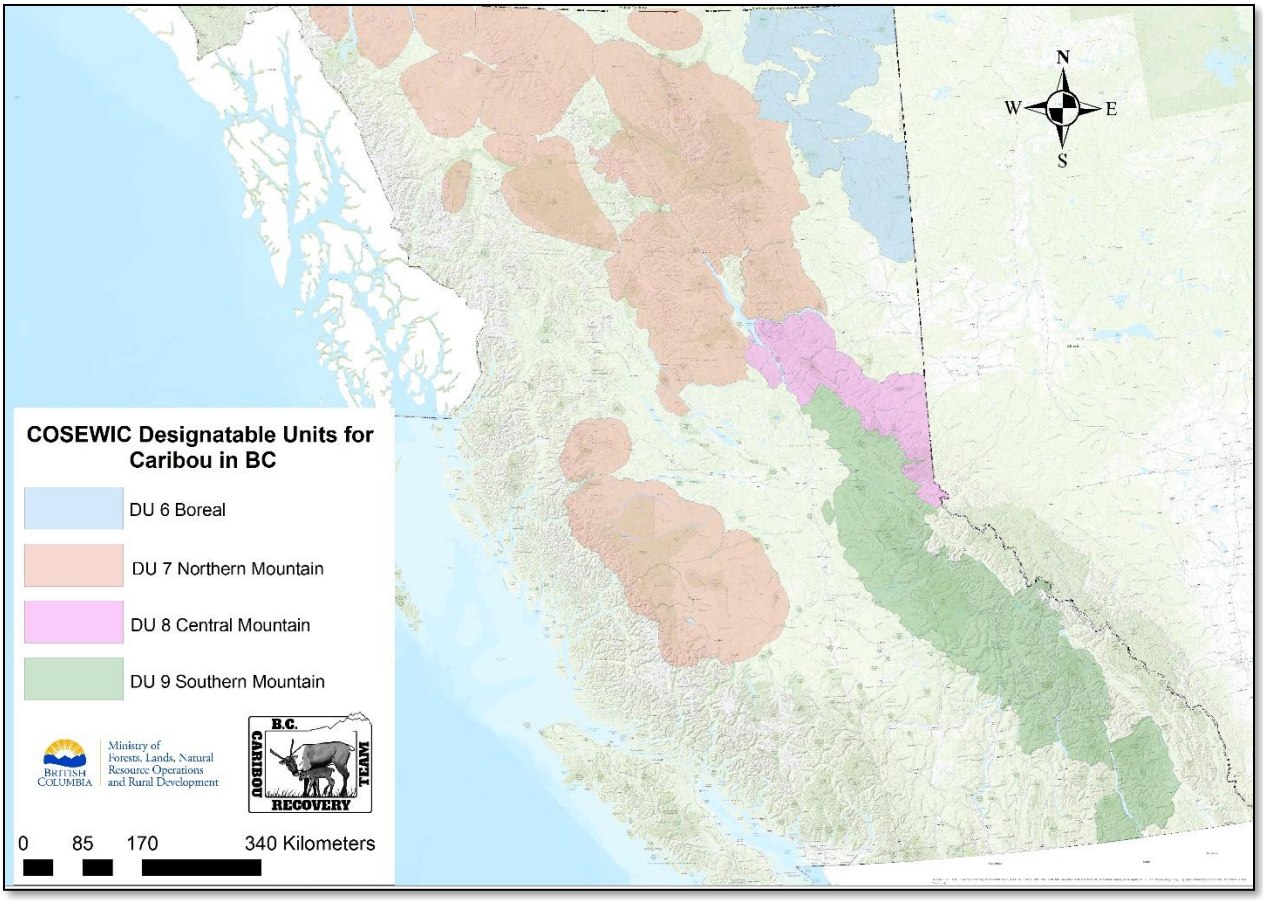

Figure 2. Map of COSEWIC Designatable Units for Caribou in BC

Survey Methods and Analyses

Several survey methods have been used in combination to gather key caribou population metrics. These metrics and the raw data types necessary to compute them are described below.

Survival Rate

Adult females can be affixed with GPS or VHF collars to calculate adult female survival. These collars send different signals when an animal is fully stationary for a set period of time (assumed dead) than when it is moving. This allows the ratio of the number of collars sending a mortality vs. an active signal to be used as a proxy for adult female mortality rate. Collar signals from VHF or offline GPS collars need to be monitored quarterly via fixed wing flights to obtain information on seasonal mortality levels.

In this report, adult female survival is calculated yearly, from April 1st to March 31st based on a staggered entry design (Pollock et al., 1989; Skalski, 2005). Survival rate is based on the number of animals alive at the start of the period, the number of animals that die during that period, and the number of animals whose status becomes unknown during that period. Animals of unknown status are censored from the date they go offline for GPS, or when they cannot be located via VHF, and provide partial survival information throughout the period (DeCesare et al., 2016).

It is essential to note that this survival rate is only based on collared adult females; known harvest and road kills of uncollared animals are not computed in the metric, so survival rates presented in this report might be overestimated.

Recruitment Rate and Population Estimates

Late winter aerial surveys are conducted from late February to March via helicopter to locate and classify (sex and age) animals. The results of such surveys provide recruitment metrics (proportion of 9-10 months old calves in the population; calf:cow ratio), the bull:cow ratio, and can sometimes provide population estimates. Recruitment metrics inform whether a population is self-sustaining, with 15-16% calves in a population and 26 calves:100 cows considered the minimum targets for a population to be reproductively stable (Bergerud, 1992; DeCesare et al., 2012). The information gathered from aerial surveys depends on how they are designed.

Recruitment Surveys

The goal of recruitment surveys is strictly to obtain a minimum count of animals by directly flying to active collars, and sex and age all the animals encountered to gather the following metrics:

i) Percentage of calves;
ii) Calves to females ratio; and
iii) Bulls to females ratio.

Recruitment surveys cannot be used to estimate population size.

Mark-Resight Surveys

As opposed to recruitment surveys, mark-resight surveys allow for the calculation of a population size estimate based on the sightability of marked (or collared) animals. During these surveys, all of the survey area is flown, and all animals observed (either opportunistically or tracked via telemetry) are counted and classified. Then, the following data are used to derive a population estimate:

- The number of marked animals (or number of active collars available), M
- The number of recaptured animals (or number of collars located opportunistically), R
- The total number of animals located opportunistically, C

One common method used to estimate population size is the Petersen method (Krebs, 2017) which only requires one capture event and one relocation event of some of the animals to calculate the population estimate (N). This method assumes that the proportion of recaptured animals (R/M) is the same as the proportion of animals observed opportunistically (C/N). With this method, the population estimate is calculated as follows:

$$N = (C * M)/R$$

However, the above equation often lends to overestimations of populations, especially in small populations. The modification below corrects this bias, preventing overestimation when (M + C) > N, or if there are at least seven recaptures of marked animals (R > 7). It calculates the population estimate as follows:

$$N = \frac{(C+1) * (M+1)}{R+1} - 1$$

The Petersen corrected equation is the one used in this report to calculate 2021 population estimates for the Graham and Pink Mountain caribou populations. It is important to note that the Petersen equation (corrected or uncorrected) is generally applied without distinction to the entire survey area, despite obvious differences in sightability levels depending on habitat type. This would lead to overestimations if a high number of collars tracked via telemetry ends up providing a low proportion of the animal count.

One solution that could be used to resolve this would be to stratify the survey area into high, medium and low sightability potential areas, and then:

i) apply the Petersen equation for survey areas with a high sightability potential (such as high alpine areas) and provide a population estimate for these areas; and

ii) add all animal counted in areas with low and medium sightability to the high sightability area estimate calculated in i).

This would lead to the provision of a blended population estimate, but could lead to underestimations if the number of animals observed in medium and low density areas is low.

Population Growth Rate

Generally, population growth rates are derived from multiple population estimates (Caughley, 1977). Since obtaining accurate and precise population estimates from wildlife data is difficult, an alternative method to derive growth rate from survival and recruitment data (the recruitment-mortality method, or RM) was developed by (Hatter & Bergerud, 1991), with lambda, the finite rate of change, calculated as follows:

$$\lambda = S / (1 - R)$$

where:

- S is the survival rate (equals to 1-M, where M is the mortality rate)
- R is the recruitment rate

A female-specific equation to account for the fact that caribou population metrics are mainly assessed through the tracking of collared females was also proposed (Hatter & Bergerud, 1991). An adjustment to the R factor of the female-specific RM equation was developed by (DeCesare et al., 2012) to avoid overestimations in λ that result from not accounting for juvenile-adult age-ratios.

The adjusted RM equation becomes:

$$\lambda = S / (1 - Rrm)$$

where:

$$Rrm = \frac{number\ of\ female\ calves}{number\ of\ females\ of\ all\ age\ classes}$$

The (DeCesare et al., 2012) equation is the one used in this report to calculate λ. The population growth rate (r) is derived from λ, as follows:

$$r = \lambda - 1$$

This means that $\lambda < 1$ represents a declining population or a negative growth rate (r < 0%); $\lambda > 1$ represents an increasing population or a positive growth rate (r > 0%); and $\lambda = 1$ represents a stable population or a null growth rate (r = 0%). Figure 3 provides an overview of population growth rates of all DU 7 caribou populations in Northeast BC, based on the above equation.

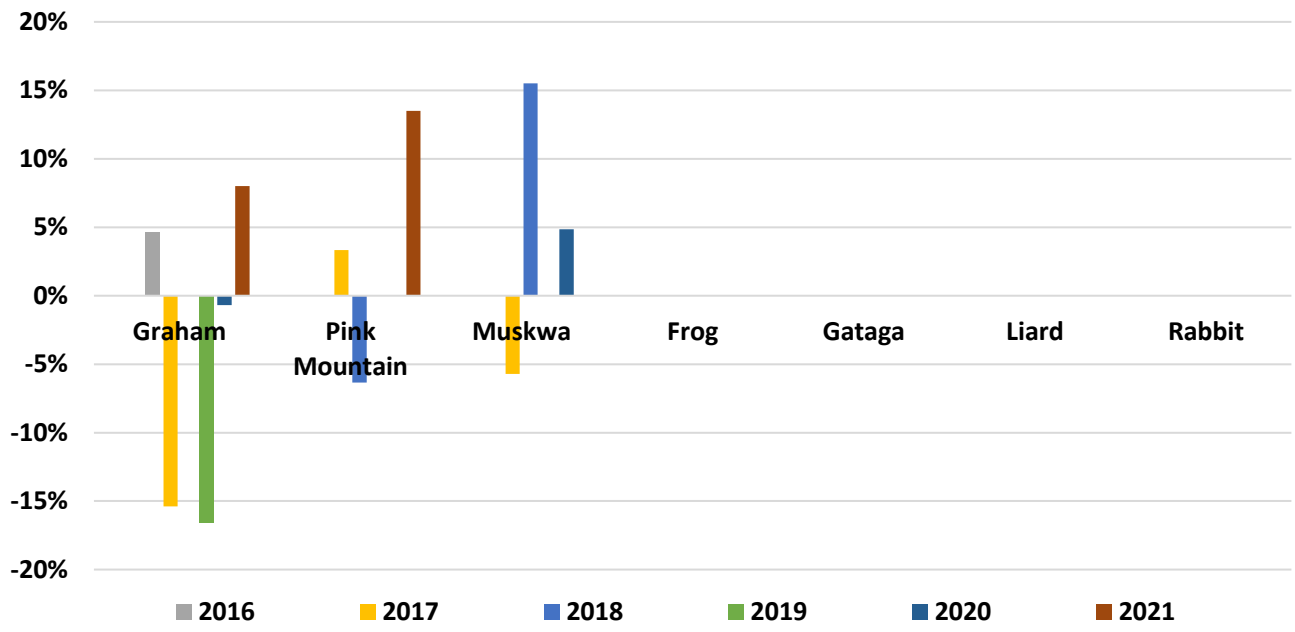

Figure 3. Growth rates for DU 7 caribou herd ranges in Northeast BC, from 2016 to 2021. There was no data to calculate growth rates for the Frog, Gataga, Liard and Rabbit caribou herds.

Northeast BC Northern Mountain Caribou Populations

Graham

Study Area

The Graham caribou range is bordered south by the Peace River, extending westward to Williston Lake and then northward along the Ospika River. From the WAC Bennet Dam, the range limit reaches the Halfway River, which also delineates its northernmost boundary. The range encompasses a 9,681 km^2 surface area, which includes high elevation alpine mountains (alt. 1800m) north of the Chowade River as well as south and west of the Graham River. The rest of the range is composed of subalpine mid-elevation parkland forests (1500m alt.) and low elevation conifer forests (below 1200m alt.). Protected areas within the range include the Graham Laurier Provincial Park and the Butler Ridge Park (Figure 4).

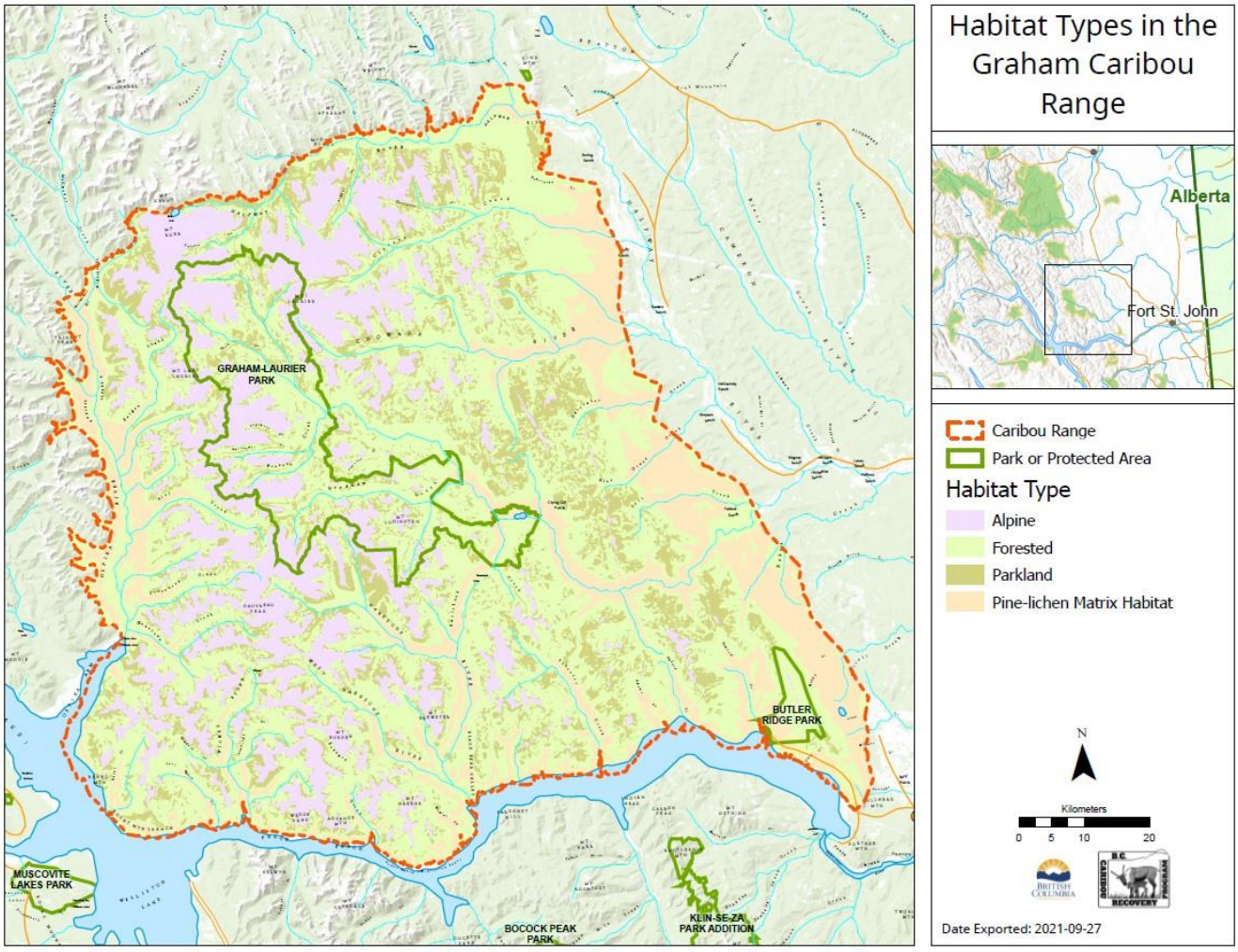

Figure 4. Map of habitat types within the Graham herd range

The First Nations with territories overlapping the land used by the Graham herd include:

- Blueberry River First Nation
- Doig River First Nation
- Halfway River First Nation
- Horse Lake First Nation
- Dene Tha First Nation
- McLeod Lake Indian Band
- Tsay Keh Dene Band
- Saulteau First Nation
- West Moberly First Nation

Survey and Management History

In 1988, 530 caribou were estimated in the Graham population via reconnaissance surveys. This estimate was considered to represent only 25% of the population from the 1960s, as a major population crash had occurred in the early 1970s that is speculated to have been caused by harsh winter conditions and predation (Harper, 1988).

As a response to logging interests in the Graham range and due to a general lack of information on habitat use, population dynamics and predation (Harper, 1988), a radio collaring program was implemented to monitor 9 to 10 adult females (Backmeyer, 1990). This program led to the first documented aerial mark resight survey for the Graham caribou population in 1989, and provided a count of 587 animals, suggesting that the estimate put forward in Harper (1988) was an underestimation. Although conditions during the 1989 survey did not allow to relocate enough collars to reliably estimate the population size (only 3 relocated out of 9 active), the author assumed that if collars were equally distributed, there could have been 1761 animals in the population (Backmeyer, 1990).

Mark-resight surveys continued to be conducted periodically in the Graham range between 1989 and 2009. Surveys focused particularly on 11 survey blocks within the high elevation winter range (HEWR; Figure 5). In 2009, the population was estimated at 708 animals (95% CI 311-1558 (Culling & Culling, 2009)). In 2014-2015, 22 VHF collars were deployed on adult females, with the objective to update the 2009 estimate (Culling & Culling, 2015).

The results from the 2015 late winter survey provided a population estimate of 347 (95% CI 207-660). This sharp population decline is further supported by the minimum counts in the survey blocks south of the Chowade River, which fell from 497 in 1989 to 90 in 2015 (Backmeyer, 1990; Culling & Culling, 2015).

Once the latest experimental wolf control program was implemented in the Central Mountain South Peace caribou populations (Quintette, Kennedy Siding and Klinse Za) in 2015, the Graham population served as a control population with no wolf control. This enabled to assess the effect of wolf control on adult female survival. Because of the improved survival of adult females in the Central Mountain populations and of the continued population decline of Graham caribou from 2015 to 2019 (Government of British Columbia, 2019), wolf control was implemented in this range in 2020 to recover the population to self-sustaining levels.

5 year review: 2016-2021

Distribution of caribou and results from survey counts

Graham caribou spend most of their winters in mountainous areas, where they feed on terrestrial lichens found on wind swept alpine ridges. From 2016 to 2021, late winter aerial surveys were conducted in the Graham range every year except in 2018 (Table 1). The 2021 survey was the most thorough, as all alpine areas within the range were flown to detect and classify animals, including the ones west of the Graham River and Schooler Creek that are either classified as high elevation summer range (HESR) or are unclassified (Figure 5).

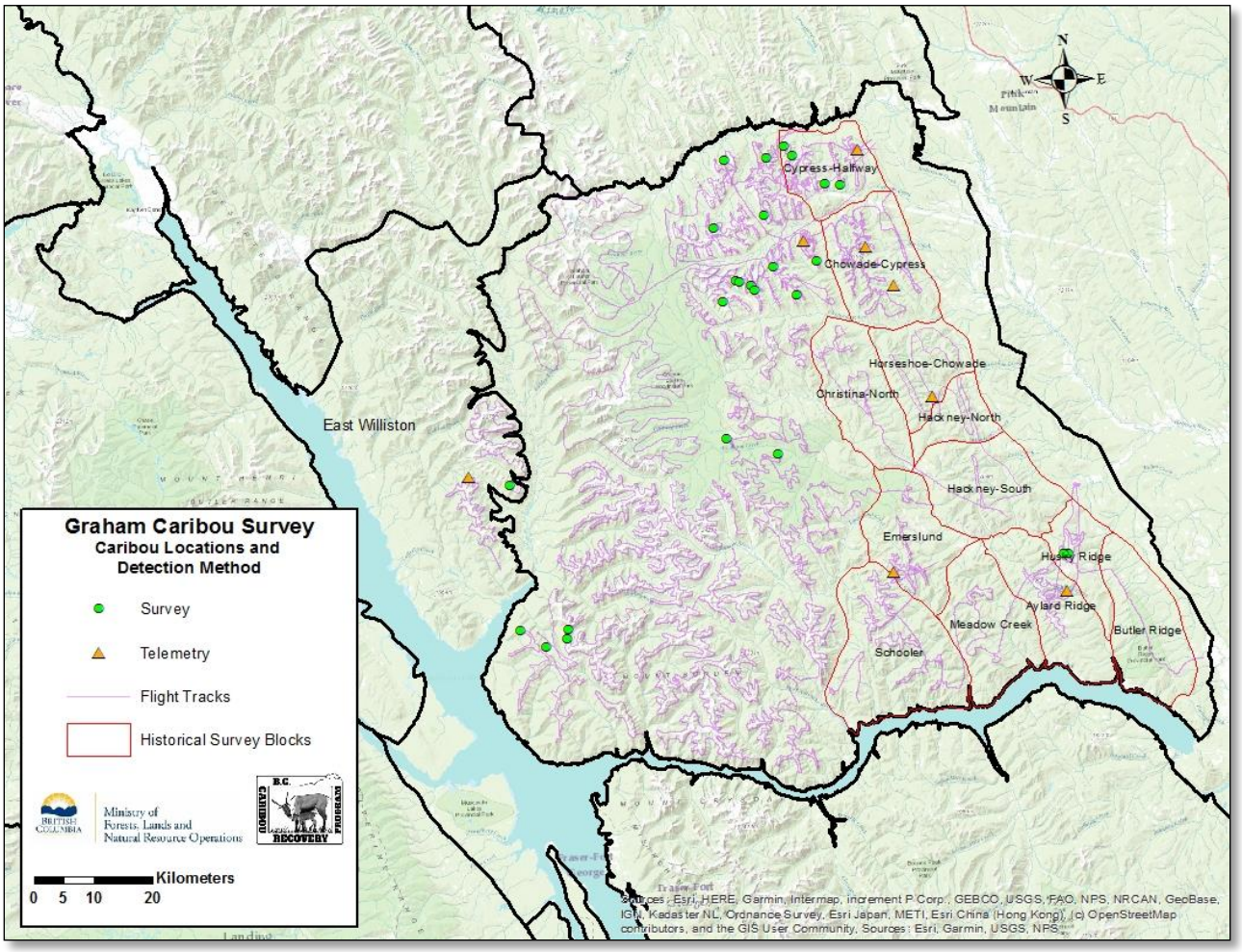

Figure 5. Map of the 2021 Graham caribou late winter population survey. The map indicates flight lines, locations of caribou observed opportunistically and tracked via telemetry, and the delineation of historical survey blocks

In 2016, 136 animals were counted within the 12 survey blocks of the HEWR, and 45 animals were counted outside, for a total of 181 caribou (Table 1). Of these, 64% were found in the Cypress Halfway and Chowade Cypress blocks (Culling & Culling, 2016). In contrast, 42 animals were counted during the 2021 inventory within the same survey blocks, against 89 outside, for a total of 131 animals observed (Table 1), although two groups were missed in the Aylard and Horseshoe Chowade blocks, as 2 females were heard active but could not be located. Further, only 15% of the animals were found in the Cypress Halfway and Chowade Cypress blocks. The majority of caribou were still detected north of the Chowade River (68%), but animals were found mainly to the west of these blocks, east of the Graham River.

These results, associated with the fact that no caribou were observed within the Butler Ridge blocks in 2016 and 2021, could indicate that the Graham caribou population is undergoing a westward range shift due to more anthropogenic disturbance on the eastern side of the range. This hypothesis will be evaluated during future recruitment and mark-resight surveys, which will be conducted on a rolling basis every year as long as wolf control is implemented in the area.

Table 1. Results from caribou late winter surveys in the Graham herd range, 2015-2021

Year	Survey type	Area searched	Survey conditions	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	Total
2015	Mark Resight	30% of HEWR	Excellent	40	21	130	50	27	8	215
2016	Mark Resight	30% of HEWR	Good	36	25	121	29	21	10	181
2017	Recruitment	30% of HEWR	Not reported	24	16	56	6	11	0	73
2018	No survey									
2019	Recruitment	30% of HEWR	Poor	15	7	40	23	11	2	76
2020	Recruitment	30% of HEWR	Excellent	14	11	27	1	8	37	73
2021	Mark Resight	100% of alpine	Good	29	16	53	41	21	16	131

Key Population Metrics and Trends

The proportion of calves in the Graham caribou population has been in majority below the minimum target of 15-16%, with a mean of 13.9% since 2015 (Table 2). Adult female survival has averaged 82% over the same time period. This number, coupled with below target recruitment, has led to a negative growth rate of -4% on average since 2015. The situation seems to have improved following the implementation of wolf control in 2020, as recruitment reached 16% calves and adult females survival rate 90% in 2021 (Table 2). The increasing growth rate observed from 2020 to 2021 suggest that the Graham caribou population could increase in the future in the absence of adverse population pressures. The population will continue to be monitored to assess any changes in key metrics as long as wolf reduction is ongoing.

Table 2. Key population metrics from the Graham herd range, 2015-2021

Year	Calf %	Calf:cow ratio	Survival Rate	Lambda DeCesare (2021 - Females only) $\lambda = S / (1-Rrm)$	Growth Rate (r)	Number of active collars monitored (based on# of collars active at start of sampling period)
2015	12.60	0.21	NA	NA	NA	NA
2016	11.60	0.17	0.96	1.047	4.7%	27 (all VHF)
2017	15.1	0.20	0.77	0.846	-15.4%	26 (all VHF)
2018	NA	NA	0.65	NA	NA	20 (15 VHF, 5 GPS)
2019	14.50	0.28	0.73	0.835	-16.5%	20 (15 VHF, 5 GPS)
2020	11.00	0.30	0.86	0.993	-0.7%	22 (18 VHF, 4 GPS)
2021	16.03	0.40	0.90	1.08	8%	19 (15 VHF, 4 GPS)
Mean	**13.91**	**0.26**	**0.82**	**0.96**	**-4%**	

Population estimates from Mark-Resight surveys

Population estimates from mark-resight surveys of the Graham caribou population have showed a sharp declined since 2009; this decline was still noticeable over the last 5 years, as the population estimate obtained in 2016 over only 30% of the range (230; 95% CI 116-447) was higher than the population estimate obtained in 2021 over the entire range (219; 95% CI 123-402; Table 3). These numbers were obtained with comparable numbers of collars available and collars located opportunistically, and under good survey conditions.

Table 3. Available population estimates for the Graham herd range

Year	# of available collars	# of collars located opportunistically & tracked	Status of remaining collars	Population estimate for survey area (95% CI)*	Blended estimate (Population estimate + count outside survey area)
2009	20	3 & 17	NA	708 (311-1558)**	NA
2015	27	20 & 6	1 unknown	347 (207-660)	373
2016	22	11 & 10	1 mortality	230 (116-447)	298
2021	19	9 & 7	2 active, 1 unknown	219 (123-402)	/

*Petersen corrected equation used to calculate all population estimates
**Unreliable estimate due to poor survey conditions

Pink Mountain

Study Area

The Pink Mountain caribou range is bordered south by the Halfway River and north by the Muskwa River, and encompasses a 9,511 km^2 surface area. The majority of the range is composed of mountainous terrain, although the eastern portion includes large tracks of low elevation coniferous forests that extend 30 km eastward of Highway 97, up to the junction of Buckinghorse River and Medana Creek. Protected areas within the range include the southern portion of the Northern Rocky Mountains Provincial Park, Redfern-Keily Provincial Park, Prophet River Hot Springs Park, Buckinghorse-Wayside Park, Pink Mountain Park, Sikanni Chief River Ecological Reserve, and Sikanni Falls Protected Area (Figure 6).

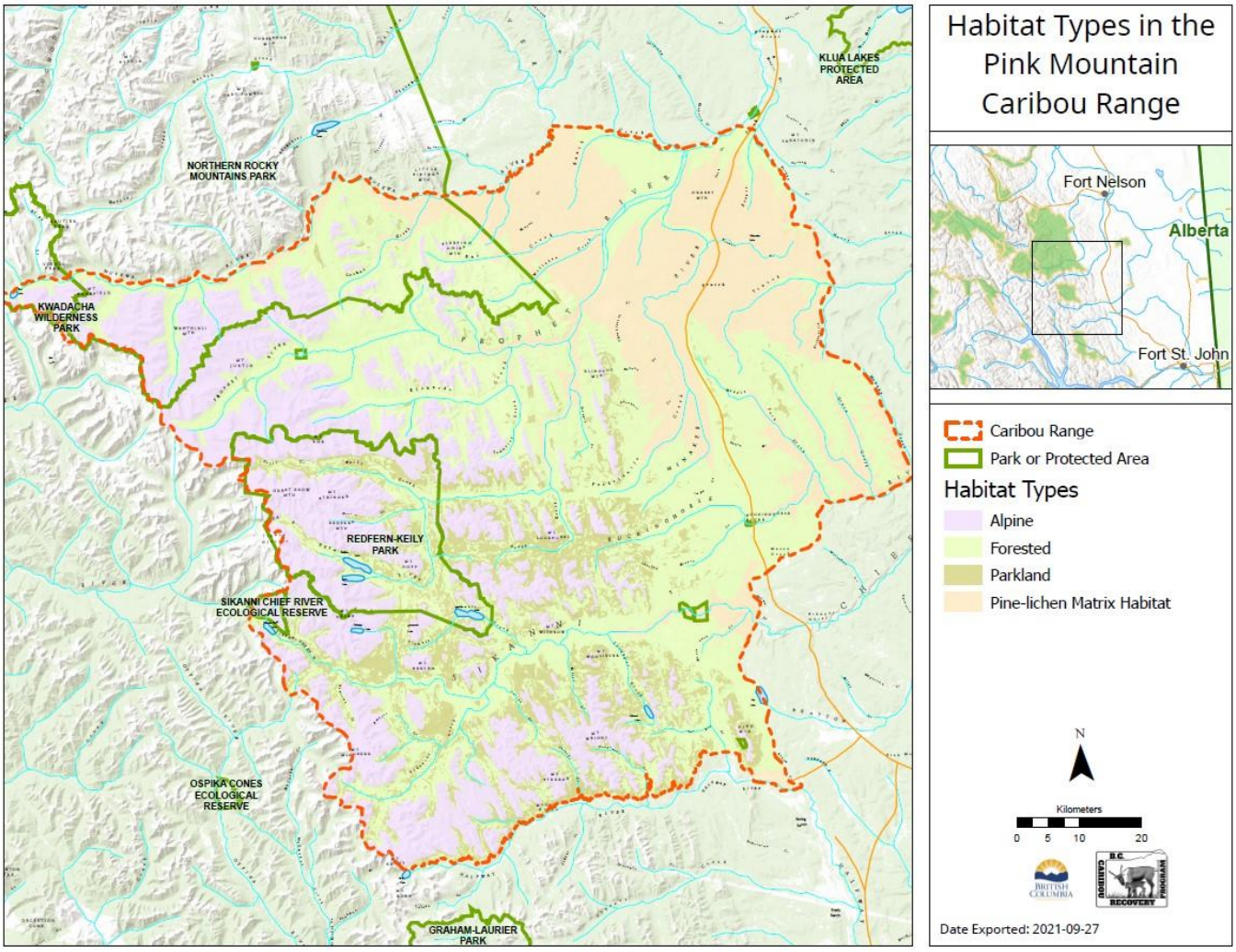

Figure 6. Map of habitat types within the Pink Mountain herd range

The First Nations with territories overlapping the land used by the Pink Mountain herd include:

- Blueberry River First Nation
- Dene Tha First Nation
- Doig River First Nation
- Halfway River First Nation
- Horse Lake First Nation
- Saulteau First Nation
- Tsay Keh Dene Band
- West Moberly First Nation
- Kaska Dena Council
- Kwadacha
- Prophet River First Nation
- Liard First Nation

Survey and Management History

Traditional knowledge has documented that in the fall and winter, Pink Mountain caribou have crossed the Alaska Highway eastward, towards the muskeg habitat around the Tommy Lakes and the boreal Chinchaga caribou population (Leech & Bates, 2016). GPS data from collared animals has not been able to identify these movements, but Councilor Wayne Yahey (Blueberry River First Nation) directly observed caribou migrating along this route as recently as October 2021, which had not been seen for the past 20 years (*Jane Calvert, pers. com*).

Historical survey data has documented uncommon caribou movements, for example when a similar surface area surveyed in 1968, 1969 and 1978 respectively yielded a 1018, 2675, and 203 count (Bergerud, 1978). The major difference between the late 1960s counts, only one year apart, can be explained by the difference in weather conditions, as 1969 was an atypical winter with extremely cold temperatures and deeper snow than usual, which could have led caribou to use more of the windswept alpine areas (Bergerud, 1978). The 1968 and 1978 surveys, on the other hand, were conducted during conditions where caribou would have been more likely to use lower elevation forests, leading to lower survey counts. The count difference between 1968 and 1978 over the same survey area still suggests that the population had declined significantly in 10 years, most likely due to the negative effects of overhunting compounded with low calf recruitment (Bergerud, 1978).

From the late 1970s to early 1980s, wolf reductions were implemented in the Pink Mountain and Muskwa ranges by local outfitters and maintained at <10 wolves/1,000km^2. Following the cessation of the reduction, densities had increased to 39/1,000km^2 (Bergerud & Elliott, 1998). Further experimental reductions were then implemented by the Government of British Columbia from 1984 to 1987, and wolf densities decreased to 22/1,000km^2 by 1990. At that time, the estimated number of caribou for the Pink Mountain and Muskwa ranges combined was about 3,000 (Bergerud & Elliott, 1998).

From 1990 to 2015, the Pink Mountain population was monitored infrequently. In 2012, twenty incidental caribou observations obtained during a Stone sheep survey in wildlife management unit 7-42 yielded a count of 165 caribou, including 124 adults females and 22 calves (13% calves and 0.18 calf:cow ratio), illustrating low recruitment.

5 year review: 2016-2021

Distribution of caribou and results from survey counts

In 2015, as a result of the concerns regarding strong caribou declines in DU 8, a proposal to deploy VHF collars on 15 adult females and conduct annual aerial surveys in the Pink Mountain range of DU 7 from 2016 to 2018 was put forward (Bridger & Arnison, 2015). The rationale was that the population had not been surveyed since 2000 and that the declines observed in DU 8 could have been occurring concurrently in DU 7 without being noticed. The deployment of VHF collars was going to allow for monthly tracking of adult female survival, and late winter surveys would provide information on recruitment. Movement analyses would also allow the delineation of an Ungulate Winter Range (Bridger & Arnison, 2015).

Following the monitoring program implemented in 2016, 4 surveys were conducted over 6 years in the Pink Mountain range, including one mark-resight survey in 2021 (Table 4, Figure 7).

Table 4. Results from late winter caribou surveys in the Pink Mountain herd range, 2015-2021

Year	Survey type	Area Searched	Survey conditions	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	TOTAL
2016	Recruitment	100% of alpine	Poor	34	NA	150	35	22	45	252
2017	Recruitment	50% of range	Excellent	50	12	187	103	32	0	322
2018	Recruitment	50% of range	Good	32	5	161	39	37	0	237
2019	No survey									
2020	No survey									
2021	Mark resight	100% of alpine	Good	53	20	225	83	61	8	377

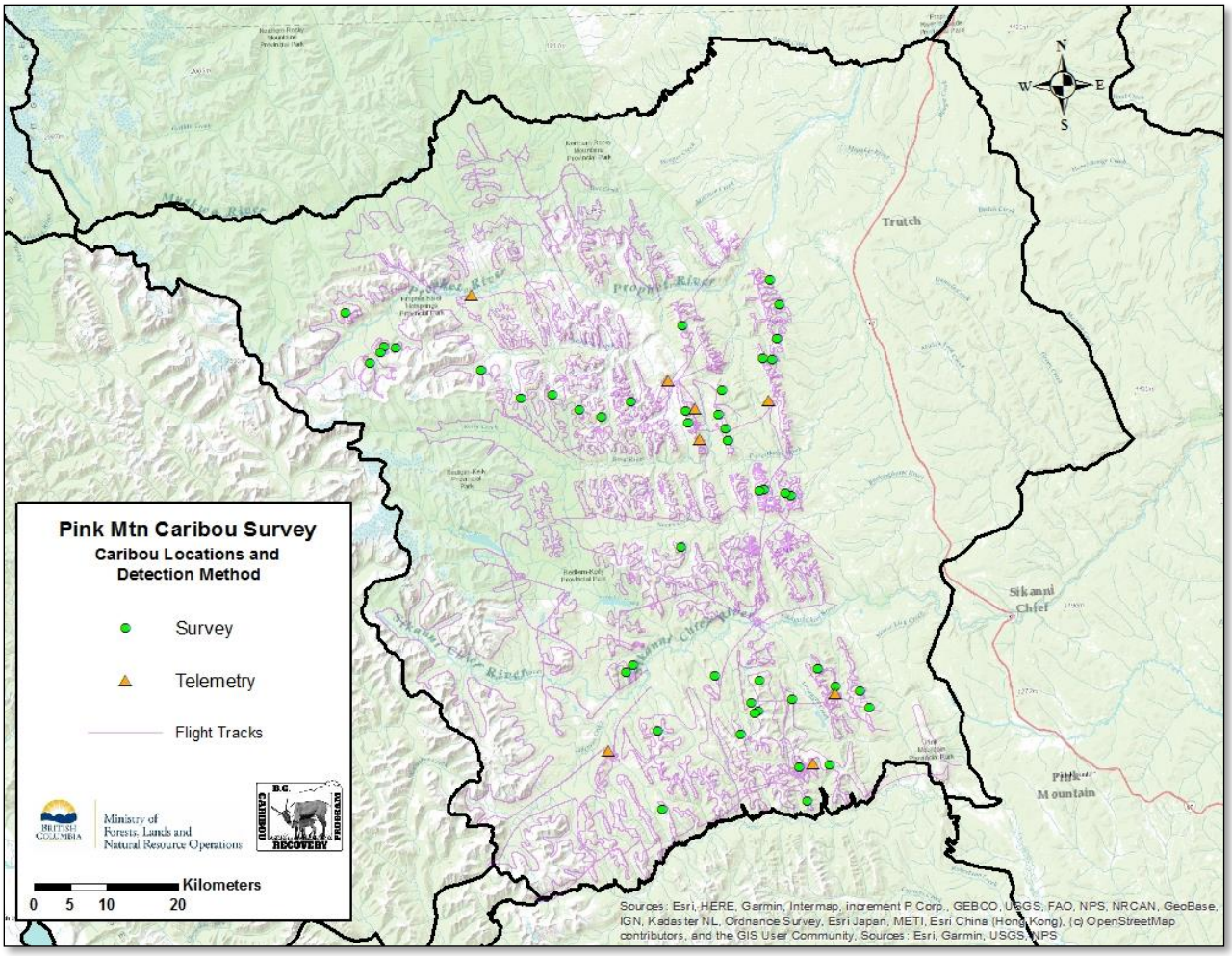

Figure 7. Map of the 2021 Pink Mountain caribou late winter population survey. The map indicates flight lines and locations of caribou observed opportunistically and tracked via telemetry

Key Population Metrics and Trends

Over the years surveyed since 2016, vital rates in the Pink Mountain caribou population indicated a declining trend. The proportion of calves and the calf:cow ratio respectively averaged 12.6% and 0.2, which are both below target for recruitment, while adult female survival averaged 88% (Table 5).

Results from the 2016 survey counted 252 animals, with a calf percentage and a calf:cow ratio well below target for population renewal (8.7% and 0.15 calf:cow ratio, respectively). The 2017 survey yielded similar evidence of low recruitment, although adult female survival was high (Table 5).

Concerns about the loss of traditional hunting opportunities brought forward by Blueberry River First Nation led to the implementation of a 3-year provincial wolf reduction program from 2018 to 2021, with a starting wolf density of 13 wolves/1,000km^2. Although weather conditions and CoVid-19 prevented staff from conducting surveys in 2019 and 2020, the results from the 2021 survey, which covered the entire alpine areas, showed a clear improvement across all metrics (16.2% calves, 0.27 calf:cow ratio, 100% adult female survival), indicating stability for that year, and a positive growth rate for the population (Table 5). These result support the potential for future population growth, especially if calf recruitment continues to increase. The population will continue to be monitored to assess any changes in key metrics as long as wolf reduction is ongoing.

Table 5. Key population metrics from the Pink Mountain herd range, 2015-2021

Year	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)	Survival Rate	Lambda DeCesare (2021 - Females only) $\lambda = S / (1-Rrm)$	Growth Rate (r)	Number of active collars monitored (based on # of collars active at start of sampling period)
2016	8.7%	0.15	NA	NA	NA	NA
2017	9.9%	0.17	0.95	1.033	3.3%	21 (18 VHF, 4 GPS)
2018	15.6%	0.23	0.84	0.937	-6.3%	25 (17 VHF, 8 GPS)
2019	NA	NA	0.80	NA	NA	23 (16 VHF, 7 GPS)
2020	NA	NA	0.80	NA	NA	28 (12 VHF, 16 GPS)
2021	16.2%	0.27	1.00	1.135	13.5%	30 (7 VHF, 23 GPS)
Mean	**12.6%**	**0.20**	**0.88**	**1.03**	**3.5%**	

Population estimate from the 2021 Mark-Resight survey

Throughout 2021, 33 collars (11 VHF and 22 GPS) were monitored to assess adult female survival. Prior to the start of the 2021 mark resight survey, 21 collars were active and 11 unknown. Of the 21 active collars, 14 were observed opportunistically and provided a count of 363 animals, 6 were tracked via telemetry and provided a count of 14 animals, and one was only heard active. Applying the Petersen corrected equation on these results provides a population estimate of 533 animals (95% CI 333-879), which is most likely an overestimate as the 28% of collars that were tracked only provided 3.7% of the animal count.

A blended population estimate for the same survey would yield an estimate of 466 animals (460 estimated in high density areas, 95% CI 288-759, plus six animals observed in medium and low density areas; see page 9 for calculation of blended estimate).

Muskwa

Study Area

The Muskwa caribou range is bordered south by the Muskwa River and north by the Liard River, and encompasses a 20,936 km^2 surface area. It extends eastward to the Prophet River and westward to the Gataga River, and up to Moose Lake and Muncho Lake. The westernmost portion of the range is composed of high elevation mountains, especially directly south and north of the Tuchodi Lakes, and east and west of Wokkpash Lake. Lower elevation forested areas can be found around Stone Mountain Park and Summit Lake, between the Tetsa and Prophet Rivers to the east, and between the Tetsa and Liard Rivers to the north. Protected areas within the range include the majority of the Northern Rocky Mountains Provincial Park, Stone Mountain Park, Muncho Lake Park, Prophet River Wayside Park, Toad and Liard Rivers Hotsprings Parks, and Liard River Corridor Park (Figure 8).

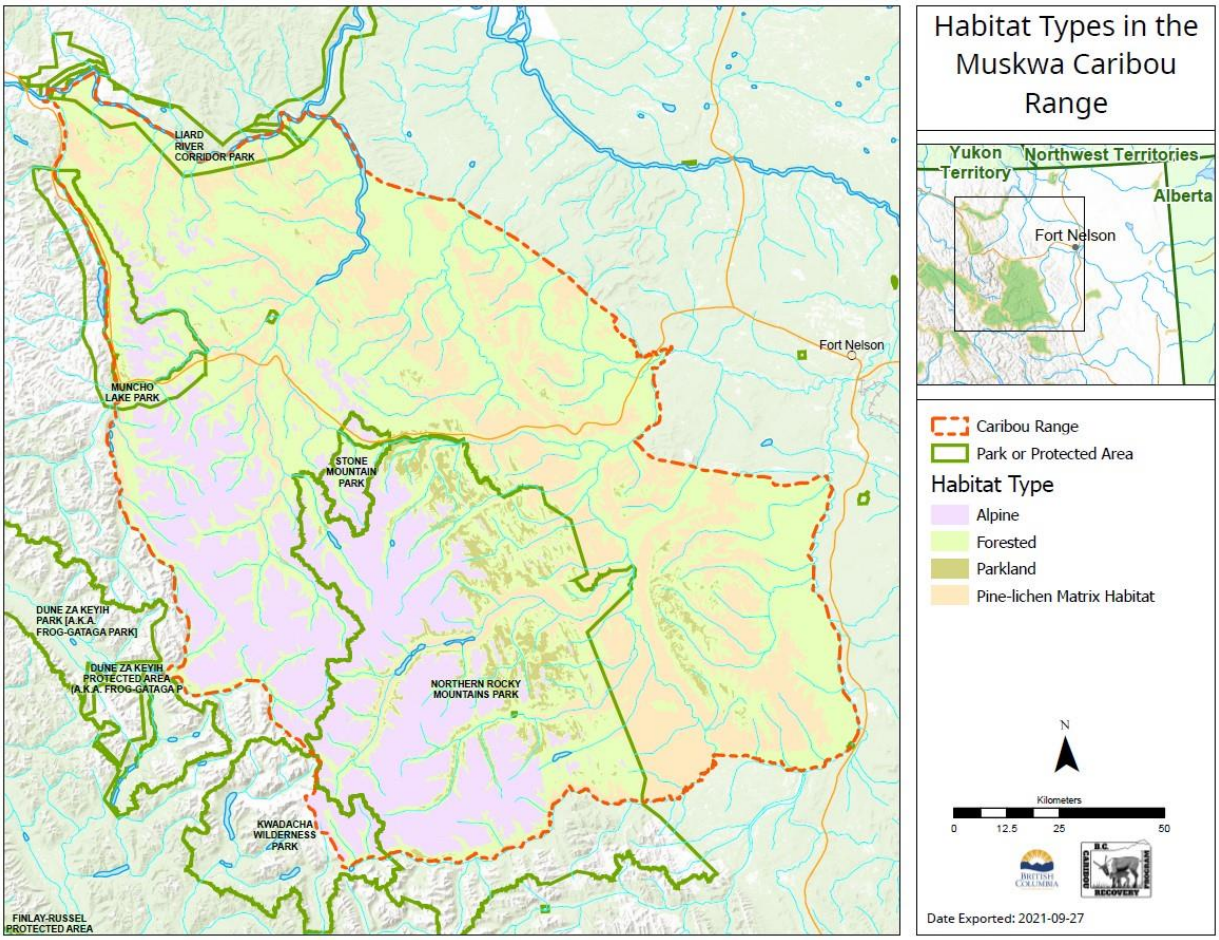

Figure 8. Map of habitat types within the Muskwa herd range

The First Nations with territories overlapping the land used by the Muskwa herd include:

- Acho Dene Koe
- Dene Tha First Nation - Area B
- Doig River First Nation
- Fort Nelson First Nation
- Halfway River First Nation
- Kwadacha
- Prophet River First Nation
- West Moberly First Nations - T8 Area Under Appeal
- Kaska Dena Council
- Liard First Nation

Survey and Management History

Local guide outfitters have been known to actively reduced wolf numbers to <10 wolves/1,000km^2 from the late 1970s to the early 1980s (Bergerud & Elliott, 1998). During that period, calf recruitment had peaked at a ratio of45.7 calves:cow (Bergerud & Elliott, 1998). After wolf reductions stopped, wolf densities increased to 39/1,000km^2, which prompted the Government of British Columbia to implement further reductions from 1984 to 1987, to 22 wolves/1,000km^2. By 1990, the estimated number of caribou for both the Muskwa and Pink Mountain ranges combined was about 3,000, but calf recruitment was low (17.5 calves:cow; Bergerud & Elliott, 1998). Expert opinion also estimated the population at 1,250 individuals in 1996 (Heard & Vagt, 1998), but the reliability of these historical estimates is difficult to assess as no survey data or survey conditions were described. From 2000 to 2021, the highest number of caribou counted for the Muskwa herd was 738 animals, counted in the Winter of 2007 as incidentals from a sheep survey (unpublished historical inventory data).

Before this, a specific caribou inventory program had been implemented between 2000 and 2004, which involved deploying collars on adult females for assessments of recruitment and survival (Radcliffe et al., 2005). Results from this program indicate that calf recruitment levels in the Fall and Winter have been overall below the recommended target for a stable population (Bergerud, 1992). The seasonal means of calf recruitment metrics in Fall and Winter are similar and do not suggest that rut counts are biased against calves in the Muskwa range (Table 6).

Over the course of this program, 46 collars were deployed. By the end of the program, 12 cows had been confirmed dead, 13 collars had been offline for more than 6 months, 2 collars had dropped, and 3 had gone offline recently, leaving only 16 active collars in the population (Radcliffe et al., 2005).

Table 6. Results from caribou seasonal surveys in the Muskwa herd range, 2000-2004 (compiled from Radcliffe et al., 2005)

Year	Season	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	TOTAL	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)
2000	Fall	48	0	154	86	43	5	288	14.93	0.28
2001	Fall	68	7	414	114	99	31	658	15.05	0.24
2002	Fall	78	15	323	123	64	5	515	12.43	0.20
2003	Fall	63	11	243	85	58	25	411	14.11	0.24
								Seasonal means	14.13	0.24
2001	Winter	43	22	254	106	75	22	457	16.41	0.30
2002	Winter	58	29	202	125	60	14	401	14.96	0.30
2003	Winter	63	13	200	70	34	20	324	10.49	0.17
								Seasonal means	13.96	0.25
2001	Summer	51	23	159	55	128	119	461	27.77	0.81
2002	Summer	76	21	173	51	101	76	401	25.19	0.58
2003	Summer	53	14	329	54	84	60	527	15.94	0.26
2004	Summer	57	8	288	105	113	10	516	21.90	0.39
								Seasonal means	22.70	0.51

For comparison purposes, the raw data from this project was used to reanalyze mortality rates based on the staggered entry method currently used in the Northeast region, based on an April 1st to March 31st year (Table 7). Results from this reanalysis indicate that the Muskwa population was overall stable from 2000 to 2004 (average growth rate 0.66%), but it is important to note that there were only 3 years of calf recruitment data to calculate λ.

Table 7. Key population metrics from the Muskwa herd range, 2000-2004

Year	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)	Survival Rate	Lambda DeCesare (2021 - Females -only) λ = S / (1-Rrm)	Growth Rate (r)	Number of active collars monitored (based on # of collars active at start of sampling period)
2000-2001*	16.41	0.30	0.93	1.07	7.1%	30
2001-2002	14.96	0.30	0.92	1.06	6.2%	27
2002-2003	10.49	0.17	0.82	0.89	-11.3%	30
2003-2004**	NA	NA	0.93	NA	NA	17
Mean	**13.96**	**0.25**	**0.90**	**1.01**	**0.66%**	

*Caribou collared in Oct. 2000 (only 21 weeks of data)

** No survey that year, so no calf recruitment data

5 year 2016-2021

From 2016 to 2021, the Muskwa caribou population was surveyed via late winter recruitment surveys 3 times (Table 8). Results from these surveys show much lower counts than from 2001 to 2003 (Table 6).

Table 8. Results from caribou late winter surveys in the Muskwa herd range, 2016-2021

Year	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	TOTAL
2016	No survey						
2017	44	15	109	30	22	16	177
2018	19	7	61	12	19		92
2019	No survey						
2020	34	23	80	30	26	5	141
2021	No survey						

Although calf recruitment metrics were below target in 2017 (Table 9), the associated growth rate for that year is unreliable due to low sample size (only 7 collars monitored). Accurate estimates of survival and growth rate for the Muskwa caribou population have been complicated by the difficulty associated with maintaining a high enough number of collared females. A third of the collars deployed from 2018 to 2020 have gone offline and no longer transmit a VHF signal. Overall, the 2018 and 2020 results indicate demographic stability, but larger datasets are required to accurately assess the status of the population. Stronger indicators of survival rates are critical as the number of human-caused mortalities in this range is concerning. From 2018 to 2021, 12 caribou mortalities were reported in this range (including one bordering Rabbit), of which 1 was identified as poaching and 6 as vehicle collisions.

Additional collars are planned to be deployed in the range within the next few years to have increased range coverage of collared female to assess survival, and to conduct a mark-resight survey in 2024-2025.

Table 9. Key population metrics from the Muskwa herd range, 2016-2021

Year	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)	Survival Rate	Lambda DeCesare (2021 - Females - only) $\lambda = S / (1-Rrm)$	Growth Rate (r)	Number of active collars monitored (based on # of collars active at start of sampling period)
2016	NA	NA	NA	NA	NA	NA
2017	12.43	0.20	0.86	0.947	-5.3%	7
2018	20.65	0.31	1.00	1.156	15.6%	18
2019	NA	NA	0.63	NA	NA	16
2020	18.44	0.33	0.90	1.046	4.6%	19
2021	NA	NA	1.00	NA	NA	24
Mean	**17.17**	**0.28**	**0.88**	**1.05**	**5.0%**	

Frog

Study Area

The Frog caribou range is bordered west by the Frog River, east by the Kechika River, and south by the Finlay River. The range encompasses a 5,038 km^2 surface area, which is mainly composed of alpine and forested areas. Protected areas within the range include the Dune Za Keyih (Frog-Gataga) Park, and a small section of the Finlay-Russel Park (Figure 9).

The First Nations with territories overlapping the land used by the Frog herd include:

- Halfway River First Nation
- Kwadacha
- Tahltan Central Government
- Takla Nation
- West Moberly First Nation
- Kaska Dena Council
- Liard First Nation

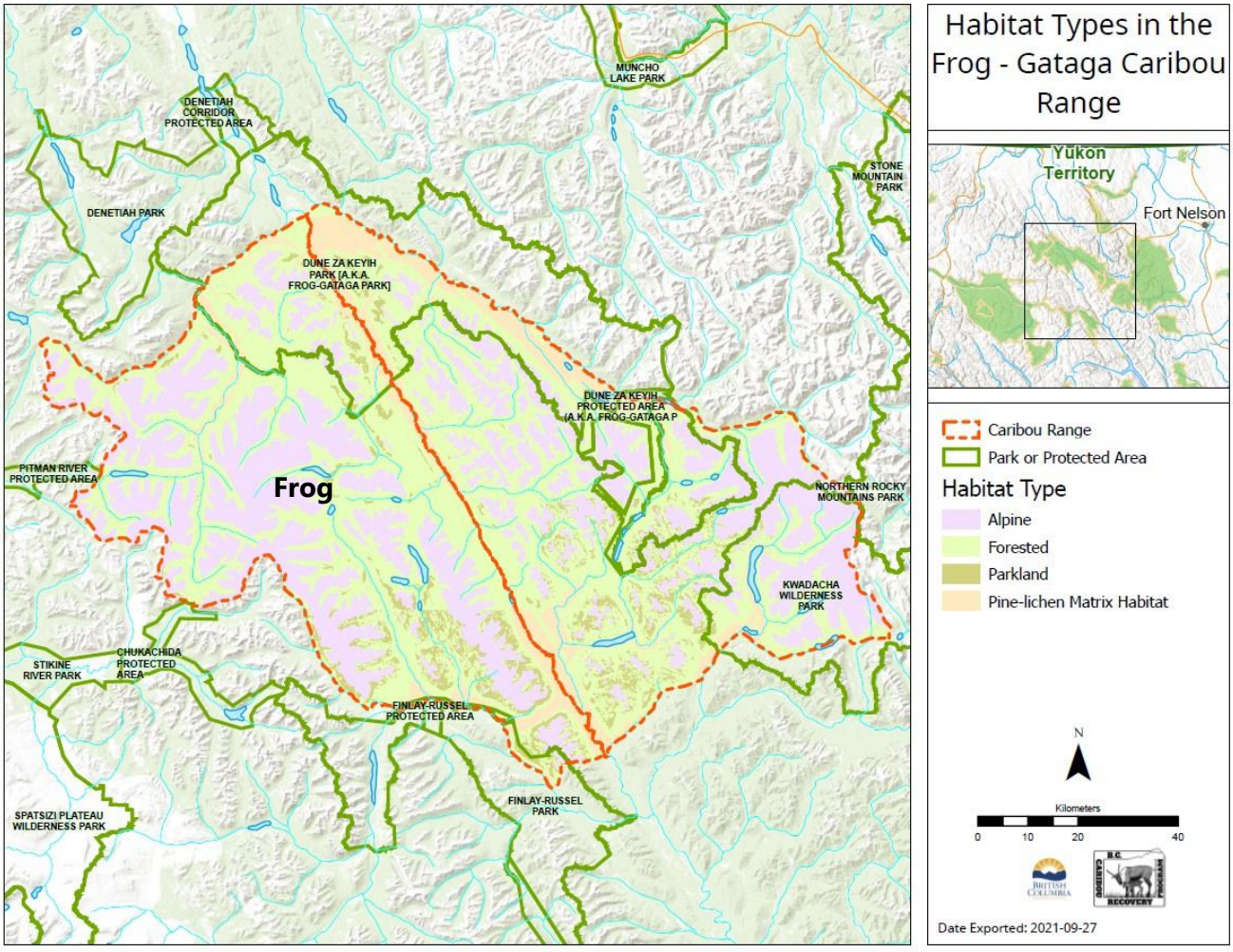

Figure 9. Map of habitat types within the Frog herd range (red boundary on the west side of the map)

Survey and Management History

Records from the late 1970s indicated between 100-300 animals in the Frog herd (also referred to as the Johiah Lake herd; Bergerud, 1978). In 1996, expert opinion estimated the Frog population at 150 individuals (Heard & Vagt, 1998).

In 2000, 55 adult females were collared in Frog and Gataga and were monitored until 2003 as part of a habitat use monitoring program to respond to industrial mining interests in the area (Elliott, 2004). Recruitment surveys were conducted in 2000 and 2001 in Gataga, Frog, and Rabbit (Table 10), however, no data was provided on caribou numbers in 2002 or 2003. In the 3 years of the monitoring program, annual mortality was about 10%, with 41 live cows remaining by the end of the program. At that time, it was suggested that animals from the Spatsizi population were experiencing an eastward range shift, which could have increased the caribou numbers within the Frog herd boundary to 2-3 times the estimated numbers from the mid-1990s, however, no survey data was provided to support the suggested numbers (Elliott, 2004).

Movements from adult females were also recorded from areas of caribou trace occurrence south of the Frog herd boundary, northwards into the population range (MacDonald & McNay, 2013; Sittler et al., 2015), and cross range movements have been regularly observed between Frog, Gataga and Rabbit (Meyhoff et al., 2021). This can lead to lower range counts than expected when surveys are conducted, as collared animals are assigned to the range in which they are observed on the day of the survey for recruitment calculation purposes. In 2015, Sittler et al. had recommended updating the range boundary to include the zone of trace occurrence south of the Frog herd, however this did not occur during the latest provincial range boundary update in 2021.

No specific information related to wolf reduction could be found for this herd range in historical records, but the fact that wolves were reduced in the Muskwa and Horseranch areas in the late 1970s to late 1980s could have had benefited caribou in Frog, Gataga and Rabbit (Bergerud & Elliot, 1986; Bergerud & Elliott, 1998).

Table 10. Results from caribou seasonal surveys in the Frog herd range, 2001-2021

Year	Season	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	Unlc. Age	TOTAL	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)
2010	Fall	/	/	/	/	11	81	0	92	11.96	/
2012	Fall	/	/	/	/	10	65	0	75	13.33	/
2012	Fall*	3	/	/	/	3	18	0	21	14.29	/
2001	Winter	24	12	170	36	39	0	0	245	15.92	0.23
2009	Winter*	17	/	59	17	6	0	0	82	7.32	0.10
2013	Winter**	2	/	16	6	6	5	0	33	18.8	0.38
2020	Winter*	6		67	18	20	3	6	114	17.54	0.30
2021	Winter	6	7	23	11	5	0	0	39	12.82	0.22

*Trace occurrence (partial survey in 2012; incidentals from sheep surveys in 2009 and 2020)

**Two groups, including one just south of the southern Frog boundary (H and I in MacDonald & McNay, 2013)

5 year 2016-2021

In 2018, a capture program was launched where 7 collars were deployed on adult females in Frog. For unknown reasons, no recruitment survey was conducted following this program, and of the seven collared cows, 2 died and 3 had their collars stop transmitting within one year of deployment. Of the remaining 2 cows, one died and one collar went offline in 2019, leaving no active collars by 2020. This lack of data and small sample size make survival estimates for that herd from 2018 to 2020 unreliable, if not impossible.

Another capture program was implemented in 2020-2021 to deploy higher numbers of collars over 2 years (9 collars deployed in 2021 in the Frog range), and a recruitment survey followed where 39 animals were counted through the relocation of 7 collars (the only missed collar was outside of the herd boundary). Calves represented 12.8% of the classified animals, and the calf:cow ratio was 21.7 (Meyhoff et al., 2021). Although these numbers are below target for calf recruitment, we should caution the small sample size from which these metrics were calculated. Of the 9 cows collared in 2021, 8 are still alive and one died as a result of wolf predation. An additional 6 cows were collared during the 2022 field season, one of which also died from wolf predation. The remaining 13 active collars should provide a larger dataset for a mark-resight in 2023 that will lay the foundation for the obtention of essential key metrics for this population. The current status and trend for this population are unknown.

Gataga

Study Area

The Gataga caribou range is bordered west by the Kechika River, north by the Gataga River, and south by the Warneford River eastward toward Chesterfield Lake. The range encompasses a 5,008 km^2 surface area, which is mainly composed of alpine and forested areas. Protected areas cover 45% of the range and include the Dune Za Keyih (Frog-Gataga) Park, the Dune Za Keyih (Frog-Gataga) Protected Area, and the Kwadacha Wilderness Park (Figure 10).

The First Nations with territories overlapping the land used by the Gataga herd include:

- Doig River First Nation
- Fort Nelson First Nation
- Halfway River First Nation
- Kwadacha
- Prophet River First Nation
- West Moberly First Nations
- Kaska Dena Council
- Liard First Nation

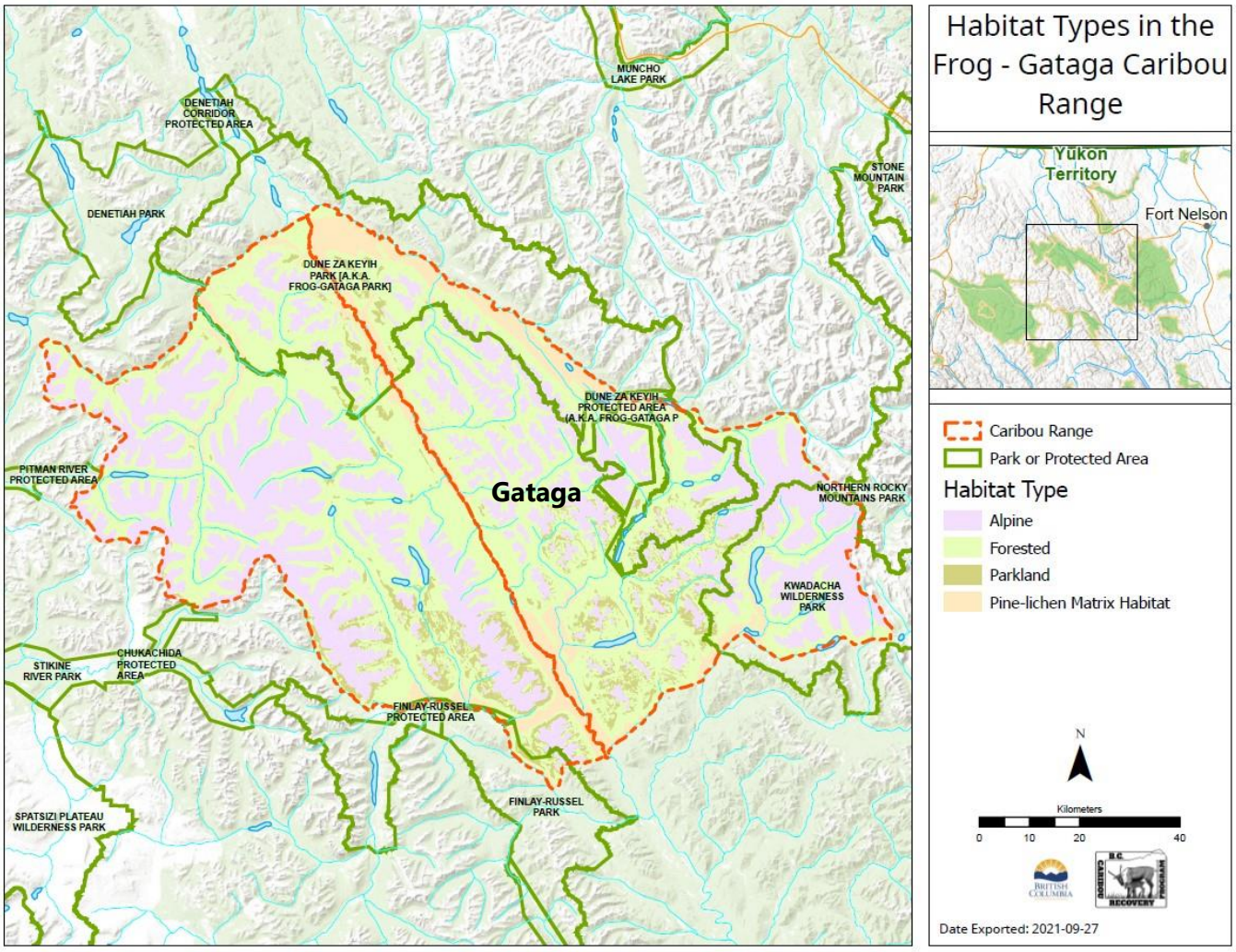

Figure 10. Map of habitat types within the Gataga herd range (red boundary on the east side of the map)

Survey and Management History

The Gataga caribou population was considered to have about 50 animals in 1978, although only 15 animals were counted that winter (Bergerud, 1978); recruitment was low (13%) but this number is likely unreliable as it seems that the full range was not surveyed. In the mid-1990s, expert opinion estimated the population at 250 individuals (Heard & Vagt, 1998).

Two recruitment surveys conducted in 2000 and 2001 covered Gataga, Frog, and Rabbit (Table 10 and Table 11), but no information was recorded in 2002 and 2003 beyond the movement data from the habitat utilization monitoring program implemented from 2000 to 2003 (Elliott, 2004). In the 3 years of the monitoring program, annual mortality was about 10%, with 41 collars remaining by the end of the program (Elliott, 2004). In 2007, incidental data from a sheep survey also provided information, but no dedicated caribou survey was completed in this range until 2021 (Table 11).

Table 11. Results from caribou seasonal surveys in the Gataga herd range, 2000-2021

Year	Season	Number of groups	Number of collars observed	Females	Males	Calves	Uncl. Adults	TOTAL	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)
2000	Fall	18	18	166	54	45	/	265	16.98	27.11
2001	Winter	6	2	26	5	8	0	39	20.51	30.77
2007	Winter	11	/	/	/	12	126	138	8.70	NA
2021	Winter	8	6	42	19	10	19	90	11.11	23.81

5 year 2016-2021

In 2018, a capture program was launched in Frog and Gataga (Figures 9 and 10), where 9 collars were deployed on adult females in Gataga. For unknown reasons, no recruitment survey was conducted following this program, and of the 9 collared cows, 2 died in 2018, 2 in 2019, and one in 2020. Three collars stopped transmitting in 2019, and one in 2020, leaving no active collar in that range by 2021. No recruitment survey was conducted following the 2018 captures, and the number of collars that went offline render survival estimates for 2019 (78%) and 2020 (53%) unreliable due to low sample size. No other information on trend can be provided considering the lack of data still existing for this population.

Another capture program was implemented in 2020-2021 during which 8 cows were collared in the Gataga range, and a recruitment survey followed. A total of 90 animals were counted, with 11% of calves in the population and 24 calves:100 cows (Meyhoff et al., 2021), which is slightly below target (Bergerud, 1992). Three of these collared cows have since died including 2 due to independent avalanches, and another collar stopped transmitting, leaving 4 active collars from the 2021 capture session. Seven cows were then collared during the 2022 field season, of which one died of unknown causes, leaving 6 active collars from the 2022 capture session.

Unfortunately, movements of collared cows between Gataga and Rabbit have led to the loss of the 4 remaining collars from the 2021 capture session and 3 of 6 collars from the 2022 capture session, not leaving enough active collars in Gataga to conduct a thorough survey in 2022. This suggests that future collaring programs that aim to successfully implement a mark-resight survey in the Gataga range might need to focus on the western side of the range, where caribou numbers are generally lower.

Rabbit

Study Area

The Rabbit caribou range is bordered west by the Kechika River, east by the Trout and Toad Rivers along the Alaska Highway (Highway 97), south by the Gataga River, and north by the Liard River. The range encompasses a 11,791 km^2 surface area with alpine habitat mainly distributed through the southeastern portion of the range. These alpine areas are surrounded by forest or parkland habitat, whereas the northwestern portion of the range is mainly composed of matrix habitat. Protected areas within the range include the Muncho Lake Park, the Dune Za Keyih (Frog-Gataga) Park and a very small portion of the Dune Za Keyih (Frog-Gataga) Protected Area, as well as the Denetiah Corridor Protected Area (Figure 11).

The First Nations with territories overlapping the land used by the Rabbit herd include:

- Doig River First Nation
- Fort Nelson First Nation
- Kwadacha
- Kaska Dena Council
- Liard First Nation

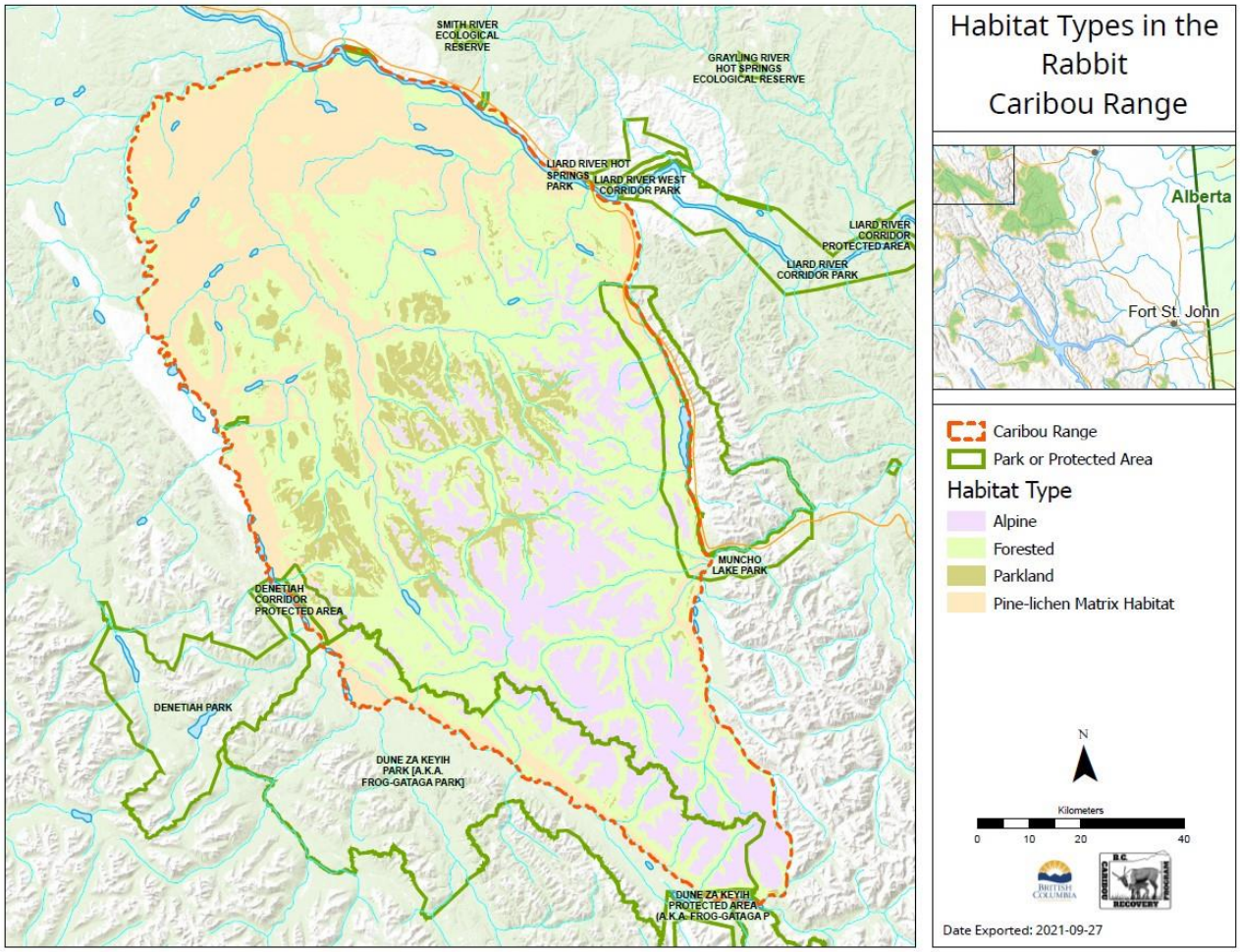

Figure 11. Map of habitat types within the Rabbit herd range

Survey and Management History

No reliable population estimation seems to exist for the Rabbit herd, except for information from 2007. In the late 1970s, only few counts of over restricted areas within the range provided information (Bergerud, 1978). In 1996, expert opinion estimated the population at 800 individuals (Heard & Vagt, 1998), and in 2000, 636 caribou were counted within the range of which 11.32% were calves (Table 12). Incidental counts from a sheep winter survey conducted in 2007 provided a count of 1132 caribou, and 15.83% calves among all aged individuals (Table 12). Based on the expectation that some animals were missed, the population was estimated at 1300 individuals at the time. This 2007 survey is probably the most thorough caribou count for the Rabbit herd within the last 20 years, but the estimate obtained from it should be taken with caution, as the survey was specifically designed for sheep, and not caribou.

Table 12. Results from caribou seasonal surveys in the Rabbit herd range, 1996-2021

Year	Season	Females	Males	Calves	Uncl. Adults	Uncl. Age	TOTAL	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)
1996	Summer	76	46	65	167	0	354	18.36	0.86
2000	Winter	425	139	72	0	0	636	11.32	0.17
2001	Winter	31	13	10	0	0	54	18.52	0.32
2007	Winter	/	/	164	872	96	1132	15.83	/
2021	Winter	233	25	70	34	0	362	19.34	0.30

5 year 2016-2021

The Rabbit caribou population has lacked monitoring over the last few decades, so there is no data to provide prior to 2021 for the 2016-2021 time period. In 2020-2021, a 2-year capture program was launched to address the lack of data in several Northern Mountain herds. Twenty-six collars were deployed in 2021, and three animals have since died and one collar has stopped transmitting. The recruitment survey that followed the 2021 deployment yielded 362 animals, 19.3% calves, and 30 calves:100 cows (Meyhoff et al., 2021), which, although being indicative of positive recruitment (Bergerud, 1992), could still represent a low sample size.

Another 15 cows were collared in 2022, of which 3 died within 2 months, leaving 22 active collars from 2021, 12 from 2022, and another 7 that have moved from Gataga for a total of 40 collars in the Rabbit range. This number is on target to implement a thorough mark-resight survey in 2022.

The newly deployed collars in Rabbit should provide an indication of the importance of the zone of trace occurrence between Horseranch, Rabbit, Spatsizi, Frog and Thutade, and could further the rationale to include this area within official herd boundaries (Sittler et al., 2015; Wilson, in prep.).

Liard

Study Area

The Liard caribou range borders the Yukon Territory to the north. It encompasses a 5,068 km^2 surface area that is mainly composed of forested and matrix habitat. In this range, caribou distribution is restricted to the high elevation alpine plateau on the eastern side of the range, right north of the Grayling River Hot Springs Ecological Reserve. Other protected areas within the range include small portions of the Smith River Ecological Reserve and the Liard River Hot Springs Park, while major waterbodies include the Smith, Crow, Grayling and Scatter Rivers (Figure 11).

The First Nations with territories overlapping the land used by the Liard herd include:

- Acho Dene Koe
- Fort Nelson First Nation
- Kaska Dena Council
- Liard First Nation

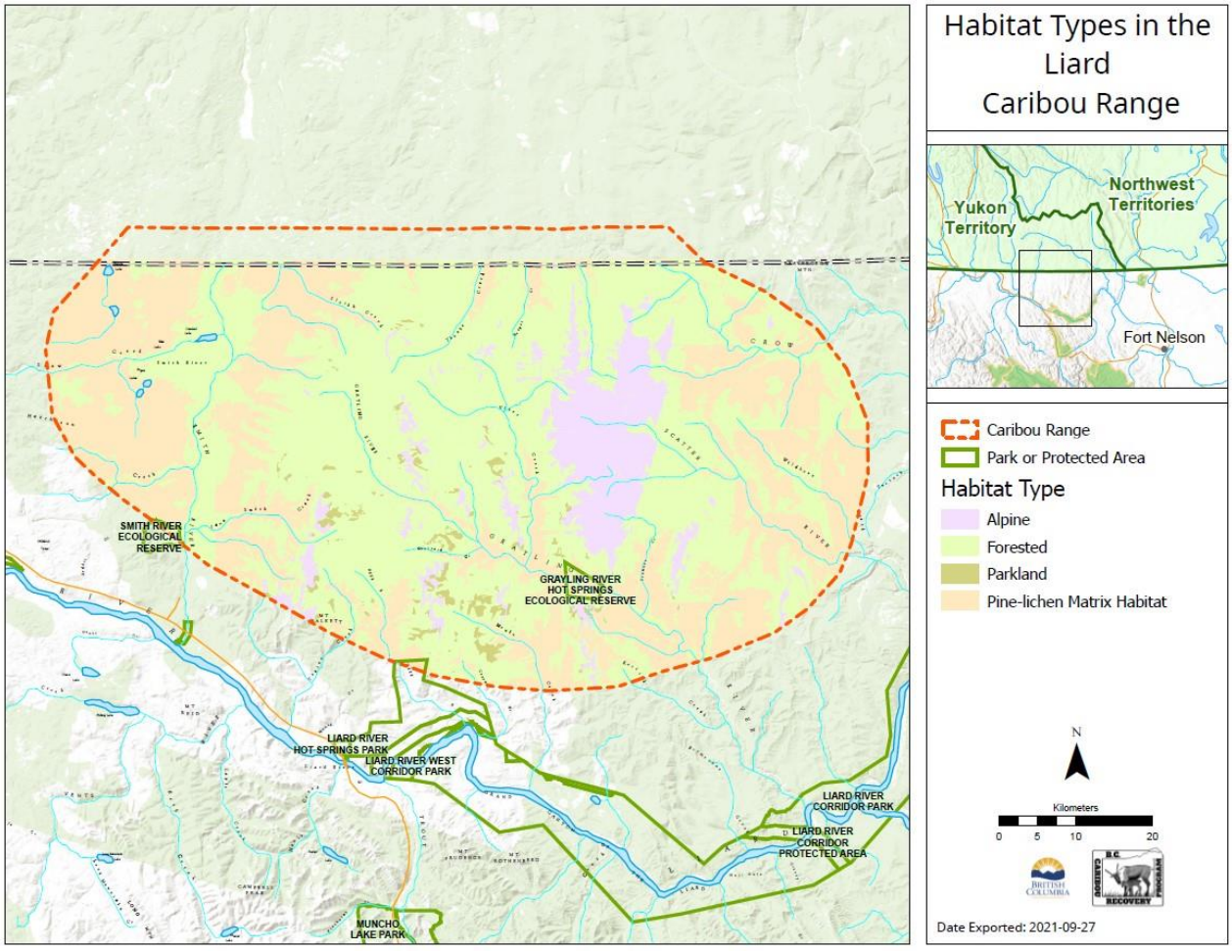

Figure 12. Map of habitat types within the Liard herd range.

Survey and Management History

In 1975, the Liard caribou population was most likely peaking due to wolf control implemented by guide outfitters in the early 1970s. Surveys conducted both in the summers and winters yielded 200 to 325 animals, which could be an artefact of predator reduction. By 1978, the count had decreased to 125 animals (Bergerud, 1978), and the highest number of animals counted since then has been 173 animals in the Fall of 2010 (McNay et al., 2014).

Historically, this population has displayed low calf recruitment levels (Table 13) that could indicate a decline, but total counts have remained stable except in the winter of 2021 when weather conditions prevented from covering the entire Liard Plateau (Meyhoff et al., 2021). In 2002, Yukon biologists deployed 3 collars to monitor the movement of adult females. These collars were no longer active by 2004, so the Fall survey conducted in 2005 did not attempt to relocate these females. All of the Plateau was searched, and 141 animals were found. Calf recruitment was lower than target (13% of calves in the population and 19.6 calves per 100 cows. One large group of 56 individuals was also encountered during this survey (Powell, 2006).

In the early 2010s home range size, seasonal movements, populations estimate, pregnancy and parturition rates, survival rates, mortality causes, and habitat use were determined based on collar data and aerial surveys. The data collected was used to determine desired habitat conditions to recommend location of legally designated conservation areas (Ungulate Winter Range and Wildlife Habitat Areas (McNay et al., 2014).

Table 13. Results from caribou seasonal surveys in the Liard herd range, 1977-2011

Year	Season	TOTAL	Calf Recruitment Rate (calf % of population)	Calf Recruitment Rate (calf:cow ratios)	Reference
1977	Fall	93	9.7%	/	Bergerud 1978
1978	Fall	93	/	/	Bergerud 1978
2005	Fall	141	13.0%	19.6	Powell 2006
2010	Fall	173	7.0%	10	McNay et al. 2014
2011	Fall	120	5.0%	7	McNay et al. 2014
2020	Fall	131	3.8%	10	Unpublished data
2021	Fall	124	16.1%	/	Unpublished data
1975	Winter	325	/	/	Bergerud 1978
1978	Winter	68	10.3%	/	Bergerud 1978
2010	Winter	81	4.0%	4.2	Thiessen 2010
2011	Winter	159	7.0%	10	McNay et al. 2014
2017	Winter	87	8%	20.6	Unpublished data
2021	Winter	75	11.0%	14	Meyhoff et al. 2021
1975	Summer	>200	/	/	Bergerud 1978
2010	Summer	94	12.0%	/	McNay et al. 2014
2011	Summer	117	17.2%	24	McNay et al. 2014

5 year 2016-2021

As part of the Northern Mountain Caribou strategy, inventory planning was implemented to fulfil data gaps for several caribou populations in the Northeast, including the Liard Plateau, which had been last fully surveyed in 2011 (the 2017 data was a partial survey; *M.Bridger, pers. com.*). Surveys were conducted in 2020 and 2021, with good conditions during the two fall survey and poor during the winter survey, which yielded a much lower count that expected (Meyhoff et al., 2021). The fall surveys indicated that the population is above 100 individuals, with 73 individuals counted in a single group in 2021.

In 2021, a capture program was implemented to deploy 8 collars; out of 3 capture attempts, one female was successfully collared and 2 died during capture, which led to the decision to halt the program in Liard for that year. Captures in other ranges (over 60 individuals) did not lead to any mortality.

Overall, recent fall and winter calf recruitment numbers seem to align, with no clear sign that fall counts are biased against calves. The extremely low calf proportion in 2020 had raised some concerns, but subsequent surveys showed higher recruitment levels, although below target level. Eight collars were successfully deployed in 2022, leaving a total of 9 active collars in the range that will be used to conduct a mark-resight survey in 2022 to gather survival information on this population, and to provide estimates of growth rate and population size.

Conclusion and Recommendations

In Northeast BC, most of the 7 woodland caribou (*Rangifer tarandus caribou*) populations belonging to the Northern Mountain Designatable Unit (DU 7) are data deficient. Only the Graham population has been monitored regularly since 2014. Because of this, it is difficult to assess the trend and general status of these populations. The Pink Mountain herd has recently been monitored for survival, calf recruitment, and population size. Both the Graham and Pink Mountain populations are currently undergoing wolf control because of low calf recruitment and either low or declining growth rate over the past 5 years. Providing consistent and defensible data for these herds is essential to properly assess the effects of predator control. This management tool is being undertaken as a stop gap measure while caribou habitat is being recovered. Implementing additional protection measures is necessary to recover populations to self-sustaining levels, and planning an exit strategy from predator control once they have reached target levels will also be needed.

The Southern and Central Mountain caribou declines have shown that there is a need for more consistent monitoring of the other Northern Mountain herds if the Province's goal is to prevent their uplisting. For the Muskwa, Frog, Gataga, Rabbit and Liard herds, monitoring key population metrics is imperative to determine trends so that so any potential decline can be identified and managed for in a timely manner. Based on recommendations by regional biologists, an inventory schedule has been approved as part as the Northern Mountain Caribou Strategy to allow for consistent monitoring of these herds. Specifically, populations under wolf control will receive yearly recruitment surveys and mark-resight surveys every 3 years, while populations without wolf control will have increased collaring efforts to obtain recruitment baseline data, followed by mark-resight surveys every 4 years. The regular mark-resight surveys will allow the gathering of population size estimates that demographic trends can easily be drawn from.

Beyond gathering essential population metrics on a regular basis, it is also essential to review past and current information on distribution. It is well documented that a significant number of caribou can be found right outside the southwestern edge of the Frog boundary, so a range boundary update is likely warranted. Other herd boundaries in this DU are currently being reviewed across the province to potentially update herd delineations based on telemetry data (Wilson, *in prep*). We suggest that documented trace occurrence information is also considered for future herd boundaries updates.

Finally, we propose the implementation of additional recovery programs to improve caribou survival. Specifically, implementing roadkill prevention programs in the Muskwa and Rabbit ranges would be important. Over the past 3 years, 50% of documented mortalities in the Muskwa range have been due to road kills. The stretch of Highway 97 from the Tetsa River Lodge to the Summit Lake Campground, where caribou cross the road on a regular basis and where mortalities have been documented, could be managed to improve survival, as well as the area from Muncho Lake to Liard River that forms the boundary between the Muskwa and Rabbit herds.

Acknowledgments

The Northeast Caribou Recovery Team would like to acknowledge and thank all Indigenous Nations on which territory the caribou surveys listed in this report were conducted. We would also like to thank Barb Anderson for the development of the Northern Mountain Caribou Strategy and Leo de Groot for his support of all caribou inventory projects in the province and for reviewing the present report.

We would also like to thank Scott Schilds, Joelle Scheck, Mike Bridger, Chris Lewis, Michael Huck, Kristen Peck, Dominica Harrison, Sonja Leverkus, Sejer Meyhoff, and Chris Addison for their assistance in gathering the 2021 survey data, and Canadian Wildlife Capture for successful captures in 2021 and 2022.

Finally, we thank Jamie Reemond for supporting habitat stratification and mapping for the 2021 surveys, Inge-Jean Hansen for her essential mentorship on VHF flights, and all volunteers and field staff that have assisted in gathering the essential data presented in this report.

Literature Cited

Anderson, B. (2020). *Northern Mountain Caribou Strategy* (p. 36). BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Backmeyer, R. (1990). *Graham River caribou study progress report* (p. 14).

Bergerud, A. T. (1978). *Status and management of caribou in British Columbia*.

Bergerud, A. T. (1992). Rareness as an Antipredator Strategy to Reduce Predation Risk for Moose and Caribou. In D. R. McCullough & R. H. Barrett (Eds.), *Wildlife 2001: Populations* (pp. 1008–1021). Springer Netherlands. https://doi.org/10.1007/978-94-011-2868-1_77

Bergerud, A. T., & Elliot, J. P. (1986). Dynamics of caribou and wolves in northern British Columbia. *Canadian Journal of Zoology*, *64*(7), 1515–1529. https://doi.org/10.1139/z86-226

Bergerud, A. T., & Elliott, J. P. (1998). Wolf predation in a multiple-ungulate system in northern British Columbia. *Canadian Journal of Zoology*, *76*(8), 1551–1569. https://doi.org/10.1139/z98-083

Bridger, M., & Arnison, C. (2015). *Peace region inventory project- Pink Mountain caribou survey*.

Caughley, G. (1977). *Analysis of vertebrate populations*. Wiley.

Committee on the Status of Endangered Wildlife in Canada. (2014). *COSEWIC assessment and status report on the caribou, Rangifer tarandus: Northern mountain population, central mountain population, southern mountain population, in Canada* (p. 113).

Culling, D., & Culling, B. (2009). *Graham caribou herd 2009 late winter inventory* (p. 19).

Culling, D., & Culling, B. (2015). *Graham caribou herd 2015 late winter inventory* (p. 36).

Culling, D., & Culling, B. (2016). *Graham caribou herd 2016 late winter inventory*.

DeCesare, N. J., Hebblewhite, M., Bradley, M., Smith, K. G., Hervieux, D., & Neufeld, L. (2012). Estimating ungulate recruitment and growth rates using age ratios. *The Journal of Wildlife Management*, *76*(1), 144–153. https://doi.org/10.1002/jwmg.244

DeCesare, N. J., Hebblewhite, M., Lukacs, P. M., & Hervieux, D. (2016). Evaluating sources of censoring and truncation in telemetry-based survival data: Telemetry-based survival monitoring. *The Journal of Wildlife Management*, *80*(1), 138–148. https://doi.org/10.1002/jwmg.991

Elliott, J. (2004). *Frog Gataga Report 2004* (p. 20). BC Ministry of Water, Land and Air Protection.

Government of British Columbia (2019). *South Peace caribou recovery following 5 years of experimental wolf reduction* (p. 29). BC Ministry of Forests, Lands, Natural Resources and Rural Operations.

Government of Canada. (2020, February 21). *Background on Section 11 and partnership agreements for the Southern Mountain Caribou* [Backgrounders]. Environment and Climate Change Canada. https://www.canada.ca/en/environment-climate-change/news/2020/02/background-on-section-11-and-partnership-agreements-for-the-southern-mountain-caribou.html

Harper, F. (1988). *Regional wildlife plan for the Peace subregion*.

Hatter, I. W., & Bergerud, W. A. (1991). Moose recuriment adult mortality and rate of change.pdf. *Alces: A Journal Devoted to the Biology and Management of Moose*, *27*, 65–73.

Heard, D., & Vagt, K. (1998). Caribou in British Columbia: A 1996 status report. *Rangifer*, *18*. https://doi.org/10.7557/2.18.5.1548

Krebs, C. J. (2017). *Chapter 2, Estimating Abundance and Density: Mark-Recapture Techniques* (p. 58).

Leech, S., & Bates, P. (2016). *Blueberry River First Nation indigenous knowledge study of Chinchaga muskeg caribou and Pink Mountain caribou*.

MacDonald, F., & McNay, S. (2013). *Herd boundary refinement for the Chase, Spatsizi, and Frog caribou herds in north-central British Columbia: Capture and collaring* (No. 440; p. 17). Wildlife Infometrics Inc.

McNay, R. S., Giguere, L., & Brumovsky, V. (2014). *Identification of designated areas for the ongoing management of Liard Plateau woodland caribou (Rangifer tarandus caribou) in British Columbia* (No. 439; p. 43). Wildlife Infometrics Inc.

Meyhoff, S., Leverkus, S., & Addison, C. (2021). *Winter recruitment survey 2021—Liard Plateau, Rabbit, Gataga and Frog herds* (p. 18).

Pollock, K. H., Winterstein, S. R., Bunck, C. M., & Curtis, P. D. (1989). Survival analysis in telemetry studies: The staggered entry design. *The Journal of Wildlife Management*, *53*(1), 7. https://doi.org/10.2307/3801296

Powell, T. (2006). *Range use and Fall composition of the Liard caribou herd in Yukon and northern BC*.

Radcliffe, G., Tripp, T., & Wilmott, T. (2005). *Caribou population ecology, Northern Muskwa-Kechika*.

Reid, A., & DeGroot, L. (2018a). *South Purcell Caribou Census Report* (p. 8). BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Reid, A., & DeGroot, L. (2018b). *South Selkirk Mountains Caribou Census Report* (p. 8). BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Seip, D., & Jones, E. (2013). *Population Status of Caribou Herds in the Central Mountain Designatable Unit within British Columbia, 2013* (p. 34). BC Ministry of Environment.

Sittler, K., McNay, R. S., & Giguere, L. (2015). *Herd boundary refinement for the Chase, Spatsizi, and Frog caribou herds in north-central British Columbia: Final report 2012-2015* (No. 499; p. 48). Wildlife Infometrics Inc.

Skalski, J. (2005). Estimating population sex ratios. In *Wildlife Demography: Analysis of sex, age and count data*.