

SOUTH NAHANNI AND COAL RIVER NORTHERN MOUNTAIN CARIBOU HERDS: POPULATION STATUS AND DEMOGRAPHIC CHARACTERISTICS



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Executive Summary

In 2008 a multi-year (2008 – 2011), multi-jurisdictional (Environment Yukon, Parks Canada, and Northwest Territories Department of Environment and Natural Resources) project was initiated to examine the distribution and habitat use of the South Nahanni mountain caribou herd, and the population status and demographic characteristics of the South Nahanni and Coal River herds. Both herds are found in the Greater Nahanni Ecosystem in the border region of Yukon and the Northwest Territories. A number of factors led to this project being undertaken, including:

- a perceived decline of the South Nahanni herd
- the accessibility of both herds via the Nahanni Range Road
- increasing mineral exploration (particularly in the South Nahanni herd's range)
- the incorporation of caribou distribution data into the planning process for the expansion of Nahanni National Park Reserve and the creation of a new national park to the north in the Sahtu Settlement Area (Nááts'ihch'oh National Park Reserve).

This report describes the population/demographic work conducted during the project.

In the fall of 2008, 30 satellite radio-collars were deployed on adult female caribou in the South Nahanni herd. Data from these collars were collected from October 2008 to March 2013. Using the collared animals as a marked sample, a mark-resight survey of the South Nahanni herd was completed in October 2009. This survey yielded a population estimate of 2105 (SE = 355). The best estimate of the herd's trend since the previous population estimate in 2001 is that the herd is stable to slightly increasing. Composition surveys conducted annually from 2008 to 2011 suggest an increasing sex ratio (i.e., increasing bull numbers). Recruitment (indexed by the calf:cow ratio) showed considerable variability and were consistent with recruitment patterns observed in mountain caribou herds across Yukon. Notably, 2008 and 2009 were poor years for calf recruitment, with 2010 and 2011 recruitment rates returning to rates suitable to allow for a stable herd growth rate. The average recruitment rate from 2008 to 2011 was 18 calves per 100 cows. The average sex ratio over this time was 39 bulls per 100 cows. The estimated harvest rate, based on reported licensed harvest and estimated subsistence harvest for the herd, was within the recommended 2 – 3% range as noted in Yukon's 1996 Woodland Caribou Management Guidelines, and no harvest restrictions are deemed necessary at this time.

Concurrent with the work conducted on the South Nahanni herd, annual composition surveys were also carried out on the Coal River herd. Similar to the South Nahanni herd, recruitment rates showed high variability and patterns consistent with other Yukon mountain caribou herds. The average recruitment rate during 2008 – 2011 was 27 calves per 100 cows. The adult

sex ratio of the herd was stable during 2008 – 2011 and averaged 33 bulls per 100 cows. A formal population estimate of the herd is lacking. An expert opinion-based working number of a minimum of 450 animals is currently in place, which is largely based on minimum counts of animals observed during composition surveys. Based on reported licensed and estimated subsistence harvest numbers in the Yukon and NWT, the harvest rate of this herd may be exceeding levels recommended in Yukon’s Woodland Caribou Management Guidelines. This would be consistent with the lower sex ratio in the herd, which is one of the lowest among monitored mountain caribou herds in the Yukon.

Key Findings

South Nahanni Herd

- We estimated there were 2,105 animals in the South Nahanni herd. The herd appears to be stable to slightly increasing since the last estimate in 2001.
- The current estimated harvest is below the recommended 2–3% limit.
- No harvest restrictions on the South Nahanni herd are warranted at this time.

Coal River Herd

- We consistently observed roughly 33 bulls per 100 cows—one of the lowest observed sex ratios for harvested mountain caribou herds in Yukon. Low bull numbers may indicate that bull mortality (from all sources) is elevated.
- The estimated harvest rate may be above the recommended 2–3% limit.
- Given the low sex ratio in the herd, its accessibility to hunters, the uncertainty surrounding the size of the herd, and a harvest rate potentially exceeding recommended levels, additional work related to the population status and sustainability of the harvest may be warranted.

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Introduction

Caribou (*Rangifer tarandus*) in the Greater Nahanni ecosystem (GNE) are an important cultural, subsistence, and ecological resource. Increasing mineral exploration in the area, the relative accessibility of these caribou to hunters via the Nahanni Range Road and other access routes, and a perceived decline in animal numbers (following a composition survey in 2007) generated concern regarding the status of caribou in the area. A number of separate herds are found during at least part of the year in the GNE including the South Nahanni, Redstone, Coal River, La Biche, and Finlayson herds. However, the degree of distinctiveness of these herds is not certain and range overlap exists (Figure 1). Caribou in the GNE are members of the Northern Mountain ecotype of woodland caribou (*R. t. caribou*)—a designated Species of Special Concern under Canada’s Species at Risk Act.

Due to conservation concerns surrounding caribou in the GNE, a multi-jurisdictional (Environment Yukon, Parks Canada, and Northwest Territories Department of Environment and Natural Resources) research program was initiated in 2008 to assess the movements, distribution, and demographic status of caribou in the South Nahanni herd. This current project builds upon previous collaborative research efforts dating back to the mid-1990s. The specific focus of this project was to assess

the spatial distribution and habitat use of the South Nahanni herd, and population characteristics of both the South Nahanni and Coal River herds. More detailed information for the herds was also required to inform environmental assessment processes for all three jurisdictions. Additionally, there was interest from Parks Canada regarding caribou distribution to inform the planning process related to the proposed expansion of Nahanni National Park Reserve and the creation of a new national park to the north in the Sahtu Settlement Area (Nááts’ihch’oh National Park Reserve).

Demographic data for caribou in the GNE were relatively limited. For the South Nahanni herd, 7 composition surveys were previously conducted between 1995 and 2007, and the herd’s size was estimated in 2001 (Gullickson and Manseau 2000, Gunn et al. 2002). Previous demographic data for the Coal River and La Biche herds were minimal, consisting of one composition survey of each herd (1997 and 1993, respectively). Distribution information for caribou in the GNE was more complete. Traditional very high frequency (VHF) radio-collars were deployed on the South Nahanni herd from 1995 to 2001 providing information regarding its distribution (Gullickson and Manseau 2000, Gunn et al. 2002). In 2001 and 2004 satellite (Argos) radio-collars were deployed on the Coal River and La Biche herds (Weaver 2008), and in 2002 GPS radio-collars were deployed on the Redstone herd by the Sahtu Renewable Resources Board. The

Finlayson herd is monitored annually by Environment Yukon and its distribution has been tracked for a number of years (Adamczewski et al. 2010). For this project, the South Nahanni and Coal River herds were the primary research focus as they are the most accessible herds and occur where the greatest amount of mineral exploration and development is anticipated.

This report describes results stemming from the “population status” component of the project. A habitat, distribution, and animal movements report is forthcoming as an accompanying document. Specific objectives dealt with in this report include the capture and collaring of adult females in the South Nahanni herd, herd composition surveys of both the South Nahanni and Coal River herds, a population estimate of the South Nahanni herd, and an assessment of harvest rates of both the South Nahanni and Coal River herds.

Animal Capture and Radio-Collaring

From 30 September to 4 October 2008, 30 adult female caribou in the South Nahanni herd were captured via helicopter net gun and fitted with Argos satellite collars [Telonics Inc.; Model TAW-4610 (n = 29) and A-3310 (n = 1)]. Collars were produced with yellow belting material to enhance their visibility during subsequent resighting surveys to estimate the size of the herd (see Population Estimate of the

South Nahanni Herd section). Collars were programmed to record a location at variable frequencies throughout the year (Table 1). All collars were fitted with CR-2A breakaway mechanisms programmed to release the collar on 30 September 2011 (10 collars) or 30 September 2012 (20 collars). Collars programmed to release in 2011 were also programmed to collect more detailed information on ambient air temperature and animal activity thus reducing their battery life and consequently requiring an earlier release date. Capture and collaring activities were in accordance with a GNWT Wildlife Research Permit (WL5611) and a GNWT Wildlife Care Committee Protocol (NWTWCC 008-018). These activities were also reviewed and approved by Parks Canada and the Nah'a Dehé Consensus Team (the Aboriginal cooperative management body for Nahanni National Park Reserve).

Captures were conducted by an Environment Yukon capture crew over 17 hours using a Bell 407 helicopter. Capture locations were distributed along the YT-NWT border, north of the Cantung mine at Tungsten, east of the border near the South Nahanni River, and within Nahanni National Park Reserve (Figure 2). During the capture operations, one animal died as a result of a broken neck. This animal was located in Yukon and the meat salvaged and provided to the Yukon Conservation Officer Service Branch in Watson Lake for distribution to the Liard First Nation.

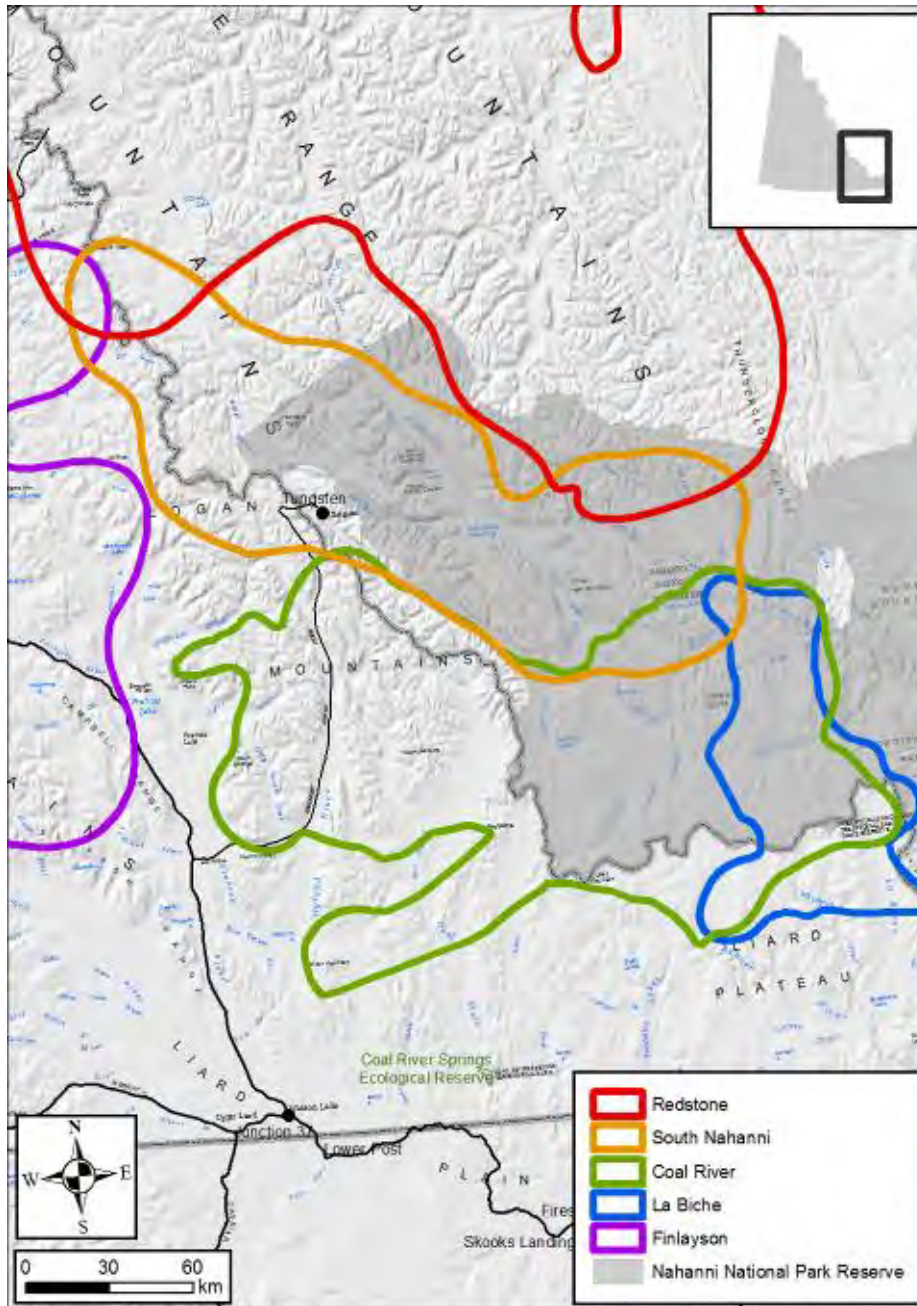


Figure 1. Generalized mountain caribou herd ranges in the Greater Nahanni ecosystem.

Table 1. Fix rate frequency for Argos satellite radio-collars deployed on the South Nahanni caribou herd (2008).

Season	Dates	Fix rate
Winter	15 November to 15 April	1 location per 7 days
Spring Migration and Calving	15 April to 15 June	1 location per 2 days
Summer (Post-calving)	15 June to 15 September	1 location per 7 days
Fall (rut)	15 September to 15 October	1 location per day
Fall Migration	15 October to 15 November	1 location per 2 days

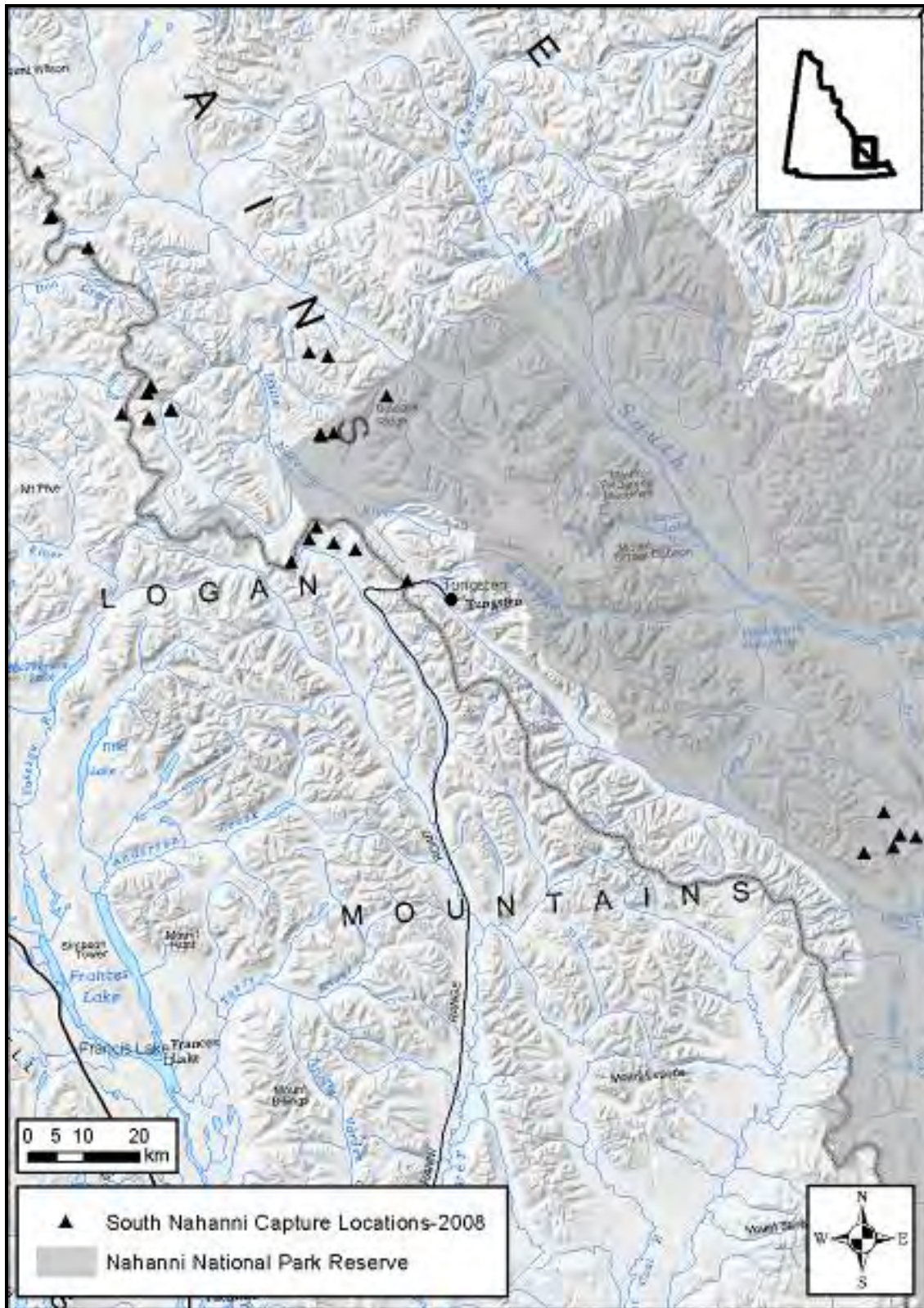


Figure 2. Locations of animal captures during fall 2008.

During the capture operations we recorded physical measurements of cows, observations of besnoitia from eye assessments, and the presence of a calf at heel and lactational status. Three cows had a calf at heel at the time of capture and 6 cows

were lactating. Four of 28 animals assessed had signs indicative of besnoitia in their eyes. Body measurements from 27 of the captured cows are provided in Table 2.

Table 2. Summary values of measurements (n = 27) obtained during capture operations on the South Nahanni mountain caribou herd, fall 2008.

Variable	Mean	Standard Error
Total Length (cm)	209.6	3.76
Shoulder Height (cm)	127.5	3.39
Chest Height (cm)	66.6	0.88
Hind foot Length (cm)	60.0	0.38
Chest Girth (cm)	130.9	1.48
Neck Circumference (cm)	49.8	0.83
Total Body Condition Score ^a	8.66	0.16

^a Maximum score is 12.0.

Composition Surveys

Composition surveys conducted during the fall breeding season (rut) are one of the primary tools used to monitor mountain caribou herds in Yukon. Aerial surveys are conducted during the rut when bulls and cows are least segregated and are found on high alpine plateaus, increasing detectability. Two key parameters are measured: calf recruitment, as indexed by the calf:cow ratio, and adult sex ratio measured as the bull:cow ratio. These surveys are not intended to estimate a herd's abundance, but rather should be considered a sample of animals from the herd. During the surveys, high elevation alpine and sub-alpine areas are flown as these areas have a high likelihood of animal occurrence, and animals within

them are more visible. Furthermore, during these surveys, we strive for adequate spatial coverage of the herd's range such that the subsequent herd composition estimates accurately represent the entire herd.

From 2008 to 2011, fall composition surveys were conducted on both the South Nahanni and Coal River herds (Tables 3 and 4; Figures 3-10). GNWT Wildlife Research Permits were obtained prior to each year's survey (WL5611, WL5621, WL5759, and WL5765, respectively). The 2007 composition survey of the South Nahanni herd was a collaborative effort between Environment Yukon and Selwyn Resources but was not formally a component of this project. Spatial coverage of the composition surveys was generally adequate for both herds (Figures 7-10). However, in

2008 (Figure 7) the northernmost portion of the South Nahanni herd could not be surveyed due to limited fuel locations, and in 2010 (Figure 9) this area could not be surveyed

due to poor weather. In 2009 (Figure 8), the eastern portion of the Coal River range could not be surveyed due to low cloud cover.

Table 3. Results from fall composition surveys of the South Nahanni caribou herd (2008 – 2011).

Dates	Number of Animals Observed	Calf:Cow Ratio (Calves:Cow)	Adult Sex Ratio (Bulls:Cow)	Survey Hours	Helicopter Model
26 – 28 Sept. 2008	245	0.095	0.355	13	Bell 206B
30 Sept. – 2 Oct. 2009	518	0.164	0.41	17.4	Bell 206B
5 – 7 Oct. 2010	385	0.261	0.26	14.0	AS350
5 – 7 Oct. 2011	484	0.247	0.439	14.0	AS350

Table 4. Results from fall composition surveys of the Coal River caribou herd (2008 – 2011).

Dates	Number of Animals Observed	Calf:Cow Ratio (Calvers:Cow)	Adult Sex Ratio (Bulls:Cow)	Survey Hours	Helicopter Model
30 Sept. – 4 Oct. 2008	341	0.12	0.343	11.3	AS350
4 Oct. 2009	148	0.227	0.320	7.0	Bell 407
2 – 4 Oct. 2010	207	0.40	0.325	13.0	AS350
2 – 3 Oct. 2011	271	0.352	0.321	12.0	AS350

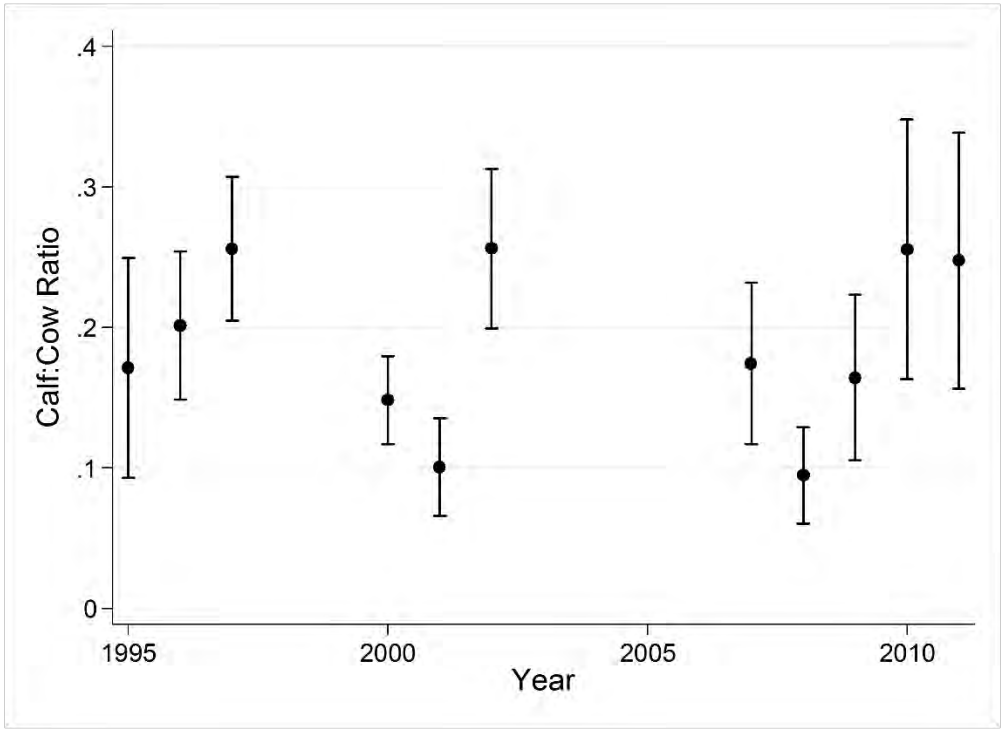


Figure 3. Recruitment rates (calf:cow ratio) for the South Nahanni caribou herd (1995 – 2011). Error bars represent 95% confidence intervals.

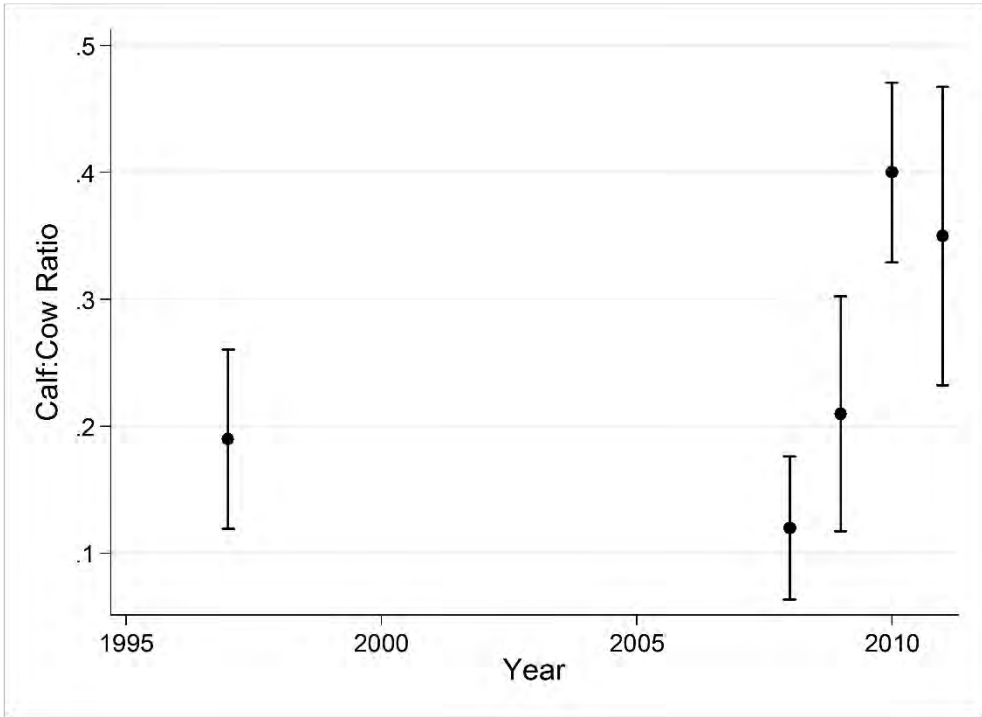


Figure 4. Recruitment rates (calf:cow ratio) for the Coal River caribou herd (1997 – 2011). Error bars represent 95% confidence intervals.

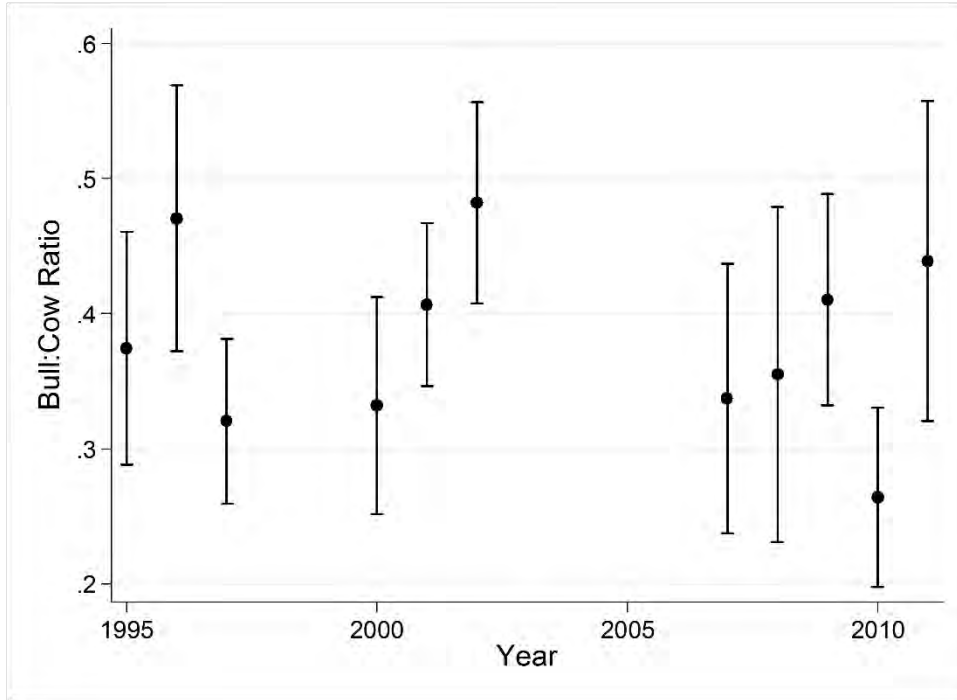


Figure 5. Adult sex ratios (bull:cow ratio) for the South Nahanni caribou herd (1995 – 2011). Error bars represent 95% confidence intervals.

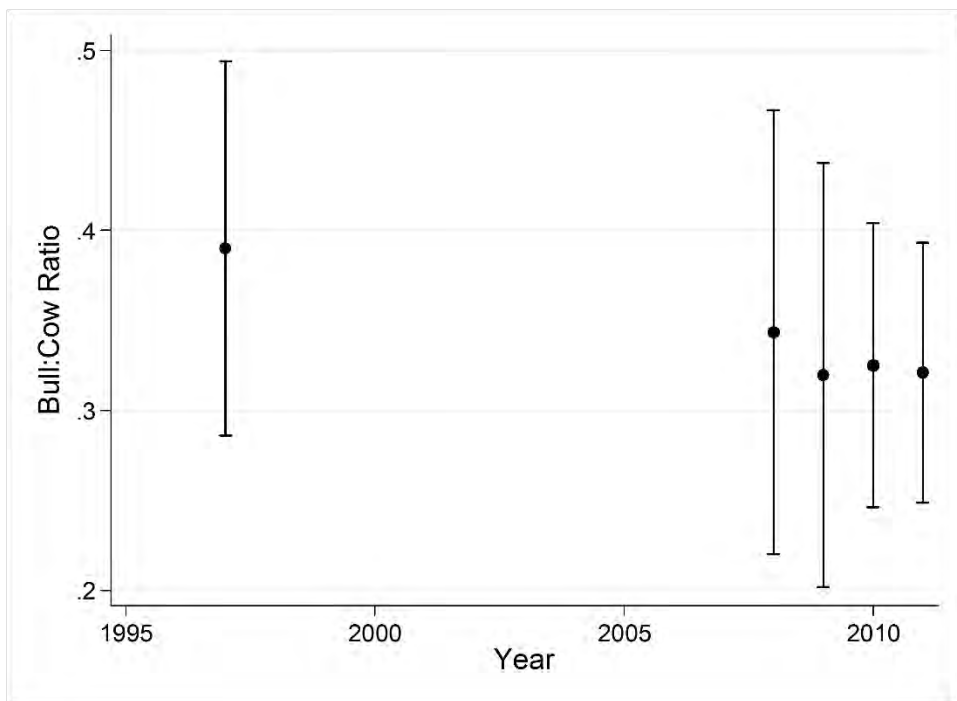


Figure 6. Adult sex ratios (bull:cow ratio) for the Coal River caribou herd (1997 – 2011). Error bars represent 95% confidence intervals.

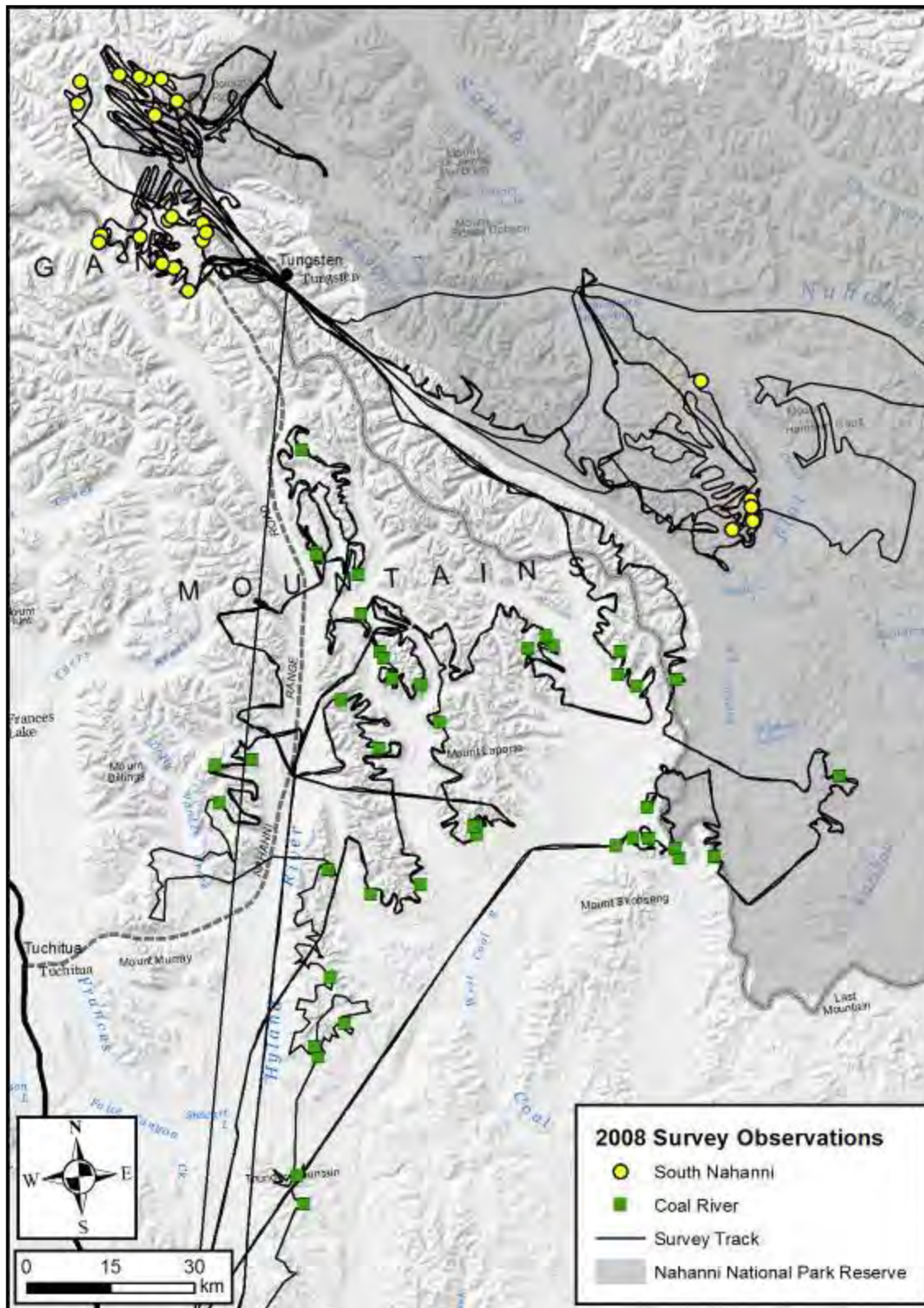


Figure 7. Survey tracks and observations for the 2008 South Nahanni and Coal River mountain caribou herd composition surveys.

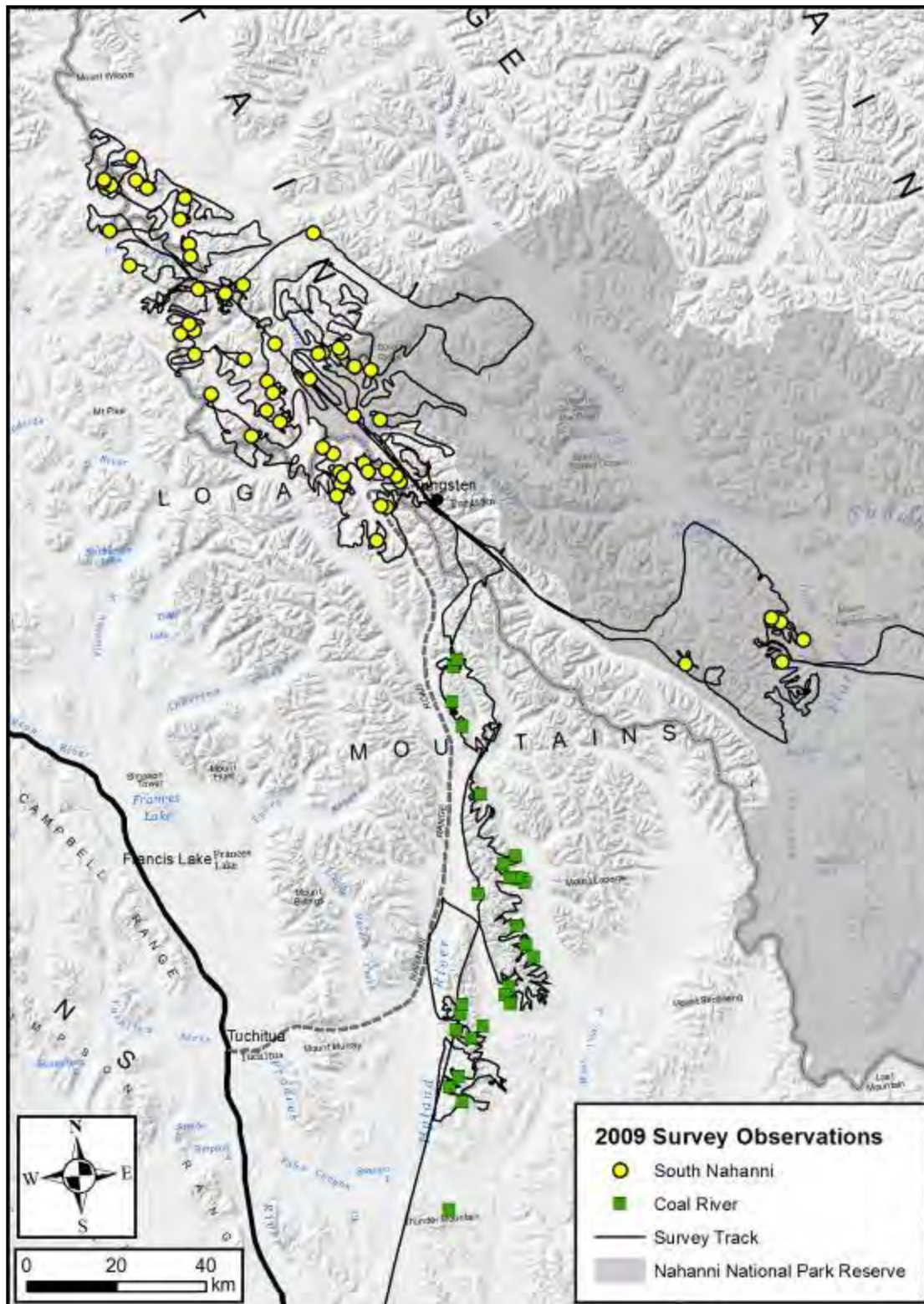


Figure 8. Survey tracks and observations for the 2009 South Nahanni and Coal River mountain caribou herd composition surveys.

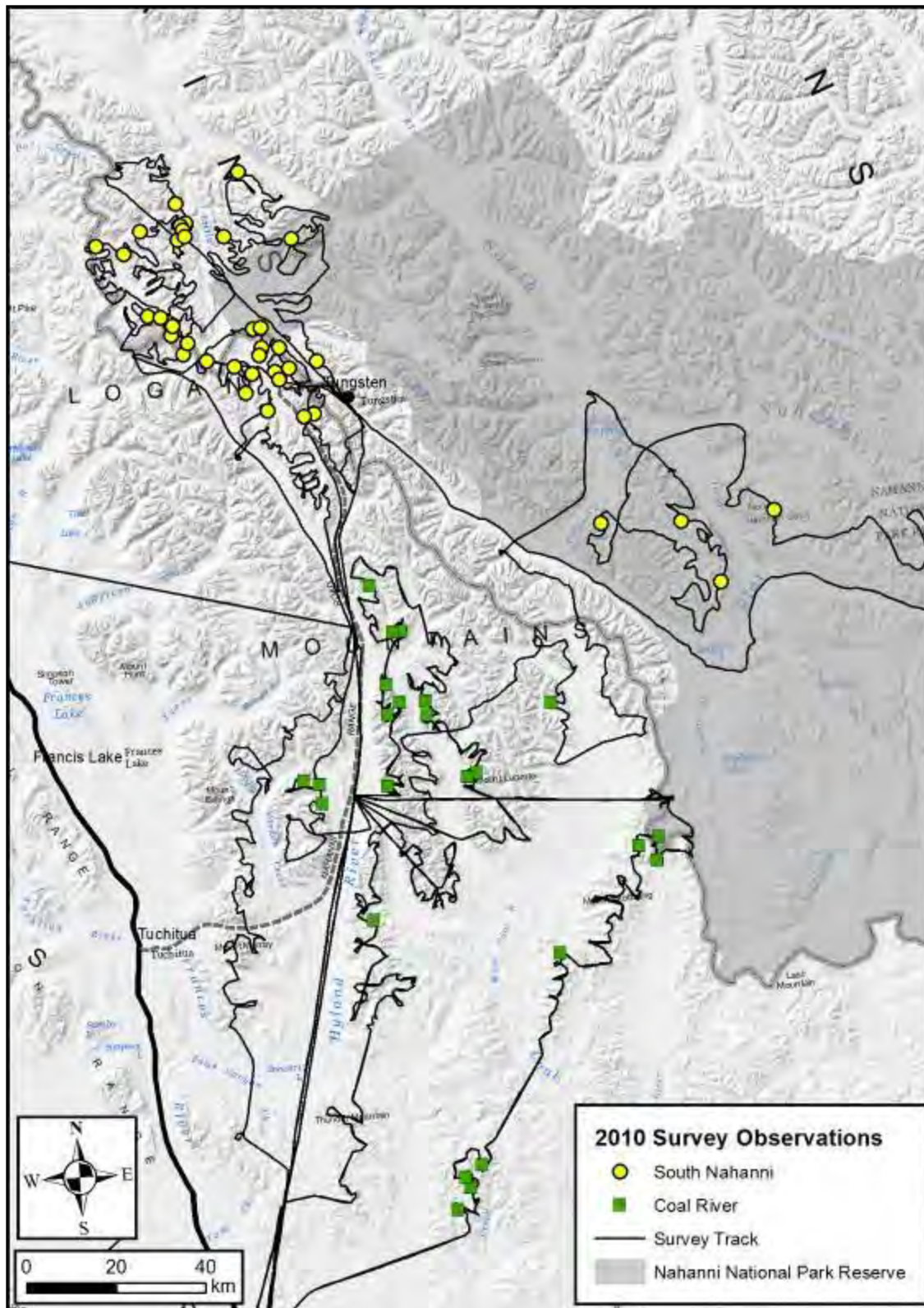


Figure 9. Survey tracks and observations for the 2010 South Nahanni and Coal River mountain caribou herd composition surveys.

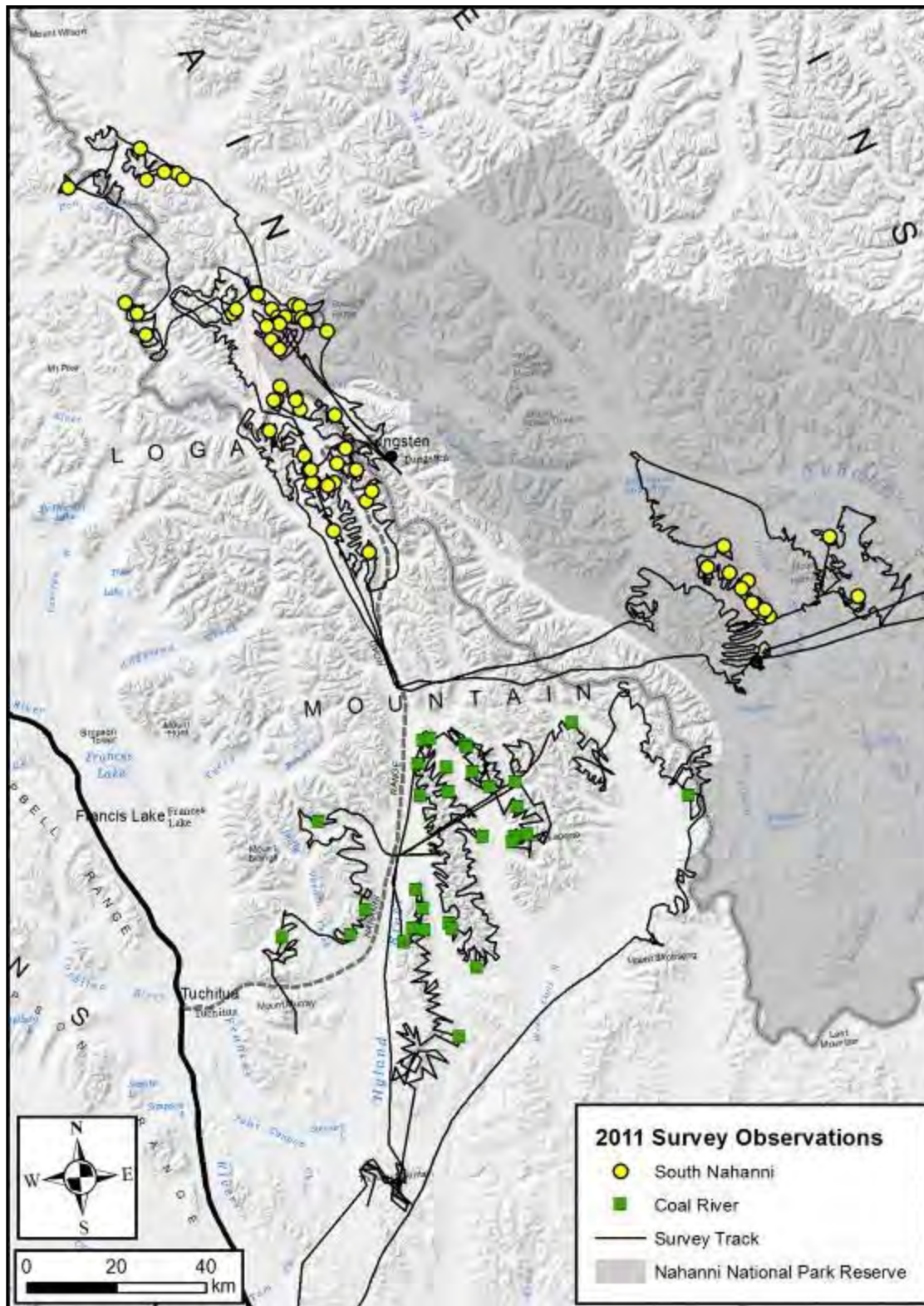


Figure 10. Survey tracks and observations for the 2011 South Nahanni and Coal River mountain caribou herd composition surveys.

Recruitment of both the South Nahanni and Coal River herds demonstrated high annual variability (Figures 3 and 4), typical of calf survival in ungulates (Gaillard et al. 1998). Yukon's updated Woodland Caribou Management Guidelines indicate a minimum recruitment rate of 20 calves per 100 cows is necessary to ensure at least a stable population growth rate, while recognizing the interplay between recruitment and adult cow survival in affecting population growth (DeCesare et al. 2012). Variance weighted average recruitment rates (95% CI) for the South Nahanni and Coal River herds from 2008 to 2011 were 0.18 (0.11 – 0.25) and 0.27 (0.15 – 0.38), respectively. The average recruitment for Coal River was sufficient for a stable-to-increasing population growth rate, while the average recruitment for South Nahanni was slightly below that which would be required for a stable growth rate. The substantially lower recruitment rates in 2008 were consistent with the generally lower recruitment for mountain caribou herds across Yukon (Environment Yukon, unpublished data), and appears to represent an extreme year which reduced the 4-year average. Recruitment rates of the Coal River and South Nahanni herds were positively, but not significantly, correlated ($r = 0.76$, $P = 0.15$).

The estimated adult sex ratio for the South Nahanni herd (Figure 5) demonstrated higher variability than for Coal River (Figure 6). The variance weighted sex ratio (2007 – 2011) was 36.8 bulls per 100 cows

(95% CI: 32.4 – 41.3) which is more typical of a moderately harvested herd. The 2010 composition survey appears to be an outlier with substantially fewer bulls observed relative to other years. It is unknown as to why so few bulls were observed in that year and thus the sex ratio estimate should be deemed unreliable. Censoring the 2010 data results in an average sex ratio of 39.1 bulls per 100 cows (95% CI: 33.7 – 44.5). From 2007 to 2011 (excluding data from 2010) there was a significant increasing trend (variance-weighted) in the adult sex ratio ($\beta = 0.027$, $SE = 0.005$). This appears to coincide with a decreasing trend in Yukon licensed harvest from 2003 – 2009. The increasing trend in sex ratio could represent a rebound effect from relatively high harvest in the late 1990s and early 2000s (see Harvest section).

Alternatively, the high variability of the estimated sex ratio from 1995 – 2011 could also suggest that animals may be being missed during the aerial surveys. It is unlikely that the adult sex ratio would change so dramatically year to year. If animals were being missed during the surveys it is most likely that these were bulls, because if cows were being missed we would expect the sex ratios to be biased more strongly in favor of bulls (i.e., sex ratio biased high). Composition surveys were conducted usually within a week-and-a-half window. However, there may be some unknown environmental factors that are influencing when bulls of the South Nahanni herd begin arriving on their breeding grounds, which differs

from cows. There are no data from radio-collared males in the herd which we could use to assess when bulls are initiating movements to these breeding areas.

The adult sex ratio for the Coal River herd was generally stable (Figure 6) with little variability from 2008 to 2011. However, a drop in the sex ratio since 1997 was observed. The sex ratio decreased slightly in 2009, likely a result of the poor recruitment in 2008 (Figure 4) leading to fewer immature bulls in the herd. The variance weighted sex ratio (2008 – 2011) was 33.0 bulls:100 cows (95% CI: 27.4 – 38.6). This is lower than the adult sex ratio observed in moderately harvested mountain caribou herds in the Yukon which is typically around 40 bulls per 100 cows. While a sex ratio of 33 bulls per 100 cows is not low enough to limit herd productivity (Holand et al. 2002), it does suggest that some factor(s) are increasing bull mortality. The high degree of consistency among the four estimates suggests the lower sex ratio was not spurious.

Population Estimate of the South Nahanni Herd

Methods

To address the challenges of working with a low density, widely distributed population in a remote mountainous location we chose to estimate the size of the South Nahanni herd using a mark-resight approach, with radio-collared adult

females in the population representing the marked sample.

We estimated the required sample size of collared animals through simulations in the program NOREMARK (White 1996). We assumed a herd size of 500 adult females, and modelled varying degrees of survey intensity (i.e., resighting rates; range: 0.5 – 0.9) and numbers of resighting sessions. From our simulations we determined that 25 – 30 collars were required to yield a population estimate with a coefficient of variation < 0.3. We opted for 30 collars to account for mortalities and collar failure between the time of capture and the resighting surveys.

Between 30 September and 4 October 2008, we captured 30 adult female caribou via helicopter net-gun and fitted them with Argos satellite collars with bright yellow bands to improve subsequent visibility (see Animal Capture and Collaring, p. 6). We programmed collar duty-cycles for daily fixes during the fall breeding season (15 Sept. – 15 Oct.; Table 1). In the year following capture 2 collared animals died, 3 collars failed, and the status of one animal was unknown, leaving 24 collared animals alive with functioning collars at the time of the surveys.

We delineated survey area boundaries based on the 2001 survey (Gunn et al. 2002) and from locations of radio-collared animals in the herd (Figure 11). Our 2009 resighting surveys extended beyond those used in 2001. From 30 September to 9 October 2009, we flew 3 independent (i.e., separate

crews and aircraft) 3-day resighting surveys via helicopter, and counted all marked and unmarked animals observed on each survey (Figures 12 – 14). We did not track collared animals by telemetry during the resighting surveys to avoid biasing the resighting rate. Following the surveys we used the radio-collar location data to identify which collared animals we had observed, which collared animals were in the survey area but not observed, and which collared animals were located outside of the delineated survey area (i.e., were unavailable to be detected).

As some collared animals were outside the survey area during one or more resighting surveys, we used the mixed logit-normal immigration-emigration mark-resight model (Program MARK Version 5.1; White and Burnham 1999, McClintock et al. 2009) to account for marked animals unavailable for resighting (Eberhardt 1990). This represents a super-population approach (Gould et al. 2005) in which our survey “population” represented a portion of the overall super-population. With

this mark-resight model, estimable parameters were:

- p** - resighting rate;
- σ** - individual heterogeneity in resighting rate;
- N** - population size on the survey area;
- N*** - the super-population size; and
- α** - change in N between resighting sessions.

We fixed $\sigma = 0$, as we deemed our number of resighting sessions insufficient to estimate it adequately. We had no a priori rationale to fix any other parameters. We compared models varying in either N, p, and α across resighting session (t), or constant across sessions (e.g., p.), by their AICc value (Burnham and Anderson 2002). Our parameter of interest was the super-population (N*) as it represents the broader group of animals from which the sampled (or observed) animals were drawn (Kendall 1999) and is the most meaningful estimate for making management decisions.

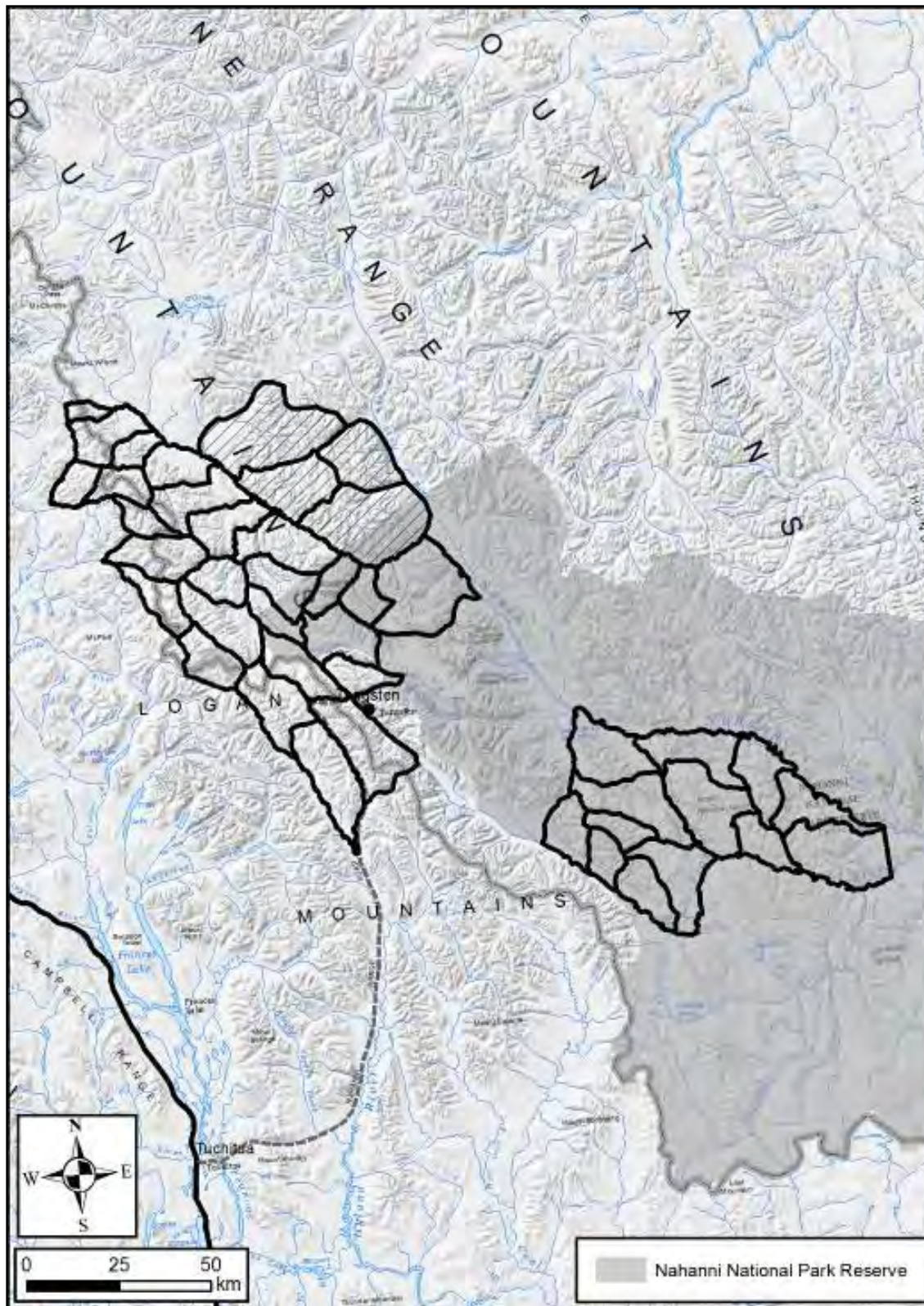


Figure 11. Survey blocks used during the 2009 mark-resight survey of the South Nahanni herd. The four hatched blocks represent areas not surveyed during the 2001 survey (Gunn et al. 2001). All remaining blocks were the same as those used in 2001.

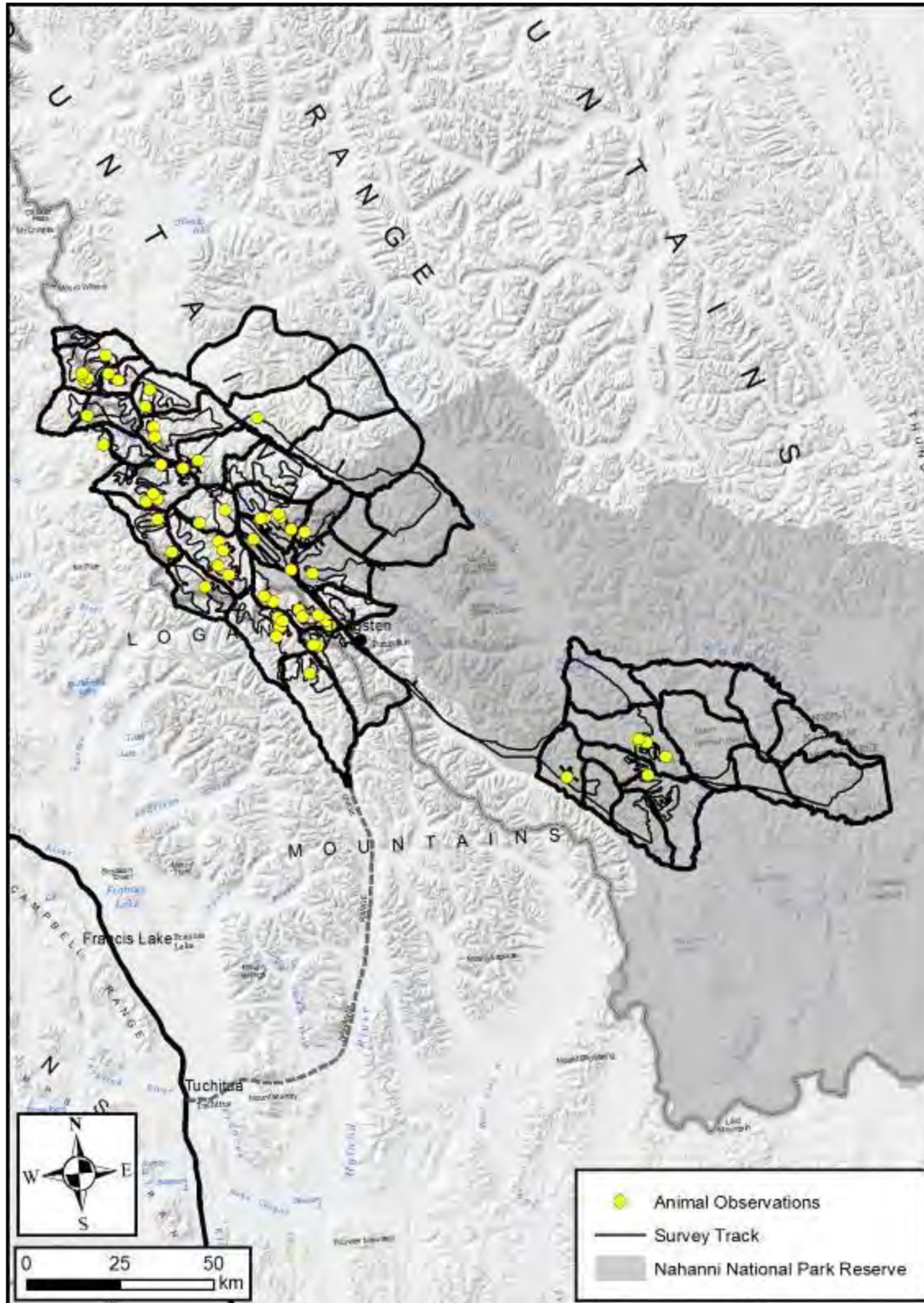


Figure 12. Animal observations and survey tracks for the first resight session of the South Nahanni mark-resight population estimate.

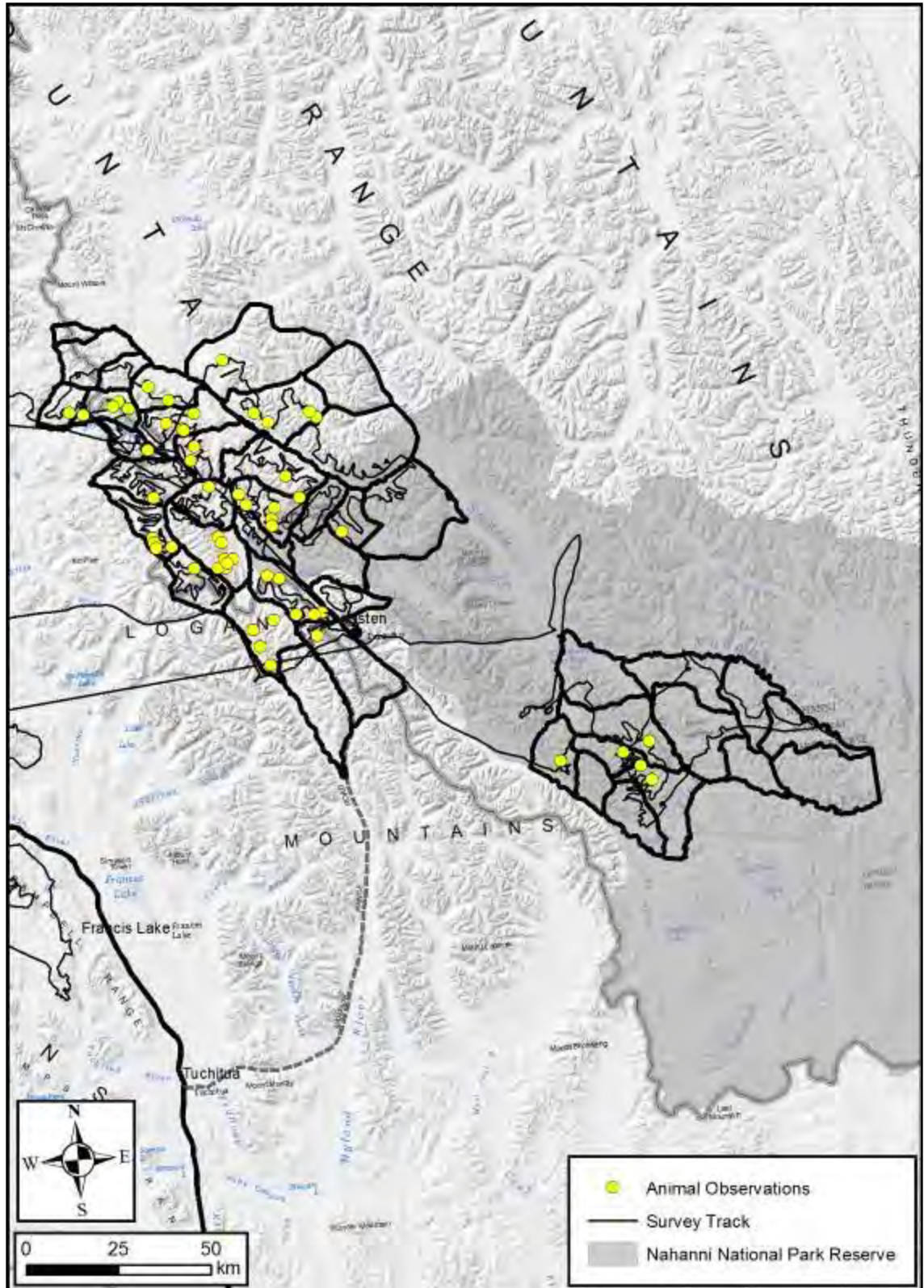


Figure 13. Animal observations and survey tracks for the second resight session of the South Nahanni mark-resight population estimate.

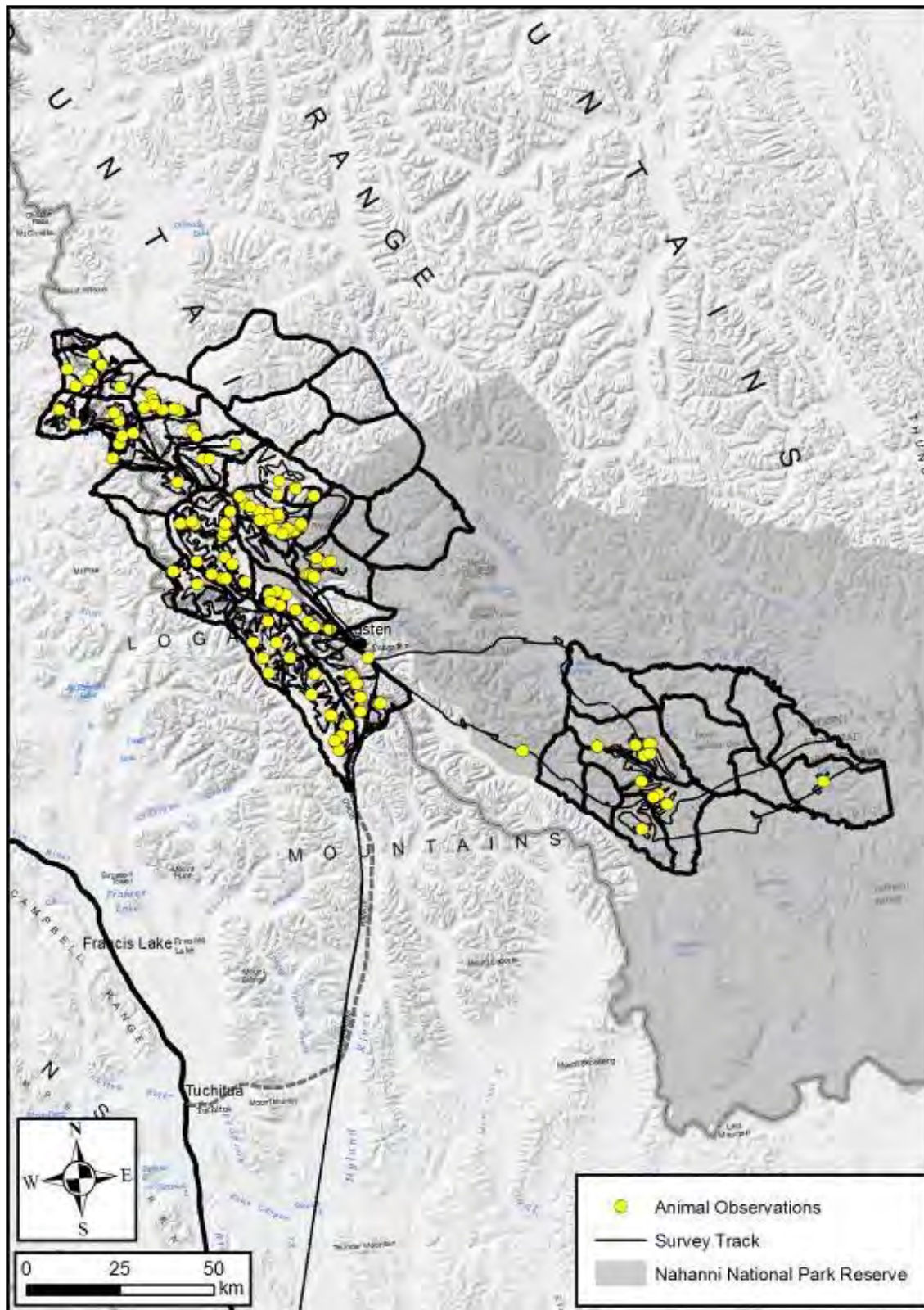


Figure 14. Animal observations and survey tracks for the third resight session of the South Nahanni mark-resight population estimate.

Results

The survey data (Table 5) most supported a model with p varying by resighting session and constant α (Table 6). Models specified with N_t did not achieve numerical convergence and are thus not reported.

Our final parameter estimates appear in Table 7. The estimated change in herd size within the survey area (α) between resighting sessions was not significantly different than zero, suggesting low, or balanced (i.e., immigration = emigration), movement during this time.

Table 5. Summary data for each resighting session of the 2009 mark-resight survey of the South Nahanni herd.

Resighting Session (Dates)	Marked Animals Observed ^a	Unmarked Animals Observed	Marked Animals Available	Survey Distance (km)	Helicopter Model
1 (30 Sept. – 2 Oct.)	8	510	19	2633	Bell 206B
2 (3 – 5 Oct.)	6	446	19	2190	AS350
3 (7 – 9 Oct.)	8	926	18	2224	Bell 407

a: 24 collars were active at the time of the survey.

Table 6. Candidate models for the analysis of the South Nahanni mark-resight data.

Model	AICc	w^a
N, N^*, p_t, α	123.28	0.78
N, N^*, p_t, α_t	125.83	0.22
$N, N^*, p., \alpha_t$	143.86	< 0.01
$N, N^*, p., \alpha$	Convergence not achieved	

a: Akaike weight

Table 7. Parameter estimates of the top-ranked immigration-emigration mark-resight model (see Table 6) for the South Nahanni caribou herd.

Variable	Parameter	Estimate	Standard Error
Resighting Rate (session 1)	p_1	0.32	0.06
Resighting Rate (session 2)	p_2	0.28	0.05
Resighting rate (session 3)	p_3	0.56	0.09
Change in N between sessions	α	-12	65
Population within survey area	N	1635	259
Super-population	N^*	2105	355

Discussion

Population change since 2001

Our current estimate of the South Nahanni herd, approximately 2,100 animals, suggests an increase in the

herd's size since 2001, when it was estimated at between 940 and 1,140 animals (Gunn et al. 2002).

However, the 2001 estimate does not represent a confidence interval, but rather 2 separate estimates based on 2 separate correction

factors. We reanalyzed Gunn et al.'s (2002) data in a mark-resight framework using NOREMARK and generated a population estimate of 1,432 (95% CI: 970 – 2,935).

In addition to a possible increase in the herd's size (Table 8), the discrepancy between the 2001 estimate and our 2009 estimate could be due to a smaller sample size of radio-collared animals in 2001, the lack of any radio-collared animals in the southern portion of the herd's range (i.e., within Nahanni National Park Reserve) in 2001, and our observation of groups of animals outside of the survey blocks used in 2001. Given these discrepancies in study design, it is

difficult to make any formal inference regarding the trend of the herd's size from 2001 to 2009, however the herd is likely stable and possibly increasing.

Herd composition

Information on the herd's composition, collected during the first resighting session, indicated a sex ratio of 41 bulls:100 cows, and a calf:cow ratio of 16.4:100 (Table 3). The percentage of calves in the herd was estimated to be 10.4%. Using the estimate of 2,105 for the herd's 2009 size yields 219 calves, 548 bulls, and 1,338 cows in the herd.

Table 8. Comparison of population estimates for the South Nahanni caribou herd.

Survey	Population Estimate	95% Confidence Interval
2001 (Gunn et al. 2002)	940 – 1,140	n/a
2001 (our revised estimate)	1,432	970 – 2,935
2009 (survey area population: N)	1,635	1,283 – 2,350
2009 (super-population: N*)	2,105	1,591 – 3,029

Assessment of survey and analytical techniques

Our use of 3 independent resighting sessions provided us with a robust estimate, with resighting rate varying by session; the highest resighting rate occurred with a faster and more powerful helicopter and weather conditions that were near ideal (i.e., clear skies and a recent snowfall) when compared with the first 2 sessions. The varying resighting rates reported here also highlight the need for caution when applying, both spatially and/or temporally, a correction factor derived from one survey to another (Gould et al. 2005).

Fewer resighting sessions would have resulted in reduced precision and different population estimates (Table 9). For example, an estimate based on only the first or second resighting sessions would have resulted in low estimates, a bias revealed to us only through the number of unique unmarked animals observed during the third session.

Adopting the immigration-emigration modeling framework allowed us to explicitly include those animals not available for resighting into a statistical model of the herd's size. The presence of satellite collared animals greatly enhanced our ability to record the identity and

location of collared animals during the survey, which we believe

enhanced our ability to more accurately estimate the herd's size.

Table 9. Super-population estimates and coefficients of variation (CV) for various combinations of the three resighting surveys (from Table 5) of the South Nahanni herd.

Resighting Surveys	Super-population Estimate	CV
1 + 2 + 3	2,105	0.17
1 + 2	1,272	0.23
1 + 3	2,200	0.22
2 + 3	1,927	0.23
1	1,214	0.06
2	1,265	0.42
3	1,708	0.23

Harvest

Yukon harvest

In Yukon, harvest of both the South Nahanni and Coal River herds is open to resident and non-resident hunters (i.e., licensed hunters) in addition to First Nation subsistence hunters. There are no permits in place for residents and outfitter harvest is not under a quota. While licensed hunters are legally required to report their kill, First Nation hunters are not and therefore complete harvest statistics for these herds are unavailable. All licensed harvest of caribou from these herds is male-only. From 1995 to 2012, the average annual harvest, by licensed hunters, was 13.1 and 10.4 caribou from the South Nahanni and Coal River herds, respectively. As this area is relatively more accessible than many other parts of Yukon, due to the Nahanni Range Road, resident harvest was slightly higher than non-resident harvest.

Average annual resident harvest was 7.5 and 5.9 caribou for the South Nahanni and Coal River herds, respectively. Average annual non-resident harvest, which includes both non-residents guided by an outfitter and those specially guided by a Yukon resident, was 5.6 and 4.4 caribou for the South Nahanni and Coal River herds, respectively.

From 1995 to 2012, licensed harvest of both herds showed a declining trend, although with considerable annual variability (Figure 15). The average annual decline in harvest was 0.42 (SE = 0.21) and 0.48 (SE = 0.19) animals for the South Nahanni and Coal River herds, respectively. The combined harvest trend, for both herds, was a reduction of 0.90 (SE = 0.28) animals per year. However, recent licensed harvest increased dramatically (nearly 3-fold) from 2009 to 2012 for the South Nahanni herd, and from 2010 to 2012 for the Coal River herd (Figure 15).

Game management subzones (GMS) are generally the smallest

unit used for harvest management in Yukon. For management purposes each GMS is attributed to a caribou herd, where applicable, in order to track harvest rates at the herd level. Licensed hunters are required to report their kill and the GMS where harvest occurred as required components of this reporting process. During 2008 to 2011 (the years of this study),

licensed Yukon harvest of the South Nahanni herd was spatially distributed over 3 subzones and Coal River harvest was distributed over 6 (Figure 16). The highest level of harvest was in GMS 1119 (35 caribou harvested over 4 years) at the top end of the Nahanni Range Road. This subzone has one of the highest harvest levels for mountain caribou in Yukon.

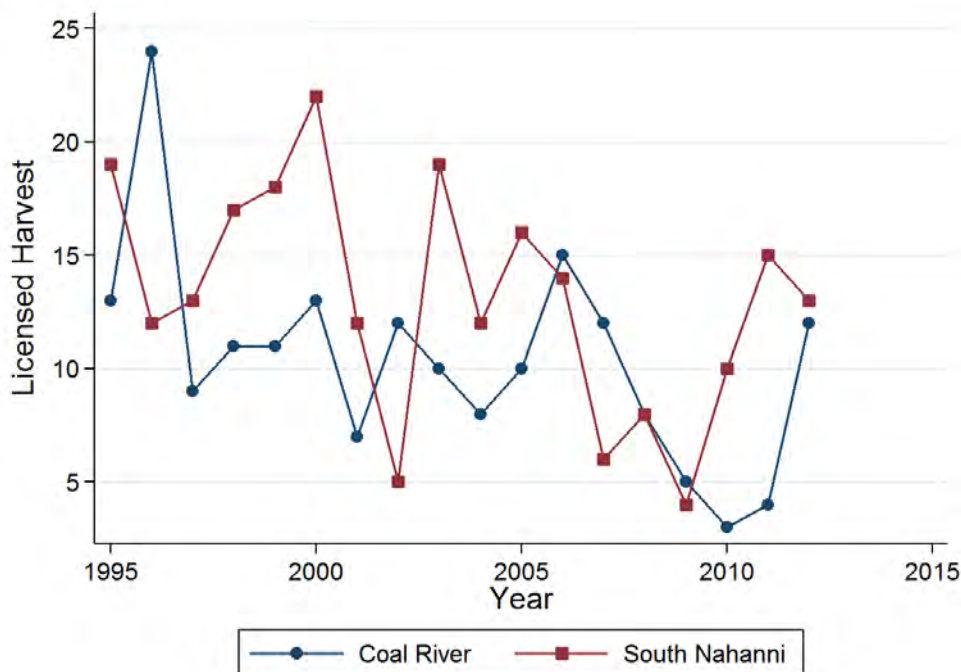


Figure 15. Yukon licensed harvest of the South Nahanni and Coal River caribou herds (1995 – 2012).

Northwest Territories harvest

Resident (non-aboriginal) harvest in the Northwest Territories (NWT) is very low, with no caribou being harvested since 2004 and a long-term average (2001 – 2012) of < 1 caribou per year (N. Larter, GNWT, pers. comm.). Non-aboriginal harvest is not restricted to bulls, however the majority of caribou harvested by resident hunters in the

NWT are bulls (Larter and Allaire 2012). Non-resident harvest is summarized over the entire Mackenzie Mountain region and the long-term average harvest was 158 bulls per year. Of note, these numbers also include harvest of the Redstone and Bonnet Plume herds to the north which are estimated at 10,000 and 5,000 animals, respectively. Approximately 15 bulls per year are harvested on average

from the South Nahanni, Coal River, and La Biche herds combined (N. Larter, GNWT, pers. comm.). Additionally, following the expansion of Nahanni National Park Reserve, all outfitting will cease after 2019 unless the outfitting concessions are bought-out before this deadline (Parks Canada 2010), which will reduce harvest on both the Coal River and South Nahanni herds. Aboriginal traditional harvest is and will continue to be permitted in the entirety of Nahanni National Park Reserve.

In both Yukon and NWT, aboriginal subsistence harvest may consist of either sex and this harvest reporting is not required. Thus total harvest numbers are not available for these herds.

Management Implications

South Nahanni Herd

Based on the composition surveys and the 2009 population estimate of ~2,100 animals, the South Nahanni herd appears to be stable to slightly increasing since the last estimate in 2001. The adult sex ratio of 39 bulls per 100 cows is generally consistent with sex ratios observed in other moderately harvested mountain caribou herds in Yukon. Given the current sex ratio and the observed trend, there is little cause for concern regarding bull numbers in the herd. Calf recruitment in 2010 and 2011 was sufficient to ensure a stable population, even though the 2008 and 2009 recruitment rates were substantially lower. These low

recruitment rates were likely a result of annual environmental variability (e.g., weather conditions) as low recruitment was observed in mountain caribou herds across Yukon in those years, suggesting a large-scale climatic effect (Hegel et al. 2010).

Yukon's woodland caribou management guidelines recommend a harvest rate of 2 – 3% (bulls) of the adult portion of the herd as sustainable. Assuming approximately 1,900 adults in the herd, this would lead to a sustainable harvest of 38 – 57 animals. Total harvest numbers in the GNE are unavailable but given an average Yukon licensed harvest of 13 animals, an assumed equal harvest by Yukon First Nations, and negligible NWT resident and NWT First Nation harvest, this leads to a harvest rate of approximately 1.4% (26 animals), not accounting for non-resident harvest in the NWT. If annual NWT non-resident harvest was an additional 7 – 8 animals (i.e., approximately half of the total harvest in this area), a harvest rate of 1.8% (34 animals) would be realized; within recommended levels. Given that First Nation harvest is unavailable we assumed it to be equal to licensed harvest in order to remain conservative with respect to harvest rates.

The current estimated harvest is below the recommended 2 – 3% level. At present there are no harvest management concerns for the South Nahanni herd.

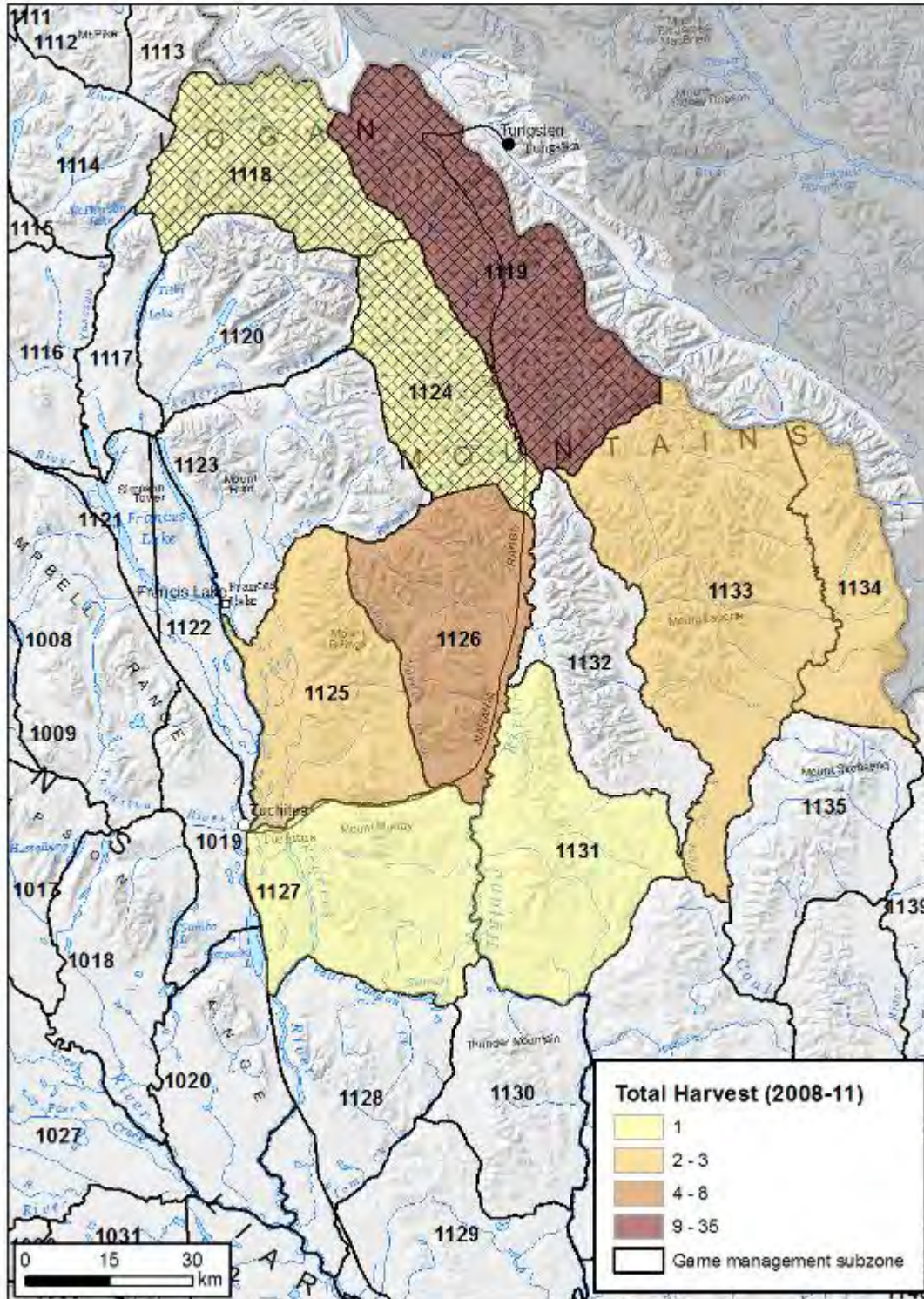


Figure 16. Licensed harvest of the South Nahanni and Coal River caribou herds for individual game management subzones (2008 – 2011). The hatched subzones represent those attributed to South Nahanni caribou.

Currently, GMSs 1112 – 1117 and 1120 – 1123 are designated as Finlayson caribou herd zones (Figure 16). GMS 1118 was previously designated as a Finlayson herd zone, but was recently (2010) re-designated to South Nahanni. Once analysis of the updated radio-collar data is completed for the South Nahanni herd it may be worthwhile to reassess this designation as these subzones may more accurately represent South Nahanni harvest; specifically GMSs 1112 – 1114. Combined harvest—nearly all by non-residents—of these subzones averages < 1 caribou per year and thus would not meaningfully increase the overall harvest rate of the South Nahanni herd if a re-designation were to occur.

An omission of this report is analysis of adult female survival based on the 2008 radio-collars. A collar retrieval project was completed in August 2013 to assess mortality, as opposed to dropped collars. Analysis of adult female survival from this information will be completed in a subsequent report.

Coal River Herd

Information regarding the abundance of the Coal River herd is lacking and a working estimate of the herd's size is 450 animals. This is based on expert opinion and fall composition survey numbers. Based on the 2008 composition survey (Table 4) there were at least 341 individuals in the herd. Given that not all animals were observed during the survey it is challenging to

provide a defensible estimate of the herd's size and it may be larger than 450. If we were to assume a resighting rate similar to that from the South Nahanni herd (Table 7), the size of the herd may be nearer to 900 – 1000. However, assuming a similar resighting rate should be considered with a high degree of caution.

Recruitment rates from 2008 to 2011 demonstrated the same pattern as South Nahanni; low recruitment in 2008 and 2009 followed by higher rates in 2010 and 2011. The rates in 2010 and 2011 were likely sufficient to offset the lower recruitment in 2008 and 2009. As with the South Nahanni herd, the variability of recruitment rates from 2008 to 2011 is likely due to annual environmental variability.

The adult sex ratios were stable over the 4 years of surveys providing confidence that they were estimated accurately. The low bull numbers may be cause for concern however as it is one of the lowest observed sex ratios for harvested mountain caribou herds in Yukon. Typically in unharvested herds the adult sex ratio ranges around 50 bulls per 100 cows due to higher natural mortality of bulls and their reduced lifespan. Thus, an adult sex ratio of 33 bulls per 100 cows may indicate that bull mortality (from all sources) is elevated.

Licensed Yukon harvest of the Coal River herd averaged 10 bulls per year, and assuming an equal subsistence Yukon First Nation harvest (to err on the side of conservatism) would yield a harvest rate over 4%. This harvest rate

assumes a herd size of 450 and does not include NWT non-resident harvest. Including an annual NWT non-resident harvest of 7–8 animals would increase the harvest rate to over 6%. As we do not have a reliable estimate of the herd's size, this harvest rate should be interpreted cautiously. To reach a harvest rate of 3% would require approximately 900 adults in the herd. Figure 17 illustrates how

harvest rates vary with different numbers of harvested animals and varying adult population sizes.

Given the low sex ratio in the herd, its accessibility to hunters, the uncertainty surrounding the size of the herd, and a harvest rate potentially exceeding recommended levels, additional work related to the population status and sustainability of the harvest may be warranted.

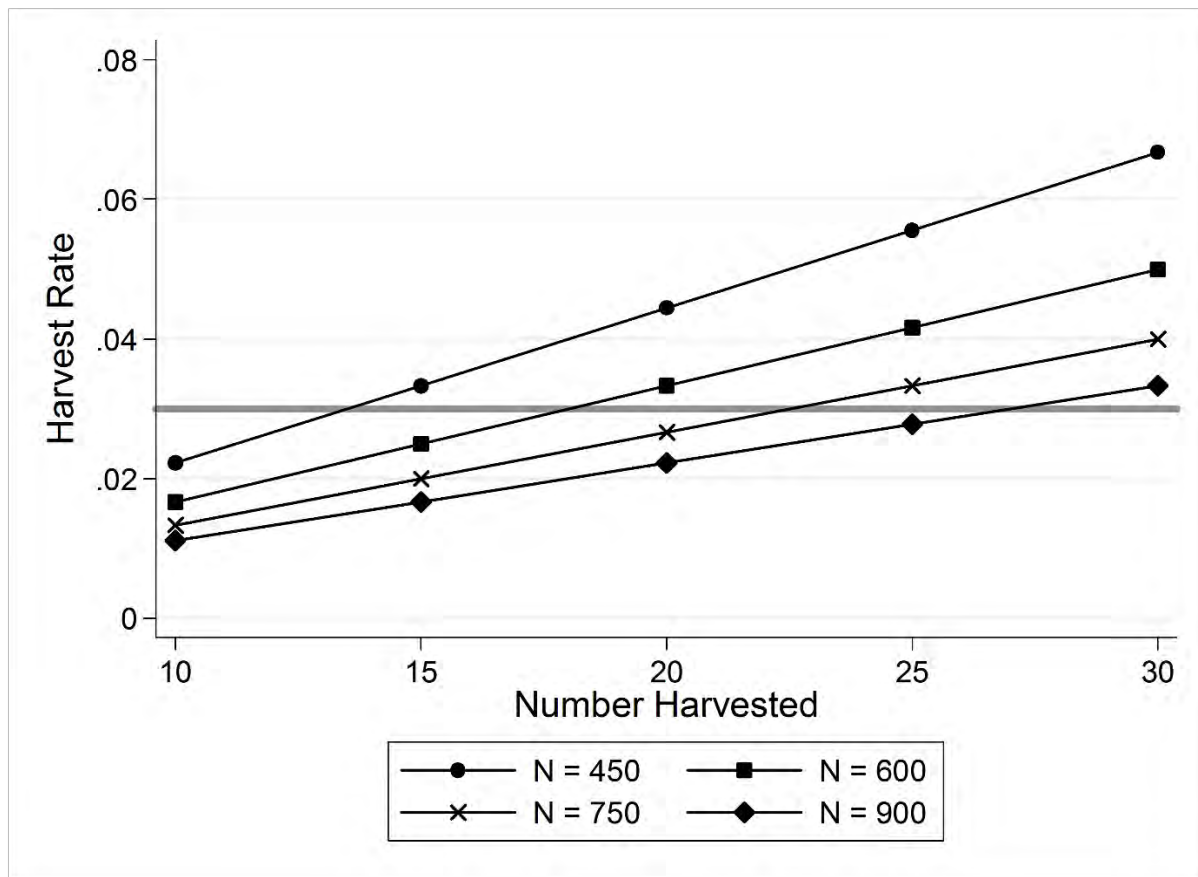


Figure 17. Harvest rates based on differing levels of harvest and adult population sizes (N) representative of the Coal River herd. The thick grey horizontal line indicates a harvest rate of 3%.

Literature Cited

- ADAMCZEWSKI, J., R. FLORKIEWICZ, R. FARNELL, C. FOSTER, AND K. EGLI. 2010. Finlayson caribou herd late-winter population survey, 2007. Yukon Fish and Wildlife Branch Report SR-10-01. Whitehorse, Yukon, Canada.
- BURNHAM, K. P., AND D. R. ANDERSON. 2002. Model selection and multi-model inference: a practical information-theoretic approach, 2nd ed. Springer, New York.
- DECESARE N. J., M. HEBBLEWHITE, M. BRADLEY, K. G. SMITH, AND D. HERVIEUX. 2012. Estimating ungulate recruitment and growth rates using age ratios. *Journal of Wildlife Management* 76:144–153.
- EBERHARDT, L. L. 1990. Using radio-telemetry for mark-recapture studies with edge effects. *Journal of Applied Ecology* 27:259–271.
- GAILLARD, J.-M., M. FESTA-BIANCHET, AND N. G. YOCCOZ. 1998. Population dynamics of large herbivores: variable recruitment with constant adult survival. *Trends in Ecology and Evolution* 13:58–63.
- GOULD, W. R., S. T. SMALLIDGE, AND B. C. THOMPSON. 2005. Mark-resight superpopulation estimation of a wintering elk *Cervus elaphus canadensis* herd. *Wildlife Biology* 11:341–349.
- GULLICKSON, D., AND M. MANSEAU. 2000. South Nahanni woodland caribou herd seasonal range use and demography. Parks Canada Agency. 79 pp.
- GUNN, A., R. FARNELL, J. ADAMCZEWSKI, J. DRAGON, AND L. LABERGE. 2002. Census for the South Nahanni mountain caribou herd: September 2001. Government of the Northwest Territories, Manuscript Report 147.
- HEGEL, T. M., A. MYSTERUD, T. ERGON, L. E. LOE, F. HUETTMANN, AND N. C. STENSETH. 2010. Seasonal effects of Pacific-based climate on recruitment in a predator-limited large herbivore. *Journal of Animal Ecology* 79:471–482.
- HOLAND, Ø., K. H. RØED, A. MYSTERUD, J. M. KUMPULA, M. NIEMINEN, AND M. E. SMITH. 2002. The effect of sex ratio and male age structure on reindeer calving. *Journal of Wildlife Management* 67:25–33.
- Kendall, W. L. 1999. Robustness of closed capture-recapture methods to violations of the closure assumption. *Ecology* 80:2517–2525.
- LARTER, N. C., AND D. G. ALLAIRE. 2012. Mackenzie Mountain non-resident and non-resident alien hunter harvest summary 2011. Northwest Territories Department of Environment and Natural Resources, Manuscript Report 220.

- McCLINTOCK, B. T., G. C. WHITE,, K. P. BURNHAM, AND M. A. PRYDE. 2009. A generalized mixed effects model of abundance for mark-resight data when sampling is without replacement. Pages 271–289 in *Modeling Demographic Processes in Marked Populations*. D. L. Thomson, E. G. Cooch, and M. J. Conroy, eds. Springer, New York, New York, USA,.
- PARKS CANADA. 2010. Nahanni National Park Reserve Management Plan. Nahanni National Park Reserve, Fort Simpson, NT.
- WEAVER, J. L. 2008. Conserving caribou landscapes in the Nahanni trans-border region using fidelity to seasonal ranges and migration routes. Wildlife Conservation Society Canada, Conservation Report No. 4. Toronto, Ontario, Canada.
- WHITE, G. C. 1996. NOREMARK: population estimation from mark-resighting surveys. *Wildlife Society Bulletin* 24:50–52.
- WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: survival rate estimation from both live and dead encounters. *Bird Study* 46(Suppl.): S120–S139.