Overview: Monitoring of Bathurst and Bluenose-East Caribou Herds, Sept. 2014
Government of the Northwest Territories, Environment and Natural Resources

Summary:
This document provides an overview of population trend, other monitoring, and management of the Bathurst and Bluenose-East (BE) caribou herds in NWT and NU, with the emphasis on the last 5 years (2009-2014). Results from a reconnaissance survey conducted in June 2014 on the calving grounds of the Bathurst herd suggests this herd, which had been considered stable 2009-2012, has declined since 2012. Results from calving ground photo surveys of the BE herd indicate this herd has declined substantially 2010-2013. The June 2014 calving ground reconnaissance survey results suggest the BE herd has continued to decline rapidly. Photo surveys are planned for the spring of 2015 to allow more precise trend estimates for both herds.

Two main sections of this overview describe results of population surveys, calving ground reconnaissance surveys, estimates of cow survival rate, spring recruitment surveys, fall composition surveys, pregnancy rates, harvest estimates, movements of collared caribou between neighbouring herds, and the management context for each herd. Information on wolf monitoring on the Bathurst range and recent wolf harvest is included. A section on long-term cycles or fluctuations of migratory caribou herds and demographic indicators of decline (low pregnancy rates, low calf recruitment and low adult cow survival) follows. The overview concludes with assessments of population trend in the Bathurst and Bluenose-East herds 2009-2014 and possible explanations for the June 2014 calving ground reconnaissance survey results.

For the Bathurst herd, the likeliest explanation for the low numbers of caribou on the calving grounds in 2014 is a combination of low natural survival rates, reduced calf productivity and survival, and to some extent harvest. Harvest of the Bathurst herd on its main winter range (management zones RBC02 and RBC03) has been greatly reduced since 2010 but some harvest is unreported and some harvest has likely occurred outside these zones. For example, harvest of Bathurst caribou may be occurring in RBC01, where the Bathurst and BE herds overlap in winter. Issues related to the reconnaissance survey methods may have affected survey results but are unlikely to account for the large apparent drop in numbers of caribou on the calving grounds. Assessment of movements of collared caribou between the Bathurst's calving grounds and its neighbouring herds' calving grounds showed no evidence of large-scale emigration from the Bathurst range 2010-2014.

For the BE herd, a combination of low natural survival, reduced calf recruitment, low pregnancy rates in some years, and a substantial cow harvest are the most probable reasons for the herd's substantial decline 2010-2013 and the continued and potentially accelerated decline to June 2014. Issues related to the reconnaissance survey methods may have affected the survey results but are unlikely to account for the large apparent decrease in caribou on the calving grounds. Assessment of movements of collared caribou between the BE's calving grounds and its neighbouring herds' calving grounds showed no evidence of large-scale emigration from the BE range 2010-2014.

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2. Introduction

In the Northwest Territories (NWT), all migratory barren-ground caribou herds monitored by the Government of the Northwest Territories Department of Environment and Natural Resources (GNWT ENR) declined substantially between 2000 and 2006-2009. As a result of these declines, monitoring of the herds was increased and management actions were taken to address declines. Population surveys have been carried out every 3 years; in addition, other monitoring has been carried out to better understand the conditions each herd is facing.

One of the monitoring surveys that ENR has used is a calving ground reconnaissance survey in June near the peak of calving. These surveys are flown by small fixed-wing aircraft at a fixed elevation above ground with 2 observers on each side. Numbers and types of caribou seen are recorded in a strip 400m wide on each side of the plane. The results are used to map the calving grounds and to provide an indicator of the numbers of caribou at least one year old on the calving ground, most of which will be breeding cows (cows with calves or cows about to calve). Estimates of caribou numbers from these surveys do not provide precise population estimates as the ground coverage is low and the variance on the estimates is large. However, these surveys have to date reliably tracked population trend when compared to more intensive calving ground photo surveys flown at 3-year intervals.

In June 2014, reconnaissance surveys were flown over the calving grounds of the Bathurst and BE caribou herds (Fig. 1) using methods consistent with previous similar surveys. In the BE herd, survey results indicated that the rapid decline documented 2010-2013 from calving ground photo surveys has continued and may have accelerated. In the Bathurst herd, previous June surveys had indicated a stable trend 2009-2012, but the June 2014 results suggested a large decline since 2012. Results of these surveys, in combination with other monitoring information, were considered serious enough to set up a meeting Aug. 27 2014 in Yellowknife with Aboriginal leaders and co-management boards to review the information and discuss what management actions should be considered. In response to comments and questions at that meeting, further meetings and more detailed review of information were planned for October 2014, along with a further leaders' meeting in early November.

The purpose of this document is to provide an overview of technical information on the two herds, mostly gathered by ENR, with the emphasis on 2009-2014. Results of monitoring are summarized with limited interpretation of trends. Two main sections describe monitoring and management of the Bathurst and BE herds. A summary on cyclical changes in caribou herds over time and on the demographic indicators of decline in caribou follows. The overview concludes with an assessment of the two herds' trend to 2014 and the likeliest explanations for the June 2014 survey results. This document is not an exhaustive analysis of these subjects, but references listed and other reports and papers provide greater detail.

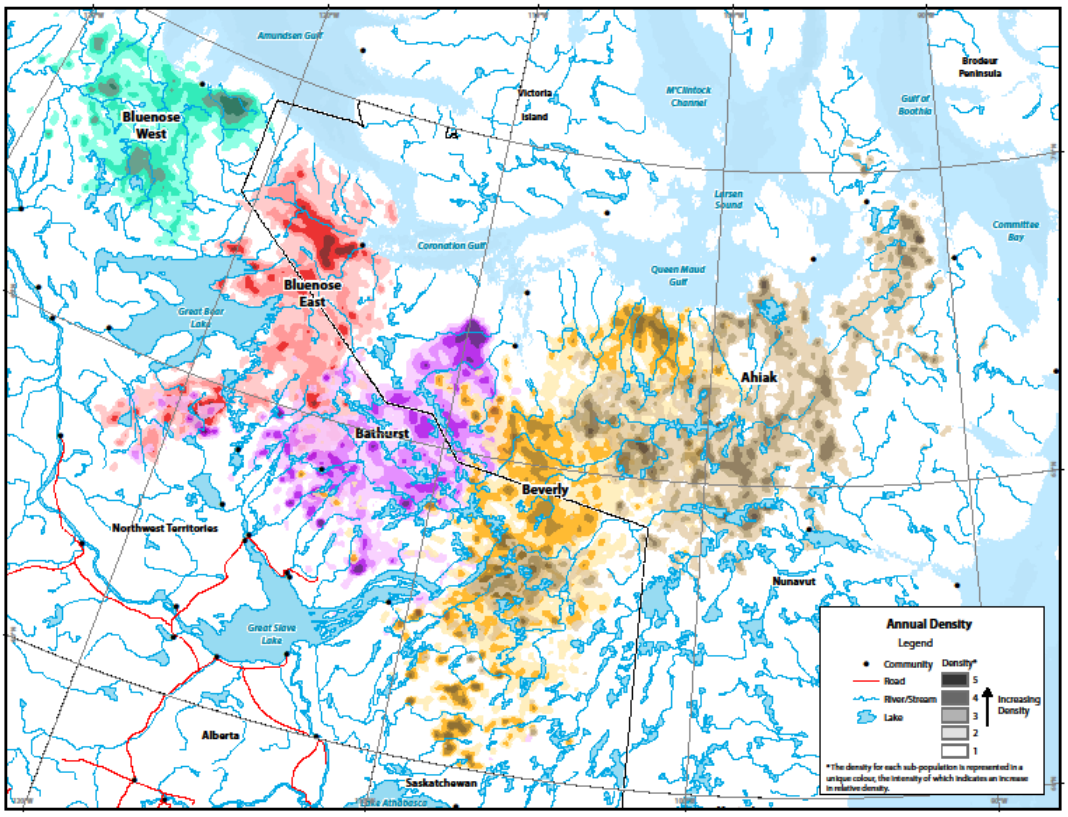


Fig. 1 Annual ranges of the Bathurst and Bluenose-East caribou herds, based on collar locations 2006-2012, and neighbouring herds. Darker areas were used more heavily than lighter more peripheral areas. Calving grounds are at the north end of the annual ranges.

Photo J. Adamczewski

3. Bathurst Herd

3.1 Population Surveys

Calving ground photo surveys have been used since the 1980s to estimate the numbers of breeding females in the Bathurst herd in June (Fig. 2). These estimates have been extrapolated to estimates of adult caribou (1.5 year-old or older) using measures of herd-wide pregnancy rate and sex ratio to account for non-pregnant cows and bulls, many of which will not be on the calving ground. Methods used in these surveys are described by Boulanger et al. (2014a) for the June 2012 Bathurst survey. Figure 2 shows the six estimates of breeding females and extrapolated herd estimates from calving ground photo-surveys of the Bathurst herd 1986-2012. The herd numbered nearly 500,000 in 1986, then declined slowly through the 1990s and more rapidly in the 2000s. The most rapid decline occurred between 2006 and 2009 when the estimate of breeding females declined from about 55,600 to 15,900, with a similar trend in overall herd size. From 2009 to 2012 the herd showed a stable trend of 32,000-35,000 adult caribou. A further calving ground photo-survey is planned for June 2015.

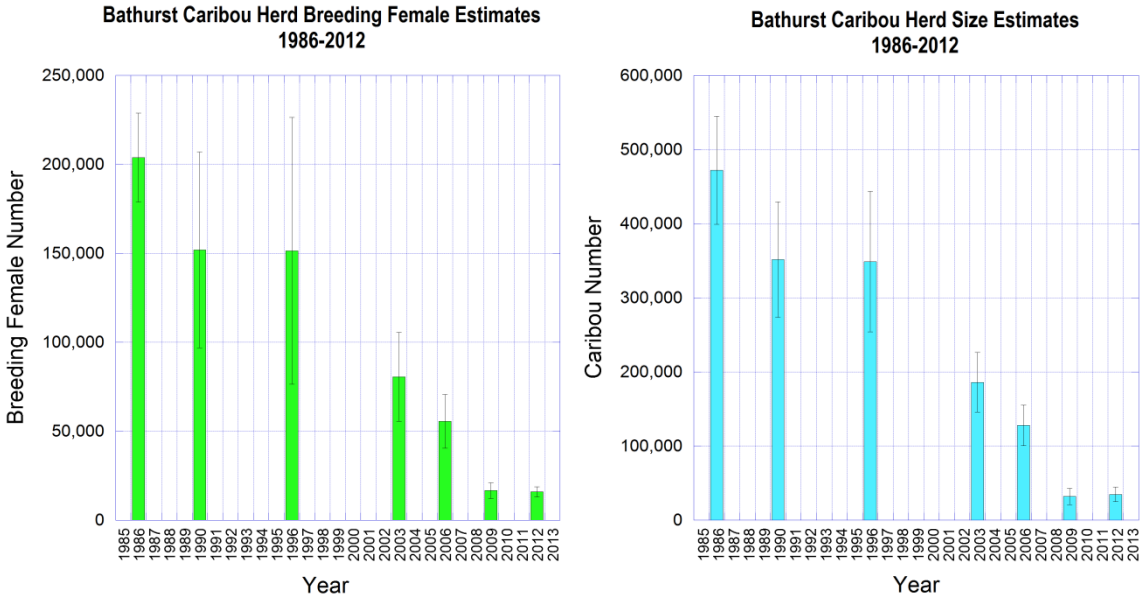


Fig. 2. Estimates of breeding females & adult caribou (1.5-year-old+) in the Bathurst herd 1986-2012

3.2 Calving Ground Reconnaissance Surveys

Reconnaissance surveys on the calving grounds are less intensive and much less expensive than calving ground photo-surveys. They provide information on where a herd's calving grounds are that year, and they provide an indicator of the numbers of caribou at least one year old on the calving ground; a high proportion of these adults are usually breeding females. The surveys are flown in June near the peak of calving using small planes that fly lines spaced 5 or 10 km apart. These surveys are not designed to provide a precise population estimate, but when flown consistently and repeated over time, they can give an index of trend in the numbers of caribou on the calving ground. Methods and results of a June 2014 calving ground reconnaissance survey for the Bathurst herd are described by Boulanger et al. (2014b) along with results from previous similar surveys beginning in 2006. Fig. 3 shows the trend in numbers of 1-year-old or

older caribou found on the calving grounds 2006-2014 for the Bathurst herd (note the 2011 survey was unsuccessful).

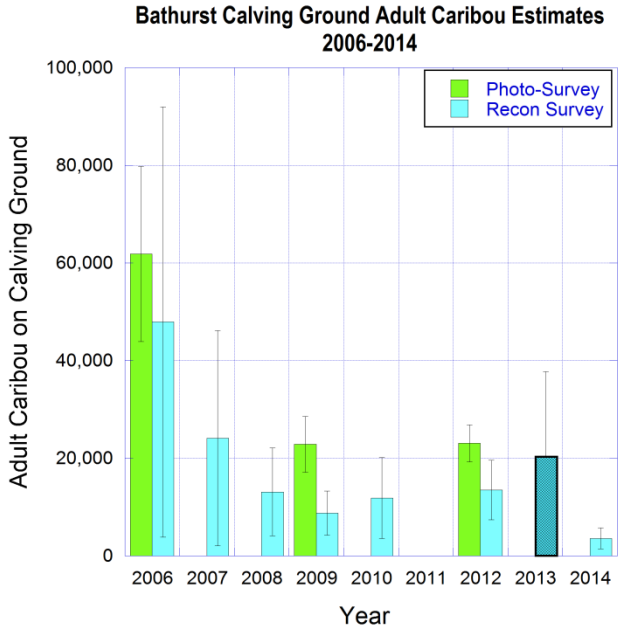


Fig. 3. Trend in numbers of caribou at 1-year-old or older on the Bathurst calving grounds 2006-2014

Figure 3 also includes the estimates of 1-year-old or older (adult) caribou on the Bathurst calving grounds derived from the calving ground photo-surveys in 2006, 2009 and 2012. Reconnaissance surveys are the initial phase of calving ground photo-surveys and are followed by more intensive photo-surveys of higher-density blocks and visual surveys of lower-density blocks. The higher numbers from the photo-surveys reflect the more complete counts of larger groups in higher-density areas from photos, compared to initial visual counts completed during reconnaissance flying. Overall, results of the reconnaissance surveys paralleled results of the photo-surveys between 2006 and 2009 and between 2009 and 2012. Numbers of adult caribou from the reconnaissance surveys declined rapidly 2006-2009, then showed a stable trend 2009-2012, in parallel to the numbers of adults estimated on the photo-survey.

A reconnaissance survey was flown June 9, 2013 (at the end of the June 2013 Bluenose-East calving photo survey) but occurred just after a snow-storm (Fig. 4). Observers' ability to sight caribou was poor. Very low numbers of caribou were seen (95 in total on transect) but this was thought in large part due to the ground conditions. The survey was suspended after the main calving area had been flown. A second reconnaissance survey was carried out on June 13, 2013 after the snow melted but it was well past the peak of calving and larger groups seen may have reflected initial post-calving aggregation. Estimates from June 13 2013 are included in Fig. 3 but may have been inflated by a few of these larger groups, which can include non-breeding cows, yearlings and bulls. Results of both recon flights in June 2013 should be considered with caution.

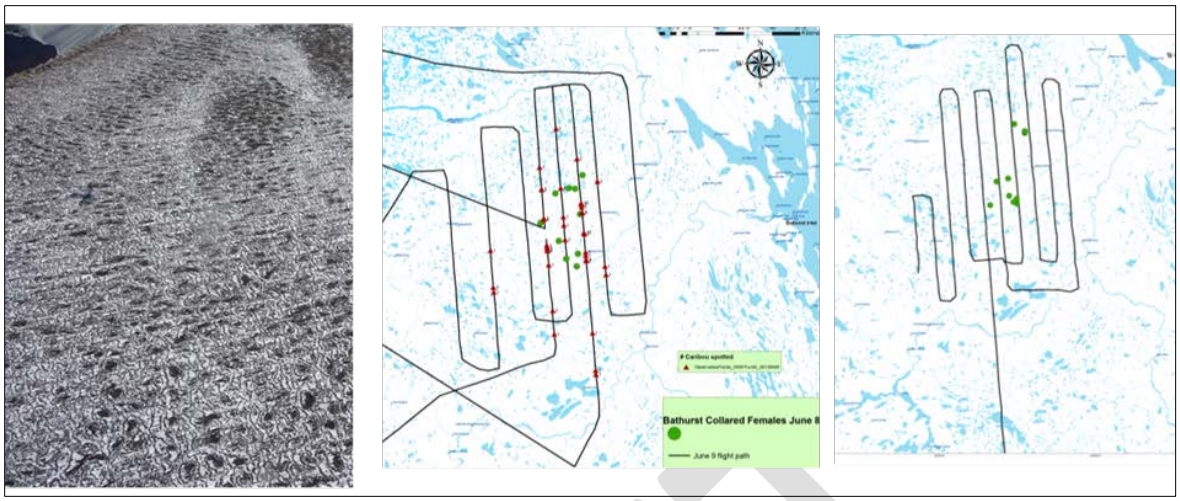


Fig. 4. Snow cover on the Bathurst calving ground June 9, 2013 (left), reconnaissance lines flown that day (middle) and reconnaissance lines flown June 13, 2013 (right). Green dots are collared cow locations and red triangles are locations of caribou groups seen.

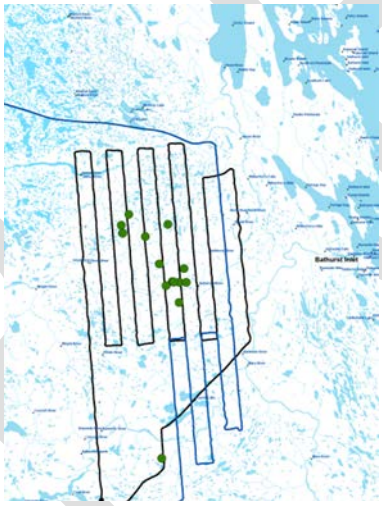


Fig. 5. Flight lines on June 8-9 2014 reconnaissance survey of Bathurst calving ground.

Results of the June 2014 Bathurst reconnaissance survey were described by Boulanger et al. (2014b) and included in Fig. 3. Weather and visibility were excellent, similar to 2012. Results of this survey suggest the Bathurst has declined since 2012. Because of the limited coverage and large variance on reconnaissance surveys, the results should be treated with caution. The 2012 recon survey resulted in an estimate of 14,390 ± 6,109 adults 1-year-old or older on the calving ground, while the 2014 recon survey resulted in an estimate of 3,594 ± 2,133 adults. Of 18 satellite-collared Bathurst caribou in June 2014, 17 were within the survey area (Fig. 5), suggesting that a high proportion of the herd's cows were on the calving ground.

Monitoring from 1996 to 2014 has shown that female caribou have consistently used the same general area southeast of Bathurst Inlet for calving (e.g. Boulanger et al. 2014a). The Bathurst herd appears to have continued to maintain a single concentrated calving area even at lower numbers (Fig. 6), presumably to maintain the advantages of gregarious calving (Bergerud et al. 2008, Griffith et al. 2002).

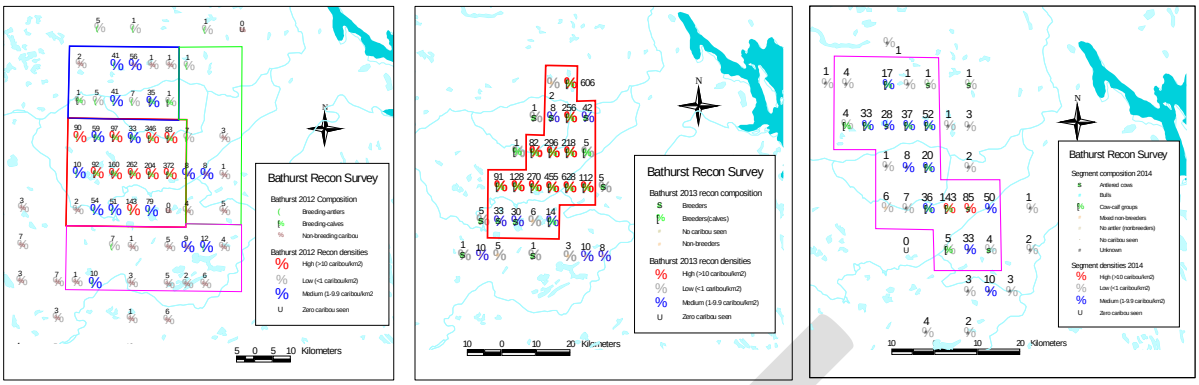


Fig. 6. Survey coverage, segment densities, and composition for the 2012 (left), 2013 (middle, June 13) and 2014 (right) Bathurst reconnaissance surveys (details in Boulanger et al. 2014b).

3.3 Adult cow survival estimates

Survival of adult female caribou is a key demographic variable for caribou herds, although it is difficult to measure. Stability of caribou herds is more closely tied to survival rates of cows than to other demographic variables (Fancy et al. 1994, Boulanger et al. 2011). Fig. 7 shows estimates of cow mortality rate compared to population rate of change based on caribou herds in Alaska, NWT and Quebec.

Overall, stable herds had cow mortality rates of 17% or less (survival of 83% or higher). Population modeling for the Bathurst herd has similarly suggested that cow survival rates of about 86% are needed for a stable herd (Boulanger et al. 2011). Estimation of cow survival rates has been carried out from collared cows in herds where collar numbers are adequate (e.g. 100 collared cows in Western Arctic and Porcupine herds) but has been difficult for the Bathurst herd, given that numbers of collars have averaged less than 20 at any given time. Cow survival has been estimated instead from a population model that uses all demographic information for the herd (Boulanger et al. 2011, 2014a). Analysis by Boulanger et al. (2011, 2014a) provided cow survival estimates for the Bathurst herd of 86% in 1985, 73% 2007-2008, 67% in 2009 and 78-79% 2009-2012. This suggested that cow survival had increased from the period of rapid decline in the Bathurst herd up to 2009, but might still be marginal 2009-2012 despite a stable herd trend 2009-2012 (Boulanger et al. 2014a).

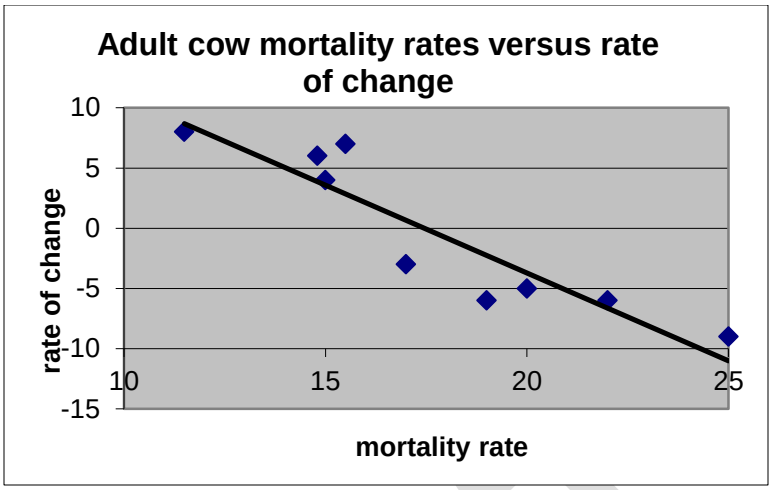


Fig. 7. Adult cow caribou mortality rate compared to population rate of change in barren-ground caribou herds (courtesy of D. Russell, CARMA, pers. comm. 2009). Herds with a rate of change of 0 are stable, increasing if the rate of change is above 0, and decreasing if the rate of change is negative.

3.4 Spring calf recruitment surveys

Spring calf recruitment surveys have been carried out frequently for the Bathurst herd since 1985. The key result from these surveys is a calf:cow ratio that provides an index of the proportion of the previous year's calves that survived to about 10 months of age. Mortality of calves in their first 6 months is often high, while calves that reach a year of age generally survive at rates similar to adults. Caution is needed in interpreting calf:cow ratios, as they can be affected by the survival rate of calves (numerator) as well as the survival rate of cows (denominator). In general, sustained calf:cow ratios of less than 20 calves:100 cows are clearly indicative of a declining natural trend in the herd. Ratios of 35-40:100 or higher usually indicate a herd likely stable and possibly increasing; however, the proportion of calves needed for a stable herd depends in part on adult female survival rates. In the George River herd, if adult and yearling female survival was 80%, then a fall calf:cow ratio of 52:100 was needed for a stable herd, while fall calf:cow ratios of 39:100 was needed for a stable herd if adult and yearling female survival was at 85% (Crête et al. 1996). In a similar way, Boulanger and Adamczewski (2014) suggested that if adult female survival was 85% in a caribou herd, spring calf:cow ratios averaging about 40:100 would be needed for stability. At cow survival estimates of 67% (Bathurst herd in 2009), the herd could not produce enough calves to achieve stability (Boulanger et al. 2011).

Calf recruitment and natural survival rates of adults show a correlation (with substantial variance) that suggests that environmental conditions favouring good calf survival also generally favour good natural adult survival (Fig.8, adapted from Bergerud 2000). Reduced spring calf:cow ratios may thus be indicators of concurrent reduced natural survival among adult caribou..

Spring calf:cow ratios for the Bathurst herd between 1985 and 2014 are shown in Fig. 9. In general, calf:cow ratios were consistently above 30:100 and frequently exceeded 40:100 from 1985 to 1995. From 2000 to 2006, calf:cow ratios declined from 29:100 to a low of 9:100 in 2006. Over this period, the herd had a declining natural trend, and a rapid decline based on calving photo-surveys and calving ground reconnaissance surveys. Higher ratios of 37-49:100 were recorded 2007-2011, over a period when the herd began to stabilize. Ratios in 2007, 2008

and 2009 may have been inflated by high cow mortality before the Bathurst harvest was substantially restricted in 2010.

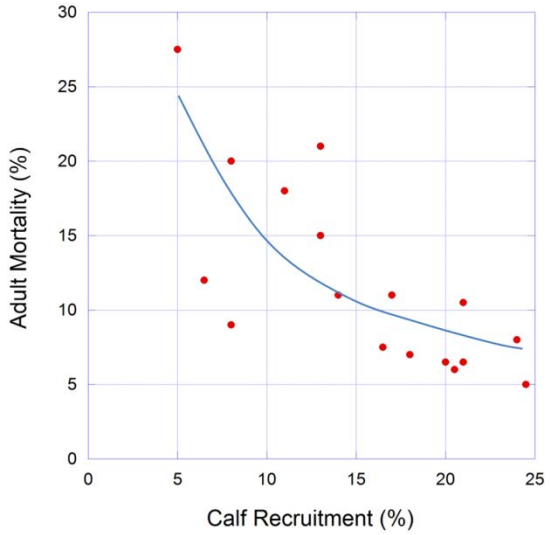


Fig. 8. Correlation between adult natural mortality rates of caribou and calf recruitment. Adapted from Bergerud, A.T. 2000. Ch. 31 (Caribou) in Ecology and management of large mammals in North America, Prentice-Hall.

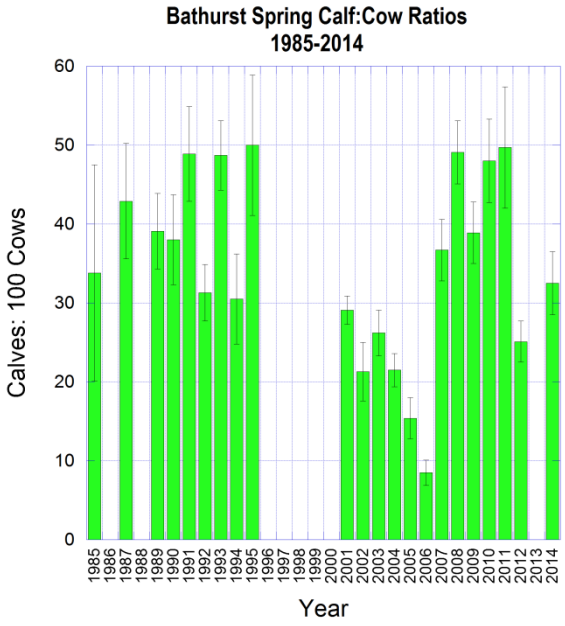


Fig. 9. Spring (late-winter) calf:cow ratios for the Bathurst herd 1985-2014.

The most recent Bathurst spring calf:cow ratios were 25:100 in 2012 and 32:100 in 2014. These are lower than the ratios recorded 2007-2011. A spring composition survey was not carried out in 2013 due to substantial mixing of Bathurst and Bluenose-East caribou. However, a fall composition survey was carried out for the Bathurst herd in Oct. 2012 (calves born in 2012); the calf:cow ratio was 24:100. Fall calf-cow ratios (calves 5 months old) are generally similar and

usually slightly higher than spring ratios (calves 10 months old). This would indicate consistently lower calf recruitment 2012-2014 (calves born in 2011, 2012 and 2013) than in 2010 and 2011 (calves born 2009 and 2010) in the Bathurst herd.

3.5 Fall composition surveys

Fall composition surveys have been conducted periodically for the Bathurst herd. The main focus of these surveys is to provide an estimate of sex ratio (bulls:100 cows) in the herd. The surveys are carried out in mid-late October near the peak of the breeding season or rut. At this time of year, with adequate spatial coverage, all segments of the herd are mixed and the male:female ratio can be estimated reliably. At other times of year, cows with calves are usually segregated (found in different areas) from bulls, yearlings and non-breeding cows. Fig. 10 shows fall bull:cow ratios for the Bathurst herd from 2004 to 2012. Bull:cow ratios between 2004 and 2008 ranged between 31 and 38 bulls:100 cows, and were higher in 2011 and 2012 at 56-58 bulls:100 cows. Bull:cow ratios in barren-ground caribou are biased towards females, as males have higher mortality rates than females at all ages and ratios of about 50:100 are common (Bergerud 2000). Ratios below 50:100 are consistent with herds experiencing poor conditions, as demonstrated for the Bathurst herd by the low bull:cow ratios in this herd 2000-2006. Increased bull:cow ratios in 2011 and 2012 appear consistent with the herd's stabilizing trend 2009-2012. As with calf:cow ratios, however, bull:cow ratios are influenced by mortality rates of both bulls and cows; high cow mortality can inflate bull:cow ratios. This may in large part account for the apparently high bull:cow ratios in 2011 and 2012 (discussed further by Boulanger et al. 2014a).

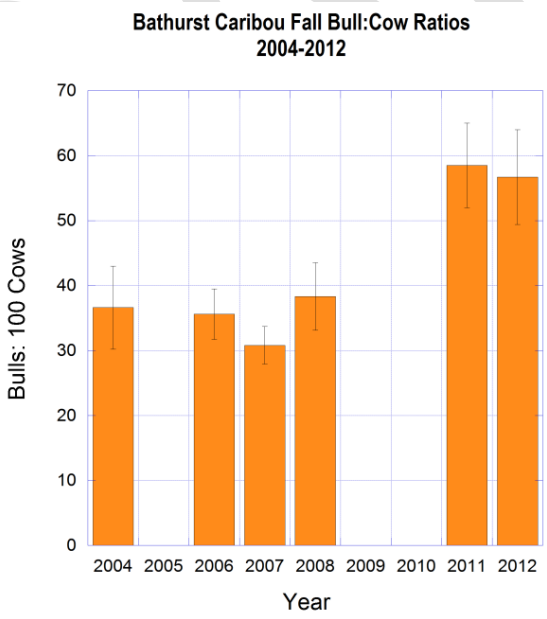


Fig. 10. Fall bull:cow ratios in the Bathurst herd 2004-2012

3.6 Pregnancy Rates

Information on pregnancy rates of Bathurst caribou cows has been collected periodically since 1990 from hunter-killed cows in the winter, but in many of the years the sample size has been small (10-15 cows or less). The low sample sizes make it difficult to consider these rates as reliably representing the herd's average pregnancy rate. In some years, pregnancy rates of

Bathurst cows have also been determined in cows captured in March/April and tested for progesterone in the serum (high in pregnant cows and very low in non-pregnant cows). The results are listed in Table 1. In most years, pregnancy rates have been relatively high (80% or more). A year that stood out for both an adequate sample size (n=150) and a low pregnancy rate (63%) was 2005; this was a year during a period (2000-2006) when Bathurst calf recruitment was consistently low (9-20 calves: 100 cows) and the herd was declining rapidly. In 1994, by contrast, 107 of 116 (92%) hunter-killed Bathurst cows were pregnant; these contrasting rates illustrate the range of pregnancy rates that have been documented in the herd.

Table 1. Pregnancy rates of Bathurst caribou cows 1990-2014 recorded either from hunter-killed animals or from blood samples of caribou captured for collar deployment.

Date	Hunter kits/Collections	Collaring	Combined
March 2014	n/a	9/13	
March 2013	Adult Cows: 5/5	7/8	12/13 (92.3%)
March 2012	n/a	13/14	
February 2011	Adult Cows: 20/25 (80%)	12/14	32/39 (82.0%)
March 2010	Adult Cows: 10/14 (71.4%)	12/14	22/28 (78.6%)
April 2009	Adult Cows: 25/28 (89.3%)		
March 2008	Adult Cows: 26/26 (100%)		
March 2005	Adult Cows: 95/150 (63.3%)		
March 1995	Adult Cows: 10/13 (76.9%)		
March 1994	Adult Cows: 107/116 (92.2%)		
March 1992	Adult Cows: 11/14 (78.5%)		
March 1991	Adult Cows: 6/10 (60%)		
March 1990	Adult Cows: 10/10 (100%)		

An NWT-wide collar deployment across multiple herds in March/April 2012 resulted in pregnancy being tested from serum progesterone in 138 cows at capture. The overall pregnancy rate was 61% (84/139), similar to the 63% recorded in Bathurst cows in 2005 during a period of rapid decline in the herd. For Bathurst cows, 12 of 13 captured or harvested females were pregnant in 2013 but this is a small sample. Although the limited Bathurst data do not provide evidence of a low pregnancy rate in 2012, the relatively low pregnancy rate across several herds on a large scale in 2012 may be indicative of a range-wide effect in several herds mediated by weather resulting in poor summer range condition leading to many cows being lean in the fall breeding season (Cameron et al. 1993, Cameron 1994).

Table 2. Pregnancy rates in 138 caribou cows captured March/April 2012 during collar deployments for herds across the NWT.

Herd	Blood collected (females)	# Pregnant	Pregnancy Rate
Bathurst	13	12	92.3
Bluenose-East	42	27	64.3
Beverly and Ahiak	27	16	59.3
Bluenose-West	34	17	50.0
Cape Bathurst	12	7	58.3
Tuktoyaktuk Peninsula	10	5	50.0
Totals	138	84	60.9

3.7 Harvest Estimates

Hunter harvest from the Bathurst herd has not been monitored reliably in all years. The harvest was estimated at 4000-6000/year, mostly cows, in 2007-2008 and 2008-2009, based on check-station results, hunter interviews and officer patrols carried out by ENR North Slave wildlife staff (Adamczewski et al. 2009). This estimate included 419 and 223 bulls taken in 2008 and 2009 by outfitter clients, less than 100 bulls taken annually by resident hunters, and an estimated 4000-5000 taken by Aboriginal hunters, primarily cows on the winter range. There is a limited harvest in Nunavut by Aboriginal hunters and outfitters.

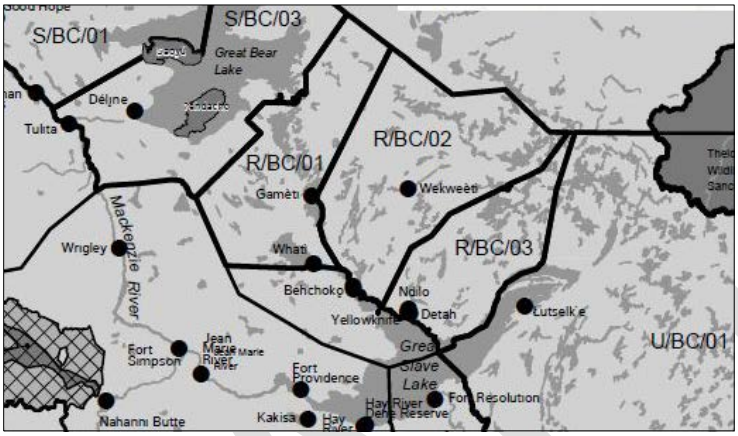
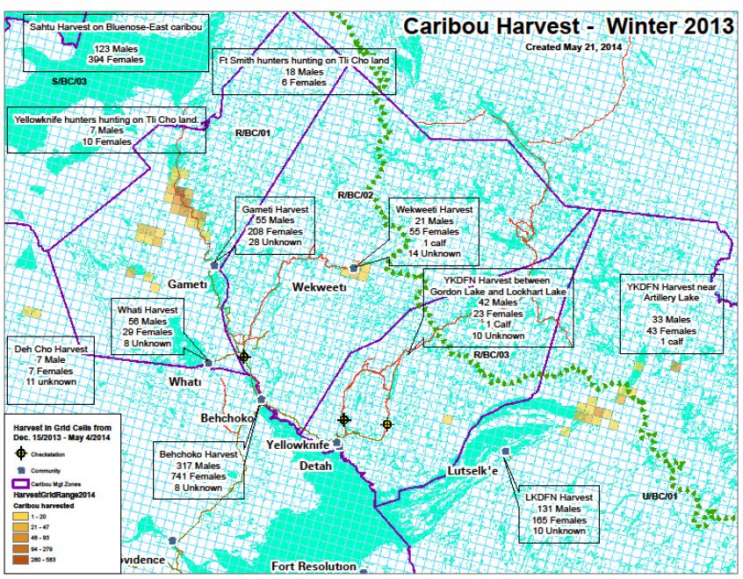


Fig. 11. NWT barren-ground caribou management zones in the main Bathurst caribou winter range and adjacent areas

Resident and outfitter harvest was closed at the end of 2009 in the NWT and Aboriginal harvest restricted to 300 or less (80% bulls or 60 or less cows), by agreement with the Tlicho government and the Yellowknives Dene First Nation in 2010. The restricted harvest applied in two management zones (RBC02 and RBC03) created to include the main NWT Bathurst winter range (Fig. 11).

Since the major harvest restrictions on the Bathurst herd in 2010, harvest in the North Slave region (primarily zones UBC01, RBC01, RBC02 and RBC03) has been monitored by a combination of check-stations, community monitors, officer patrols and estimates of community harvest from wildlife officers (Nunavut). Locations of harvested caribou are mapped and assigned to herd based on zones and collared cow locations. An example of mapped harvest from winter 2013 is shown in Fig. 12, along with a summary of estimated harvest before 2010 and Bathurst harvest as reported for RBC02 and RBC03 from 2010 to 2013. Harvest reported for RBC02 and 03 has averaged 191 caribou with a variable sex ratio. These estimates are considered under-reported; they do not include harvest in Nunavut, wounding losses or harvest of Bathurst caribou in zones outside RBC02 and RBC03.



Bathurst Harvest Estimates

2007-2009:
4000-6000/year, mostly cows

2009-2013*:
Monitors, officers, check-stations

Year	Estimated	% cows
2009-2010	300	65
2010-2011	213	58
2011-2012	87	82
2012-2013	166	42
Average	191	62

* As reported for RBC02 and RBC03; total harvest may be under-reported

Fig.12. An example of winter harvest mapped for North Slave communities and caribou management zones (left) and a summary of harvest estimates for the Bathurst herd 2007-2013 (right). Sex ratio of a portion of the reported harvest was reported as unknown; table includes sex ratio for caribou where it was reported.

To assess the likelihood and potential extent of harvest of Bathurst caribou outside the two zones where caribou harvest is limited to 300 or less (RBC02 and RBC03), winter collar locations of Bathurst and BE caribou were mapped for each winter (Dec-April) from 2010 to 2014 (Fig. 13). In addition, the numbers of collar locations, the percentages of collar locations, and the numbers of individual collared caribou from the 2 herds found in each of 5 management zones were tabulated (Table 3).

In general, BE caribou were primarily found in RBC01 and SBC03, south, east and north of Great Bear Lake, but were also found in RBC02 in 4 of the 5 winters. Bathurst collared caribou wintered mostly in RBC02 and RBC03, but 8, 14, 12, 24 and 0% of the collared caribou locations were in RBC01 in 2010, 2011, 2012, 2013, and 2014, respectively. Bathurst collared caribou also were found in UBC01 to a limited extent in 2012 and 2013; in 2013, 13% of the Bathurst collar locations were in UBC01.

Bathurst caribou wintering outside of RBC02 and RBC03 could have been exposed to additional harvest in RBC01 and to a lesser extent in UBC01. Most of the estimated/reported BE harvest since 2010 has been in RBC01, with average harvest estimated at about 2700/year, mostly cows. However, as noted further on in this summary, this estimate is considered under-reported and may be 4000 or more. The relative sizes of the two herds (Bathurst smaller than BE) and the predominance of use of RBC01 and SBC03 by BE caribou would suggest that most of the caribou harvest in RBC01 has been from the BE herd. Defining the Bathurst herd's winter distribution has been challenging due to the low collar numbers on this herd; there have generally been more collars on BE caribou. If a substantial part of the Bathurst herd wintered in RBC01 where harvest of several thousand caribou is estimated to have occurred, then some of this harvest was likely Bathurst caribou (e.g., in 2013 in the Hottah Lake area southeast of Great Bear Lake (Fig. 14).

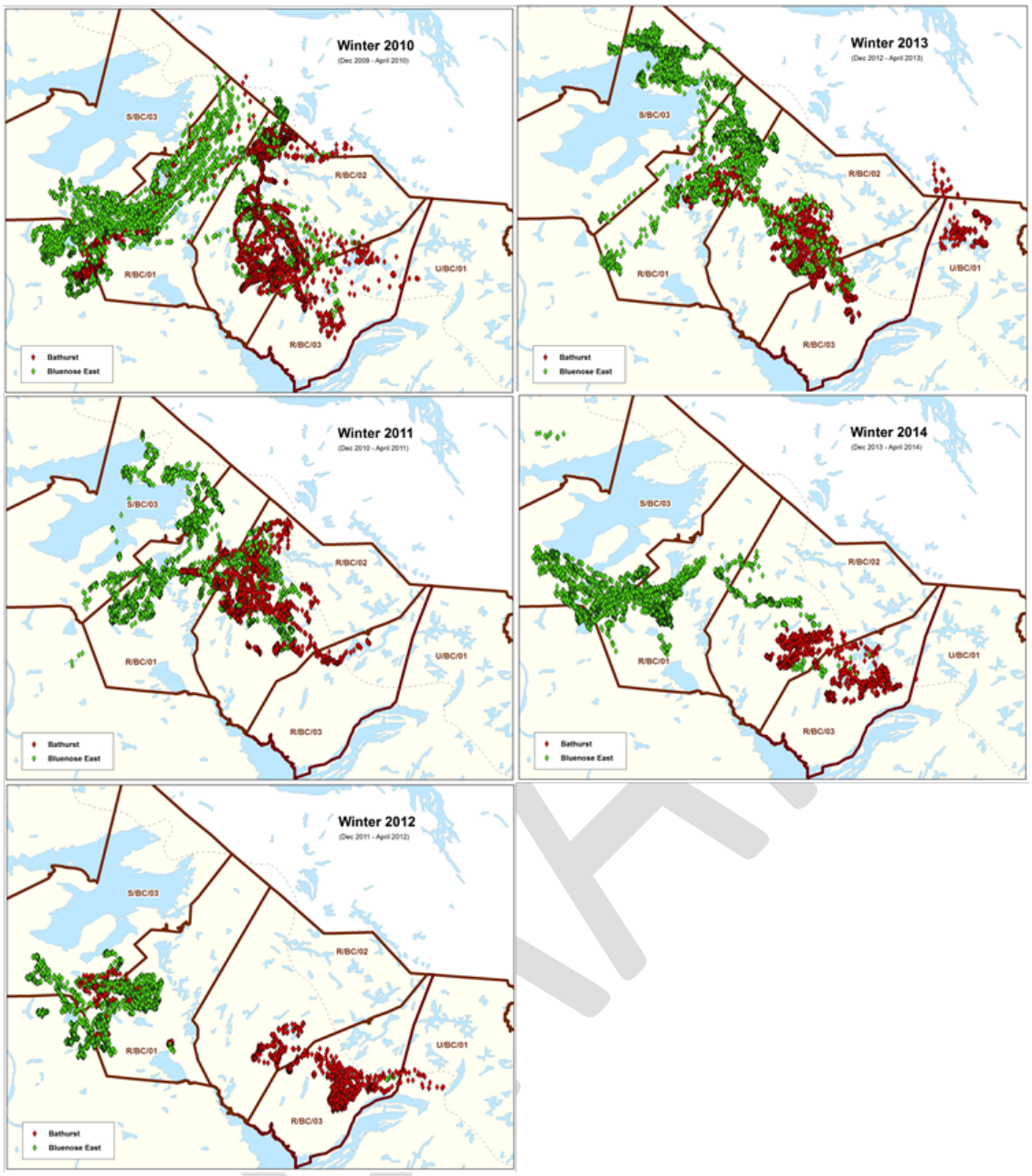


Fig. 13. Composite maps of collared caribou locations of Bluenose-East (green) and Bathurst (red) caribou during winter (Dec.-April) of 2010-2014 in relation to NWT barren-ground caribou management zones. RBC02 and RBC03 are the zones where Bathurst caribou harvest has been limited to 300 or less since Jan. 2010.

Table 3. Numbers of collared caribou locations, percentages of collar locations, and numbers of collared caribou occurring in or near NWT game management zones RBC01, RBC02, RBC03, SBC03 and UBC01 in winters 2010-2014. These numbers apply to the maps in Fig. 13.

WINTER 2010

BATHURST		HUNTING ZONES					
	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	5647	464	4387	556	0	4	236
% POINTS		0.08	0.78	0.10	0.00	0.00	0.04
# COLLARS	26	3	17	15	0	1	2

BLUENOSE EAST		HUNTING ZONES					
	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	9842	4111	1836	68	1008	0	2819
% POINTS		0.42	0.19	0.01	0.10	0.00	0.29
# COLLARS	56	46	15	4	22	0	25

WINTER 2011

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	3782	548	3046	188	0	0	0
% POINTS		0.14	0.81	0.05	0.00	0.00	0.00
# COLLARS	21	9	21	1			

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	7738	3652	2718	0	1364	0	4
% POINTS		0.47	0.35	0.00	0.18	0.00	0.00
# COLLARS	35	23	15		15		1

WINTER 2012

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	1870	216	382	1145	102	25	0
% POINTS		0.12	0.20	0.61	0.00	0.01	0.00
# COLLARS	25	4	8	15	1	6	

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	5829	3793	0	10	894	0	1132
% POINTS		0.65	0.00	0.00	0.15	0.00	0.19
# COLLARS	68	60		1	17		10

WINTER 2013

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	2114	501	942	369	0	272	30
% POINTS		0.24	0.45	0.17	0.00	0.13	0.01
# COLLARS	20	7	13	6		2	2

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	9494	3258	1473	119	4582	0	62
% POINTS		0.34	0.16	0.01	0.48	0.00	0.01
# COLLARS	51	28	22	3	25		3

WINTER 2014

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	1582	0	887	694	0	1	0
% POINTS		0.00	0.56	0.44	0.00	0.00	0.00
# COLLARS	23		17	12		1	

	TOTAL	R/BC/01	R/BC/02	R/BC/03	S/BC/03	U/BC/01	OUT
LOCATIONS	7142	3715	457	26	2544	0	400
% POINTS		0.52	0.06	0.00	0.36	0.00	0.06
# COLLARS	40	31	5	1	22		4

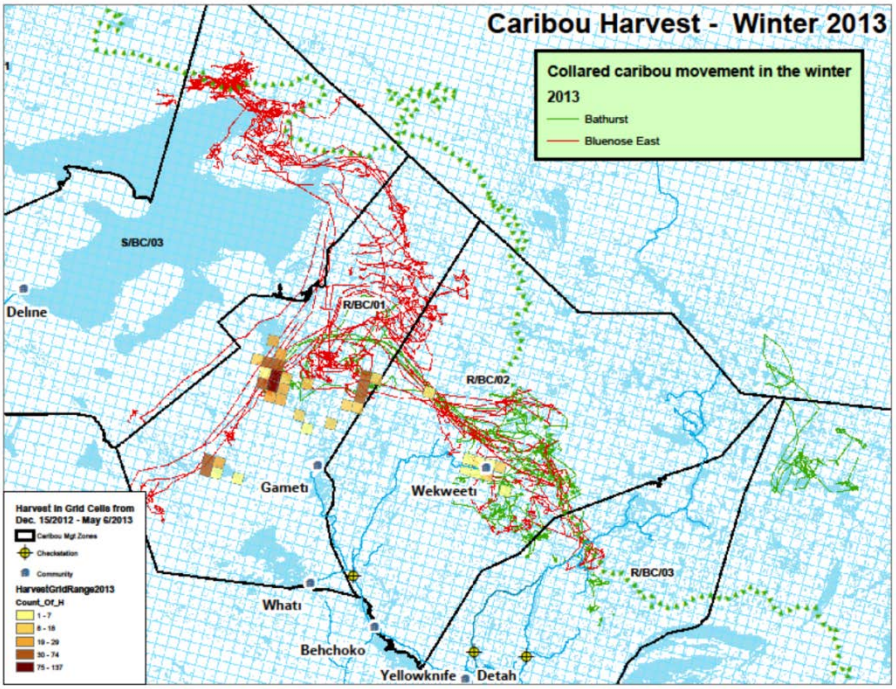


Fig. 14. Movements of collared Bathurst (green) and Bluenose-East (red) caribou in winter 2013 (Dec 2012-April 2013) in relation to caribou management zones and main harvest areas. Squares are 10x10km, coloured squares show areas where harvest was recorded and darker colours show areas with greater levels of harvest.

3.8 Wolf monitoring and harvest

Trends in the number of wolves in theNWT are of management interest because wolves are the main predator of barren-ground caribou. However, wolves are difficult to count at the population scale and high costs and potential biases inherent in existing techniques have limited efforts. Wolves on the tundra follow barren-ground caribou as caribou migrate from summer ranges on the tundra to winter ranges typically in the boreal forest. Although counting wolves in forested areas is problematic because of trees, wolves are more easily observed in the tundra. Wolves on the tundra raise their pups in dens, which are visible from the air. Wolves tend to re-use their den site each year and therefore annual surveys of den use (occupancy) over a wide area can provide a technique to monitor annual changes in wolf numbers.

Wolf numbers in the Bathurst summer range have been monitored by annual den surveys since 1996, although not always for trend analysis. Prior to 2006, different study objectives involving radio-collared wolves restricted the survey area covered. From 2006 to 2012, sampling coverage increased to establish a more representative area for monitoring trends of tundra-denning wolves. An occupancy (e.g., presence/absence) approach is used with 10 km x 10 km grid cells serving as the sampling unit. Previous research and local knowledge have shown that wolves tend to den on eskers and other gravel deposits where they can dig into the ground. Therefore, grid cells do not have to be surveyed in their entirety for wolves, but can be stratified by eskers and esker-like habitat within cells. An example of the area surveyed for wolf den occupancy is shown for summer 2012 (Fig. 15).

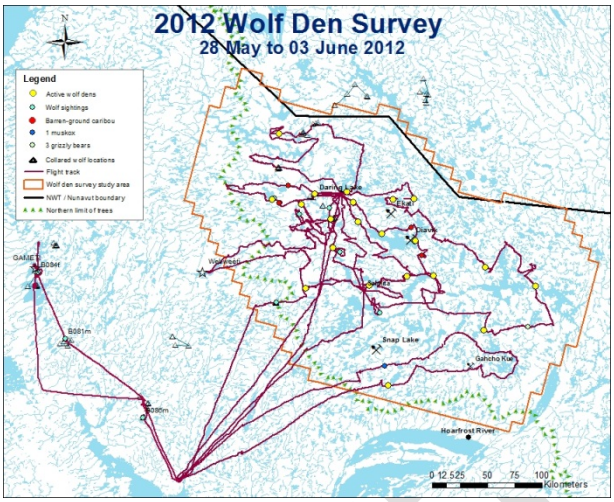


Fig. 15. Wolf den reconnaissance survey in Bathurst summer range in 2012 (D. Cluff, ENR)

An aerial survey in mid- to late August has been flown to all the active wolf dens found earlier that spring in each year to count the number of pups at dens. The number of dens visited that have pups is a subset of the number of dens found active in spring because pups could be relocated to another site and not discovered or all the pups could have died and so the parents no longer have to return to the same site for pup-rearing (Fig 16a). Ground observations of active dens are done in late summer where logistics permit to improve the accuracy of aerial counts. The most reliable number of wolf pups observed at each site in late summer or early fall is used to estimate recruitment of pups to the population. The average number of pups observed at a den or rendezvous site has declined in recent years (Fig 16b).

The pup recruitment survey in August cannot distinguish between total litter loss or site relocation as the reason why pups are not observed at revisited dens that were active earlier in spring. Doing so is critical to understand the distribution and recruitment of pups in late summer and to determine if this monitoring is an effective index of wolf abundance without using radio-collars. To address this problem, M.Sc. graduate student M. Klaczek from University of Northern British Columba (UNBC) was brought on to track collared wolves at dens to quantify the extent of litter loss at dens during 2013 and 2014. The annual spring den occupancy survey was not completed during this time.

Summary of NWT Wolf Project 2013/2014 (M. Klaczek, UNBC)

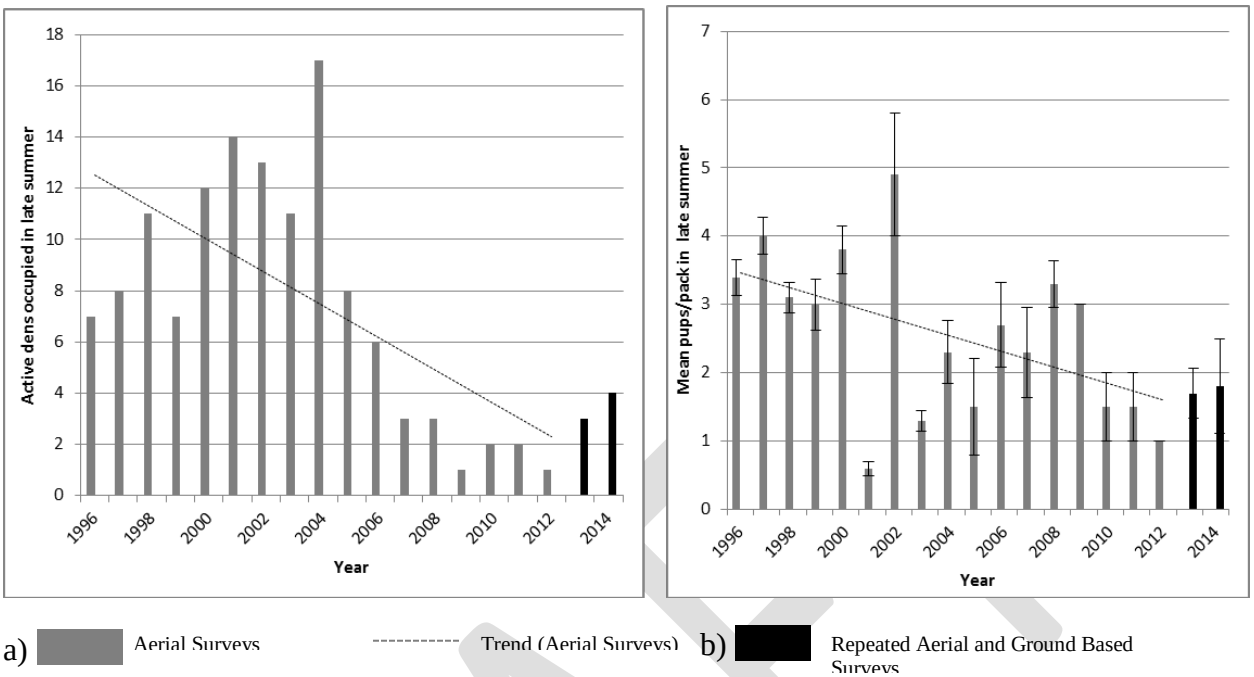


Figure 16. Observed a) number of active dens and b) pup recruitment (± SE) during annual aerial surveys (1996-2012) and repeated aerial/ground based surveys of tracked individual packs (2013-2014) on the summer range of the Bathurst herd, Northwest Territories and Nunavut Canada.

From 21-24 June, 2013, 16 female wolves were captured representing individual packs; 15 were breeding (lactating) females and 1 was a subadult (non-lactating) female. Over the 2013 and 2014 denning periods, 27 wolf packs (17 and 10 respectively) were monitored, 15 of which were monitored via a GPS collared adult female (N collared wolves = 15 and 4 in 2013 and 2014 denning periods respectively). Over 5 field sessions (total = 35 days; 3 and 2 sessions in 2013 and 2014 respectively), over 204 aerial checks were conducted to track wolf packs by visiting known den sites, radio-tracking, or by visiting clusters of GPS locations that may have represented a relocated den or rendezvous site. Over 111 hours were spent observing wolf dens/rendezvous sites on the ground over 66 separate field visits.

During the 2013 denning period, 6 of the 15 packs with a GPS collared female lost their pups by the end of August. The mean number of pups/pack declined throughout the denning period from 2.9 (± 0.31 SE) in July, 2.0 (± 0.40 SE) in August, and 1.7 (± 0.37 SE) in early September. Only 3 packs remained at their respective whelping den throughout the denning period (until early September); litter loss accounted for half of observed den abandonment. Eight active den sites (packs with pups) were located during the 2014 denning period. Only 2 of the 4 remaining GPS-collared females bred in 2014, however, wolf 432 likely lost her pups in early July, just prior to field surveys. The mean number of pups/pack declined throughout the 2014 denning period from 2.6 (± 0.6 SE) in early July to 1.8 (± 0.7 SE) in late August. Similar to 2013, only half of the monitored packs (4 of 8) remained at their whelping den throughout the denning period.

High rates of den abandonment and low pup recruitment observed during the 2013 and 2014 denning periods were consistent with observations recorded during late summer aerial surveys

since 2007 (Figure 16). These results indicate that annual recruitment of pups has declined recently. Our results corroborate previous observations on wolf populations in both Alaska (Boertje and Stephenson 1992) and elsewhere in North America (Keith 1983, Fuller 1989, Fuller et al. 2003) such that varying levels of ungulate biomass strongly influence wolf population dynamics. This may mean that the wolf tundra population on the Bathurst caribou range has also decreased, although it is not clear if this represents a change in distribution or a change in abundance.

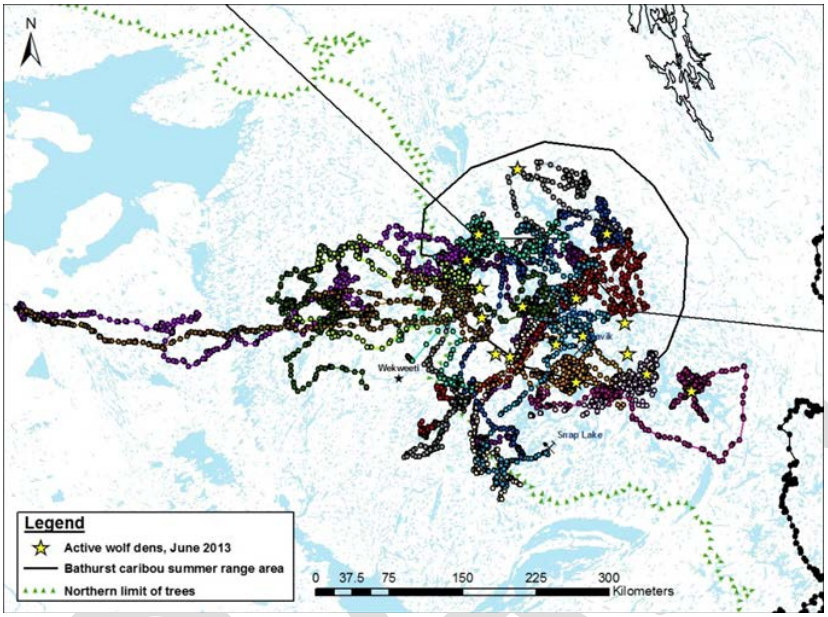


Fig. 17. Far-ranging movements of satellite-collared wolves captured in the Bathurst den survey area Oct-Dec 2013 (D. Cluff and M. Klaczek unpublished data). Different colours identify individual wolves.

Initial mapping of the movements of satellite-collared wolves captured at dens in the Bathurst range in 2013 provided an indication of the far-ranging movements of these tundra wolves in the fall and early winter (Fig. 17), over much larger distances than previously thought. These movement behaviours make the interpretation of den survey trends difficult. Further review of the information is required.

Wolf Harvest in the North Slave Region 2008-2014

As part of efforts to stabilize the caribou herds and promote their recovery, a program of increased incentives for wolf harvest was initiated in 2008/09 in the North Slave Region. Initially, financial incentives were $200 for prime pelts and $100 for carcasses. Carcasses were necropsied for a variety of samples. The intent was to increase harvest of wolves on the Bathurst winter range by 80 to 100 wolves. Only 25 wolf carcasses were submitted in the 2008-09 season. This program continued for a second year until an NWT-wide wolf carcass collection replaced it for the 2010-11 season. At that time, financial incentives were increased to $400 for prime pelts and $200 for carcasses. These programs had limited success and it is likely that survival rates of adult and calf Bathurst caribou were not meaningfully altered. For the 2013-14 season, the North Slave Region dropped back to a skull only program and payment was $50/skull, although the $400 payment per pelt was maintained. Currently, the wolf skull collection program and pelt price incentives are continuing for the 2014-15 harvest year.

Wolf harvests have been monitored annually. The total numbers of wolf carcasses reported in the North Slave Region in 2009-2010, 2010-2011, 2011-2012, and 2012-2013 were 19, 41, 80, 56 and 25 respectively (average 44, Table 1). Of the 221 wolves harvested in total, 59 were associated with dumps or sewage lagoons, 59 were taken from areas where collared Bathurst cows have not occurred in recent years (i.e., east of Great Slave Lake in areas near Artillery Lake, Reliance and Lutsel K'e), and 20 were taken in the Yellowknife area.

Table 4. Wolf Carcass/Skull Collection in the North Slave Region 2009-2014**.**

Location	2009-10*	2010-11	2011-12	2012-13	2013-14[a]
Dumps/Sewage Lagoons:					
Yellowknife/Dettah		2	2	6	
Lutsel K'e			1		
Behchoko	1	3	16	13	3
Gameti/Whati	3				4
Wekweeti		1			4
General area/Outside of:					
Yellowknife		13	4	3	
Lutsel K'e		1	6		
Behchoko/Hwy 3	1	3	2	8	3
Gameti/Whati		1			
Wekweeti			4	1	
Great Slave Lake area	3		4		
Winter Roads	4	5	7	2	9
Fort Reliance	5	1	10	6	
Artillery Lake/Sandy Lake area		9	17	4	
Grandin Lake/Hottah Lake area	1				1
other sites within NSR			3	8	1
received from outside the North Slave Region			3	1	
no location info	1	2	1	4	
TOTAL:	19	41	80	56	25

*harvest year spans 01 July to 30 June
[a]skull collection only

3.9 Movements of collared Bathurst and Bluenose-East caribou to other ranges

When declines of caribou herds are detected from population surveys, a key question that is asked is whether the caribou could have moved to a neighbouring herd's range. To address this question, June locations of collared cows where there were at least 2 consecutive annual

locations were assessed for the Bathurst and BE herds for 2010-2014, along with their neighbours to the east and west (Fig. 18). Of 149 pairs of consecutive June locations for the five herds in Fig. 18, 144 (96.6%) returned to same calving ground and 5 (3.3%) switched to a neighbouring calving ground. These rates of switching are consistent with previous similar low rates of collared cow movements to neighbouring ranges (e.g. Bathurst herd 2006-2009, Adamczewski et al. 2009). While the collar sample size is limited, this assessment suggests that large-scale movements of the Bathurst herd (and BE herd) to other ranges did not occur 2010-2014.

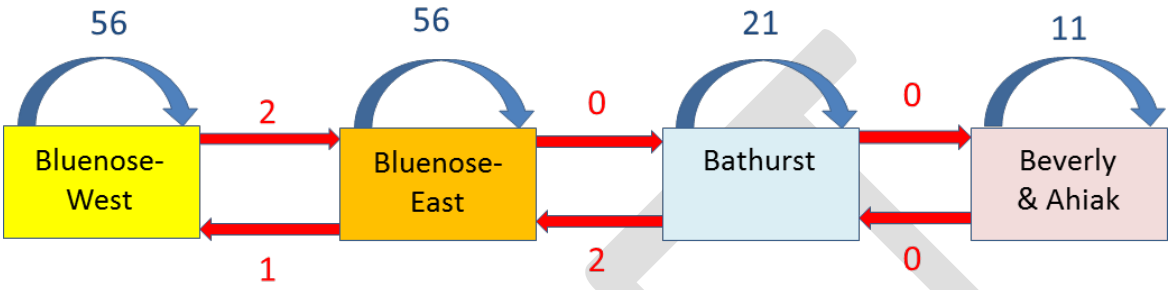


Fig. 18. Frequencies of switching between calving grounds of collared caribou cows from 5 neighbouring herds where at least 2 consecutive June locations were known, 2010-2014. Each pair of locations represents one data point. The numbers of cases where a cow returned to the same calving ground are in blue and the cows that switched are in red.

3.10 Management context for the Bathurst herd

An overall management plan for the entire range of the Bathurst herd is not in place as of Sept. 2014. However, a number of management initiatives have occurred or are underway for the herd.

Overall Bathurst herd management:
An initial management plan for the Bathurst herd was put together by a co-management process 2000-2004 by the Bathurst Caribou Management Planning Committee and a draft plan was completed in Nov. 2004 (BCMPC 2004). This plan was not signed off by all parties.

Since June 2012, there has been an ongoing effort by the Wekeezhii Renewable Resource Board (WRRB), Tlicho Government, and GNWT to develop a long term comprehensive management process for the herd, as required under section 12.5 of the Tlicho agreement. This initiative has included several meetings of the Bathurst Caribou Management Working Group, which is tasked with developing a mechanism to manage the Bathurst over the long-term. This mechanism may be a caribou board or body, similar to the Porcupine Caribou Management Board or Beverly and Qamanirjuaq Caribou Management Board. A Bathurst Caribou Harvesters' Gathering (Barnaby and Simmons 2013) was held in Jan. 2013 to help define this management mechanism.

Short-term management:
Initial harvest reductions were implemented by ENR in 2006 after a population survey showed a significant decline in the Bathurst caribou herd. Harvest allowed for resident hunters was reduced to 2 bulls/year and big-game outfitter tags were reduced from 1241 bulls in 2006 to 691 in 2007. After a further and more rapid decline documented in 2009, resident and big-game

outfitter harvest in the Bathurst range was reduced to 0. Aboriginal harvest was reduced to a target of 300 caribou (80% bulls) in management zones RBC02 and RBC03. These 300 caribou were divided equally between the Tlicho and Yellowknives Dene First Nation. Harvest has been monitored by a combination of community monitors, check-stations and officer patrols. These actions have occurred through joint management proposals submitted by the Tlicho government and GNWT-ENR to the WRRB in 2009 and 2010, an agreement between YKDFN and ENR in 2010, and recommendations since 2010 by the WRRB. The May 2010 joint management proposal and WRRB recommendations of Oct. 2010 can be found on the WRRB public registry.

In 2014, GNWT and the Tlicho submitted an updated joint proposal for management of Bathurst caribou in Wek'eezhi to the WRRB. Suggested actions included continued harvest management and a more focused predator management program centered around the Tlicho communities. Both governments were consulting on this proposal prior to announcement of the August 27 2014 meeting with Aboriginal leaders, political leaders, and co-management boards.

Land Management:

In recognition of concerns over the cumulative effects of development on the Bathurst range (including the calving grounds in Nunavut), ENR initiated a number of collaborative programs between 2012 and 2014 that related to land management. These include a range management planning process for the entire Bathurst range, a cumulative effects assessment, monitoring, and management framework, and a number of workshops focused on wildlife monitoring better suited to cumulative effects assessment, including increased emphasis on standardized monitoring protocols.

4. Bluenose-East Herd

4.1 Population Surveys

Before 2000, the Bluenose-East (BE) herd was surveyed as part of the "Bluenose" herd (Cape Bathurst, Bluenose-West and BE herds combined). Population surveys specific to the BE herd were initiated in 2000. Post-calving surveys were carried out in July and a Lincoln-Petersen estimator of herd size was used (Fig. 19). The herd was estimated at nearly 120,000 in 2000, appeared to decline to about 65,000 by 2006, then increased to an estimated 99,000 in 2010.

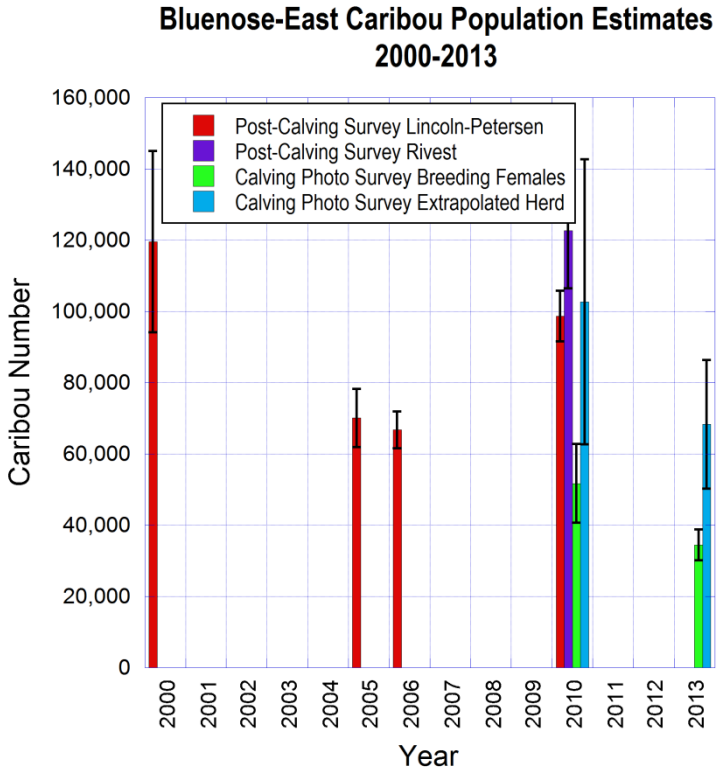


Fig. 19. Lincoln-Petersen and Rivest population estimates from a July 2010 post-calving survey from the Bluenose-East herd.

In 2010, ENR carried out a calving photo survey of the BE herd as well as a post-calving survey in July. This was the first side-by-side comparison of the two survey methods on the same herd in the same year in the NWT. Details on the survey methods and population estimates are provided by Adamczewski et al. (2014). In brief, the June photo-survey is designed to provide an estimate of the numbers of breeding females on the calving grounds. This can be extrapolated to an estimate of herd size using ratios to add in non-pregnant cows and males. The post-calving survey is based on photos of caribou groups that are tightly aggregated in July in response to biting flies. Groups may number tens, hundreds or thousands and include males and females at least one year old. An adequate number of collars is needed to find the caribou groups, and a statistical correction is then applied to account for caribou not found.

From the June 2010 survey, an estimate of breeding females of about 51,700 was derived. An estimate of adult caribou at least 1.5-years-old in the herd (ca. 102,700) was extrapolated from

the estimate of breeding females using estimates of sex ratio from a fall composition survey and an estimate of pregnancy rate in cows at least 1.5-years-old.

From the July 2010 survey, photos were taken of 41 groups of caribou that included 44 of 47 collars in the herd, and 92,481 caribou at least one year old were counted on the photos. An estimate of herd size using a Lincoln-Petersen (LP) estimator provided a herd estimate of about 98,600 caribou at least one year old. A more recent and statistically more sound estimator of herd size using calculations of Rivest gave a herd estimate of 122,700 caribou at least one year old. This estimator had not previously been used in the NWT but has been accepted in Alaska and Québec, where it was developed.

Overall, all herd estimates from 2010 indicated a herd of at least 100,000 adult caribou (1-year-old+) and a likely herd size of about 120,000.

A post-calving survey of the BE herd was attempted in July 2012 but was unsuccessful due to insufficient aggregation of caribou in much of the herd. This survey method has failed previously with the BE herd in other years and has failed in other caribou herds (e.g. Porcupine and Western Arctic herds in Alaska); it requires that nearly all the herd form large dense groups that can be photographed.

A calving photo-survey of the BE herd was carried out successfully in June 2013 and reported by Boulanger et al. (2014c). Estimates of the number of breeding females, extrapolated herd size and the number of 1-year-old+ caribou estimated in the June survey area are shown in Fig. 19. The estimate of breeding females and extrapolated herd size both declined significantly; the number of breeding females was reduced by 1/3 at 34,500 and the extrapolated herd estimate was reduced by a similar margin.

4.2 Calving ground reconnaissance surveys

As described earlier for the Bathurst herd, calving ground reconnaissance surveys have been used for some caribou herds in the NWT to map calving grounds and as a lower-cost indicator to monitor the numbers of caribou on a herd's calving grounds, most of which are breeding cows. For the BE herd, reconnaissance surveys of the calving grounds were the initial step in calving photo-surveys in 2010 and 2013. A further calving reconnaissance survey was carried out in June 2014; results were reported by Boulanger et al. (2014d). Results of these reconnaissance surveys are shown in Fig. 20, along with estimates of adults (1-year-old+) on the main calving area from the more intensive calving ground photo-surveys.

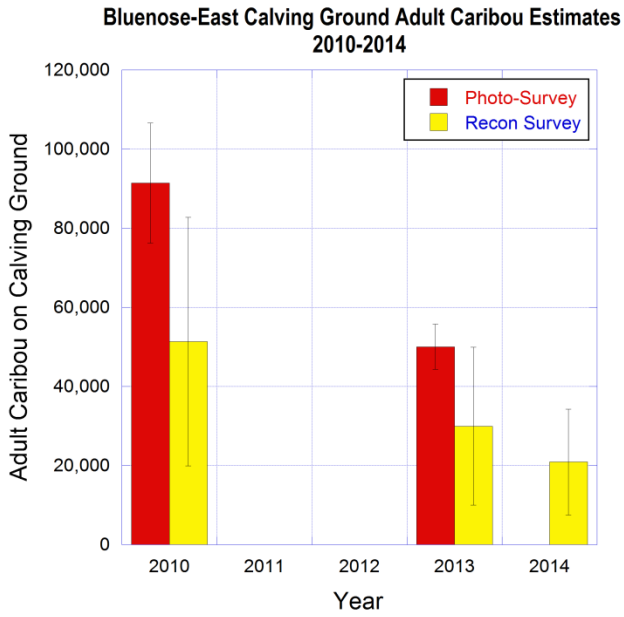


Fig. 20. Estimates of adult caribou (1-year-old+) on the Bluenose-East herd's calving grounds in 2010, 2013 and 2014 from calving photo-surveys and reconnaissance surveys

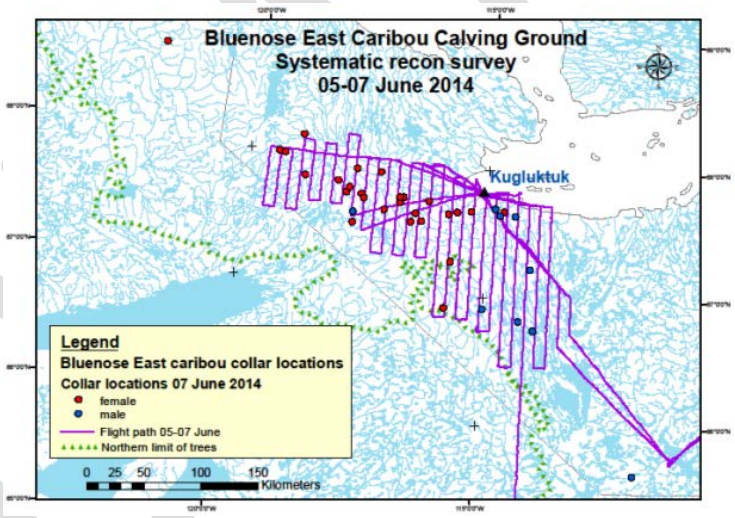


Fig. 21. Flight lines and collared caribou locations (cows red, bulls blue) from June 5-7 2014 calving reconnaissance survey over Bluenose-East calving grounds. Bulls, non-breeding cows and yearlings have been generally found south and east of Kugluktuk in recent years while the main calving grounds have been west of Kugluktuk.

Estimates from the reconnaissance surveys paralleled the trend in breeding females and extrapolated herd size in Fig. 21. Because of the relatively low coverage and high variance on reconnaissance surveys, the results should be interpreted with caution. However, the relatively rapid declining trend for the Bluenose-East herd 2010-2013 appears to be continuing. Flight lines flown on the BE 2014 June recon survey are shown in Fig. 21, with collar locations of cows and bulls. As in recent surveys of this calving ground, most of the collared cows were in the main calving area west of Kugluktuk, while most of the bulls and a few cows were south and

east of Kugluktuk where bulls, yearlings and non-breeding cows were concentrated in 2010 (Adamczewski et al. 2014).

4.3 Spring calf recruitment surveys

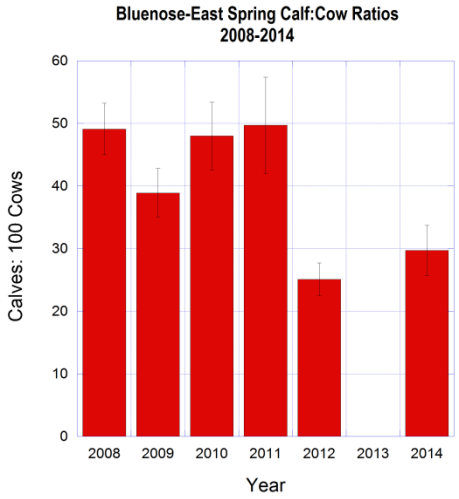


Fig. 22. Spring calf:cow ratios for the Bluenose-East herd 2008-2014 (no survey in 2013 because herds were mixed)

As described earlier for the Bathurst herd, spring (late-winter) composition surveys to monitor the ratio of calves:100 cows are used to provide an index of the number of calves in a caribou herd surviving to about 10 months of age. Recent spring calf:cow ratios for the BE herd are shown in Fig. 23. Similar to the Bathurst herd, calf:cow ratios of 38-50:100 cows were recorded 2008-2011, but lower ratios of 24 and 30 were recorded in 2012 and 2014.

4.4 Adult cow survival estimates

As noted earlier, caribou population trend is most sensitive to the survival rate of adult cows and cow survival rates of about 83% or higher are generally associated with stable herds. Cow survival based on a model that uses all demographic information available for a population was estimated at 73-75% for the BE herd 2010-2013 (Boulanger et al. 2014c), consistent with the rapid decline documented from surveys over this period.

4.5 Fall composition surveys

Fall composition surveys to estimate the ratio of bulls:cows in the BE herd were carried out in late October 2009 and 2013. In 2009, 4,531 caribou in 79 groups were classified and 42.6 bulls:100 cows were observed. In 2013, 5,381 caribou in 117 groups were classified and a similar ratio of 42.9 bulls:100 cows was observed. Bull:cow ratios of about 50:100 are common in caribou (Bergerud 2000).

4.6 Pregnancy and condition

Information on pregnancy rates in Bluenose-East caribou is available 2010-2014 from health and condition monitoring carried out collaboratively with Tlicho government and monitors during

winter harvest of caribou; a summary is included in Appendix 1. Pregnancy rates were determined in late winter by the presence of a fetus, with the results in Table 5 below.

Table 5. Pregnancy rates of Bluenose_east caribou cows 2010-2014 recorded either from hunter-killed animals or from blood samples of caribou captured for collar deployment.

Date	Hunter kits/Collections	Collaring	Combined
March 2014	Adult Cows 44/50 (88%)	7/8 (87.5%)	51/58 (87.9%)
March 2013	Adult Cows: 17/21 (81.0%)		
March 2012	Adult Cows 22/29 (75.9%)	27/42 (64.3%)	49/71 (69.0%)
February 2011	Adult Cows: 11/11 (100%)		
March 2010	Adult Cows: 31/48 (64.6%)	8/9 (88.9%)	22/28 (68.4%)

Additional pregnancy information was available in 2010, 2012 and 2014 from cows captured in late winter to deploy collars (Table 5). Blood was collected and pregnancy was assessed based on serum progesterone levels (high in pregnant cows, very low in non-pregnant cows). In 2010, 8 of 9 cows were pregnant (89.0%); in 2012, 27 of 42 were pregnant (64%) and in 2014 7 of 8 were pregnant (87.5%). Results from smaller samples of 10-15 or less should be used with caution.

Additional information on pregnancy rates of cows captured for collar deployment NWT-wide in March/April 2012 are listed in Table 2 (included earlier in the Bathurst caribou section). The overall pregnancy rates across herds in 2012 was 60.9%.

Condition of hunter-killed Bluenose-East caribou from Tlicho hunters included measuring back fat at the base of the tail. Average back fat thickness was about 10mm in 2010 and 2011, lower at less than 4mm in 2012 and slightly higher in 2013 and 2014 (Fig. 25). As a comparison, backfat thickness averaged 13.9 mm in late winter in Beverly caribou at least 2 years old 1980-1987 (n=696) at a time when the Beverly herd was increasing (Thomas and Kiliaan 1998). Backfat averaged 16mm in pregnant cows (n=583) and 3.1mm in non-pregnant Beverly cows (n=113). By this standard, Bluenose-East cows were relatively lean overall 2010-2014, their condition was relatively poor in 2012 and marginally better in 2013 and 2014.

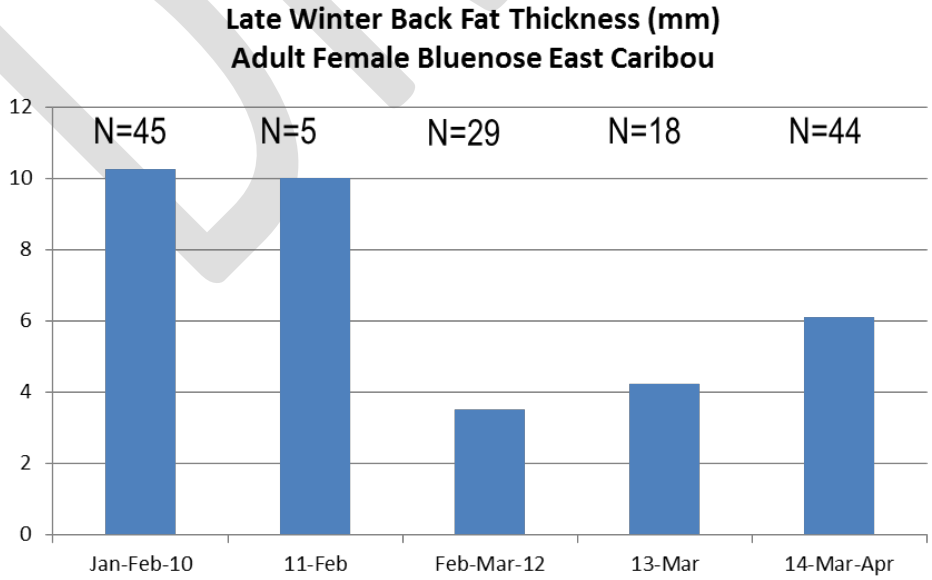
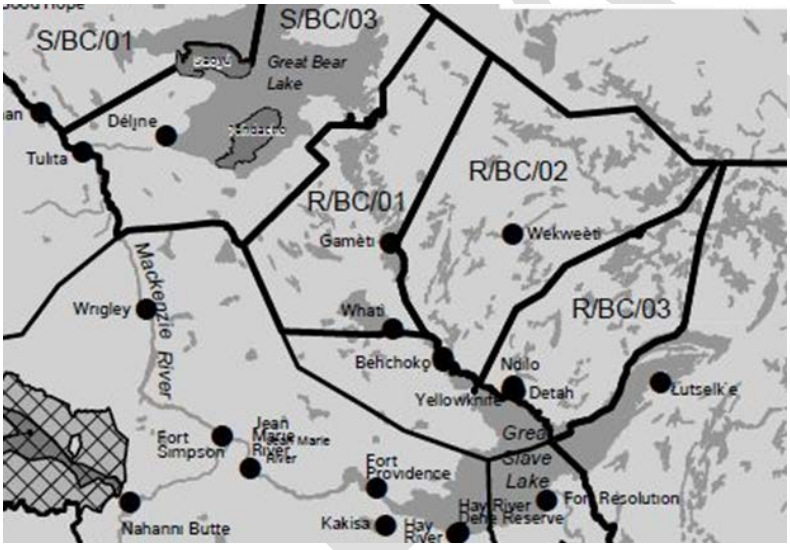


Fig. 24. Back fat thickness in hunter-killed Bluenose-East caribou cows during winters 2010-2014 as collected by Tlicho hunters during community hunts.

To place the pregnancy rates estimated for the BE herd 2010-2014 in context, the pregnancy rate of Beverly cows at least 2 years old averaged 83.7% 1980-1987 (n=708) and 86.1% in cows at least 3 years old (n=588) at a time when the Beverly herd was growing. In the George River herd, pregnancy rates of breeding-age cows averaged 89-100% during a period of increase in the herd in the 1970s, and were 59-78% during the early 1990s when the herd was declining (Bergerud et al. 2008). Recognizing the limited sample sizes in some years, the pregnancy information suggests that BE caribou had relatively low pregnancy rates in 2010 and 2012 and better pregnancy rates in 2011, 2013 and 2014. The NWT-wide low pregnancy rate in multiple herds points to a large-scale effect, possible weather-mediated, that may have affected cow condition in the breeding season on some ranges (Cameron et al. 1993) in 2012. The BE condition data 2010-2014 suggest that caribou were relatively lean over this period in comparison to the Beverly herd in the early 1980s, particularly in 2012-2014.

4.7 Harvest estimates

Harvest of the BE caribou herd was traditionally associated with the community of Deline on Great Bear Lake on the herd's winter range. Some harvest was also associated with Kugluktuk in Nunavut and Tlicho communities in NWT; however the main harvest in the North Slave region in winter was from the Bathurst herd before 2010. Resident harvest and guided-outfitter harvest of barren-ground caribou was also primarily from the Bathurst herd prior to 2010.



Bluenose-East Harvest Estimates

1998-2005:
Deline 1260/year, 60% cows (SRRB)
Limited harvest NU, Tlicho

2009-2013*:
Monitors, officers, check-stations
Primarily zones RBC01 & SBC03

Year	Estimated	% cows
2009-2010	3,466	65
2010-2011	2,918	65
2011-2012	1,766	65
2012-2013	2,562	65
Average	2,678	65

* Considered under-reported

Fig. 25. Barren-ground caribou management zones in the NWT (mostly North Slave region, left) and estimates of harvest from the BE herd 1998-2005 and 2009-2013 (right)

Since the major harvest restrictions on the Bathurst herd in 2010, harvest in the North Slave region (primarily zones UBC01, RBC01, RBC02 and RBC03) has been monitored by a combination of check-stations, community monitors, officer patrols and estimates of community harvest from wildlife officers (Deline, Nunavut). Based on collar locations, the BE herd has wintered primarily in RBC01 and SBC03, with some use of RBC02 (Fig. 13). Overlap of winter range use with the Bathurst herd has been substantial in some winters. Locations of harvested caribou are mapped and assigned to herd based on zones and collared cow locations. The

average estimated/reported BE harvest has been about 2,700 caribou/year, and likely at least 65% cows (Fig. 26). These estimates are considered minimums; wounding losses are not included, some harvest is un-reported and the true harvest may be at least 4000/year. The increased BE harvest since the winter of 2009-2010 may reflect a deflected Bathurst harvest. Some of the harvest in RBC01 has likely been from the Bathurst herd (Figs 13 and 14, Table 1), but the predominance of BE collar locations and the relative sizes of the two herds suggest most of this harvest has been from the BE herd.

4.8 Movements of collared Bluenose-East caribou

In the earlier section on Bathurst caribou, rates of switching between Bathurst and BE calving grounds and neighbouring herds on either side were assessed based on collared cows for which two or more consecutive annual calving ground locations were known (Fig. 18b). This graphic is shown again below. Sample numbers for the BE herd were higher than for the Bathurst herd, which increases confidence in the rates of switching and fidelity reported. As with the Bathurst herd, there was no evidence for large-scale movement from the Bluenose-East calving ground 2010-2014.

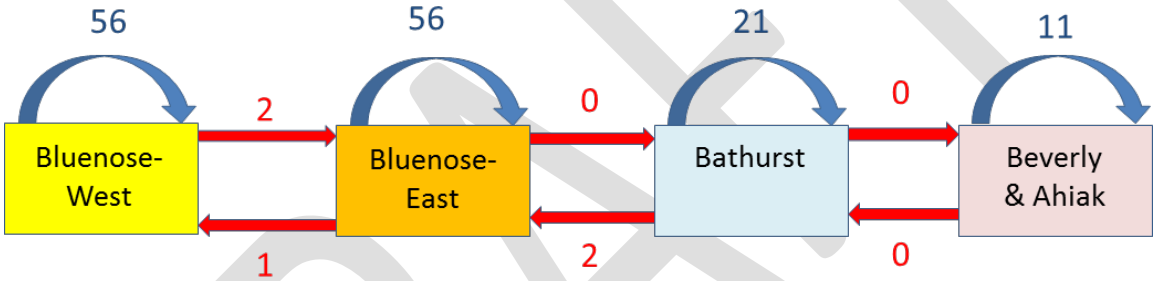


Fig. 18 (shown earlier). Frequencies of switching between calving grounds of collared caribou cows from 5 neighbouring herds where at least 2 consecutive June locations were known, 2010-2014. Each pair of locations represents one data point. The numbers of cases where a cow returned to the same calving ground are in blue and the cows that switched are in red.

4.9 Management context for the Bluenose-East herd

Overall Bluenose-East herd management:

A management plan developed through a co-management process for the Bluenose caribou herd was finalized in 2000, but was not signed off by all participants. Understanding of the "Bluenose" herd evolved in the 1990s, particularly with the use of satellite radio-collars that demonstrated that there were three separate calving grounds and three separate herds in this region. These were then named the Cape Bathurst, Bluenose-West and Bluenose-East herds. Beginning in 2000, post-calving population surveys specific to the three herds were first carried out.

A management plan for the Cape Bathurst, Bluenose-West and Bluenose-East herds was developed by the Advisory Committee for Cooperation on Wildlife Management (ACCWM, composed of chairs of co-management boards) beginning in 2007 and is expected to be finalized in 2014 (ACCWM 2014a). The plan provides for monitoring and management options depending on the herds' status. A companion document (ENR/ACCWM 2014) was developed by ENR as a technical report on the status, ranges and biological monitoring of the herd. A

second companion document (ACCWM 2014b) is a summary of community engagement meetings and comments from community participants 2007-2013 in several rounds of meetings.

Short-term management:
Resident and guided-outfitter harvest of BE caribou was closed in 2010 after declines were documented in the Bathurst and other barren-ground caribou herds. Aboriginal harvest of this herd is not currently restricted. A portion of the BE herd may winter in management zones RBC02 and RBC03, where Aboriginal harvest has been restricted since 2010 to promote recovery of the Bathurst herd. Harvest of BE caribou was monitored 1998-2005 in the Sahtu region by the Sahtu Renewable Resources Board (SRRB). Since 2010, harvest of this herd (primarily in the in the North Slave region) has been monitored by a combination of community monitors, check-stations, officer patrols and estimates of community harvest from wildlife officers (Deline, Kugluktuk). Recommendations for voluntary Aboriginal harvest restriction were made in 2006 by the SRRB and in 2010 by the WRRB, but were not enacted.

Land Management:
The ACCWM management plan includes recommendations on land use that depend on the herds' status. Overall, current concerns over mining, roads and other land uses are limited for the BE range when compared to the Bathurst range. ENR has initiated a number of collaborative programs between 2012 and 2014 for the Bathurst range, including a range management planning process, a cumulative effects framework and regional scale monitoring programs in collaboration with diamond mines. These programs may have application to the BE herd's range in the future.

5. Caribou cycles and demographics of decline

5.1 Caribou cycles

Large changes in abundance of migratory barren-ground caribou herds have long been known to Aboriginal hunters and elders (Beaulieu 2012, Bergerud et al. 2008) and have been recognized by biologists from surveys and other monitoring (Bergerud et al. 2008). Presence of caribou on winter ranges southeast of Great Slave Lake in the Rocher River area alternated between scarcity and abundance on a 30-year cycle with peaks in 1924, 1954, 1984 and an expected peak in 2014 (Beaulieu 2012). Traditional knowledge of Tlicho elders identified a high in Bathurst caribou in the 1940s and low numbers before and after this peak (Zalatan et al. 2006); a method of tracking abundance of caribou from annual spruce root scars on traditional migration trails also identified higher Bathurst caribou numbers in the 1940s and identified a more recent high in the 1980s and 1990s that concurred with biologists' surveys over the more recent period (Zalatan et al. 2006, Fig. 26).

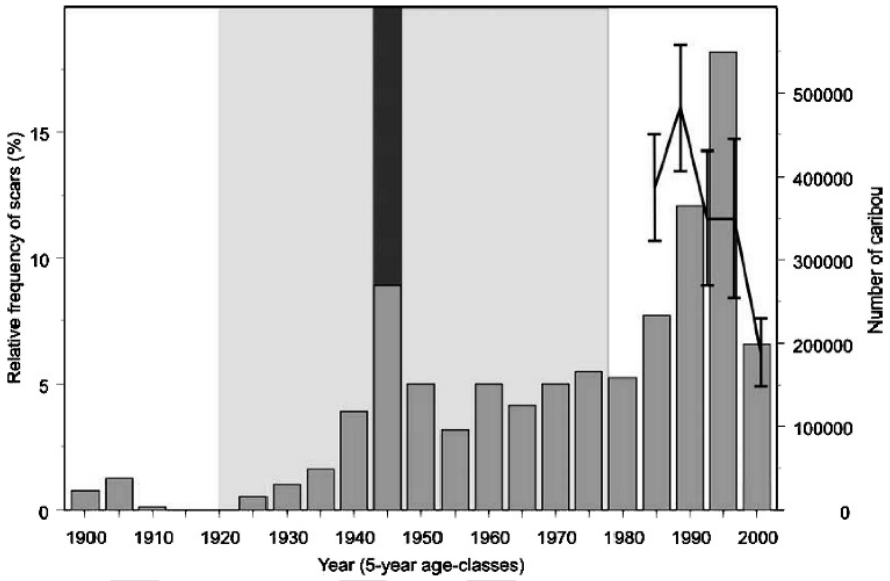


FIGURE 3. Bathurst herd caribou numbers from aerial photography surveys (1984–2003; black line; means ± SE), and abundance patterns (high = dark gray shading or low = light gray shading) derived from traditional knowledge of elders from the Dogrib First Nation relative to the scar frequency distribution for the northwest sites (Bathurst herd; bars).

Fig. 26. Relative abundance of caribou on traditional Bathurst migratory ranges inferred from spruce root scars 1900-2000, from Tlicho (Dogrib) elders (1920s-1980s), and from biologists' surveys (1980s-2000s), from Zalatan et al. (2006).

Large changes in Bathurst caribou abundance are not unique to this herd; the George River herd in Quebec/Labrador was very low in the 1950s (Bergerud et al. 2008), then increased to a peak of 700,000-800,000 in the late 1980s or early 1990s and has since declined to an estimated 14,200 in 2014 (Fig. 27).

A re-construction of the George River herd's relative abundance since the 1700s by Bergerud et al. (2008) using spruce root scarring along with related information including hunter success at traditional water crossings suggests that the length of cycles between high and low caribou numbers is not always predictable (Fig. 28), and that the highs and lows are variable. This re-construction suggested historic highs in the late 1700s, late 1800s and late 1900s and additional smaller peaks in the 1900s. These long-term fluctuations have likely occurred many times over thousands of years, with or without significant human influences.

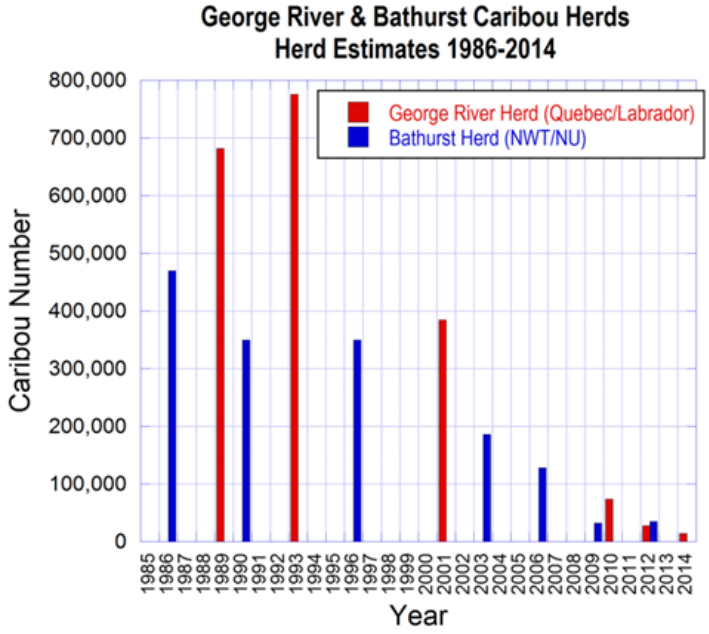


Fig. 27. Relative abundance of the Bathurst caribou herd in NWT/NU and of the George River herd in Quebec/Labrador 1985-2014. Bathurst estimates GNWT ENR extrapolated from calving photo-surveys; GR estimates 1989-2001 from co-management plan for this herd 2004 and from news-stories CBC 2010-2014.

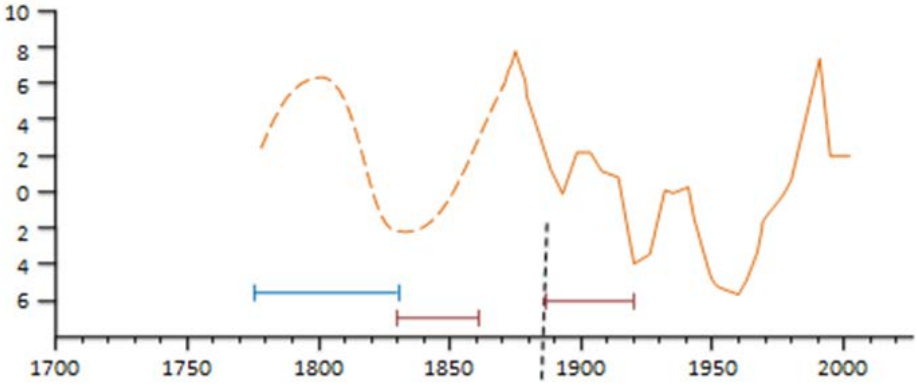


Fig. 28. Re-constructed relative abundance of the George River caribou herd 1750-2000 based on spruce root scarring, adapted from Bergerud et al. (2008).

One further example from an Alaskan/Yukon caribou herd demonstrates that long-term fluctuations in numbers of caribou herds may not follow a predictable cycle; herds may sometimes decline to relatively low numbers and remain there for extended periods. The Fortymile herd was once estimated at 300,000-500,000 in the 1920s, declined to about 50,000 in the 1950s, then declined further to a low estimated at 7,000 in the early 1970s (Valkenburg et al. 1994). Fig. 29 charts the history of this herd from 1950 to 1990. The prolonged low in caribou numbers appeared to result from a combination of high harvest, wolf predation, poor weather, and years of very poor calf recruitment (missing cohorts), and included two periods of wolf control. A recovery program for this herd included harvest limitation and non-lethal wolf removal

and has been considered a successful example of a recovery program developed through a co-management process (Gronquist et al. 2005).

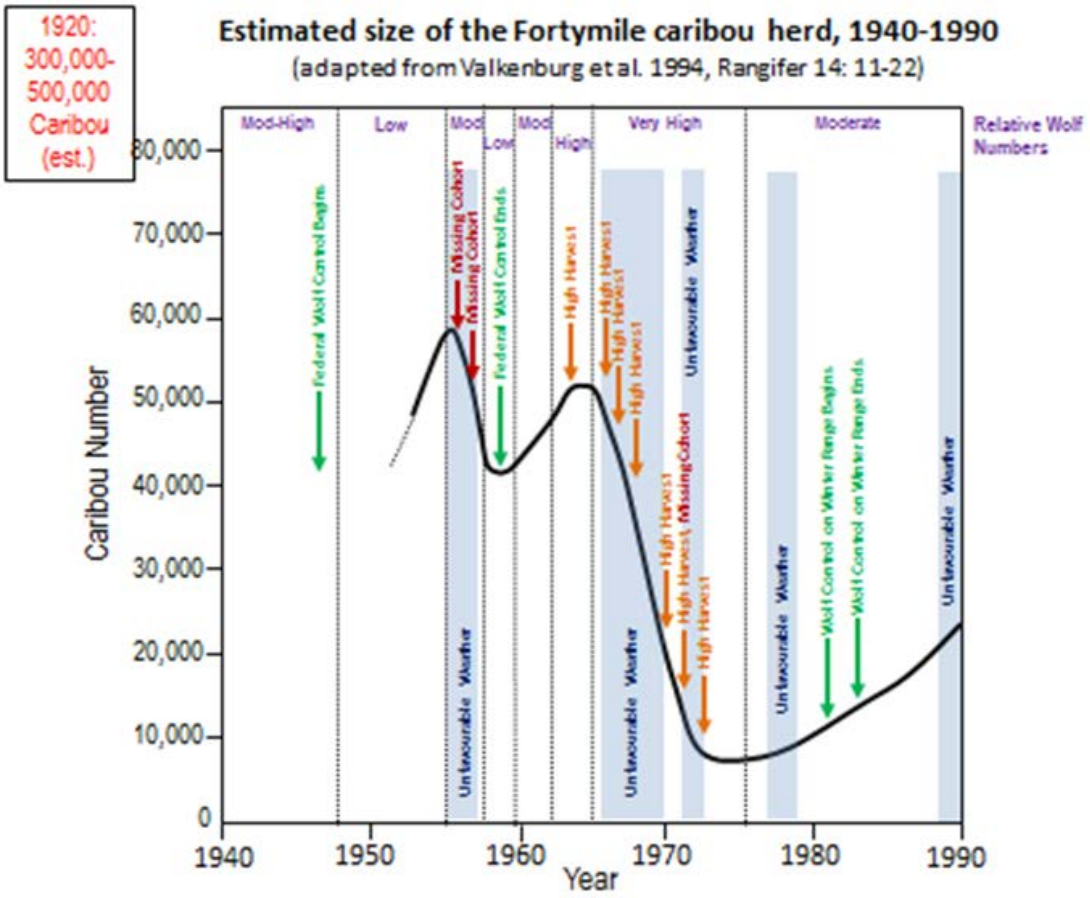


Fig. 29. Estimated size of the Fortymile caribou herd 1940-1990, adapted from Valkenburg et al. 1994.

Factors that drive cycles

Factors that drive large-scale increases and decreases of caribou herds are multiple and no one single factor explains these changes fully. However, because trends in caribou abundance are often similar regionally (Gunn 2003; exceptions do occur between neighbouring herds), climatic factors are likely key drivers that operate at large geographic scales (Gunn 2003, Vors and Boyce 2009). Decadal weather oscillations (North Atlantic Oscillation NAO, Arctic Oscillation AO, and Pacific Decadal Oscillation PDO) have been linked to population trend in four migratory tundra caribou herds in Alaska (Joly et al. 2011), but each herd was affected differently. Poorer growth of summer vegetation and reduced access to forage in winter (poor snow conditions) were likely main effects of adverse weather conditions (Joly et al. 2011).

One of the key effects of climate on migratory caribou is productivity of vegetation on the summer range (Gunn 2003); if cows have good foraging conditions over the summer, they are likely to be in good condition during the breeding season, leading to high pregnancy rates and high initial calf productivity and early calf survival in the following June (Cameron et al. 1993). Conversely, caribou cows in poor condition may not be pregnant every year (Cameron 1994).

At very high density, caribou may affect tundra vegetation negatively (thus their own forage and condition) by heavy grazing and trampling, as documented for the George River herd in the early 1990s (Manseau et al. 1996). However, negative effects of weather and environmental conditions can occur when herds are not at peak numbers. Between 2000 and 2006, late calving and low calf productivity and a likely declining natural trend were documented in the Cape Bathurst, Bluenose-West and Bathurst herds (Adamczewski et al. 2009). The large geographic scale covered by these 3 herds and the similarity of the effects over the same time period implicate weather (possibly affecting summer range and cow condition in the breeding season) as a likely key factor. All three of these herds were well below their historic highest herd size.

Predicting the effects of future weather on caribou is challenging as altered weather may have multiple implications for caribou (Joly et al. 2011). Research on the Beverly herd's winter range in the 1980s (Thomas et al. 1996, 1998) and on the Bathurst herd's winter range in the 2000s (Barrier and Johnson 2012) demonstrated caribou avoidance of recently burned areas (40-60 years) and a preference for forest at least 100 years old (Thomas et al. 1996, 1998) but suggested that overall winter range quality and lichen availability were adequate for these herds during the study periods. An increased frequency of big-fire years (such as 2014 in the NWT, Fig. 30) could have negative implications for caribou winter range if the forest shifts to a much younger age distribution with less of the slow-growing lichen caribou depend on in winter in older forests (Joly et al. 2012, Gustine et al. 2014).

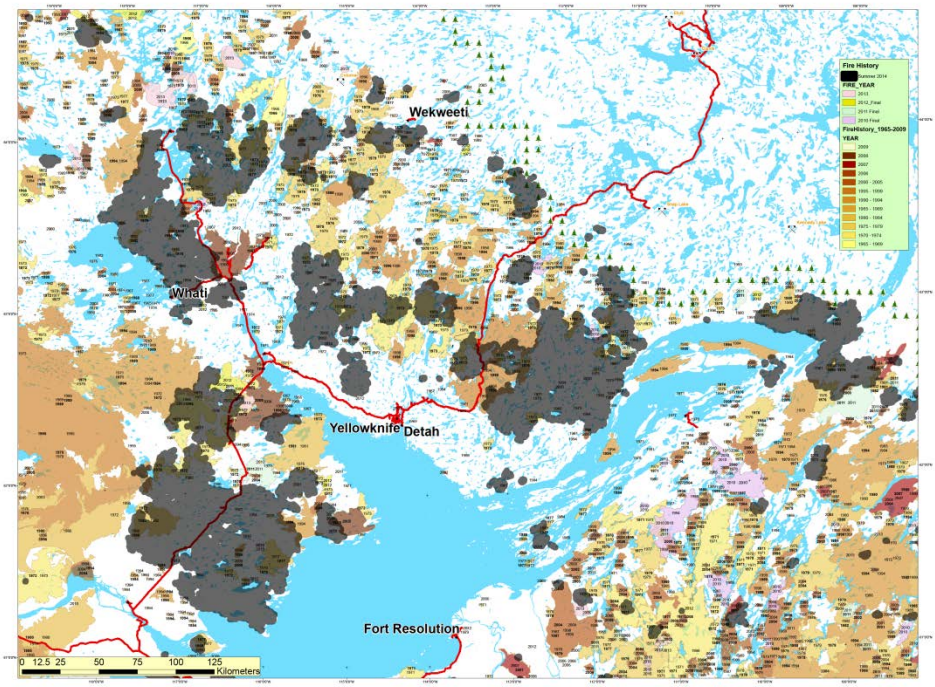


Fig. 30. Fire map showing burned areas from recent decades in the NWT in the region surrounding Great Slave Lake. Fires of 2014 are in grey. This map should be considered a draft as the fire season had not ended when the fires were mapped.

Predation is most likely to affect migratory caribou population trend at lower numbers and may prolong the period of low numbers (Valkenburg et al. 1994, Gunn 2003, Bergerud et al. 2008). Hunter harvest is also most likely to affect caribou herds at lower numbers, particularly if the

herd is declining naturally and if the scale of the harvest is large relative to herd size and composed primarily of breeding cows (Boulanger et al. 2011). Declines in the Cape Bathurst, Bluenose-West and Bathurst herds showed a similar pattern of a natural declining trend 2000-2006/2007 that was accelerated at lower numbers by substantial harvest (Adamczewski et al. 2009), with a shift to a stabilizing trend in all three herds following major harvest restriction and improved calf productivity and survival (Fig. 31).

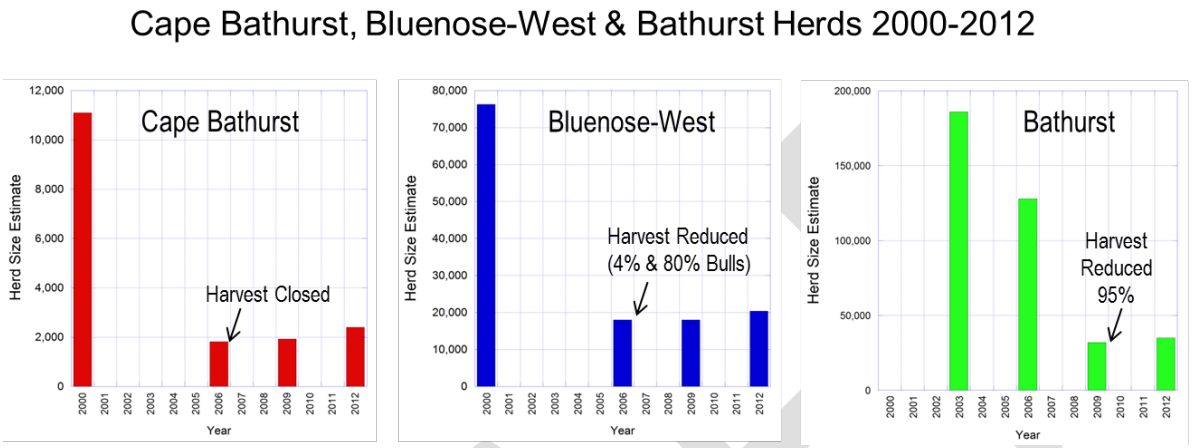


Fig. 31. Population trend and harvest reduction in the Cape Bathurst, Bluenose-West and Bathurst herds 2000-2012.

5.2 Demographics of decline in caribou

Clearly defining longer-term drivers of change in caribou herds is complex; weather can play a major role at various times of year, while predators and harvest may have smaller or larger impacts depending on herd size and trend. At a shorter time-scale in any particular herd, whether the herd is increasing, stable or declining is ultimately an annual balance between losses (caribou that die) and gains (calves that are born and survive to add to the herd). Key variables are (1) pregnancy rate or initial productivity, (2) calf survival through the first year, and (3) survival rate of cows, cow survival being the most critical to population trend (Fancy et al. 1994, Crête et al. 1996, Boulanger et al. 2011). Factors affecting caribou abundance will likely translate into changes in these vital rates. For example, a year or a period of years with very good summer range conditions and limited insect harassment will likely manifest as years with high pregnancy rates and high summer calf survival. Predators (wolves and bears) affect survival rates of calves and adults, and a substantial cow harvest will reduce the survival rate of cows.

In the George River herd in Québec/Labrador, pregnancy rates during the herd's increasing phase in the 1970s averaged 89-100%, cow survival estimates averaged 90-95%, and late-winter calf:cow ratios averaged 28-60 calves:100 cows (Bergerud et al. 2008). In the 1990s when the herd was in the early stages of decline, pregnancy rates averaged 59-78%, cow survival averaged 80-84% and late-winter calf recruitment averaged 9-19 calves:100 cows (Bergerud et al. 2008). A combination of low vital rates can lead to very rapid rates of decline: the George River herd was estimated at 74,000 in 2010, 27,600 in 2012 and 14,200 in 2014.

6. Bathurst & Bluenose-East population trend in 2014

6.1 Bathurst Herd in 2014

In this section the evidence for decline in the Bathurst herd 2010-2014 is assessed and likely causes for the low numbers of caribou recorded during the June 2014 calving ground reconnaissance surveys are considered. For clarity, possible explanations for the low numbers of caribou seen during the reconnaissance surveys are listed in Table 6, divided into potential factors resulting from the survey and potential biological factors.

Survey-related factors

The main limitation of June calving ground reconnaissance surveys is that they have relatively low coverage and the variance on estimates of caribou numbers is high. The relatively low precision means that survey estimates could be higher or lower than the true numbers. The Bathurst core calving area in June 2014 was small, so that even with 5-km spacing on flight lines, there were only 8 lines flown over the core calving area. The June 9 and 13, 2013 core calving areas were also small and had few survey lines (Boulanger et al. 2014b). A more precise photo-survey in June would have higher coverage and a lower variance attached to estimates of caribou numbers. However, despite the high variance, previous reconnaissance surveys of the Bathurst herd have reliably tracked the trend found in more precise calving ground photo surveys 2006-2009 and 2009-2012.

One potential reason for low numbers of caribou seen during the June 2014 reconnaissance survey could be if the pregnancy rate was low, meaning a significant numbers of cows were not on the main calving area. Information on pregnancy in Bathurst cows in 2014 was limited. Collared cows usually show a clear drop in movement rates when they calve. Movement rates of some collared cows did not decline below 5 km a day for a significant period of time in 2014 compared to 2012 and 2013 (Boulanger et al. 2013b), suggesting these cows were not pregnant. The pregnancy rate among 13 cows captured in March 2014 for collar deployment was 69% (9/13). However, 17 of 18 Bathurst collared cows were in the core calving area during the June 2014 survey, suggesting that a large proportion of the herd's cows (pregnant and non-pregnant) were on the calving grounds. Some non-pregnant cows are found on the calving grounds at the peak of calving in June, while others may be south of it (e.g. BE herd in 2010, Adamczewski et al. 2014).

Weather conditions during the June 2014 survey were excellent and snow cover on the main calving ground was limited, similar to 2012. The issues that occurred in June 2013 (poor sightability on June 9 due to patchy snow cover, possible post-calving aggregation on June 13) did not apply to 2014 or 2012.

If there were significant numbers of breeding cows in areas outside the survey area, this could have biased the survey results low. However, the Bathurst herd appears to have maintained a pattern of a single concentrated core calving area with very few cows in peripheral areas in recent years (see Fig. 6, Nishi et al. 2014, Bathurst calving ground in 2009, and Boulanger et al 2014a, Bathurst calving ground 2012) that continued in 2013 and 2014. In calving photo surveys (2006, 2009 and 2012), collared cow locations have consistently coincided with the concentrated calving area defined in each year.

Biological factors

The likeliest reasons for the apparent decline in caribou on the Bathurst calving ground are low cow survival rates and reduced productivity.

Previous demographic analyses suggested that survival rates of breeding females in the Bathurst herd had improved from 2006-2009 but were still low in 2009-2012 (78%). This analysis considered whether breeding female population size was at the expected number given recruitment levels (as estimated from calf-cow ratios) in years prior to the calving ground survey. The breeding female population size was lower than expected, which suggested that female adult survival was low and potentially limiting the ability of the herd to increase. It is unlikely that harvest alone could have resulted in the apparent decline 2012-2014 on the calving grounds, suggesting that the natural survival rate of Bathurst cows may have been reduced over this period. Lower spring calf:cow ratios 2012-2014 may also be indicative of lower natural cow survival rates, given the correlation between calf recruitment and natural survival rates of caribou (Bergerud 2000).

Reduced calf survival in 2012 and 2013 could have contributed to the low caribou numbers seen on the Bathurst calving ground in 2014. Evidence for reduced pregnancy rates in this herd is limited, with some indication of reduced pregnancy rates in 2014. NWT-wide, the 61% pregnancy rate in cows captured for collars in 2012 suggests a large-scale, potentially weather-mediated effect, although 12 of 13 Bathurst cows captured that year were pregnant.

The role of harvest in the apparent Bathurst decline is somewhat difficult to assess. Aboriginal caribou harvest in RBC02 and RBC03 has been limited to 300 annually since 2010 to promote recovery of the Bathurst herd. There is likely some additional unreported harvest and some wounding loss, and the target sex ratio of 20% or less cows has not generally been achieved. However, this scale of harvest from a herd of 32,000-35,000 (300-400 or around 1% of the herd) could not account for the apparent decline 2012-2014.

Low numbers of Bathurst collars have made it difficult to assess how much of the Bathurst herd has wintered in RBC01. The possibility of significant Bathurst caribou harvest in RBC01 in some winters (e.g. 2013, see Fig. 14) exists but is difficult to quantify.

There was no evidence for large-scale movement from the Bathurst herd to either of its neighbours (Bluenose-East and Beverly and Ahiak herds) from 2010 to 2014, based on the high fidelity of collared cows returning annually to the Bathurst calving ground (Fig. 18b).

Table 6: Potential reasons for decline in estimates of the Bathurst herd in 2014

Reason for decline	Evidence	Likelihood
Survey-related factors		
Low coverage (16%), high variance on recon resulted in larger aggregations of caribou not being sampled	Possible given lower recon survey coverage, but low coverage could bias the estimate low or high. Photo-survey with higher coverage will provide more precise, definitive estimate. Reconnaissance surveys have tracked trend well in BE and Bathurst herds.	Possible
Lower pregnancy rate resulted in fewer females in the core calving area.	Movement rates never declined to below 5 km per day for some collared cows. 9 of 13 (69%) of Bathurst cows captured Mar 2014 were pregnant (small sample). However, 17 of 18 collared caribou were in core area June 2014, main calving area was one well-defined block.	Possible
Lower sightability of caribou on calving ground compared to previous years	No evidence; survey conditions nearly ideal (good weather, little snow) similar to 2012.	Low
Breeding caribou not in the core calving area with collared caribou were missed	Very low densities of caribou were detected on the margins of the core area. 2012 core area was of similar size. Herd has maintained a single core area for calving since 1996. 17 of 18 collared cows in core calving area.	Low
Biological factors		
Declining trend due to reduced overall adult (cow) survival rates	Demographic analysis with the 2012 survey (Boulanger et al. 2014a) suggested that female survival rates in 2012 (78%) were still below levels needed for stable herd, herd status "fragile".	Probable
Reduced natural (cow) survival rates	Lower recruitment in 2012, 2013, 2014 than in 2010-2011; reduced recruitment correlated with reduced natural adult survival (Bergerud 2000); harvest alone could not account for apparent decline 2012-2014.	Probable
Harvest mortality decreased number of breeding females, decreased overall cow survival rates	Estimated/reported harvest in RBC03 and RBC03 300 or less with variable sex ratio; some harvest may have occurred in RBC01 because of overlap with BE herd in some winters (e.g., 2013) but low collar numbers limit assessment. Some un-reported harvest occurs.	Possible/Probable
Low pregnancy rate in some winters associated with low calf productivity and survival	Limited info on Bathurst pregnancy rates available; pregnancy has been generally high (small samples).	Possible
Reduced calf recruitment 2012-2014 affected recon survey results in 2014	Reduced spring calf:cow ratios 2012, 2013, 2014. Calves born 2012 and 2013 (but not 2014) could influence 2014 survey results.	Possible
Large-scale movement of cows from Bathurst range to other herds	Rates of collared cow switching to neighbouring herds very low 2010-2014 (consistent with other studies). Caveat in analysis is low collar numbers.	Low

6.2 Bluenose-East Herd in 2014

In this section, the evidence for decline in the Bluenose-East herd 2010-2014 is assessed and likely causes for the low numbers of caribou recorded during the June 2014 reconnaissance survey are considered. For clarity, possible explanations for the low numbers of caribou seen during the reconnaissance survey are listed in Table 7, divided into potential factors resulting from the survey and potential biological factors.

Survey-related factors

The main limitation of the June reconnaissance surveys is that they have relatively low coverage and the variance on estimates of caribou numbers is high. This means that survey estimates could be higher or lower than the true numbers. A more precise photo-survey in June would have higher coverage and a lower variance attached to estimates of caribou numbers. However, there were 20 flight lines over the main BE calving area in 2014 (See Fig. 22); this herd's calving ground has been spatially much larger than the Bathurst calving ground. Previous reconnaissance surveys of the Bathurst herd have reliably tracked the trend observed in more precise calving photo surveys 2006-2009 and 2009-2012, and in the BE herd 2010-2013.

Another potential reason for low numbers of caribou seen during the June 2014 BE reconnaissance survey could be if the pregnancy rate was low, meaning significant numbers of cows were not on the main calving area. The pregnancy rate of hunter-killed BE caribou in winter 2014 was 88% (44 of 50), which indicates a relatively high pregnancy rate that winter. In addition, the reconnaissance survey coverage was comprehensive, taking in the main calving area west of Kugluktuk and the areas south and east of Kugluktuk where bulls, yearlings and non-breeding cows have been found in recent years, and including nearly all the cow and bull collars.

Weather conditions during the June 2014 BE survey were good and snow cover on the main calving ground was limited. There was greater snow cover on more peripheral western portions of the survey area but few caribou in the area. Overall, observers' ability to sight caribou was good.

If there were significant numbers of breeding cows in areas outside the survey area, this could have biased the survey results low. However, the June 2014 BE recon survey coverage was comprehensive (see Fig. 22 and Boulanger et al. 2014d), covered the main calving area that has been documented since 2010 and earlier, and included coverage of the areas east and south of Kugluktuk where non-breeding cows, yearlings and bulls have been concentrated during several surveys. Previous surveys in 2010 and 2013 (Adamczewski et al. 2014, Boulanger et al. 2014c) did not detect any aggregations of breeding cows in these southern/eastern areas. The likelihood of a large proportion of the herd's cows being missed by the collars and by the extent of the survey area is low. Overall, survey-related factors in June 2014 are unlikely to have contributed significantly to the apparent decline in the herd.

Table 7: Potential reasons for decline in estimates of the Bluenose East herd in 2014

Reason for decline	Evidence	Likelihood
Survey-related factors		
Low coverage (8%), high variance on recon resulted in larger aggregations of caribou not being sampled	Possible given the lower reconnaissance survey coverage, but low coverage & high variance could bias count low or high. Photo-survey with higher coverage provide more precise, definitive estimate. Recon surveys have tracked trend well in BE and Bathurst herds.	Possible
Lower pregnancy rate resulted in fewer females in the core calving area.	Movement rates of collared females were below 5 km/day during survey with most cows in the core calving area. Initial reconnaissance survey covered areas with collared cows and bulls. Pregnancy in hunter-killed BE caribou in 2014 was 88% (44 of 50).	Low
Lower sightability of caribou on calving ground compared to previous years	Possible that snow cover reduced counts in peripheral areas of the calving ground (to the west). Unlikely to cause a large degree of bias in estimates. Generally good survey conditions 2014.	Low
Breeding caribou not in the core calving area with collared caribou were missed	Seven of 12 female caribou were contained within the core calving area. Lower densities of caribou were observed around collared caribou not in the core area. Overall survey area was comprehensive.	Low
Biological factors		
Demographic decline 2010-2013 continued due to reduced overall adult (cow) survival rates	Demographic analysis (part of 2013 survey report, Boulanger et a. 2014c) suggested female survival rates were low (0.73-0.75); possible combination of reduced natural survival rates and harvest.	Probable
Reduced natural (cow) survival rates	Lower recruitment in 2012 and 2014 than in 2010-2011; reduced recruitment correlated with reduced natural adult survival (Bergerud 2000); harvest alone could not account for 2010-2013 breeding female decline (Boulanger et al. 2013c).	Probable
Harvest mortality decreased number of breeding females, decreased overall cow survival rates	Estimated/reported harvest was at least 2700 caribou/year with at least 65% cows. Harvest was likely under-reported. Harvest has likely not declined in size 2010-2014, thus effect has likely increased as herd declined.	Probable
Low pregnancy rate in 2010 and 2012 associated with poor condition and reduced calf productivity	Pregnancy rate (hunter-killed) 64% in 2010; 76% (hunter-killed), 64% (captured cows) in 2012. Caribou relatively lean 2010-2014 (hunter-killed).	Possible
Reduced calf recruitment 2012-2014 affected recon survey results in 2014	Somewhat lower spring calf:cow ratios 2012 and 2014; no ratio for 2013. Calves born 2012 and 2013 (but not 2014) could influence 2014 survey results.	Possible
Large-scale movement of cows from BE range to other herds	Rates of collared cow switching to neighbouring herds very low 2010-2014 (consistent with other studies).	Low

Biological factors

The likeliest biological explanation for the reduced numbers of caribou on the BE calving grounds in June 2014 is a continuation of the decline documented from June 2010 and June 2013 calving photo surveys. This was likely the result of a combination of low natural survival rates, reduced pregnancy rates in some years (2010 and 2012), reduced calf recruitment 2012-2014, and a substantial harvest of primarily breeding cows.

Modeling by Boulanger et al. (2014c) suggested that harvest alone could not account for the reduction in numbers of breeding females from 2010 to 2014 in this herd, thus low natural survival rates likely contributed to the herd's decline over this period. At overall cow survival

rates of 73-75% (Boulanger et al. 2014c), the herd would not be able to maintain stability even with very high calf recruitment. Lower spring calf:cow ratios 2012 and 2014 may also be indicative of lower natural cow survival rates, given the correlation between calf recruitment and natural survival rates of caribou (Bergerud 2000). Condition of BE hunter-killed cows from winters 2010-2014 was relatively poor, particularly in 2012 when low pregnancy rates were documented.

Reduced productivity and survival rates combined with substantial harvest of females from a declining herd have the potential to create a continued or accelerated decline, as was observed for the Bathurst herd from 2006 to 2009 (Adamczewski et al. 2009, Boulanger et al. 2011). A similar pattern was found in the Cape Bathurst and Bluenose-West herds from 2000 to 2006 (Adamczewski et al. 2009, Boulanger et al. 2011). In the case of the Bathurst herd, the annual decline in the herd accelerated from 11.7% between 2003 and 2006 to 33.1% between 2006 and 2009. The Bluenose-East herd showed a similar annual decline rate of 16.4% 2010-2013; and may be accelerating as observed in other herd declines in the NWT.

There was no evidence for large-scale movement from the BE herd to either of its neighbours (Bluenose-West and Bathurst herds) from 2010 to 2014, based on the high fidelity of collared cows returning annually to the BE calving ground (Fig. 18b).

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8. Appendix 1. Bluenose East Caribou Health and Condition Monitoring 2010-2014

Preliminary Results; information gathered by Tlicho hunters and monitors on community hunts.

Hunter Sampling Kits:

- Information Requested:
  - Unique individual animal identification number
  - Date of harvest
  - Location of harvest
  - Hunter name
  - Comments: general & any observed abnormalities
  - Estimated age (calf, yearling, young adult, moderate adult, old adult)
  - Sex of caribou (male or female)
  - Pregnant – visual observation of fetus (yes or no)
  - Lactation status –milk in udder (yes or no)
  - Condition – hunter assessment (skinny, not bad, fat, very fat)
  - Measurement of back fat (ruler provided)
- Samples Requested:
  - Kidney + Fat
  - Incisor bar for tooth aging
  - Metatarsus (bone marrow fat analysis)

Hunter Caribou Collection & Sampling Summary:

2010

- Total caribou sample kits submitted: 114
- Sample Collection Timing:
  - 43 harvested between January 16, 2010
    - Grandin Lake
  - 71 harvested on February 13, 2010
    - Grandin Lake
- Sex composition of harvest: 49 females, 52 males, 13 not identified

2011

- Total caribou sample kits submitted: 19
- Sample Collection Timing:
  - harvested between February 7 and February 18, 2011
    - Whati (n=17, location not specified)
- Sex composition of harvest: 12 females, 2 males, 5 not identified

2012

- Total caribou sample kits submitted: 40
- Sample Collection Timing:
  - 32 harvested between on February 23, 2012

(Grandin River, Grandin Lake)

  - 8 harvested March 4-5, 2012 (Location not specified)
- Sex composition of harvest: 31 females, 6 males, 3 not identified

2013

- Total caribou sample kits submitted: 50
- Sample Collection Timing:
  - All harvested between on March 22-23, 2013 (Hottah Lake)

  - 8 harvested March 4-5, 2012 (Location not specified)
- Sex composition of harvest: 20 females, 6 males, 24 not identified

2014

- Total caribou sample kits submitted: 70
- Sample Collection Timing:
  - All harvested between on March 30th- April 1st, 2014 (Hottah Lake)
- Sex composition of harvest: 55 females, 5 males, 10 not identified

Age

Teeth submitted to Matson's Laboratory for exact age determination by cementum analysis for 2010 to 2013.

2010

Estimated Age of Harvest (hunters):

- Cows
  - 1 calf
  - 5 yearlings
  - 32 adults
- Bulls
  - 6 calves
  - 16 yearlings
  - 24 adults
  - 28 age not recorded

Tooth Cementum Age

Age Range: 1- 11
Gender: M (bull).F (cow).U (unspecified)
N= 35

Age	Number of Animals	M.F.U
1	5	4.1.0
2	11	3.3.5
3	10	6.1.3
4	2	2.0.0
5	4	2.0.2
6	0	0.0.0
7	1	0.1.0
8	0	0.0.0
9	1	0.1.0
10	0	0.0.0
11	1	0.0.1

2011

Tooth Cementum Age

Age Range: 1- 13
Gender: M (bull).F (cow).U (unspecified)
N=16

Age	Number of Animals	M.F.U
1	3	0.2.1
2	0	0.0.0
3	4	0.3.1
4	1	0.0.1
5	1	0.1.0
6	1	1.0.0
7	3	0.2.1
8	1	0.1.0
9	0	0.0.0
10	1	0.1.0
11	0	0.0.0
12	0	0.0.0
13	1	0.1.0

2012

Tooth Cementum Age

Age Range: 1- 9
Gender: M (bull).F (cow).U (unspecified)
N=36

Age	Number of Animals	M.F.U
1	1	0.1.0
2	5	1.4.0
3	8	1.6.1
4	9	2.6.1
5	3	0.2.1
6	2	0.2.0
7	4	0.4.0
8	0	0.4.0
9	4	0.4.0

2013

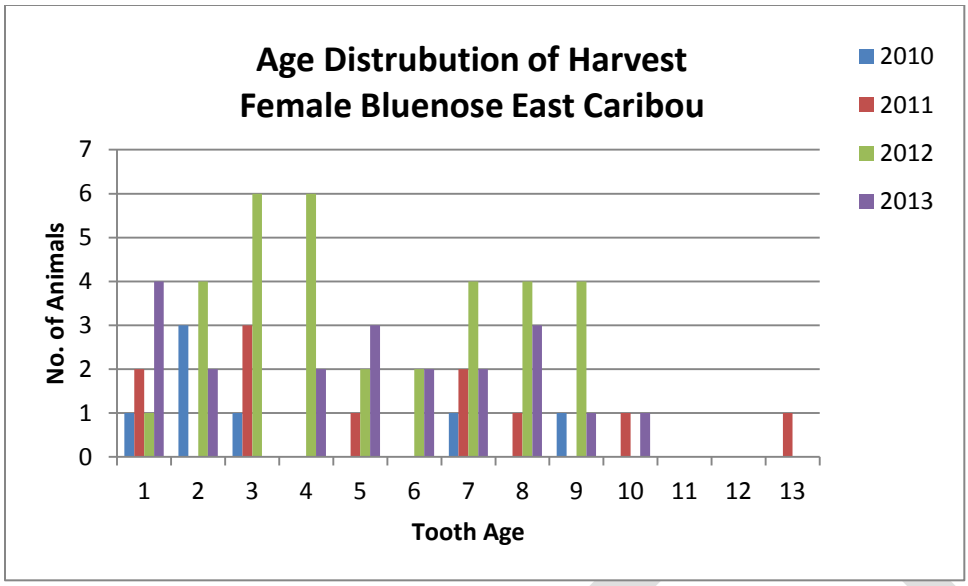
Tooth Cementum Age

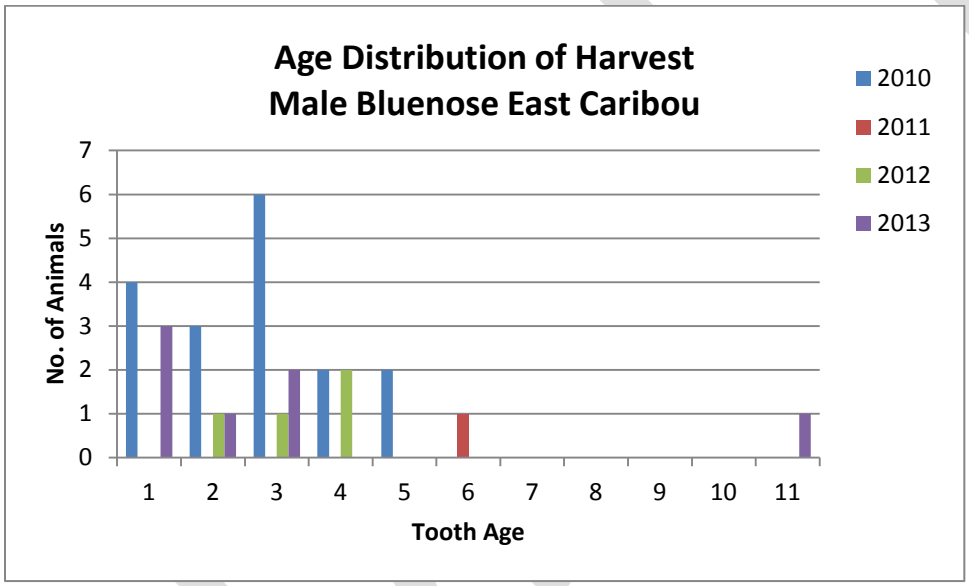
Age Range: 1- 13
Gender: M (bull).F (cow).U (unspecified)
N=29

Age	Number of Animals	M.F.U
1	8	3.4.1
2	3	1.2.0
3	2	2.0.0
4	2	0.2.0
5	3	0.3.0
6	2	0.2.0
7	2	0.2.0
8	3	0.3.0
9	1	0.1.0
10	1	0.1.0
11	1	1.0.0
12	0	0.0.0
13	1	0.1.0

2014 Age pending

Conclusion: a lot of young animals harvested in 2013. This could suggest recruitment into the population which is good; however sample sizes are limited.





Field Assessment of Condition (hunters):

An assessment of the body condition of each caribou was done by hunters using a subjective condition score with four categories (*skinny*, *not bad*, *fat* and *very fat*). Hunter assessments suggested caribou were generally in generally good body condition for the age, sex and time of year, with a range in condition scores for each sampling interval.

2010

Not assessed

2011

- Cows
  - Very fat: 0
  - Fat: 2
  - Not bad: 9

  - Skinny: 1

- Bulls
  - Very fat: 0
  - Fat: 0
  - Not bad: 0
  - Skinny: 2
  - Not recorded: 6

2012

- Cows
  - Very fat: 0
  - Fat: 6
  - Not bad: 21
  - Skinny: 2

- Bulls
  - Very fat: 0
  - Fat: 0
  - Not bad: 6
  - Skinny: 0
  - Not recorded: 5

2013

- Cows
  - Very fat: 0
  - Fat: 3
  - Not bad: 11
  - Skinny: 6

- Bulls
  - Very fat: 0
  - Fat: 0
  - Not bad: 1
  - Skinny: 5
  - Not recorded: 25

2014

- Cows
  - Very fat: 0
  - Fat: 5
  - Not bad: 44
  - Skinny: 12

- Bulls
  - Very fat: 0
  - Fat: 0

- Not bad: 2
- Skinny: 3
- Not recorded: 22

- Conclusions: Bulls generally in worse body condition than cows – cows generally in good body condition. This supports what we know about cows/bulls at this time of year.

Back Fat Measurements:

Back fat measurements (mm) were taken by hunters by measuring the thickness of fat over the back at the base of the tail.

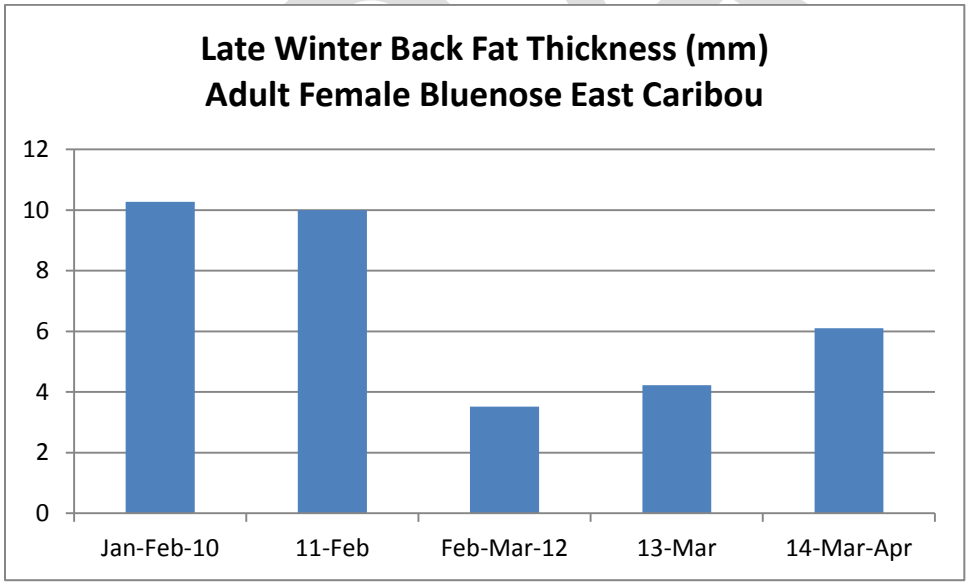
- **2010** Adult cows (n=45): mean 10.27 +/- 9.9 (range 0-38)
  Adult bulls (n=40): mean 2.35 +/- 4.0 (range 0-23)

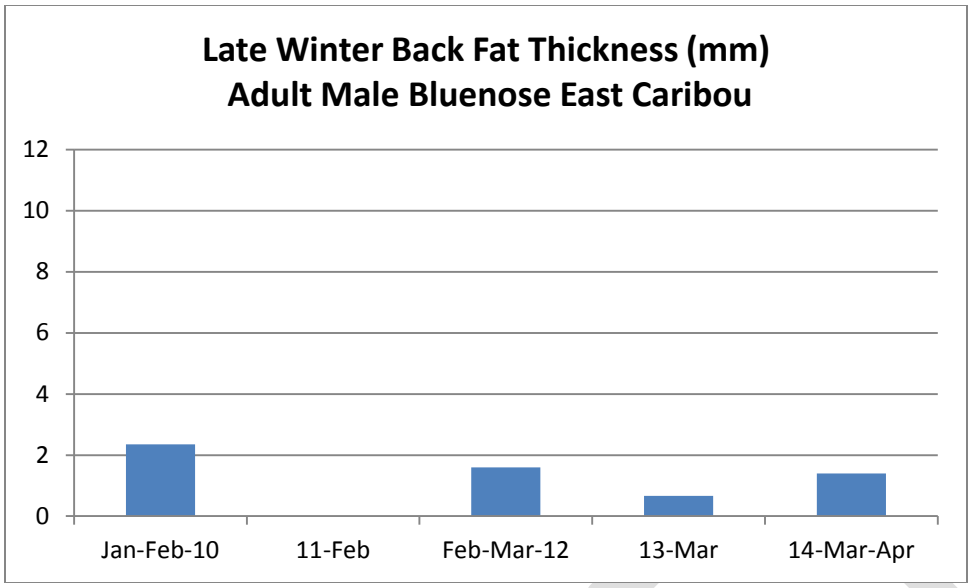
- **2011** Adult cows (n=5): mean 10.0 +/- 10.0 (range 0-20)
  Adult bulls (n=1): mean 0

- **2012** Adult cows (n=29): mean 3.52 +/- 4.46 (range 0-15)
  Adult bulls (n=5): mean 1.60 +/- 3.58 (range 0-8)

- **2013** Adult cows (n=18): mean 4.22 +/- 5.43 (range 0-15)
  Adult bulls (n=6): mean 0.67 +/- 0.82 (range 0-2)

- **2014** Adult cows (n=44): mean 6.10 +/- 7.28 (range 0-35)
  Adult bulls (n=5): mean 1.40 +/- 1.34 (range 0-3)





Conclusions: cows in generally better body condition than bulls – this supports hunter assessment of body condition data. Body condition of cows in 2014 was generally better than that in 2012 and 2013.

Kidney Fat:

Kidney fat index (KFI) is a widely used measure used as an indicator of abdominal fat reserves (Harder and Kirkpatrick 1994). Kidneys were evaluated using a standardized technique to provide a ratio of the weight of the kidney fat to the weight of the kidney X 100; the KFI is reported as a percentage and can be >100%. The amount of kidney fat was variable within and between sampling periods, with all animals having some amount of kidney fat stores.

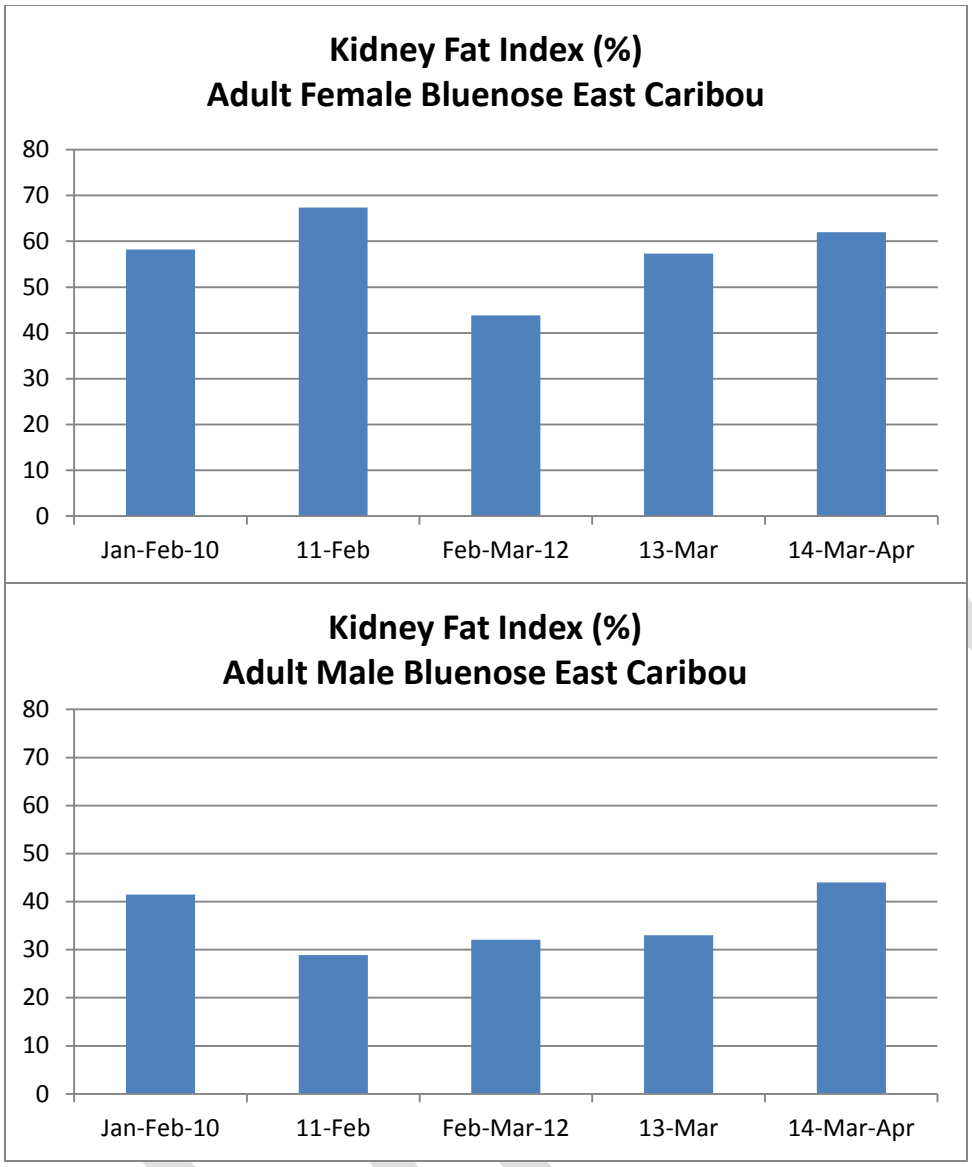
- **2010** Adult cows (n=38): mean 58.2% +/- 27.3 (range 0.5- 114.1%)
  Adult bulls (n=39): mean 41.5% +/- 29.9 (range 12.0 – 175.8%)
  Gender not recorded (n=9): mean 42.8% +/- 7.3 (range (31.3-53.6%)

- **2011** Adult cows (n=12): mean 67.4% +/- 30.5 (range 36.6 – 155.4%)
  Adult bulls (n=2): mean 28.9% +/- 18.5 (range 15.8-42.0%)
  Gender not recorded (n=5): mean 48.9% +/- 21.6 (range (18.7-72.2%)

- **2012** Adult cows (n=30): mean 43.8% +/- 20.5 (range 12.43 – 92.3%)
  Adult bulls (n=6): mean 32.1% +/- 11.4 (range 20.0- 50.8%)

- **2013** Adult cows (n=21): mean 57.3% +/- 23.3 (range 25.0 – 105.1%)
  Adult bulls (n=6): mean 33.0% +/- 16.0 (range 11.5- 49.3%)

- **2014** Adult cows (n=49): mean 62.0% +/- 24.4 (range 13.0 – 129.0%)
  Adult bulls (n=5): mean 44.0% +/- 20.5 (range 25.0- 74.0%)
  Gender not recorded (n=11): mean 71.0% +/- 31.1 (range (38.0-151.0%)



Conclusions: same as above – cows in better body condition than bulls. Animals generally in good body condition. KFI >30 is generally good body condition.

Generally, there appears to be an increasing trend in back fat and kidney fat stores from 2012 to 2014.

Bone Marrow Fat:

Fat content of the bone marrow has long been related to the physiological condition of animals. Neiland (1970) reported the percent fat in the marrow of barren-ground caribou was almost identical to percent oven-dry weight. Bone marrow fat is the last reserve to be mobilized and reflects condition only at the lower end of an overall animal condition after other body fat deposits have been exhausted. The results here are reported as the % oven dry-weight of bone marrow from the metatarsus.

- **2013** Adult cows (n=21): mean 83.0% +/- 22 (range 37.0 – 130.8%)
  Adult bulls (n=7): mean 93.4% +/- 5.9 (range 81.5 – 97.1%)

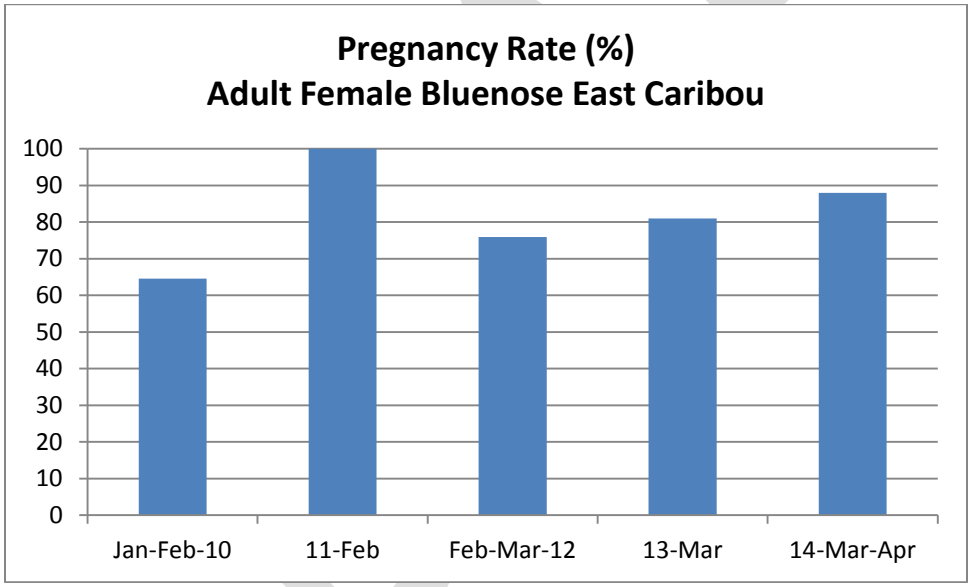
- **2014** Adult cows (n=55): mean 92.8% +/- 5.4 (range 60.0 – 97.6%)
  Adult bulls (n=5): mean 86.6% +/- 11.0 (range 67.6 – 96.0%)
  Gender not recorded (n=10): mean 90.9% +/- 8.3 (range (68.0-97.3%)

Bone marrow fat >75% is good body condition. Based on bone marrow assessment, animals were in good body condition. Fat stores are used up in order from subcutaneous fat (under the skin) to kidney fat, to bone marrow fat. Bone marrow fat is the last to go. Generally only a good indicator of body condition at the lower end of the range, when animals are in really poor shape. In 2014, caribou had excellent bone marrow fat stores.

Pregnancy Rates:

Pregnancy rates were determined in late winter by the presence of a fetus.

- **2010** Adult cows: 31/48 (64.6%)
- **2011** Adult cows: 11/11 (100.0%)
- **2012** Adult cows: 22/29 (75.9%)
- **2013** Adult cows: 17/21 (81.0%)
- **2014** Adult cows: 44/50 (88.0%)



Pregnancy Data for Collared Caribou March 2012

Pregnancy status determined based on analysis of serum progesterone levels

2010
Pregnancy Rate: **8/9 (89.0%)**

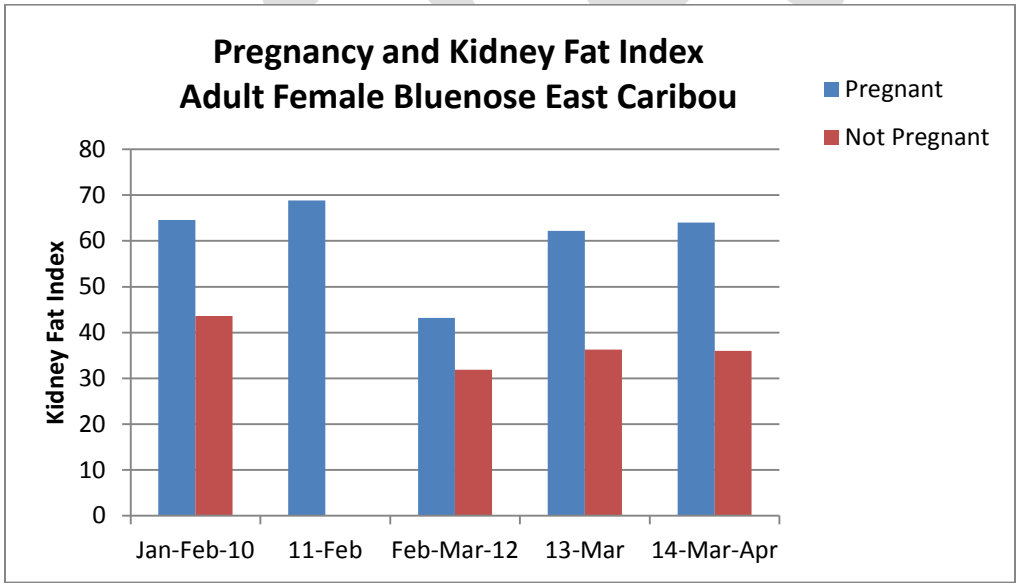
2012
Pregnancy Rate: **27/42 (64.0%)**

2014
Pregnancy Rate: **7/8 (87.5%)**

Hunter assessed pregnancy rates appear to be in line with those found through analysis of serum (blood) progesterone levels from collared caribou at the time of collaring, recognizing some of the limited sample sizes involved..

Kidney Fat Index in Relation to Pregnancy

- **2010** Pregnant (n=25): mean 64.6% +/- 26.2 (range 3.2- 114.1%)
  Not Pregnant (n=12): mean 43.6% +/- 27.3 (range 0.5 – 95.1%)
- **2011** Pregnant (n=11): mean 68.8% +/- 31.6 (range 36.6 – 155.4%)
- **2012** Pregnant (n=22): mean 43.2% +/- 18.2 (range 12.43 – 73.5%)
  Not pregnant (n=6): mean 31.9% +/- 12.2 (range 16.6- 50.0%)
- **2013** Pregnant (n=17): mean 62.2% +/- 21.9 (range 35.5 – 105.1%)
  Not pregnant (n=4): mean 36.3% +/- 18.3 (range 25.0- 63.4%)
- **2014** Pregnant (n=40): mean 64.0% +/- 23.3 (range 16.0 – 129.0%)
  Not Pregnant (n=4): mean 36.0% +/- 29.8 (range 13.0- 79.0%)



Pregnant caribou generally appear to have higher kidney fat index (aka better body condition) than those that were not pregnant. This supports the importance of good body condition in maintaining reproductive potential of the herd.

Generally, animals appeared to be in better body condition in 2014 than in the previous two years. This was reflected by a higher recorded pregnancy rate. Since interpretation is limited by a small sample size, trends are not statistically validated, however, they do give some indication of the health status of the herd. The sample size obtained in 2014 was larger than that in previous years which gives more strength to the data.

9. Appendix 2: Stable, declining and increasing caribou herds: A simple view of the numbers

Caribou herds can increase or decline at substantial rates. The 3 examples below are for a herd of 100,000 that is (1) stable, (2) declining, or (3) increasing, with corresponding survival and pregnancy rates. The calculations are simplified but realistic, and the rates of change, survival and pregnancy are based on known examples from caribou herds in North America. Even in a stable or increasing herd, there is high turnover and many caribou die every year. However, the deaths are spread out over large areas and over the entire year, and predators and scavengers usually dispose of dead caribou within a few days. Only in cases of mass die-offs (e.g. Peary caribou in 1974-1975) are large numbers of carcasses likely to be found, in situations where predators and scavengers are unable to keep up with the dead caribou available.

Example 1: Stable herd of 100,000
End of May: 60,000 cows, 40,000 bulls (1 year old or older), 83% pregnancy in the cows.

Just after calving in early June: 60,000 cows, 40,000 bulls, 50,000 newborn calves (total 150,000).

A year later (end of May again):

Cows had mortality rate of 15% (survival 85%) so 9000 died, 51,000 lived.
Bulls had mortality rate of 30% (survival 70%) so 12,000 died, 28,000 lived.
Calves had mortality rate of 58% (survival 42%) so 29,000 died, 21,000 lived to one year.
Total 51,000 cows + 28,000 bulls + 21,000 yearlings (male and female) = 100,000 (stable herd).
Calf:cow ratio in May would be about 41 calves:100 cows.

Mortality rates of calves are always highest, bulls generally have higher mortality rates than cows, and cows usually have the lowest mortality rates. Assuming here that calves at one year (yearlings) have mortality rates similar to adults; they are usually similar.

Over that year, 9,000 + 12,000 + 29,000 died (50,000 total).

Example 2: Herd of 100,000 declining at 19%/year
(note estimated Bluenose-East decline rate 2010-2013 was 16%/year)

End of May: 60,000 cows and 40,000 bulls, pregnancy rate of 67%.

Just after calving in June: 60,000 cows, 40,000 bulls, 40,000 calves (total 140,000).

A year later (end of May again):

Cows had mortality rate of 25% (survival 75%) so 15,000 died, 45,000 lived.
Bulls had mortality rate of 35% (survival 65%) so 14,000 died, 26,000 lived.
Calves had mortality rate of 75% (survival 25%) so 30,000 died, 10,000 lived.
Total 45,000 + 26,000 + 10,000 = 81,000, decline of 19%.
Calf:cow ratio in May would be about 22 calves:100 cows.

Over that year, 59,000 (15,000 + 14,000 + 30,000) caribou died.

Example 3: Herd of 100,000 growing at 13%/year

(note George River caribou herd was increasing at an estimated 14%/year 1950s-1980s)

End of May: 60,000 cows and 40,000 bulls, pregnancy rate of 90%.

Just after calving in June: 60,000 cows, 40,000 bulls, 54,000 calves (total 154,000).

A year later (end of May again):

Cows had mortality rate of 10% (survival 90%) so 6,000 died, 54,000 lived.
Bulls had mortality rate of 20% (survival 80%) so 8,000 died, 32,000 lived.
Calves had mortality rate of 50% (survival 50%) so 27,000 died, 27,000 lived.
Total 54,000 + 32,000 + 27,000 = 113,000, increase of 13%.
Calf:cow ratio in May would be about 50 calves:100 cows.

Over that year, 41,000 (6,000 + 8,000 + 27,000) caribou died.