Calf Production and Adult Sex Ratio in the Bathurst and Bluenose East Herds of Barren-Ground Caribou 2006-2016

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ABSTRACT

Regular monitoring of calf production and adult sex ratio are used to help determine trend in numbers of barren-ground caribou (*Rangifer tarandus groenlandicus*). Calf production via calf:cow ratio is an index of the potential for a herd to increase. Adult sex ratio is used as an index of herd status and is an important parameter in population estimates that are derived from photo censuses of caribou on the calving ground. We estimated calf production and adult sex ratio in the Bathurst and Bluenose East herds by classifying caribou from a helicopter or on the ground into sex and age classes in late winter (March/April) and fall (October). The fall counts, conducted during the rut, serve to estimate adult sex ratio. This report summarizes these composition surveys for the Bathurst herd from 2006-2016 and from 2008-2016 for the Bluenose East herd.

Calf production in spring 2006 was very low for the Bathurst caribou herd with a calf:cow ratio of 0.086 (SE=0.007). Calf production rebounded in subsequent years, but has since declined again to 0.200 (SE=0.014) in 2016. Calf production peaked in March 2008 with a calf:cow ratio of 0.497 (SE=0.020) and remained relatively steady until March 2012, when the calf:cow ratio dropped to 0.251 (SE=0.013). The current calf:cow ratio (March 2016) is the lowest estimate for the Bathurst herd since 2006. The Bluenose East herd showed a calf production trend similar to the Bathurst herd, where it had also peaked in March 2008 at 0.483 calves/cow (SE=0.017), and remained relatively stable for another three years, until a decline to 0.272 calves/cow (SE=0.015) in March 2012. The ratio reached its lowest in March 2015 at 0.212 (SE=0.023) calves/cow. The latest spring calf:cow estimate for the Bluenose East herd was in March 2016 and is more encouraging at 0.319 (SE=0.020). Although fewer composition surveys have occurred in the fall than in spring, seasonal cow:calf ratios suggest a pattern of a steady decline in calf production for both herds since 2008.

The adult sex ratio for the Bathurst caribou herd has fluctuated among years, rising from a bull:cow ratio of 0.305 (SE=0.016) in October 2007 to a high of 0.580 (SE=0.034) in October 2011. Currently, the proportion of bulls in the Bathurst herd is about average with a bull:cow estimate of 0.490 (SE=0.025) from October 2014. Only three fall composition surveys have been done for the Bluenose East caribou since 2008, but they suggest a similar decline has occurred for this herd. In October 2009, the bull:cow ratio for Bluenose East caribou was 0.429 (SE=0.017), 0.426 (SE=0.018) in October 2013, and most recently, 0.417 (SE=0.029) in October 2015.

Because calf:cow and bull:cow ratios have a numerator and denominator that can vary independently between surveys, caution is needed with their interpretation of trends, as they could be misleading. However, given the current decrease in the population size for both the Bathurst and Bluenose East herds, and corresponding reductions in group size, number of caribou classified, and percentage of calves observed during most seasonal surveys, calf production and proportion of bulls in the population have declined over the last decade.

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INTRODUCTION

The abundance and health of barren-ground caribou (*Rangifer tarandus groenlandicus*) populations in the north is of critical importance to the Northwest Territories (NWT) and its residents. To assess status and demographic trends of these caribou, herd composition and age class ratios are commonly collected (e.g., Caughley 1974, McCullough 1994, Bender 2006). Composition surveys count the number of bulls, adult females (cows), and calves to calculate calf to cow and bull to cow ratios. Often bulls are further classified as either young or prime (Williams & Fournier 1996, Gunn et al. 2005a). Yearlings are sometimes distinguished, but typically not consistently enough to be accurate nor are they sexed. Therefore, at best yearlings become part of the male to female ratio, but otherwise ignored except for inclusion in the total count.

Assessing the proportion of offspring relative to adult females in herd composition counts has its limitations (McCullough 1994). Critical assumptions are equal sex ratio at birth and similar rates of mortality between male and female calves. Furthermore, differential cow mortality between adjacent seasonal comparisons confounds interpretation because the cow count in the ratio's denominator would not be constant (McCullough 1994). When these assumptions are valid, calf to cow ratios can serve as an index of productivity (calf recruitment) and may be highly correlated with rates of population change (Krebs et al. 1986, Bender 2006). The bull to cow ratio provides an estimate of the number of bulls in the herd and is included in the calculation of population size estimates from calving ground surveys. The bull:cow ratio is also useful to monitor sex-selective harvest in polygynous mating systems.

Large changes in calf:cow ratios most likely reflect changes in calf survival rates assuming that pregnancy rates are less variable than calf survival, and calf survival, much like cow survival, heavily influences population growth rates (Bergerud 2000). Calf:cow ratios mainly estimate recruitment, which is the product of pregnancy rate and calf survival. For the GNWT, estimating overwinter calf:cow ratios provides a measure of recruitment of new caribou into a herd and possibly calf survival if both fall and spring compositions surveys are available, and assuming constant adult female survival (Gunn et al. 2005a). However, calf survival can now be better estimated with an Ordinary Least Squares (OLS) model that has since been developed to use calf:cow ratios, collar data, and survey data (Boulanger et al. 2011). Although calves are the only age class reliably recognizable in the field, by the time they are about one year old, their survival is assumed to approximate the survival of older caribou (Gunn et al. 2005a). Therefore, the ratio of calves to total number of caribou (i.e., the percentage of calves) in late winter can be used an index of recruitment.

Given its importance as an indicator of overall status of caribou productivity, overwinter calf recruitment and overall herd productivity are considered core monitoring actions that are intended to be maintained on a permanent basis regardless of the status of the herd (Bathurst Caribou Draft Management Plan 2004). Consequently, the response from the Wek'èezhìi Renewable Resource Board (WRRB) to the Tłįchǫ Government (TG)/Environment and Natural Resources (ENR) joint proposal for recovery of the Bathurst caribou herd has recommended conducting the late winter/spring calf cow composition surveys annually. Similarly, the Advisory Committee for the Co-operation on Wildlife Management (ACCWM) overseeing the development of a management plan for the Bluenose East herd (among others) identifies spring and fall composition surveys to be a regular component of a Bluenose East caribou monitoring plan (ACCWM 2014).

Composition surveys to estimate over-winter calf production were conducted by the Wildlife Division at ENR Headquarters from 1979 to 1995, paused for five years, then resumed in 2001 (Williams & Fournier 1996, Gunn et al. 2005a). Beginning in March 2006, the North Slave regional office assumed responsibility for conducting these surveys for the Bathurst caribou herd. Prior to spring 2009, the Sahtu regional office conducted composition surveys for the Bluenose East herd. However, for the spring 2009 survey, the North Slave Region (NSR) assisted with the reconnaissance component. Beginning with the Fall 2009 survey, the NSR assumed responsibility for conducting Bluenose East composition surveys for all subsequent years.

The Bluenose East herd often winters in the northeastern portion of the NSR, which can sometimes lead to significant range overlap with the adjacent Bathurst caribou herd. While it became logistically practical to conduct the composition surveys from the NSR, increased residency time of the Bluenose East herd in this region also lead to more interest in the herd by North Slave communities.

METHODS

Prior to each composition survey, one or more reconnaissance flights in a fixed wing aircraft (e.g., de Havilland Turbo Beaver or a small Cessna Caravan) was used to determine the current distribution of caribou. The initial assessment of current range use was given by locations of collared caribou cows tracked by satellite. Caribou cows from the Bathurst herd have been collared since 1996 and serve to delineate herd spatial distribution on a coarse scale (Gunn et al. 2001). Although the collaring program began with only 10 satellite collars in 1996, current deployment has increased since then and sought to maintain 20 collared cows each year. As of late March 2016, this deployment increased to maintaining 50 collars annually on the Bathurst herd. Nevertheless, some collared caribou stray from the Bathurst herd, die, or a collar fails such that collectively not all locations from collared individuals may be available or relevant to a survey. Furthermore, the number of caribou associated with a given collared caribou is unknown. Therefore, reconnaissance flights serve to further identify areas where caribou may occur but where collars are absent and also indicate abundance of caribou at these sites and where there are collars.

Reconnaissance flights are "semi-systematic" and cover the area with collared caribou, the known distribution of barren-ground caribou derived from any previous aerial surveys or monitoring programs done earlier that winter, and include recent reports of caribou sightings from communities and aircraft pilots. Often a reconnaissance survey in spring is flown as transects. In these cases, a more complete determination of caribou abundance and distribution is needed to inform planning for new deployment of radio-collars. Typically, the reconnaissance team is composed of one observer/navigator in the front (co-pilot seat), and four observers in the back seats. The number of caribou, incidental sightings, and fresh tracks are recorded, plus a GPS track obtained of the flight path. Maps showing this information are created for use during the classification part of the survey.

For the composition/classification survey, a helicopter (Bell 206B, 206L or A-Star) was used to search for caribou groups in the vicinity of satellite collared caribou cows and where caribou were observed during the reconnaissance flight(s). Depending on the interval between reconnaissance and composition surveys, some shift in location is expected, as caribou move about the landscape, especially during fall. Flight paths are dispersed across the known barren-ground caribou distribution of interest where possible. In years where overlap in the winter range of adjacent herds (Bluenose East and Ahiak/Beverly herds) was substantial, we focused on areas where only the target herd was found.

Caribou were classified from the helicopter hovering slowly behind groups of animals. The observer in the front classified caribou, usually with the aid of image-stabilized binoculars, and the recorder in the back entered the information on data sheets or in a tablet. When present, the third person assisted as an observer to locate caribou. Initially, we classified only small groups (<30 caribou) from the air. However, n the last five years, most of these larger groups have been classified from the air and in the last year, no ground based observations have occurred. When we did land the helicopter for the larger groups, we walked to within 100-200m of the caribou and viewed them through a spotting scope supported by a tripod. We then classified caribou as we encountered them through the scope (Gunn et al. 2005a). We assigned a Global Positioning System (GPS) waypoint to each discrete caribou group we classified. Therefore, the group, via its GPS waypoint, is the sample unit in the analyses.

Not all caribou in large groups are classified. For ground-based classification, caribou may be too far away, remained bedded, escape into the trees, or move toward already classified caribou and could be double-counted. Therefore, a representative sample is attempted by focusing on a group or line of caribou and classifying those. This reduces any subtle tendencies such as being drawn to more visible individuals like prime bulls, or being influenced by either habitat or behavior (Samuel et al. 1992). Given that not all individuals in large groups are classified, we have recently tended to classify all sizes of groups of caribou from the air and forego the ground-based approach. Still, not all caribou are classified, but sampling occurs throughout the group while we take a precautionary approach to not double-count caribou if uncertainty develops about what sub-groups have been classified. We believe we are obtaining a more representative sample because saving time not landing allows us to classify more groups elsewhere. Group sizes tend to be heavily skewed, therefore we report the median group size rather than its average. Non-integer medians were rounded down to the nearest integer.

Sex determination of caribou was based primarily on the presence of a darken vulva patch for cows. Absence of a vulva patch and the presence of a penis sheath distinguished bulls. In the fall, mature bulls can easily be identified by their large size and large antlers. However, during spring surveys prime bulls are antlerless, having dropped their antlers since the rut. Therefore, one must confirm the absence of a vulva patch and the presence of a penis sheath to reliably distinguish bulls from the occasional genetically antlerless ("bald") cows.

Age categories for classification were calves (<1 year old), yearlings (1 to <2 yrs old), cows, young bulls, and mature (or "prime") bulls. Calves were distinguished by their small body size and relatively short, rounded face. Yearlings were intermediate-sized caribou with a straight face profile. Young bulls were small-bodied males and had antlers roughly less than the height of the shoulder to the ground (fall) or still had antlers (late winter)[Gunn et al. 2005a]. Cows without antlers (i.e., genetically polled) are sighted occasionally during fall and spring survey and are recorded as "bald" cows (Gunn et al. 2005a). Yearlings are difficult to classify and tend to be recorded opportunistically and not sexed. The number of yearlings classified has been small and were not considered representative of the herd. Because yearlings are also not usually sexed, the yearling count was not incorporated into the calf:cow or bull:cow ratio estimation, and therefore ignored, except for in the total count of classified caribou.

Although a bull:cow ratio was initially calculated in previous summaries in some of the earlier spring surveys, no search effort was made to specifically find bulls. Because bulls segregate themselves in smaller groups after the rut and are more spatially dispersed, a bull:cow ratio during these late winter/spring surveys is not likely representative of a herd's true sex ratio. Furthermore, in later years, small groups of caribou visually confirmed to be bulls were often ignored and consequently not

recorded. Therefore, bull:cow ratios were not provided for spring composition survey statistics, however, these values can be easily calculated from the information provided in each survey summary should this parameter be desired.

Beginning with the Bluenose East caribou 2013 fall composition survey, we used a Trimble Yuma 2 rugged tablet to enter observations and obtain GPS waypoints. Aerial survey specific software, Aerial Wildlife Survey – Observation Collector (AWS-OC), was developed by Caslys Consulting Ltd. (Caslys 2015). The data entry software was a modification of software designed and used by Nunavut biologists during the Queen Maud Gulf (Beverly/Ahiak) calving ground surveys in June 2011 using Dell™ tablets. Since then, further modification by ENR and Caslys lead to the AWS-OC software being implemented in the Bathurst caribou herd calving ground photo census in June 2012 on the Yuma 2 tablets. The AWS-OC offers an efficient, user-friendly interface (e.g., Appendix D) and has now replaced paper-based data collection.

Incidental sightings of wildlife such as moose, wolves, grizzly bears, muskoxen, or wolverines were noted during surveys but only total numbers observed for each survey were provided in this report. Maps showing flight tracks for reconnaissance and composition surveys and observations caribou were created using ArcMap 10.3.1 (ESRI 2015) and are presented in Part 2 of this report. Detailed observation data tables for each composition survey are compiled as supplementary information as Part 3 of this report, and available upon request.

Calculations & statistical analysis
Calf-cow & bull:cow ratios
For each year surveyed, a calf to cow ratio was estimated as the total number of calves divided by the total number of cows and yearling females (Gunn et al. 2005a). Bull to cow ratios were similarly estimated as the sum of the young and prime bulls and male yearlings divided by the total number of cows and yearling females. We ignored yearlings of unknown sex but included them in the total count of all caribou classified. Calf:cow and bull:cow estimates are ratios of two variables taken from a simple random sample. Therefore, rather than a ratio of two simple measurements (e.g., as in taxonomy), the variables used vary among sampling units and therefore must incorporate their means and standard errors (Atchley et al. 1976, Krebs 1989). We provide the proportion of calves in counts (as a percentage) as a separate potential measure of annual recruitment (McCullough 1994). We have made little use of this metric beyond reporting it because we further classify adults by sex to obtain a calf to cow ratio estimate.

Prior to using the Yuma 2 tablets, survey data were entered daily into a spreadsheet and the variance and SE were calculated using Tukey's jackknife estimator, which did not require assumptions about normality of the data (Cochran 1977:178; Krebs 1989:464; Sokal & Rolf 1981:796). A t-statistic with degrees of freedom as one minus the number of groups was used with these jackknifed estimates to calculate a co-efficient of variation (CV) and symmetrical confidence intervals. With the switch to the tablet in October 2013, data entry occurs on the fly and the ratio estimates and CV fields are instantly updated and available, which can assist survey effort in real time. However, resampling via bootstrapping (Efron 1987, Davison & Hinkley 1997, Puth et al 2015) offers a better method to calculate these confidence intervals because it does not assume normality and allows the interval to be asymmetrical. Therefore, we used bootstrapping to re-calculate all estimates of SE and corresponding confidence intervals for all calf:cow and bull:cow ratios reported here. We used package "boot" (Canty & Ripley 2016) in program R 3.3.0 (R Core Team 2016) to do this. Consequently, we resampled 10,000 times each seasonal data set using each caribou group surveyed as the sample unit (Samuel et al. 1992)

to generate percentile-based confidence limits (Manly 1997, Puth et al. 2015). An example of the R code used for this analysis is given in Appendix 1.

Co-efficient of variation (CV)

The CV is useful for comparing uncertainty in estimates because it describes the dispersion of a variable without depending on its measurement unit to do so. This allows CVs to be compared to each other in ways that other measures (e.g., standard deviations, root-mean-squared residuals) cannot (UCLA: Statistical Consulting Group, from
http://www.ats.ucla.edu/stat/mult_pkg/faq/general/coefficient_of_variation.htm [last accessed 21 July 2016]). The CV of an estimate is calculated as the ratio between the standard error (SE) and the actual estimate, and often expressed as a percentage. The higher the CV, the greater the dispersion is in the variable.

RESULTS

Spring 2006

Bathurst caribou

A reconnaissance flight occurred on 22 March 2006 with the composition survey starting six days later. Composition flights occurred from 28-31 March and on 04 April, and spanned a wide geographic range from Wekweeti, through Gordon Lake, and easterly past Reliance and to Eileen Lake (Fig. A1). The flight loop (856 km, 8.4 hrs.) between Yellowknife and Wekweeti occurred on 04 April to include the area where Bathurst caribou collar 167 (PTT 45902) was located. There were 14 collared caribou from the Bathurst herd, 16 collared individuals from the Bluenose East herd, and 20 collared caribou from the Ahiak herd during the survey period that helped direct survey coverage (Fig. A1).

We classified 9,913 caribou in 378 groups, comprising 7,483 cows, 645 calves, 1,783 bulls and 3 yearlings. Among the bulls, 965 were young bulls while 818 were prime bulls. We observed 243 antlerless ("bald") cows. Group sizes of caribou that were classified ranged from 1 to 158, with a median of 18. The calf:cow ratio was 0.086 (SE=0.007) with a confidence interval of 0.072 to 0.102 (Table 1) and a CV of 8.1%. The percentage of calves in the sample was 6.5%. Total distance flown for the composition survey was 3,760 km in 31.4 hours.

Incidental sightings of wildlife included 27 wolves (group sizes 1, 1, 1, 1, 1, 3, 4, 5, 5, 5), 3 moose (1 group), 1 wolverine (at a kill site), and 27 muskoxen. Among the 27 wolves sighted, 9 of them (2 groups of 4 and 5 wolves) were at kill sites. Twelve other kill sites were noted but no wolves were observed at them (just the wolverine at one of the kill sites).

Fall 2006

Bathurst caribou

A reconnaissance flight occurred on 20 October 2006 and the composition survey conducted from 23-25, 30 October. Caribou had moved southwest since the reconnaissance survey three days earlier and were concentrated in two main areas, north of Wekweeti and southwest of Wekweeti (Fig. A2). There were 14 collared caribou from the Bathurst herd, 12 collared individuals from the Bluenose East herd, 16 collared caribou from the Ahiak herd, and 5 collared caribou from the Beverly herd during the survey period that helped direct survey coverage (Fig. A2).

We classified 5,616 caribou in 69 groups, comprising 3,156 cows, 1,276 calves, 1,151 bulls and 13 yearlings. Among the bulls, 372 were young bulls while 779 were prime bulls. We observed 20 antlerless ("bald") cows. Group sizes of caribou classified ranged from 10 to 447, with a median of 49. The calf:cow ratio was 0.402 (SE=0.023) with a confidence interval of 0.360 to 0.451 (Table 2) and a CV of 5.7%. The percentage of calves in the sample was 22.7%. The bull:cow ratio was 0.362 (SE=0.021) with a confidence interval of 0.323 to 0.404 (Table 2) and a CV of 5.2%. Total distance flown for the composition survey was 2,997 km in 24.5 hours.

Incidental sightings of wildlife included 11 wolves (groups sizes 3, 8), 1 grizzly bear at a kill site, 8 moose (group sizes 5, 2, 1), and 3 wolverines. Wolves were heard howling at two sites where we landed for ground classification. About 50 caribou were observed south of Greenstockings Lake, west of where the composition survey began and therefore were not included in the classification total.

Spring 2007

Bathurst caribou

A reconnaissance flight occurred on 27 March 2007 and the composition survey occurred from 28-30 March. Caribou were concentrated in three main areas during the survey. One cluster was located north of Lac Grandin, a second group was strung out to the northeast of Gameti, and a third cluster south of Indin Lake (Fig. A3). There were 21 collared caribou from the Bathurst herd, 14 collared individuals from the Bluenose East herd, and 16 collared caribou from the Ahiak herd during the survey period that helped direct survey coverage (Fig. A3). Deployment of nine new collars (cows) on Bathurst caribou occurred from 13-17 March (J. Williams, ENR, pers. comm.).

We classified 10,121 caribou in 133 groups, comprising 7,001 cows, 2,576 calves, 530 bulls and 14 yearlings. Among the bulls, 318 were young bulls while 212 were prime bulls. We observed 89 antlerless ("bald") cows. Group sizes of caribou that were classified ranged from 10 to 762, with a median of 45. The calf:cow ratio was 0.368 (SE=0.021) with a confidence interval of 0.327 to 0.409 (Table 1) and a CV of 5.7%. The percentage of calves in the sample was 25.5%. Total distance flown for the composition survey was 2,011 km in 19.2 hours.

Incidental sightings of wildlife included 13 wolves (group sizes 1, 1, 5, 6), 2 moose (group sizes 1, 1), 1 wolverine, 2 bald eagles, and 1 golden eagle. Five kill sites were noted but no wolves were observed at these sites.

Fall 2007

Bathurst caribou

A reconnaissance flight occurred on 20 October 2007 and the composition survey occurred from 24-26, 28 October. Caribou had moved to southwest since the reconnaissance survey four days earlier and were concentrated in two main areas, south of Wekweeti and southwest of Warburton Bay of Mackay Lake (Fig. A4). There were 24 collared caribou from the Bathurst herd, 8 collared individuals from the Bluenose East herd, 16 collared caribou from the Ahiak herd, and 15 collared caribou from the Beverly herd during the survey period that helped direct survey coverage (Fig. A4).

We classified 7,334 caribou in 156 groups, comprising 3,899 cows, 2,151 calves, 1,190 bulls and 94 yearlings. Among the bulls, 520 were young bulls while 670 were prime bulls. We observed 84 antlerless ("bald") cows. Group sizes of caribou that were classified ranged from 3 to 457, with a median of 33. The calf:cow ratio was 0.552 (SE=0.013) with a confidence interval of 0.526 to 0.577 (Table 2) and a CV of 2.4%. The percentage of calves in the sample was 29.3. The bull:cow ratio was 0.305 (SE=0.016) with a confidence interval of 0.275 to 0.337 (Table 2) and a CV of 5.2%. Total distance flown for the composition survey was 2,878 km in 21.0 hours.

Incidental sightings of wildlife included 5 wolves (1 group), 26 moose (group sizes 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 3, 4, 5), 2 wolverines, and 2 grizzly bears (one of which was near a kill site). Three kill sites were noted but no wolves were present at them.

Spring 2008

Bathurst caribou

Reconnaissance flights occurred on 23 and 34 March 2008 and the composition survey occurred from 25-27, 29 March. One main cluster of caribou occurred south of Wekweeti. Some Bathurst caribou collars were west of Gameti in the Grandin Lake area. However, Bluenose East collared caribou were also in that area (Fig. A5). There were 15 collared caribou from the Bathurst herd, 23 collared individuals from the Bluenose East herd, 14 collared caribou from the Ahiak herd, and 12 collared caribou from the Beverly herd during the survey period that helped direct survey coverage (Fig. A5). Deployment of new collars on Bathurst caribou did not occur in the spring, but rather in late fall. However, deployment of 18 new collars (cows) occurred on 26-27 March for Bluenose East caribou (J. Williams, ENR, pers. comm.).

Total distance flown for the composition results not including the 28 March data (west of Gameti) and the morning of 29 March (north of Gameti) because of spatial overlap with the Bluenose East herd (Fig, A5), was 1,970 km in 16.5 hours. In that time, we classified 4,501 caribou in 117 groups, comprising 2,689 cows, 1,336 calves, 418 bulls and 59 yearlings. Among the bulls, 202 were young bulls while 216 were prime bulls. We observed 24 antlerless ("bald") cows. Group sizes of caribou that were classified ranged from 8 to 138, with a median of 30. The calf:cow ratio was 0.497 (SE=0.020) with a confidence interval of 0.458 to 0.538 (Table 1) and a CV of 4.2%. The percentage of calves in the sample was 29.7.

If we include the classification data from 28 March and the morning of 29 March 2008, where overlap occurred with Bluenose East collared caribou, results do change noticeably. The total caribou classified increased to 7,284 caribou in 155 groups, comprising 4,261 cows, 2,357 calves, 554 bulls and 113 yearlings. Among the bulls, 277 were young bulls while another 277 were prime bulls. The observed number of antlerless ("bald") cows increased to 45. Group sizes of caribou that were classified ranged from 8 to 200, with a median of 34. The calf:cow ratio was 0.553 (SE=0.018) with a confidence interval of 0.518 to 0.589 and a CV of 3.25%. The percentage of calves in the sample was 32.4. Total distance flown for the composition survey including all dates was 2,678 km in 23.0 hours. However, given the extensive spatial overlap with Bluenose East caribou west and north of Gameti, omitting the 28 March and morning of 29 March data for Bathurst caribou survey results is recommended given that a reasonable sample size was obtained for Bathurst caribou in the area of no confounding overlap.

Incidental sightings of wildlife not including the 28th and morning of 29th March (due to overlap with Bluenose East caribou) comprised 62 wolves (group sizes 2, 3, 3, 4, 5, 6, 6, 6, 8, 9, 10), 4 moose (group sizes 1, 1, 2), and 1 wolverine. Two kill sites by wolves were noted but no wolves observed there (just

the wolverine that was sighted). If we include the incidental sightings from 28-29 March, an additional 9 wolves (group sizes 1, 2, 6), 6 moose (group sizes 1, 1, 2, 2), 2 wolverines, and 1 bald eagle were observed.

Fall 2008

Bathurst caribou

Reconnaissance flights occurred on 08 and 20 October 2008 and the composition survey occurred from 21-24 October. The 08 October flight was too early for it to be the only reconnaissance flight because daily travel of caribou is high during the fall migration, although the flight revealed cluster formations of caribou. Weather was above normal for the week prior and virtually all the snow on the ground had melted. The tundra was virtually snow-free up to the southern half of Contwoyto Lake, Nunavut. Ptarmigan were abundant and exceptionally visible on the tundra and shrubs without snow. The reconnaissance flight on 20 October better determined target areas during the composition survey. Caribou concentrated around Courageous Lake and in a couple of areas east of Contwoyto Lake (Fig. A6). Another cluster of about 1,000 caribou were observed on the west side of Contwoyto southeast of the closed Lupin mine site during the 20 October flight but we could not fly there due to extensive fog.

There were 10 collared caribou from the Bathurst herd, 28 collared individuals from the Bluenose East herd, and 46 collared caribou from the Ahiak/Beverly herd during the survey period that helped direct survey coverage (Fig. A6). Deployment of 15 new collars (cows) on Bathurst caribou occurred on 18 November (J. Williams, ENR, pers. comm).

We classified 3,645 caribou in 46 groups, comprising 2,145 cows, 684 calves, 813 bulls, and 3 yearlings. Among the bulls, 380 were young bulls while 433 were prime bulls. We recorded 32 cows without antlers ("bald"). Group sizes of caribou that were classified ranged from 2 to 541, with a median of 43. The calf:cow ratio was 0.319 (SE=0.018) with a confidence interval of 0.288 to 0.356 (Table 2) and a CV of 5.6%. The percentage of calves in the sample was 18.8 (SE= 0.912). The bull:cow ratio was 0.379 (SE=0.024) with a confidence interval of 0.331 to 0.427 (Table 2) and a CV of 6.3%. Total distance flown for the composition survey was 2,240 km over an estimated 15.3 hours.

Incidental sightings of wildlife included 11 wolves (group sizes 1, 2, 3, 5), 18 muskoxen (group sizes 7, 11), 1 wolverine, 2 red foxes (both with dark pelage), and 2 grizzly bears (one which was likely close to a kill site because of the many ravens nearby).

Spring 2009

Bathurst caribou

A reconnaissance flight occurred on 24 March 2009 and the composition survey from 25-26, 28 March. Caribou were concentrated in two main areas during the survey (Fig. A7). One cluster was located east of Wekweeti. A second group was east of Contwoyto Lake, an area occupied there since fall. A small cluster of caribou were located east of Gameti. There were 22 collared caribou from the Bathurst herd, 33 collared individuals from the Bluenose East herd, 28 collared caribou from the Ahiak herd, and 14 collared caribou from the Beverly herd during the survey period that helped direct survey coverage (Fig. A7). Deployment of three new collars (cows) on Bathurst caribou occurred on 17 April (J. Williams, ENR, pers. comm.).

We classified 5,636 caribou in 100 groups, comprising 3,673 cows, 1,467 calves, and 489 bulls (no yearlings classified). Among the bulls, 310 were young bulls while 186 were prime bulls. We recorded 38 cows without antlers ("bald"). Group sizes of caribou that were classified ranged from 8 to 179, with a median of 45. The calf:cow ratio was 0.399 (SE=0.019) with a confidence interval of 0.363 to 0.438 (Table 1) and a CV of 4.8%. The percentage of calves in the sample was 26.0. Total distance flown for the composition survey was 2,485 km in 22.9 hours.

Incidental sightings of wildlife included 14 wolves (group sizes 1, 2, 5, 6), 9 moose (group sizes 1, 2, 2, 2, 2), 3 wolverines, 1 red fox, 6 muskoxen, and 1 otter. Two kill sites by wolves were noted but no wolves observed there. We saw one harvested caribou on a small lake immediate south of Snare Lake (i.e., by people). We saw two dead caribou, possibly ones that died of injuries, about 7½ km to the northeast from the harvest site, near the southern shoreline of Snare Lake (east end).

Bluenose East caribou

Reconnaissance flights occurred from 25 February to 03 March 2009 and the composition survey was from 28-30 March (Fig. A8). Reconnaissance survey flights were split between the North Slave and Sahtu regional staff. Reconnaissance flights were transect-based to more completely map out the general distribution and abundance of caribou for subsequent deployment of radio-collars. The composition survey was conducted by the Sahtu Region. While cows, calves, and bulls were classified, further classification of cows (antlered vs. non-antlered) and bulls (small vs. prime) was not done.

The reconnaissance survey conducted by the Sahtu region was based out of Deline and focused on the peninsula between the Dease Arm and the McTavish Arm of Great Bear Lake, the shore line along the peninsula containing the Sweet Grass Hills, and south of Deline to the west side and northern tip of Keller Lake (Fig. A8). The reconnaissance effort by the North Slave Region was based out of Gameti and went from the Etna and Grandin Lakes, eastward past Hottah Lake and up to Indin Lake. Transects ended north near Port Radium and Akaitcho and Morceau lakes (ca. 80 km west of Napaktulik Lake (Fig. A8). The composition survey focused on the areas east of Keller Lake, to Hottah Lake, and up to the Port Radium area (Fig. A8).

There were 34 collared caribou from the Bluenose East herd and 24 collared individuals from the Bathurst herd during the survey period that also helped direct survey coverage (Fig. A8). Deployment of 41 new collars (29 cows, 12 bulls) on Bluenose East caribou occurred from 11-21 March (J. Williams, ENR, pers. comm).

We classified 6,110 caribou in 97 groups, comprising 3,653 cows, 1,403 calves, and 1,054 bulls (no yearlings classified). Group sizes of caribou that were classified ranged from 3 to 558, with a median of 33. The calf:cow ratio was 0.384 (SE=0.014) with a confidence interval of 0.356 to 0.412 (Table 1) and a CV of 3.6%. The percentage of calves in the sample was 23.0. Total distance flown for the composition survey was 2,384 km in 17.5 hours.

Incidental sightings of wildlife included 29 wolves (group sizes 1, 1, 1, 2, 2, 2, 2, 4, 5, 9), two groups of 2 moose, 3 wolverines, and 1 golden eagle. One kill site with one wolf (included in total) was observed.

Fall 2009

Bathurst caribou
A fall composition survey for Bathurst caribou herd was not done in 2009. Instead, survey efforts were redirected to the Bluenose East herd to augment its monitoring.

Bluenose East caribou
A reconnaissance flight was done on 16 October 2009 and the composition survey was flown on 19-20 October. For the reconnaissance survey, caribou were scattered south of Acasta Lake, through to Exmouth Lake and down to Rodrigues Lake. These caribou had moved southwest and were about 80 km northeast of Gameti during the composition survey (Fig. A9). There were 22 collared caribou from the Bluenose East herd and 10 collared individuals from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A9). The area enclosing all the caribou classified and collared Bluenose East caribou was relatively small at approximately 4,300 km^2.

For the Bluenose East herd, we classified 4,531 caribou in 79 groups, comprising 2,399 cows, 1,104 calves, and 1,028 bulls. We did not distinguish yearlings. Group sizes of caribou that were classified ranged from 3 to 345, with a median of 46. The calf:cow ratio was 0.460 (SE=0.017) with a confidence interval of 0.427 to 0.495 (Table 4) and a CV of 3.7%. The percentage of calves in the sample was 24.4. The bull:cow ratio was 0.429 (SE=0.017) with a confidence interval of 0.396 to 0.463 (Table 4) and a CV of 4.0%. Total distance flown for the composition survey was 1,693 km in 13.2 hours.

Incidental sightings of wildlife included 9 moose (group sizes 1, 1, 1, 1, 2, 3), 1 grizzly bear, 1 red fox, and 1 bald eagle. No wolves were sighted. One kill site on ice was observed near where the bald eagle was flying.

Spring 2010

Bathurst Caribou
Reconnaissance flights occurred on 15-16, and 19 March 2010 and the composition survey on 31 March and 03 April. Reconnaissance flights were transect-based to more completely map out the general distribution and abundance of caribou for subsequent deployment of radio-collars. Bathurst caribou were spread out along a northwest to southeast direction from Indin Lake through Upper Carp Lake to Payne Lake (Fig. A10). There were 23 collared caribou from the Bathurst herd, 47 collared individuals from the Bluenose East herd, and 23 collared caribou from the Ahiak herd during the survey period that helped direct survey coverage (Fig. A10). Deployment of 15 new collars (cows) on Bathurst caribou occurred from 31 March to 02 April (J. Williams, ENR, pers. comm).

For the Bathurst herd, we classified 1,819 caribou in 53 groups, comprising 1,041 cows, 509 calves, and 269 bulls (no yearlings classified). Among the bulls, 156 were young bulls while 113 were prime bulls. We recorded 29 cows without antlers ("bald"). Group sizes of caribou ranged from 4 to 160 individuals, with a median of 25. The calf:cow ratio was 0.489 (SE=0.021) with a confidence interval of 0.449 to 0.532 (Table 1). The percentage of calves in the survey was 28.0. The CV was 4.4%. Total distance flown for the composition survey was 1,335 km in 10.8 hours.

Incidental sightings of wildlife included 28 wolves (group sizes 1, 1, 2, 2, 2, 2, 3, 3, 4, 8), 1 moose, and 1 bald eagle. Of the 28 wolves, 7 were observed at kill sites (n=3). Another 5 kill sites were observed but no wolves were sighted at them. Two hunters on snowmobiles were observed on Smokey Lake.

Bluenose East caribou

Reconnaissance flights occurred from 17-18 March 2010 and the composition survey from 06-07 April. Reconnaissance flights were transect-based to more completely map out the general distribution and abundance of caribou for subsequent deployment of radio-collars. Coverage in the Bluenose East was a westward extension of effort from the Bathurst coverage (Fig. A10, A11). North-south transects that were flown began at Gameti and then ran westward past Keller Lake. These transects were flown north up to Hottah Lake and the McVicar arm of Great Bear Lake, and as far south as the north shore of Lac la Martre and Tseepantee Lake (Fig. A11).

There were 36 collared caribou from the Bluenose East herd and 21 collared individuals from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A11). Deployment of 17 new collars (11 cows, 6 bulls) on Bluenose East caribou occurred from 01-02 April (J. Williams, ENR, pers. comm.). The composition survey occurred northwest of Gameti . Concentration of caribou was heaviest in the Grandin/Etna lakes area. Caribou were also prevalent along the southwestern shore of Hottah Lake and the northeast side of Keller Lake (Fig. A11). Total distance flown for the composition survey was 1,882 km in 13.9 hours.

For the Bluenose East herd, we classified 6,597 caribou in 100 groups, comprising 4,047 cows, 1,887 calves, and 663 bulls (no yearlings classified). Among the bulls, 413 were young bulls while 250 were prime bulls. We recorded 57 antlerless ("bald") cows. Group sizes of caribou ranged from 3 to 264 individuals, with a median of 43. The calf:cow ratio was 0.466 (SE=0.012) with a confidence interval of 0.444 to 0.489 (Table 3) and a CV of 2.6%. The percentage of calves in the survey was 28.6. Total distance flown for the composition survey was 1,882 km in 13.9 hours.

Only one moose was sighted as incidental sightings of wildlife. No wolves were sighted but 9+ kill sites were observed. One caribou harvest kill site was observed and some other harvest sites were apparent in the area (i.e., sighted from a distance).

Fall 2010

No surveys for either Bathurst caribou or Bluenose East caribou.

Spring 2011

Bathurst caribou

Reconnaissance flights occurred on 01-02 April and the composition survey on 04-05 April 2011. There were 14 collared caribou from the Bathurst herd and 26 collared individuals from the Bluenose East herd during the survey period that helped direct survey coverage. The collared caribou showed an overlap with the adjacent Bluenose East herd to the northwest (Fig. A12). Consequently, the composition survey did not go further northwest beyond Brown Water Lake (about 90 km northeast of Gameti). Classification of caribou, presumable mostly from Bathurst herd, proceeded in a southeasterly direction to Armi and Upper Carp lakes area (Fig. A12). Note, however, that Bluenose East collared caribou were scattered throughout that distribution. Deployment of 13 new collars (cows) on Bathurst caribou occurred on 4-5 April (J. Williams, ENR, pers. comm.).

For the Bathurst herd, we classified 2,758 caribou in 89 groups, comprising 1,279 cows, 598 calves, and 867 bulls (no yearlings classified). Among the bulls, 455 were young bulls while 412 were prime bulls. We observed 14 antlerless ("bald") cows. Group sizes of caribou ranged from 3 to 105 individuals, with a median of 23. The calf:cow ratio was 0.462 (SE=0.019) with a confidence interval of 0.426 to 0.499 (Table 1) and a CV of 4.1%. The percentage of calves in the survey was 21.7. Total distance flown for the composition survey was 1,895 km in 13.4 hours.

Incidental sightings of wildlife included 12 wolves (group sizes 2, 2, 4, 4), 2 moose, and 1 bald eagle. Three kill sites were observed but with no wolves sighted at them.

Bluenose East caribou

Reconnaissance flights occurred on 01-02 April and the composition survey on 07-08 April 2011. There were 21 collared individuals from the Bluenose East herd and 18 collared caribou from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A13). These collars revealed significant overlap between Bluenose East caribou and the adjacent Bathurst caribou herd. A judgment call was made to use Little Crapeau Lake as the eastern extent of the Bluenose East herd for classification purposes. Caribou located 20 km away at Brown Water Lake were classified as Bathurst caribou (Fig. A13). Deployment of only one new collar (a cow) on Bluenose East caribou occurred 04 April 2011 (J. Williams, ENR, pers. comm).

For the Bluenose East herd, we classified 5,846 caribou in 63 groups, comprising 3,295 cows, 1,366 calves, and 1,185 bulls (no yearlings classified). Among the bulls, 843 were young bulls while 342 were prime bulls. We recorded 47 antlerless ("bald") cows. Group sizes of caribou ranged from 4 to 424 individuals, with a median of 63. The calf:cow ratio was 0.415 (SE=0.016) with a confidence interval of 0.385 to 0.449 (Table 3) and a CV of 3.9%. The percentage of calves in the survey was 23.4. Total distance flown for the composition survey was 1,310 km in 11.5 hours.

Incidental sightings of wildlife included 19 wolves (group sizes 1, 1, 2, 4, 11) and 3 instances of 1 moose. Six kill sites were observed but with no wolves sighted at them. A kill site was observed with the group of 11 wolves (near Hottah Lake). Two of these wolves were white, the rest were black and could be boreal wolves. There could have been a 12th wolf in that group but could not be confirmed. Similarly, the observer was not certain if there were 4 or 5 wolves in the second group.

Fall 2011

Bathurst caribou

The fall composition survey occurred on 23 and 25-26 October 2011. There was no reconnaissance flight prior to the survey due to adverse weather. Consequently, we relied exclusively on the distribution of collared caribou and our observations during the composition survey to obtain a representative sample. There were 10 collared caribou from the Bathurst herd and 8 collared individuals from the Bluenose East herd during the survey period that helped direct survey coverage (Fig. A14).

Caribou were located from the east side of Jolly Lake and eastward to Mackay Lake and southwest of Lake of the Enemy (Fig. A14). There was no significant overlap between Bluenose East and Bathurst caribou at the time of the survey. However, one collared caribou (Id # 7062) with GPS collar PTT 91497

was located with the Bathurst collared cows. This caribou (Id# 7062) was classified as a Bathurst herd caribou in 2010 because it was on the Bathurst calving ground that summer. However, this caribou went on the Bluenose East calving ground in 2011 and therefore was re-assigned as a Bluenose East caribou. Its last reported location occurred on 18 Dec 2011, when its collar failed. Therefore, we don't know where this caribou calved in 2012.

For the Bathurst herd, we classified 4,965 caribou in 52 groups, comprising 2,598 cows, 859 calves, and 1,508 bulls (no yearlings classified). Among the bulls, 681 were young bulls while 827 were prime bulls. We observed 39 antlerless ("bald") cows. Group sizes of caribou ranged from 1 to 924 individuals, with a median of 48. The calf:cow ratio was 0.331 (SE=0.016) with a confidence interval of 0.298 to 0.359 (Table 2) and a CV of 4.8%. The percentage of calves in the survey was 17.3. The bull:cow ratio was 0.580 (SE=0.034) with a confidence interval of 0.524 to 0.653 (Table 2) and a CV of 5.9%. Total distance flown for the composition survey was 1,398 km in 9.8 hours.

Incidental sightings of wildlife included 27 wolves (group sizes 1, 1, 1, 2, 9, 13) and 4 red foxes. One of these wolves occurred just outside of Yellowknife, on a trail south of Walsh Lake. Consequently, this wolf is not associated with the Bathurst caribou and probably should be removed from the total number sighted. One caribou cow was observed north of Warburton Bay, Mackay Lake, about 10 minutes southwest of the initiation of the composition survey, and seemingly out-of-place.

Spring 2012

Bathurst caribou
Reconnaissance flights occurred on 11, 13-14 March 2012 and the composition survey on 28 March and 02 April. Reconnaissance flights were again transect-based to more completely map the general distribution and abundance of caribou for subsequent deployment of radio-collars (Fig. A15). The northern and southern limits of the transect lines flown were reached when there was 1) an absence of old or fresh tracks at the end of each transect line, 2) no reports of caribou sightings or presence since the fall migration beyond the area surveyed, and 3) no presence of collared animals in the area. Based on this reconnaissance survey, 13 new collars were deployed on cows on 24-25 March.

During the survey period, there were 23 collared caribou from the Bathurst herd and 27 collared individuals from the Bluenose East herd that helped direct survey coverage (Fig A13). There were two main concentrations of Bathurst caribou during the spring survey. One group was centered about the Wecho River from east of the Bousso River toward Bessonette Lake and extending over to the western area of Lower Carp Lake (Fig. A15). The second group was located northeast of Gordon Lake, around Agassiz and Spencer lakes, then southeast to Rolfe Lake and Payne Lake.

For the Bathurst herd, we classified 4,269 caribou in 99 groups, comprising 2,621 cows, 659 calves, 988 bulls, and 1 yearling. Among the bulls, 490 were young bulls while 498 were prime bulls. Among the cows, 31 were antlerless ("bald") cows. Group sizes of caribou ranged from 3 to 170 individuals, with a median of 36. The calf:cow ratio was 0.251 (SE=0.013) with a confidence interval of 0.227 to 0.276 (Table 1) and a CV of 5.2%. The percentage of calves in the survey was 15.5. Total distance flown for the composition survey was 1,555 km in 14.5 hours.

Incidental sightings of wildlife included 10 wolves (group sizes 2, 2, 3, 3), 3 moose (group sizes 1, 1, 1), and 1 bald eagle. Five kill sites were observed but with no wolves sighted at them.

Bluenose East caribou

Reconnaissance flights occurred from 05-08 and 10 March 2012 for a total of 30.1 hours flown and 5,629 km travelled (including ferry time). Reconnaissance flights were transect-based, similar to the coverage planned over the Bathurst herd area, to more completely map out the general distribution and abundance of caribou for subsequent deployment of radio-collars (Fig. A16). A significant effort was needed to adequately cover the anticipated winter distribution of Bluenose East caribou this year. One day of flying was needed to survey the area north of Gameti to the northeast side of Great Bear Lake, Dismal Lakes, and Kugluktuk in Nunavut. No presence of fresh or old caribou tracks were observed on the survey path with the exception of about 65 caribou observed on the northeast side of Great Bear Lake.

The most westward transect line on the west side of Keller Lake marked the end of the reconnaissance coverage for the Bluenose East herd (Fig. A16). This was because the number of caribou and fresh tracks (a day after significant snowfall) along surveyed lines had been decreasing steadily in the previous two transects adjacent to the east. In addition, we knew that hunters from Deline had not been reporting any caribou in the area for the previous six weeks and they had concluded that Bluenose East caribou had moved east. This eastward movement of caribou presumed by hunters was confirmed by collared caribou that were observed migrating rapidly from the area towards Etna Lake. Furthermore, weather conditions to the west were deteriorating, so no additional advantage of continuing was expected. Based on the systematic reconnaissance survey, 60 collars were deployed, 42 on cows, and 18 collars on bulls. Collar deployment occurred from 14-23 March. The composition survey was flown on 29 March. There were 65 collared caribou from the Bluenose East herd and 3 collared individuals from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A16).

For the Bluenose East herd, we classified 4,022 caribou in 76 groups, comprising 2,661 cows, 724 calves, and 637 bulls (no yearlings classified). Among the bulls, 436 were young bulls while 201 were prime bulls. We did not observe any antlerless cows ("bald"). Group sizes of caribou ranged from 6 to 248 individuals, with a median of 37. The calf:cow ratio was 0.272 (SE=0.015) with a confidence interval of 0.245 to 0.303 (Table 3) and a CV of 5.5%. The percentage of calves in the survey was 18.0. Total distance flown for the composition survey was 1,090 km in 8.0 hours.

Incidental sightings of wildlife included 15 wolves (group sizes 1, 1, 1, 1, 1, 1, 4, 5) and 1 moose. Six kill sites were observed although no wolves were sighted at them.

Fall 2012

Bathurst caribou

The fall composition survey occurred on 22-24 October 2012. There was no reconnaissance flight prior to the survey due to adverse weather. Consequently, we relied exclusively on the distribution of collared caribou and our observations during the composition survey to obtain a representative sample. There were 15 collared caribou from the Bathurst herd and 21 collared caribou from the Beverly/Ahiak herd during the survey period that helped direct survey coverage. The Beverly/Ahiak collars were far to the east, northeast of Artillery Lake, and therefore having o overlap with the Bathurst caribou (Fig. A17).

Bathurst caribou were organized in three main groups during the composition survey. The main concentration was all along the north shores of Courageous Lake and Starfish Lake (Fig. A17). Some of this group then went south towards Jolly Lake while others to the east travelled past Snake Lake to towards Mackay Lake. Small groups of caribou were observed north on the east side of Yamba Lake and up to the west side of Fry Inlet of Contwoyto Lake. A third group of caribou aligned themselves between Mackay Lake and Outram Lake. We accessed these groups of caribou by basing on out the Snap Lake mine. Although caribou were slightly north of Snap Lake during the survey, they did not make it that far during our stay.

For the Bathurst herd, we classified 4,400 caribou in 33 groups, comprising 2,469 cows, 562 calves, and 1,369 bulls (no yearlings classified). Among the bulls, 610 were young bulls while 759 were prime bulls. We observed 19 antlerless ("bald") cows. Group sizes of caribou ranged from 1 to 818 individuals, with a median of 37. The calf:cow ratio was 0.228 (SE=0.019) with a confidence interval of 0.195 to 0.295 (Table 2) and a CV of 8.3%. The percentage of calves in the survey was 12.8. The bull:cow ratio was 0.554 (SE=0.029) with a confidence interval of 0.498 to 0.613 (Table 2) and a CV of 5.2%. Total distance flown for the composition survey was 1,856 km in 15.6 hours.

Incidental sightings of wildlife included 1 group of 4 wolves, 4 moose (separate occurrences), 1 grizzly bear, and 1 group of about 30 muskoxen. One kill site was observed but with no wolves seen.

Spring 2013

There was no composition survey conducted in Spring 2013 for either the Bathurst or Bluenose East herd. Based on locations of collared caribou, there was too much overlap between the two herds such that herd-specific calf:cow ratios would not be possible. However, deployment of eight new collars (cows) on Bathurst caribou occurred from 25-26 March, but none on Bluenose East caribou (J. Williams, ENR, pers. comm).

Fall 2013

Bluenose East caribou

The fall composition survey occurred on 20, 22-23 October 2013. There was no reconnaissance flight prior to the survey due to adverse weather. Consequently, we relied exclusively on the distribution of collared caribou and our observations during the composition survey to obtain a representative sample. There were 28 collared caribou from the Bluenose East herd and 9 collared individuals from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A18).

Most of the caribou observed were around Exmouth Lake and westward to Wopmay Lake. Another group was located around the Acasta River and towards Dune Lake and southward from there. Smaller groups of caribou were observed at Acasta Lake and northward between Scotstaun and Ardent lakes. No caribou were seen when we circled around Bishop Lake (Fig. A18).

For the Bluenose East herd, we classified 5,369 caribou in 107 groups, comprising 3,000 cows, 1081 calves, 1,278 bulls, and 10 yearlings. Among the bulls, 452 were young bulls while 826 were prime bulls. We observed 12 antlerless ("bald") cows. Group sizes of caribou ranged from 1 to 378 individuals, with a median of 29. The calf:cow ratio was 0.360 (SE=0.014) with a confidence interval of 0.334 to 0.388

(Table 4) and a CV of 3.6%. The percentage of calves in the survey was 20.1.The bull:cow ratio was 0.426 (SE=0.018) with a confidence interval of 0.390 to 0.461 (Table 4) and a CV of 4.2%.

This was the first use of the Yuma 2 tablet with the Aerial Wildlife Survey - Observation Collector (AWS-OC) software prepared by Caslys Consulting Ltd. for ENR (Caslys 2015). The GPS log from the tablet was only used doing the data observation and therefore was not turned on at the beginning or end of the survey to record the complete track file. Nonetheless, a separate GPS is always used to track our entre flight. Consequently, flight track distances based on the tablet GPS log files are abbreviated and were 620 km, 513 km and 423 km for 20, 22, and 23 October respectively, for a total distance of 1,556 km and times of 5.4, 5.4, and 3.9 hours respectively (14.7 hours total). When the flight tracks are added for the positioning from Yellowknife to the start of the observational data recording (tablet), the total distance flown becomes 2,142 km. The total flight time for the entire survey was 16.2 hours.

Incidental sightings of wildlife included 7 wolves (group sizes 2, 2, 3), 7 moose (group sizes 1, 1, 1, 2, 2), 1 grizzly bear, 1 wolverine, and 1 red fox. No kill sites were observed.

Spring 2014

Bathurst caribou

Reconnaissance flights occurred on 04-05, and 07 March 2014 and the composition survey from 10-12 March. Reconnaissance flights were again transect-based to more completely map the general distribution and abundance of caribou for subsequent deployment of radio-collars. Prior to the survey, there were 8 collared caribou from the Bathurst herd, 17 collared individuals from the Bluenose East herd, 6 collared caribou from the Ahiak herd, and 2 collared individuals from the Beverly herd during the survey period that helped direct survey coverage (Fig. A19). Fifteen collars were deployed on female caribou in the Bathurst range from 11-13 March (J. Williams, ENR, pers. comm.).

Caribou observed were concentrated in two main areas. One area was between the Wecho river south of Armi Lake and up to Snare Lake. The second area occurred east of Gordon Lake to the Beaulieu River and Perlson Lake (Fig. A19).

For the Bathurst herd, we classified 2,323 caribou in 87 groups, comprising 1,505 cows, 490 calves, 325 bulls, and 3 yearlings. Among the bulls, 195 were young bulls while 130 were prime bulls. We observed 17 antlerless ("bald") cows. Group sizes of caribou ranged from 2 to 159 individuals, with a median of 19. The number of groups classified was relatively low because the area of overlap between Bathurst caribou and adjacent herds were not covered to avoid misclassifying caribou from other herds. The calf:cow ratio was 0.326 (SE=0.015) with a confidence interval of 0.298 to 0.355 (Table 1) and a CV of 4.6%. The percentage of calves in the survey was 21.1. Total distance flown for the composition survey was 1,694 km in 15.7 hours.

Incidental sightings of wildlife included 5 wolves (group sizes 1, 4), 6 moose (group sizes 1, 1, 1, 1, 2), and 1 group of 15 muskoxen. No kill sites were observed.

Bluenose East caribou

A reconnaissance flight occurred on 06 March using transects. This effort was combined with the Bathurst area reconnaissance survey to the east so that a more complete map could be generated of the

general distribution and abundance of caribou for subsequent deployment of radio-collars in both areas. The composition survey occurred on 12-13 March. Caribou were found south of Hottah Lake and westward to Etna Lake and slightly beyond. A separate group of caribou was also located northeast of Keller Lake beyond the reconnaissance area from the week before (Fig. A20). There were 17 collared caribou from the Bluenose East herd, 7 collared individuals from the Bathurst herd, and 6 collared caribou from the Ahiak herd during the survey period that helped direct survey coverage (Fig. A20). Collars (8 females, 7 males) were deployed on Bluenose East caribou from 13-16 March.

For the Bluenose East herd, we classified 5,120 caribou in 142 groups, comprising 3,388 cows, 1,011 calves, 720 bulls, and 1 yearling. Among the bulls, 499 were young bulls while 221 were prime bulls. We observed 26 antlerless ("bald") cows. Group sizes of caribou ranged from 2 to 343 individuals, with a median of 18. The calf:cow ratio was 0.298 (SE=0.016) with a confidence interval of 0.270 to 0.332 (Table 3) and a CV of 5.4%. The percentage of calves in the survey was 19.7. Total distance flown for the composition survey was 1,339 km in 13.1 hours.

Incidental sightings of wildlife included 35 wolves (group sizes 2, 2, 3, 3, 3, 5, 8, 9) and 9 moose (group sizes 1, 1, 1, 1, 1, 2, 2). No kill sites were observed.

Fall 2014

Bathurst caribou
There were 15 collared caribou from the Bathurst herd and 28 collared individuals from the Bluenose East herd during the survey period that were used to help direct survey coverage (Fig. A21). However, no reconnaissance flight was possible because of adverse weather for fixed wing flying. The composition survey occurred on 22 October 2014. Caribou observed were concentrated from Starfish Lake to the north shore of Jolly Lake (Fig. A21). Some collared caribou from the Bathurst herd were still in Nunavut towards Nose Lake and Beechy Lake (Back River). We were unable to reach these areas because of icing conditions. On 27 October, we officially ended the composition survey because we were nearing the expected end of the rut and segregation of the bulls was increasingly likely.

For the Bathurst herd, we classified 2,927 caribou in 30 groups, comprising 1,679 cows, 425 calves, and 823 bulls (no yearlings classified). Among the bulls, 274 were young bulls while 549 were prime bulls. We observed 25 antlerless ("bald") cows. Group sizes of caribou ranged from 4 to 292 individuals, with a median of 65. The calf:cow ratio was 0.253 (SE=0.019) with a confidence interval of 0.213 to 0.287 (Table 2) and a CV of 7.5%. The percentage of calves in the survey was 14.5. The bull:cow ratio was 0.490 (SE=0.025) with a confidence interval of 0.444 to 0.540 (Table 2) and a CV of 5.1%. Total distance flown for the composition survey was 1,112 km in 6.6 hours.

Incidental sightings of wildlife included 18 wolves (group sizes 1, 2, 5, 10) only. No other sightings, including kill sites, were observed.

Spring 2015

Bathurst caribou
An extensive reconnaissance survey was flown from 23-27 February 2015 using transects to map caribou distribution for new collar deployment for Bathurst, Bluenose East and Beverly herds. Transects were

spaced 20 km apart and spanned from Deline in the west to past Kennady Lake in the east (Fig. A22). The reconnaissance effort specific to the Bathurst caribou area occurred from 25-27 February.

Bathurst caribou were concentrated south of Snare Lake in the Wecho Lake/Wecho River area, east over to Tsan Lake, and south to Thetis Lake and The Nine Lakes. Bathurst caribou were also concentrated in a separate group around Delmar Lake and eastward to Wolverine Lake (Fig. A22). At the time, there were 14 collared caribou from the Bathurst herd, 22 collared individuals from the Bluenose East herd, and 1 collared individual from the Beverly/Ahiak herd during the survey period that also helped direct and interpret the composition survey coverage (Fig. A22). Consequently, caribou further east in the Gahcho Kue/Hoarfrost River area were thought to be from the Beverly herd. This interpretation was also based on collared caribou from the Beverly herd that had moved into the Reliance area earlier in December. Some of these Beverly caribou may have navigated around the recent burn there and travelled northwest.

Deployment of 40 new collars (21 cows, 19 bulls) on Bathurst caribou occurred from 13-17 March (J. Williams, ENR, pers. comm). The additional collars deployed reflected agreement to increase the number of collars on Bathurst caribou to 50, 30 of which would be cows. It was all the first time that bulls were collared.

The composition survey occurred from 05-07 March after leaving Gameti once the Bluenose East survey was done. Although there were 4 collared Bluenose East caribou in the Wekweeti area, we believed that most of the caribou in that area were Bathurst caribou. Therefore, we considered the area of caribou distribution south of Wekweeti and east of Gordon Lake, but west of Gahcho Kue, as belonging to the Bathurst herd (Fig. A22). However, collar deployment on caribou after the composition survey, and their herd affiliation that was revealed later in June when on the calving grounds, showed more overlap between the Bluenose East and Bathurst herds than anticipated. Although this area could be dropped from the analysis, doing so would only leave the area east of Gordon Lake for exclusively Bathurst caribou. In that area, only 11 groups were located and classified (group size from 5 to 51), which only totaled 201 caribou. With only 27 calves and 87 cows classified in the area, the calf:cow ratio was 0.310, and the percentage of calves 13.4. Although these parameters are similar to the estimates from the larger analysis, sample is too low to be reliable. Consequently, the composition survey for the Bathurst herd in spring 2015 should be interpreted with caution, because of the overlap with the Bluenose East herd. Nevertheless, the calf:cow and % calves estimates for the Bluenose East herd were near identical to those for the Bathurst caribou.

For the Bathurst herd, we classified 2,742 caribou from 84 groups, comprising 1,772 cows, 417 calves, and 553 bulls (no yearlings classified). Among the bulls, 282 were young bulls while 271 were prime bulls. We observed 14 antlerless ("bald") cows. Group sizes of caribou ranged from 3 to 165 individuals, with a median of 20. The calf:cow ratio was 0.235 (SE=0.013) with a confidence interval of 0.211 to 0.260 (Table 1) and a CV of 5.5%. The percentage of calves in the survey was 15.2. Total distance flown for the composition survey was 1,196 km in 11.0 hours.

Incidental sightings of wildlife included 24 wolves (group sizes 1, 2, 3, 3, 4, 4, 7), 9 moose (group sizes 1, 1, 1, 1, 2, 3), and 1 red fox. Three kill sites were observed in total, with 2 of them having 4 wolves each (included in total wolf count) and one other site with no wolves sighted.

Bluenose East caribou

An extensive reconnaissance survey was flown from 23-27 February 2015 using transects to map caribou distribution for new collar deployment for Bathurst, Bluenose East and Beverly herds. Transects were spaced 20 km apart and spanned from Deline in the west to past Kennady Lake in the east (Fig. A23). The reconnaissance effort that would have targeted the Bluenose East caribou occurred from 23-25 February.

There were 23 collared caribou from the Bluenose East herd and 14 collared individuals from the Bathurst herd during the composition survey period that helped direct survey coverage (Fig. A23). Bluenose East caribou were scattered from Keller Lake in the west through the Grandin River and eastward to Rome Lake. Caribou were also located north of Gameti by Devreker Lake (Fig. A23). These caribou were included in the composition survey but the survey ended after that, given some uncertainties in herd membership. Bluenose East collared cow 14751 was southeast of Little Crapeau Lake. Therefore, the group of caribou further south in the Ingray and Chartrand lakes area were thought to be mostly Bluenose East caribou, but some overlap with the Bathurst herd could have occurred, and this group was not surveyed for their composition. Deployment of 31 new collars (15 cows, 16 bulls) on Bluenose East caribou occurred from 17-20 March (J. Williams, ENR, pers. comm).

The composition survey for Bluenose East caribou occurred 03-04 March. We left Gameti on 05 March, and caribou encountered on our flight east in the Wecho Lake to Upper Carp Lake were omitted from the Bluenose East composition survey because extensive overlap with the Bathurst herd was suspected. Indeed, collar deployment on caribou after the survey, and their herd affiliation that was revealed later on the calving grounds in June, confirmed our suspicions.

From the June 2015 collar locations on calving grounds, our flight track through the caribou concentrations south of Wekweeti appears to have sampled both herds. In hindsight, Bluenose caribou were north of our flight track leaving Gameti on 05 March and extended eastward up until Wekweeti. However, the area south of Snare Lake, was heavily mixed with caribou from both Bluenose East and Bathurst herds.

For the Bluenose East herd, we classified 1133 caribou from 60 groups, comprising 741 cows, 157 calves, and 233 bulls, and 2 yearlings. Among the bulls, 137 were young bulls while 96 were prime bulls. We observed 5 antlerless ("bald") cows. Group sizes of caribou ranged from 1 to 71 individuals, with a median of 13. The calf:cow ratio was 0.212 (SE=0.023) with a confidence interval of 0.168 to 0.258 (Table 3) and a CV of 10.5%. The percentage of calves in the survey was 13.9.

Total distance flown for the composition survey was 1,666 km in 10.4 hours for 03 and 04 March inclusive. The survey effort (407 km, 3.4 hrs) from Gameti to Yellowknife on 05 March is shown separately here because of overlap of Bluenose East and Bathurst caribou between Gameti and Wekweeti, and south of Wekweeti (Fig. A23).

Incidental sightings of wildlife included 37 wolves (group sizes 1, 1, 1, 2, 3, 3, 4, 8, 14), 10 moose (8 groups of 1, 1 group of 2), 1 wolverine, 1 red fox, 21 boreal caribou (2 groups: 8 and 13), and 1 great horned owl. No kill sites were observed.

Fall 2015

Bluenose East caribou

The fall composition survey occurred on 28 and 30 October 2015. The flight on October 29th was grounded due to adverse weather. The survey had been delayed a week to allow for the caribou to move further south. Collared caribou suggested that the bulk of the herd was northeast of Great Bear Lake (Fig. A24). We cancelled the reconnaissance flight prior to the survey because of the week delay and the extensive distance required for travel to the area from Yellowknife. Therefore, we relied exclusively on the distribution of collared caribou and our observations during the composition survey to obtain a representative sample. There were 42 collared caribou from the Bluenose East herd, 46 collared caribou from the Bluenose West herd, and 33 collared individuals from the Bathurst herd during the survey period that helped direct survey coverage (Fig. A24).

The survey was based out of Gameti. Our first encounter with caribou occurred with an isolated group of 3 (1 cow, 2 bulls) east of Wopmay Lake. However, the bulk of the Bluenose East caribou herd were located about 100 to 200 km further north of this group. The leading edge of migrating caribou began around Broken Dish Lake and Somandre Lake and continued diagonally northeast through Pellier Lake. Most of the caribou observed were east of Hornby Bay of Great Bear Lake, as suggested by the cluster of collared caribou locations (Fig. A24). The Port Radium airstrip was a geographically optimal site to cache our fuel, given these caribou were distributed relatively far north at this time of year.

For the Bluenose East herd, we classified 4,190 caribou in 51 groups, comprising 2,376 cows, 824 calves, and 990 bulls. Yearlings were not distinguished. Among the bulls, 335 were young bulls while 655 were prime bulls. We observed 3 antlerless ("bald") cows. Group sizes of caribou ranged from 2 to 563 individuals, with a median of 31. The calf:cow ratio was 0.347 (SE=0.015) with a confidence interval of 0.318 to 0.376 (Table 4) and a CV of 4.3%. The percentage of calves in the survey was 19.7.The bull:cow ratio was 0.417 (SE=0.029) with a confidence interval of 0.367 to 0.479 (Table 4) and a CV of 6.9%.

Total distance flown out of Gameti was 1,716 km and required 10.2 hours of helicopter time. Positioning (238 km) from Yellowknife to Gameti (1.2 hrs) and our subsequent return to Yellowknife (1.1 hrs) was not included in these survey totals as caribou were only located north of Gameti.

Incidental sightings of wildlife included 4 wolves (groups sizes 1, 1, 2) once past Gameti, 25 moose (10 groups of 1, 3 groups of 2, and 3 groups of 3), 1 red fox, and 1 bald eagle. Two additional wolves were observed just outside of Yellowknife (north of Long Lake) and not part of the Bluenose East caribou range.

Spring 2016

Bathurst caribou

A reconnaissance survey occurred on 22 March 2016. Although its main purpose was to explore the western distribution of Bluenose East caribou, the latter third of the route was used to assess two northern aggregations of Bathurst caribou, one north of Point Lake and a second by Napaktulik Lake in Nunavut. The return leg of the flight also passed through a concentration of caribou south of Wekweeti. There were 31 collared caribou from the Bathurst herd and 39 collared individuals from the Bluenose East herd that helped direct survey coverage (Fig. A25).

The spring composition survey occurred on 23, 24 and 28 March 2016. A large grouping of caribou south of Wekweeti was observed southeast of Wehcho Lake and north of Armi Lake. Some aggregations of caribou occurred between Reindeer Lake and Phoenix Lake. Further southeast, caribou were concentrated in the Brown Lake area and thereafter spread out more thinly in the Bridge Lake and Spencer Lake areas. Two northern pockets of Bathurst caribou, as identified by collared caribou, occurred north of Point Lake, west of Itchen Lake, and the southeastern shore of Napaktulik Lake (Nunavut).

For the Bathurst herd, we classified 2,233 caribou from 38 groups, comprising 1,693 cows, 339 calves, and 201 bulls (no yearlings classified). Among the bulls, 143 were young bulls while 58 were prime bulls. We observed 20 antlerless ("bald") cows. Group sizes of caribou classified ranged from 3 to 455 individuals, with a median of 28.5. The calf:cow ratio was 0.200 (SE=0.014) with confidence limits of 0.168 to 0.221 (Table 1) and a CV of 7.0%. The percentage of calves in the survey was 15.2. Total distance flown for the composition survey was 2,221 km in 15.7 hours.

Incidental sightings of wildlife included 16 wolves (group sizes 9, 5, 2), 11 moose (group sizes 4, 2, 1, 1, 1, 1, 1), and 1 red fox. Three kill sites were observed in total, one of which had 5 wolves present (included in total wolf count). The other two kill sites had virtually nothing remaining except for a blood stained depression in the snow that was packed down all around it.

Sixteen caribou (9 cows, 7 bulls) were newly collared in late March 2016 on the Bathurst caribou winter range. Another four caribou (2 cows, 2 bulls) were collared in an overlap area with the adjacent Bluenose East herd and remains to be seen how these four collared caribou separate out between the two herds.

Bluenose East caribou

A reconnaissance survey occurred on 22 March 2016, primarily to assess the extent of the western distribution of Bluenose East caribou for both the composition survey effort and new collar deployment. However, part of the reconnaissance effort was used to explore the extent of two northern pockets of collard Bathurst caribou. There were 39 collared individuals from the Bluenose East herd and 31 collared caribou from the Bathurst herd that helped direct survey coverage (Fig. A26).

The spring composition survey occurred on 25 and 26 March 2016. The majority of the herd occurred between Hardisty and Hottah lakes and to the northeast from there between Ellington Lake and Devreker Lake. This eastern distribution also extended in a string of sightings from the north end of Ingray Lake north to Little Crapeau Lake. A northern pocket of caribou occurred on the Northeast peninsula of Great Bear Lake, between the Dease Arm and McTavish Arm. Most observations there consisted of bulls, as indicted by the collared caribou present, but some mixed groups were also observed.

For the Bluenose East herd, we classified 2,519 caribou from 77 groups, comprising 1,781 cows, 568 calves, and 170 bulls (no yearlings classified). Among the bulls, 109 were young bulls while 74 were prime bulls. We observed 12 antlerless ("bald") cows. Group sizes of caribou ranged from 1 to 216 individuals, with a median of 21. The calf:cow ratio was 0.319 (SE=0.020) with confidence limits of 0.284 to 0.363 (Table 3) and a CV of 6.3%. The percentage of calves in the survey was 22.5. Total distance flown for the composition survey was 2,297 km in 15.1 hours.

Incidental sightings of wildlife included 11 wolves (group sizes 3, 2, 2, 2, 1, 1), and 9 moose (group sizes 2, 2, 2, 1, 1, 1). Eleven kill sites of wolves were observed in total, but only one of them had wolves (2) currently present (included in total wolf count). The other 10 kill sites had virtually nothing remaining except for the characteristic blood stained depression in snow where the carcass had been and with hard packed snow all around it.

Twelve caribou (10 cows, 2 bulls) were newly collared in late March 2016 on the Bluenose East winter range. Another four caribou (2 cows, 2 bulls) were collared in an overlap area with the adjacent Bathurst herd and remains to be seen how these four collared caribou separate out between the two herds.

Summary of Seasonal Compositional Surveys

Late winter/spring composition surveys for the Bathurst herd from 2006 to 2016 showed significant fluctuations in cow:calf ratios and percentage of calves observed over the last 11 years of monitoring (Table 1). The total number of groups classified dropped noticeably since 2009 as it became harder to locate independent groups given the concomitant decrease in size of the herd. An apparent decline in Bathurst calf:cow ratios was also suggested from the six fall composition surveys (Table 2, Fig. 1). The bull:cow ratios for the Bathurst herd showed more modest fluctuations among years, with the ratios from 2011 to 2015 appearing higher than previous years (2006 to 2008). Fluctuations occurred in the percentage of calves over the last 11 years of monitoring (Table 1).

Late winter/spring composition surveys for the Bluenose–East herd from 2008 to 2016 showed a general declining trend in cow:calf ratios and percentage of calves observed over the last nine years of monitoring (Table 3). The total number of groups classified fluctuated since 2008 with no discernable pattern. Finding groups for the spring classification surveys were noticeably easier for the Bluenose East herd than the Bathurst herd, as the Bluenose East was significantly more numerous (e.g., approximately twice the size of the Bathurst herd, at least in recent years) and possibly less proportionally dispersed. Typically, once a group of Bluenose East caribou was classified, little search effort was needed to find the next group of caribou. For the Bathurst herd, additional time for searching for caribou was needed. However, this perceived difference in search effort between the two herds in March 2015 was not apparent.

Although only three fall composition surveys have occurred for the Bluenose East caribou since 2009, the bull:cow ratio has been stable at about 42 bulls per 100 cows (Table 4, Fig. 2). Comparison with the Bathurst herd is not possible because in 2009, 2013, and 2015 when the Bluenose East fall composition surveys were done, no corresponding fall survey occurred for the Bathurst herd.
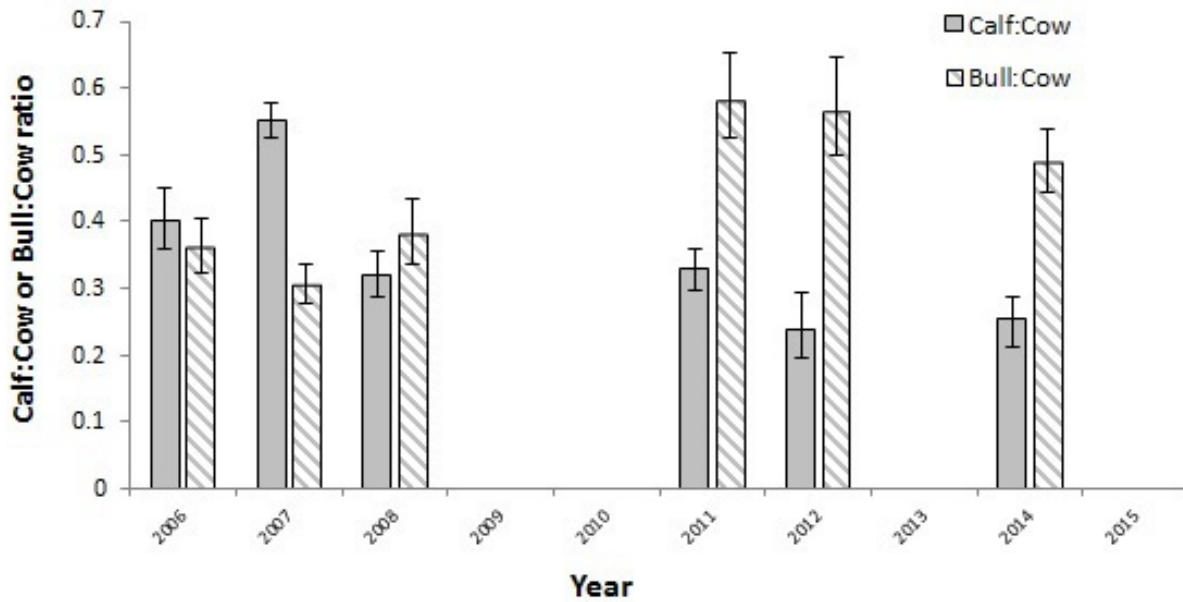
Figure 1. Calf:cow and bull:cow ratios for the Bathurst caribou herd during the October composition surveys, 2006-2014. No fall surveys occurred in 2009, 2010, 2013 and 2015. Error bars show 95% confidence intervals (asymmetric), calculated via bootstrapping.
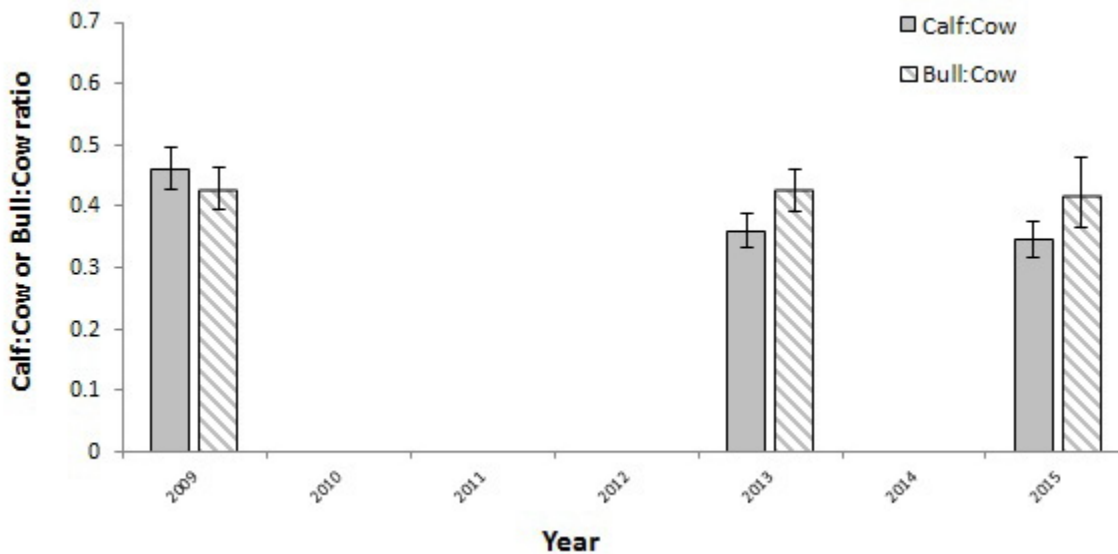

Figure 2. Calf:cow and bull:cow ratios for the Bluenose caribou herd for the fall composition surveys conducted in October 2009, 2013, and 2015. Error bars show 95% confidence intervals (asymmetric), calculated via bootstrapping.

Remarkably, the spring calf:cow ratios for the Bathurst and Bluenose East caribou were statistically identical since 2008, except for 2016 (Fig. 3). Although differences were far from significant, calf:cow ratios for the Bluenose East herd were consistently lower than Bathurst calf:cow ratios, except for spring 2012. No similar comparison between the two herds could be made for fall composition results because no concomitant surveys occurred then.

The cohort of calves from a herd surveyed in the fall would be the same cohort surveyed the following spring. Therefore, the calf:cow ratio from that cohort in the fall may be expected to be somewhat higher than its calf:cow ratio the following spring, given that some calf mortality would occur from fall to spring and assuming cow mortality was constant between consecutive surveys. This pattern appears to hold for Bathurst caribou except for 2008-09 (Fig. 4). The percentage of calves in the survey sample does not show the same relative difference between the fall and following spring surveys, although the seasonal differences are not statistically different except for 2008-09 (Fig. 5). The percentage of calves observed in these surveys has declined over the decade (Fig. 5).

The number of antlerless ("bald") cows from the Bathurst herd has fluctuated since 2001 (Fig. 6.). Although the proportion of antlerless cows peaked in spring 2005 at 4.7%, less than 3% of cows observed are antlerless during most seasons (Fig. 6). The lowest proportion of antlerless cows was 0.5% in spring 2008. The frequency of the upper percentages of antlerless cows tended to occur in the early 2000s (Fig. 6) when the size of Bathurst herd population was greater.

Table 1. Summary of the Bathurst caribou spring (late March/early April) composition surveys, 2006-2015. 95% confidence limits (CL) calculated via bootstrapping.

Year	Total caribou classified	Total groups classified	Median group size	Calves /cow	SE[*]	CL[†]	CL[†]	% calves in sample
2006	9,913	378	18	0.086	0.007	0.072	0.102	6.5
2007	10,121	133	45	0.368	0.021	0.327	0.409	25.5
2008	4,501	117	30	0.497	0.020	0.458	0.538	29.7
2009	5,636	100	45	0.399	0.019	0.363	0.438	26.0
2010	1,819	53	25	0.489	0.021	0.449	0.532	28.0
2011	2,758	89	23	0.462	0.019	0.426	0.499	21.7
2012	4,269	99	36	0.251	0.013	0.227	0.276	15.4
2013	no survey	--	--	--	--	--	--	--
2014	2,323	87	19	0.326	0.015	0.298	0.355	21.1
2015[a]	2,742	84	20	0.235	0.013	0.211	0.260	15.2
2016	2,233	38	28	0.200	0.014	0.168	0.221	15.2

[*] SE = Standard Error [†] CL=95% Confidence Limit (lower & upper)
[a] partial overlap with Bluenose East caribou herd

Table 2. Summary of the Bathurst caribou fall (October) composition surveys, 2006-2014. 95% confidence limits (CL) calculated via bootstrapping.

Year	Total caribou classified	Total groups classified	Median group size	Calves /cow	SE[*]	CL[†]	CL[†]	% calves in sample	Bulls /cow	SE[1]	CL[2]	CL[2]
2006	5,616	69	49	0.402	0.024	0.360	0.451	22.7	0.362	0.021	0.323	0.404
2007	7,334	156	33	0.552	0.013	0.526	0.577	29.3	0.305	0.016	0.275	0.337
2008	3,645	46	43	0.319	0.018	0.288	0.356	18.8	0.379	0.024	0.331	0.427
2009	no survey	--	--	--	--	--	--	--	--	--	--	--
2010	no survey	--	--	--	--	--	--	--	--	--	--	--
2011	4,965	52	48	0.331	0.016	0.298	0.359	17.3	0.580	0.034	0.524	0.653
2012	4,400	33	37	0.228	0.019	0.195	0.266	12.8	0.554	0.029	0.498	0.613
2013	no survey	--	--	--	--	--	--	--	--	--	--	--
2014	2,927	30	65	0.253	0.019	0.213	0.287	14.5	0.490	0.025	0.444	0.540

[*] SE = Standard Error [†] CL= 95% Confidence Limit (lower & upper)

Table 3. Summary of the Bluenose East caribou spring (late March/early April) composition surveys, 2008-2015. 95% confidence limits (CL) calculated via bootstrapping.

Year	Total caribou classified	Total groups classified	Median group size	Calves /cow	SE[*]	CL[†]	CL[†]	% calves in sample
2008	5,683	84	34	0.483	0.017	0.451	0.517	26.8
2009	6,110	97	33	0.384	0.014	0.356	0.412	23.0
2010	6,597	100	43	0.466	0.012	0.444	0.489	28.6
2011	5,846	68	63	0.415	0.016	0.385	0.449	23.4
2012	4,022	76	37	0.272	0.015	0.245	0.303	18.0
2013	no survey	--	--	--	--	--	--	--
2014	5,120	142	18	0.298	0.016	0.270	0.332	19.7
2015[a]	1,133	60	13	0.212	0.023	0.168	0.258	13.9
2016	2,519	77	21	0.319	0.020	0.284	0.363	22.5

[*] SE = Standard Error   [†] CL= 95% Confidence Limit (lower & upper)

[a] does not include overlap area with Bathurst caribou south of Wekweeti.

Table 4. Summary of the Bluenose East caribou fall (October) composition surveys, 2009-2014. 95% confidence limits (CL) calculated via bootstrapping.

Year	Total caribou classified	Total groups classified	Median group size	Calves /cow	SE[*]	CL[†]	CL[†]	% calves in sample	Bulls /cow	SE[2]	CL[3]	CL[3]
2009	4,531	79	46	0.460	0.017	0.427	0.495	24.4	0.429	0.017	0.396	0.463
2010	no survey	--	--	--	--	--	--	--	--	--	--	--
2011	no survey	--	--	--	--	--	--	--	--	--	--	--
2012	no survey	--	--	--	--	--	--	--	--	--	--	--
2013	5,369	107	29	0.360	0.014	0.334	0.388	20.1	0.426	0.018	0.390	0.461
2014	no survey	--	--	--	--	--	--	--	--	--	--	--
2015	4,190	51	31	0.347	0.015	0.318	0.376	19.7	0.417	0.029	0.367	0.479

[*] SE = Standard Error   [†] CL=95% Confidence Limit (lower & upper)
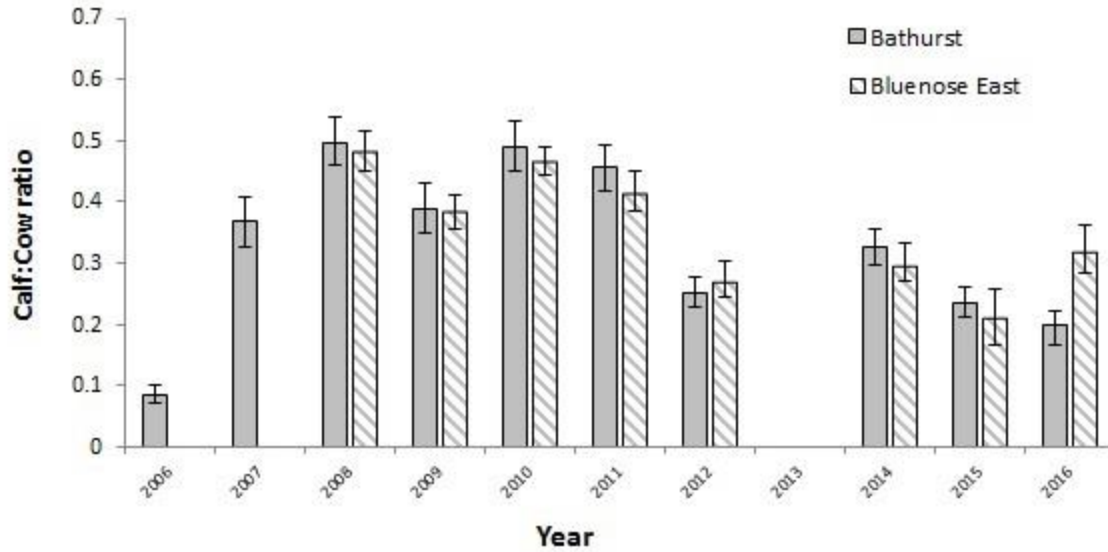
Figure 3. Spring calf:cow ratios for the Bathurst caribou herd 2006-2016 and Bluenose East herd, 2008-2016. There was no survey in 2013 because of overlap with the Bluenose East herd. Error bars show 95% confidence intervals (asymmetric), calculated via bootstrapping.
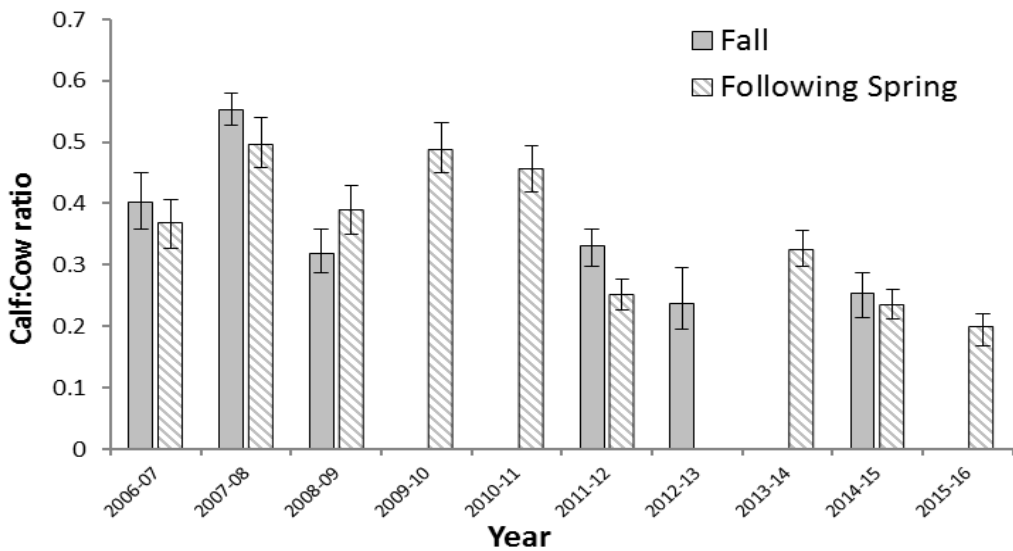

Figure 4. Calf:cow ratios for seasonal cohorts of the Bathurst caribou herd from the fall composition survey to the following spring. Error bars show 95% confidence intervals (asymmetric), calculated via bootstrapping.
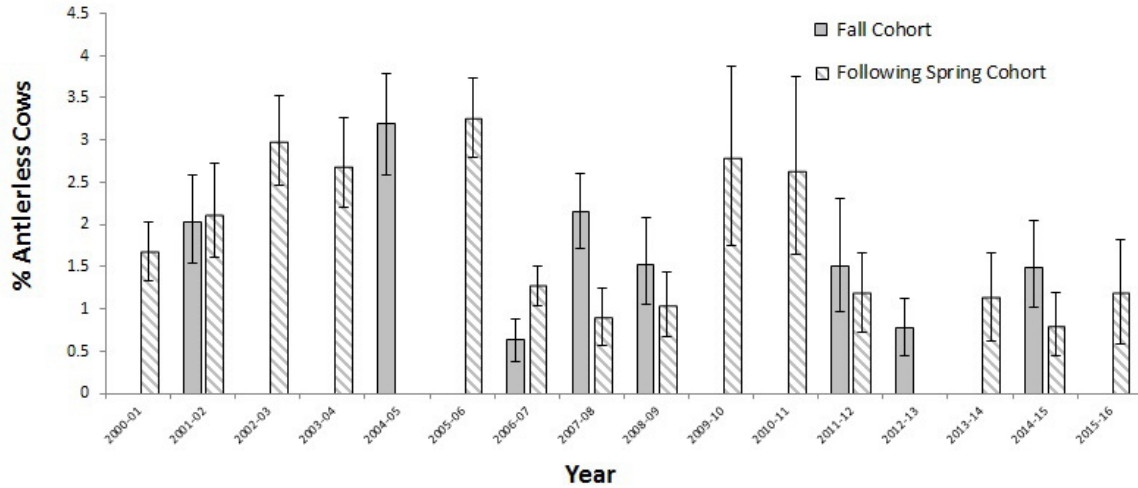
Figure 5. Percentage of calves in the survey based on composition surveys in the fall (October) and following spring (March or April) for the Bathurst caribou herd. Error bars show 95% confidence intervals (asymmetric), calculated via bootstrapping. No spring survey occurred in 2013. No fall surveys occurred in 2005, 2009, 2010, and 2013.
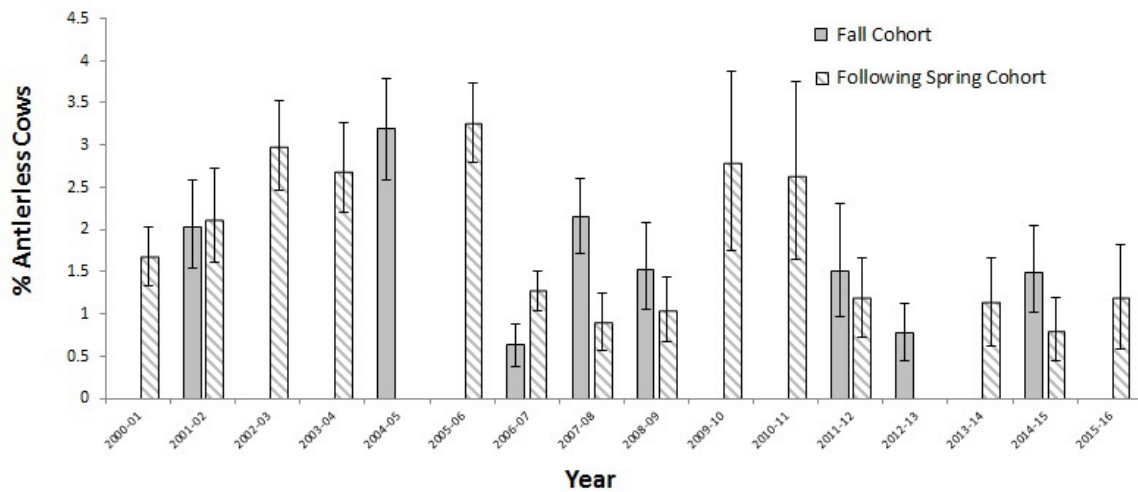

Figure 6. Percentage of antlerless ("bald") cows in the Bathurst herd based on composition surveys 2001-2016. Fall and spring composition surveys are paired, when possible, to reflect seasonal cohorts.

DISCUSSION

The Bathurst caribou herd has declined continuously since 1996, when the population was estimated at 349,046 (SE=94,880) animals (Gunn et al. 1997). In June 2003, the population estimate for the Bathurst herd was 186,005 ±40,100 (Gunn et al. 2005b), then at 128,047 ±27,343 in June 2006 (Nishi et al. 2007), at 31,897 ±10,932 caribou in June 2009 (Nishi et al. 2014), and recently at 34,690 ±9,755 in June 2012 (Boulanger et al. 2014a). Similarly, the Bluenose East herd has also declined in recent years from an estimated 98,646 ±7,125 caribou in June 2010 (Adamczewski et al. 2014) to 68,295 ±18,041 in June 2013 (Boulanger et al. 2014b). Calving ground delineation surveys in June 2014 for both Bathurst and Bluenose East caribou, although having inherently greater uncertainty, indicated the declines had not subsided (Boulanger et al. 2014c, Boulanger et al. 2014d). Indeed, the most recent population results from the 2015 calving ground photo census was 19,769 (SE=3,532) for the Bathurst herd (Boulanger 2016) and 38,592 (SE =2,233) for the Bluenose East herd (Boulanger et al. 2016). The general trend of declining calf:cow, bull:cow, and % calves in the seasonal composition surveys from 2006 to 2016 reported here have been consistent with these population changes for both herds. These independent measures of population size have been critical to interpreting herd composition counts because composition counts by themselves do not estimate population size changes (McCullough 1994).

Calf ratios

Calf production for the Bathurst herd (as measured by the ratio of calves:cows) was consistently above 0.300 (30 calves:100 cows) and frequently exceeded 0.400 from 1985 to 1995 when herd size was relatively large (Appendix B in Part 2 of this report). Normally, productivity must exceed a calf:cow threshold of 0.300 to achieve positive recruitment of calves. However, calf production dipped below 0.300 between 2001-2006 and a population decline became apparent. Higher spring calf:cow ratios of 0.368 to 0.489 were recorded from 2007-2011 (Table 1), a time when the herd appeared to have stabilized. However, ratios in 2007, 2008 and 2009 may have been inflated by high cow mortality before the Bathurst harvest was substantially restricted in 2010. Indeed high cow mortality seems likely between October 2008 and March 2009 (Fig. 4). Model-based demographic analysis simultaneously uses composition data, collar survival data, and herd size estimates to model demography and are potentially robust to some of the confounding factors associated with singular interpretation of age and sex ratios (Boulanger et al. 2011).

A spring composition survey was not done in 2013 due to overlap of Bathurst and Bluenose-East caribou distribution. However, a fall composition survey was completed for the Bathurst herd the season prior, in October 2012 (calves born in 2012). That survey reported a calf:cow ratio of 0.237. Fall calf-cow ratios (calves ~5 months old) are usually slightly higher than the following spring ratios when calves are about 10 months old (Fig. 4). This would indicate consistently lower calf recruitment during 2012-2014 than from 2007 and 2011 in the Bathurst herd.

Caution is also needed in the interpretation of these ratios. Composition surveys are based on change-in-ratio methods (Williams et al. 2002, Harris et al. 2008) and are subject to their inherent biases. Use of age and sex class ratios depend on a stable denominator, that is, the proportion of cows classified in these composition surveys reflects the true proportion in the herd. It is likely that this assumption was not met between surveys, which would confound their interpretation.

For example, this may have happened with the Bathurst calf productivity (calf:cow ratios) from the fall 2008 survey to the spring 2009 one (Fig. 4). The fall 2008 survey reported a calf:cow ratio of 0.319

(0.287 to 0.357) but the index was higher at 0.389 calves:cow (0.350 to 0.430) for the spring 2009 survey (Table1,2, Fig. 4). However, the 95% confidence intervals are wide enough that the paired estimates could be considered statistically the same. Alternatively, the fall 2008 survey east of Contwoyto Lake where some Bathurst caribou collars were located could have been influenced by an influx of Beverly/Ahiak caribou as revealed by collar locations assigned by herd membership (Fig. A6).

Caughley (1974) and McCullough (1977, 1994) argued that calf:cow ratios alone do not provide a good measure upon which to predict changes in population size. For example, no change in calf:cow ratios could indicate that the population is either stable, declining at a constant rate, or declining at a variable rate under the influence of hunting. Therefore, independent assessments of population size are required to validate demographic changes indicated by composition counts (Caughley 1974, McCullough 1977, 1994). Periodic population estimates on the calving ground (3-6 year intervals) provide that support. The June 2015 photographic population census results recently released for both Bathurst and Bluenose East herds will help in fully interpreting the latest composition counts and both herds' subsequent trajectory.

Given that the number of adult females classified comprises the denominator in this ratio and adult female survival is thought to have declined in recent years, calf:cow ratios are likely reflecting instability between years of this parameter. This pattern is further supported by the apparent increase in calf production for the same cohort of calves in October 2008 (0.389) to the following spring (0.357). The 2008-09 Bathurst surveys were also anomalous for the percentage of calves being larger in the spring compared to the previous fall. The percentage of calves in the fall 2008 survey was 18.7, which was then followed by 25.6% calves in the spring 2009 survey (Fig. 5). The denominator in this case is the total number of caribou classified, however, the number of cows remain the largest component of the total and likely has the greatest influence. Three of the four other seasonal comparisons showed greater point estimates of the %calves in the spring compared to previous fall surveys (Fig. 5). However, the differences are not statistically significant and are small enough that they could simply reflect differences with the number of bull-only groups classified between corresponding seasons. The number of yearlings classified is very small and would not significantly influence the total.

Initial demographic modelling by Boulanger et al. (2011) detected a decreasing trend in adult survival. This trend was not detected in a stand-alone analysis of survival of radio-collared caribou, although given the relatively few collars (≤20) deployed on Bathurst caribou then, detecting such a trend was unlikely (Rettie 2008). Boulanger et al. (2011) discuss the covariance between fecundity and calf, yearling, and adult female survival and how the latter can inflate ratios. Nevertheless, calf recruitment (productivity) and natural survival rates of adult caribou show a correlation (albeit with substantial variance) suggesting that environmental conditions favoring good calf survival also generally favor good natural adult survival (Bergerud 2000). Reduced spring calf:cow ratios may thus be indicators of concurrent reduced natural survival among adult caribou (GNWT Environment and Natural Resources 2014).

Bull ratios

Bull:cow ratios between 2006 and 2008 for the Bathurst herd ranged between 0.305 and 0.379, were higher in 2011 and 2012 at 0.580 and 0.554 respectively, but were down slightly to 0.490 in 2014 (Table 2, Fig. 1). Bull:cow ratios in barren-ground caribou are usually biased towards females, as males have higher mortality rates than females at all ages and ratios of about 0.500 (50 bulls:100 cows) are common (Bergerud 2000). Ratios below 0.500 are consistent with herds experiencing poor conditions, as demonstrated for the Bathurst herd by the low bull:cow ratios from 2006-2008, and 2014. Increased bull:cow ratios in 2011 and 2012 are consistent with the Bathurst herd's apparent stabilizing trend from

2009-2012. However, as with calf:cow ratios, bull:cow ratios are influenced by mortality rates of both bulls and cows. Indeed high cow mortality between periods can inflate bull:cow ratios and be misleading. This could account for the apparently high bull:cow ratios in 2011 and 2012 (discussed further by Boulanger et al. 2014a).

On an annual timescale however, adult sex ratio is assumed to be relatively constant. Over longer periods of time (or in very small populations) adult sex ratios can change with a bias to either sex. When herds are increasing and calf survival is high, the proportion of bulls increases. For example, the Qaminurjuaq herd was increasing in the early 1980s and the pregnancy rates and calf survival were high. In 1981, the sex ratio (>1 year old) for the Qaminurjuaq herd was 0.830 bulls:cows (Heard and Calef 1986).

Prior to 2001, the adult sex ratio for the Bathurst herd had not been measured and not until fall 2004 was sampling considered representative (Gunn et al. 2005a). However, since monitoring began, the proportion of bulls in the Bathurst herd has fluctuated between years and can likely be linked to herd decline and the interplay of factors responsible for the decline. Fewer fall composition surveys have occurred for the Bluenose East herd compared to Bathurst caribou. Nevertheless, the bull:cow ratio for the Bluenose East herd has been relatively stable since 2009 at about 42 bulls per 100 cows. Although currently acceptable, management of caribou seeks to exceed this threshold to avoid declining trends in population size (Western Arctic Caribou Herd Working Group 2011).

Caution must be given to avoid bull:cow ratios less than 0.018 (18 bulls:100 cows). Modeling studies on elk (*Cervus elaphus*), another gregarious, herding species, have shown that this threshold is needed to maintain genetic diversity and subsequently adaptive potential (Hard et al. 2006). Furthermore, it is prudent to ensure a sufficient number of larger, older males survive for breeding (Hard et al. 2006).

Overlap in winter ranges

Composition surveys for the Bathurst herd have occurred each spring from 2006 to 2016, except for 2013 (10 of a possible 11 times). That year, both the Bathurst and Bluenose East spring composition surveys were cancelled because of substantial overlap between the two herds over winter. Spatial-temporal overlap has occurred between the two herds before, at least partially. Based on locations of collared caribou mapped by herd assignment (retrospectively, once newly collared caribou have migrated to a calving ground), spring composition surveys in 2007, 2009, 2011, and 2015 have showed some partial winter range overlap between Bathurst and Bluenose East caribou (Figs. A3, A7 & A8, A12 & A13, A22 & A23 in Part 2 of this report). Add in the cancellation of the 2013 spring composition surveys because of overlap, and a recent pattern becomes apparent of partial overlap occurring every two years. Partial spatial and temporal overlap between adjacent herds complicates the logistics and sampling effort, but a representative sample may still be obtained. While herd management seeks independent herd survey information, the curious similarity between spring cow:calf ratios (Fig. 3) between the Bathurst and Bluenose East caribou herds, despite fidelity to different calving grounds, warrants further investigation. In some years, overlap with the Beverly/Ahiak herd was a concern, especially October 2008. However, with the continued decline of the Bathurst herd, overlap with the Beverly/Ahiak herd has not been an issue recently.

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APPENDICES

Appendix 1. R code example for bootstrapping calf:cow and bull:cow ratios for confidence limits.

```
# the hash tag symbol denotes comments as R ignores anything after the hash tag for that line.
setwd("D:/CARIBOU/BATHURST caribou/Composition surveys/2014/2-Fall 2014/Bootstrapping")  # easier with RStudio
library("boot", lib.loc="C:/Rsoftware/Rlibrary")  #  load the bootstrapping package
# read in the data to a data.frame; substitute applicable folder and filename (in CSV format)
compdata <- read.csv("D:/CARIBOU/BATHURST caribou/Composition surveys/2014/2-Fall
      2014/Bootstrapping/Bathurst_Fall2014comp_R.csv")   # all one command line; data can be imported easier with RStudio
View(compdata)  # optional, view the data on the screen

# creates data vectors needed for analyses; column number used will depend on the structure of data table imported
cowsWA <- compdata[,2]      # number of cows With Antlers in column 2
cowsWOA <- compdata[,3]     # number of cows Without Antlers in column 3
cowsTot <- compdata[,4]     # total number of all cows classified in column 4
calves <- compdata[,5]      # number of calves in column 5
bullsY <- compdata[,6]      # number of young bulls in column 6
bullsP <- compdata[,7]      # number of prime bulls in column 7
bullsTot <- compdata[,8]    # total number of all bulls in column 8
yearlings <- compdata[,9]   # number of yearlings in column 9
total <- compdata[,10]      # total number of all caribou classified in column 10
# optional – view newly created data vectors on the screen for checking
cowsWA
cowsWOA
cowsTot
calves
bullsY
bullsP
bullsTot
yearlings
total

# create the dataframes from the vector data above
CalfCow <- data.frame(calves,cowsTot)
BullCow <- data.frame(bullsTot,cowsTot)

# create summary statistics
sum(total)                  # total caribou classified
median(total)               # median group size
sum(calves)/sum(cowsTot)    # calf:cow ratio;  need to multiply by 100 to get calves/100 cows
sum(calves)/sum(total)*100  # % calves in the composition survey
sum(bullsTot)/sum(cowsTot)  # bull:cow ratio;  need to multiply by 100 to get bulls/100 cows

# SE and CI for calf:cow ratio
bCC <- boot(CalfCow,function(a,i) sum(a$calves[i])/sum(a$cowsTot[i]), 10000)  # bCC; b for bootstrapping, CC for Calf:Cow
bCC                 # bootstrap statistics for calf:cow ratio; resampled values are in bCC$t
st(bCC$t)           # standard error of resampled calves/cow ratios; duplicated from bCC statistics
bCCLimits <- boot.ci(bCC,conf=0.95,type="perc", index=1)   # type = "all" for other types available
bCCLimits           # gives the upper & lower confidence limits
# SE and CI for bull:cow ratio; not calculated in spring composition surveys due to gender segregation.
bBC <- boot(BullCow,function(a,i) sum(a$bullsTot[i])/sum(a$cowsTot[i]), 10000)  # bBC; b for bootstrapping, BC for Bull:Cow
bBC                 # bootstrap statistics for bull:cow ratio; resampled values are in bBC$t
st(bBC$t)           # standard error of resampled bull/cow ratios; duplicated from bBC statistics
bBCLimits <- boot.ci(bBC,conf=0.95,type="perc", index=1)  # type = "all" for other types available
bBCLimits
```

Appendix 2. Supplementary Information

Calf production and adult sex ratio in the Bathurst and Bluenose East herds of barren-ground caribou, 2006-2016. Part 2 – Appendices – Composition survey maps and supplementary information.
Contains all the figures (maps) prefixed with an "A" (Appendix A), plus Appendices B, C, and D.

Calf production and adult sex ratio in the Bathurst and Bluenose East herds of barren-ground caribou, 2006-2016. Part 3 - Observation data tables.
Contains all the observations recorded during each composition survey from 2006 to 2016.