Technical Report on the Cape Bathurst, Bluenose-West, and Bluenose-East Barren-Ground Caribou Herds

Companion Report to *Taking Care of Caribou*: The Cape Bathurst, Bluenose-West, and Bluenose-East Barren-Ground Caribou Herds Management Plan

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This report presents the recent scientific knowledge and status of the Cape Bathurst, Bluenose-West and Bluenose-East Caribou Herds and gaps in knowledge. Research suggestions are presented for consideration by the co-management boards responsible for managing these herds.

This technical report is one of two companion documents to Taking Care of Caribou: The Cape Bathurst, Bluenose-West and Bluenose-East Caribou Herds Management Plan. The other companion report compiles comments made by community members during engagement meetings on the plan. Readers should refer to that document for a community perspective on the topics discussed in this report.

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1.0 Range

The caribou described in this report are migratory barren-ground caribou (*Rangifer tarandus groenlandicus*) that may be found in northern tundra regions of the Northwest Territories and Nunavut between the Mackenzie and Coppermine Rivers, and north of Great Bear Lake to the Arctic coast. As a migratory species, they undertake large-scale movements from their northern calving grounds where they mass in large aggregations at calving in early summer to wintering areas at or south of the tree line where they are generally much more dispersed across the landscape. Within this large region described above there are three herds of barren-ground caribou: the Cape Bathurst, the Bluenose West and the Bluenose East caribou herds.

1.1 Historical Range

Biological studies of these caribou were documented at least as early as the 1950s (Banfield 1954) with increasing focus by government in the 1960s and 1970s, at a time when the range of barren-ground caribou in this region encroached on the Reindeer Grazing Preserve (Thomas 1969; Hawley 1970; Brackett et al 1982). Thomas (1969) introduced the name Bluenose herd for caribou that calved in an area around Bluenose Lake and that wintered northwest of Great Bear Lake, including in this definition the Colville Lake herd and part of the Great Bear Lake herd, each previously identified and named by Banfield (1954). In 1974 and 1975 Hawley et al. used results of low resolution aerial surveys to document the range of these caribou (Figure 1.1; Hawley et al. 1976). These surveys showed that calving areas in 1975 were concentrated in the Melville Hills east of Paulatuk, with lower density calving around Bluenose Lake on the tundra between Paulatuk and Kugluktuk as well as occurring east of the Hornaday River and the Old Horton River Channel of Cape Bathurst (Figure 1.2; Hawley et al. 1976). For about 30 years (1960s to 1990s) these caribou were managed by government as the Bluenose herd.

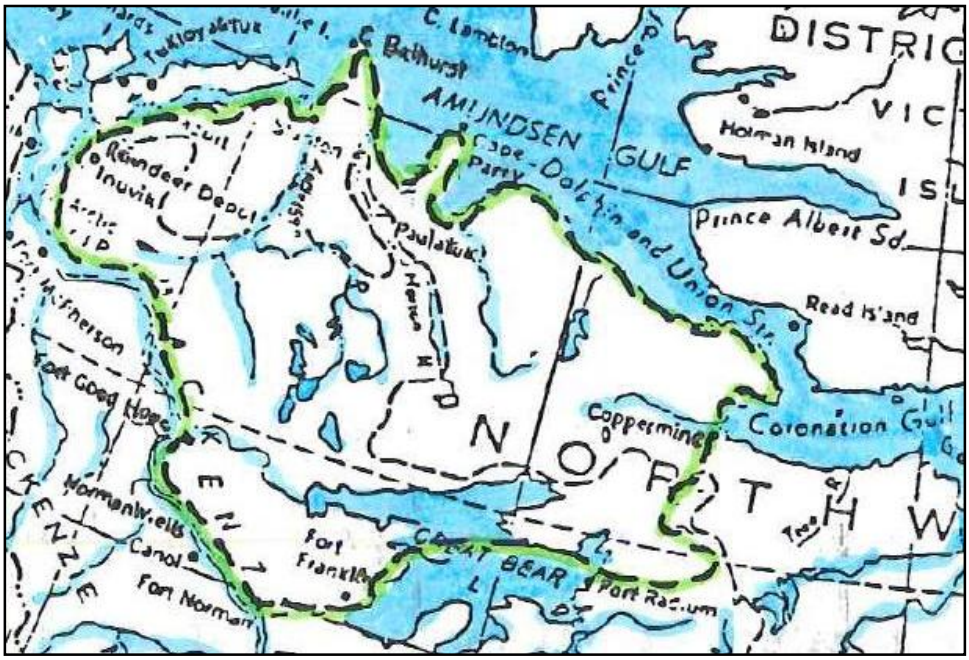

Figure 1.1 The range of the “Bluenose” caribou herd shown in green, as it was defined in the 1970s using aerial surveys (Hawley et al. 1976).

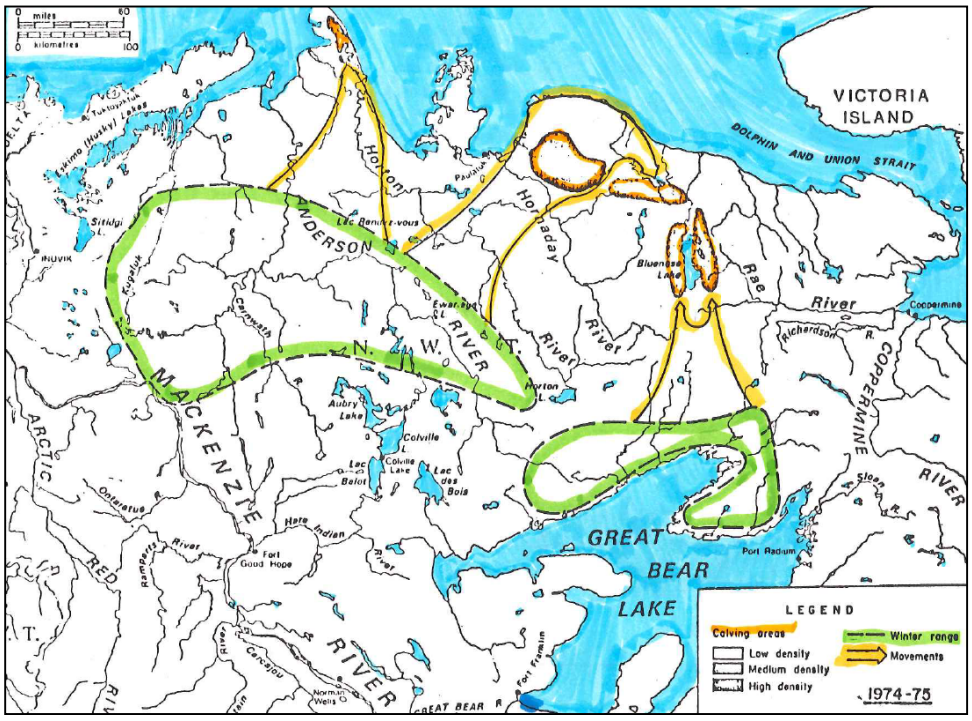

Figure 1.2 1974-75 Wintering area, spring migrations, and calving areas of the “Bluenose” caribou herd for the 1974-1975 seasons found during aerial surveys (Hawley et al. 1976).

Figure 1.3 shows the area that was considered the ”Bluenose” herd up until the mid-1990s based on aerial surveys, limited radio-collar data (from VHF radio-collars, not satellite tracked collars), and observations of caribou by harvesters out on the land.

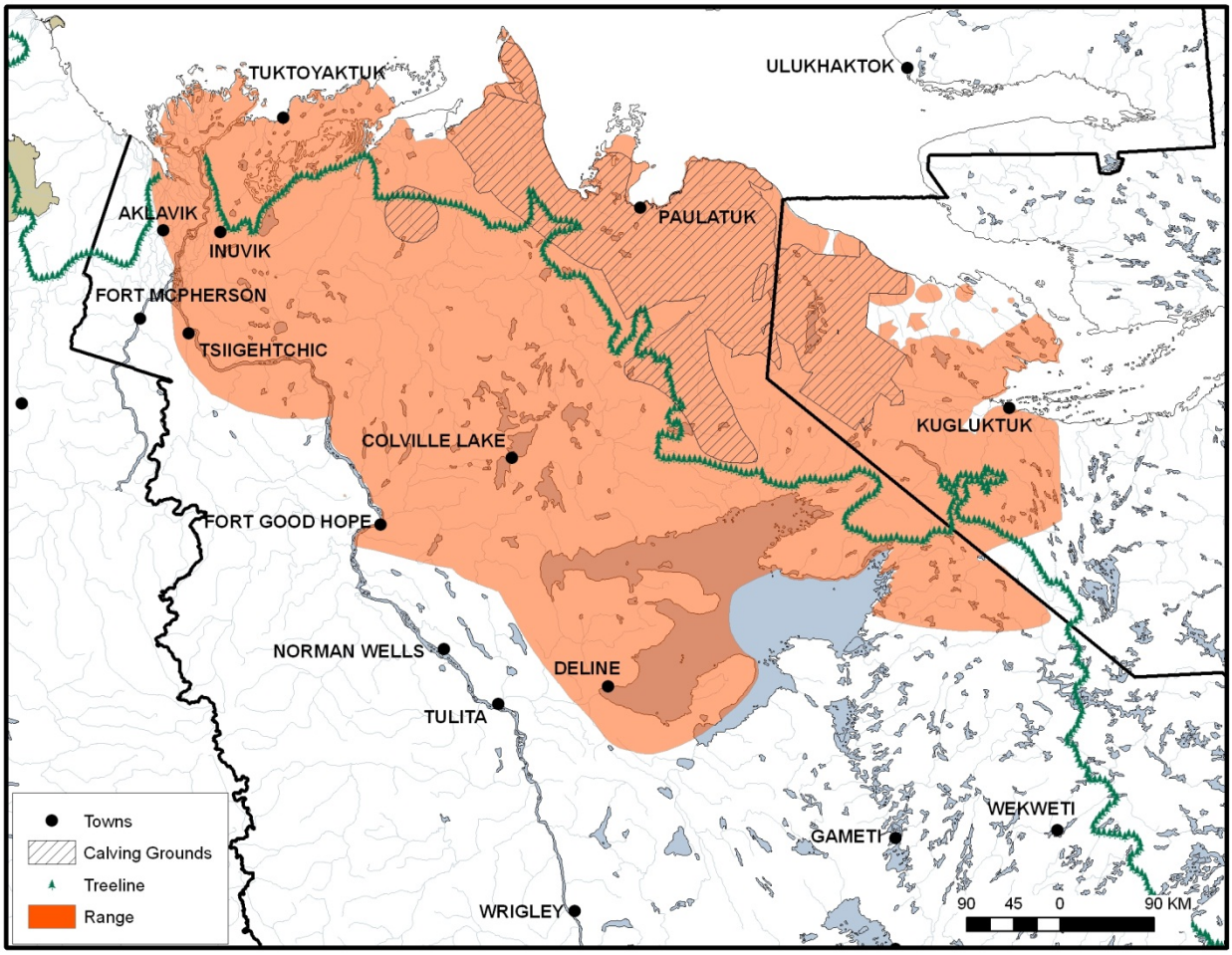

Figure 1.3 Range of the “Bluenose” caribou herd based on aerial surveys and caribou observations from the 1960’s to 1993 (ENR, unpublished data).

1.2 Current Range and Herd Definition

Barren-ground caribou herds have traditionally been defined according to the calving grounds they use (Gunn and Miller 1986). The female caribou that group together when calving, together with other females, juveniles and associated males make up a herd which can be considered to be a different subpopulation from adjacent herds (Fisher 2008). A commonly agreed upon definition of a calving ground is the area used by pregnant cows from the time of birth of the calves until the calves begin to feed on their own (Russell et al. 2002). The naming of these caribou as the

"Bluenose" caribou herd in reference to Bluenose Lake was based on one of multiple calving areas noted during surveys (see calving areas noted in Figure 1.2; Hawley et al 1976).

Scientific knowledge about caribou in this area has changed over time as improvements to available technology and study methods have been made. The most current and best knowledge is used to define herds and, as a result, the designations of herds can change over time (Fisher 2008). In 1994, historic survey data from population and telemetry surveys done between 1966 and 1993 were examined to define the seasonal ranges of the Bluenose herd. This analysis used new technology, a Geographic Information System (GIS), and the results showed that there were 3 separate calving grounds and two rutting areas for these "Bluenose" caribou (Nagy *et al.*, 2005). The use of different seasonal ranges throughout each year and especially of different calving grounds led to the designation of these caribou as three herds: the Cape Bathurst, Bluenose-West and Bluenose-East caribou herds (Nagy et al. 2005).

Introduction of GPS and satellite radio-collars to research methodology have since allowed for better understanding and definition of the herds within the "Bluenose" range.
Movement data from satellite collared adult cow caribou between 1996 and 1999 showed three very distinct and separate calving areas: (1) on the Cape Bathurst Peninsula; (2) in the Melville Hills west of Bluenose Lake; and (3) the area east of Bluenose Lake around the Rae and Richardson rivers.

The core ranges (as 90% utilization distributions of collared cows) and calving grounds of the Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds developed from satellite and GPS-tracked radio-collared cows between 1996 and 2008 are shown in Figure 1.4. These ranges are just the core area used by collared cows and are underestimated for the whole herd since adult male caribou movements were not used for the analysis. Adult bull caribou have only been monitored using collars on the Cape Bathurst range since 2007 and on the Bluenose-West and Bluenose-East ranges since 2009.

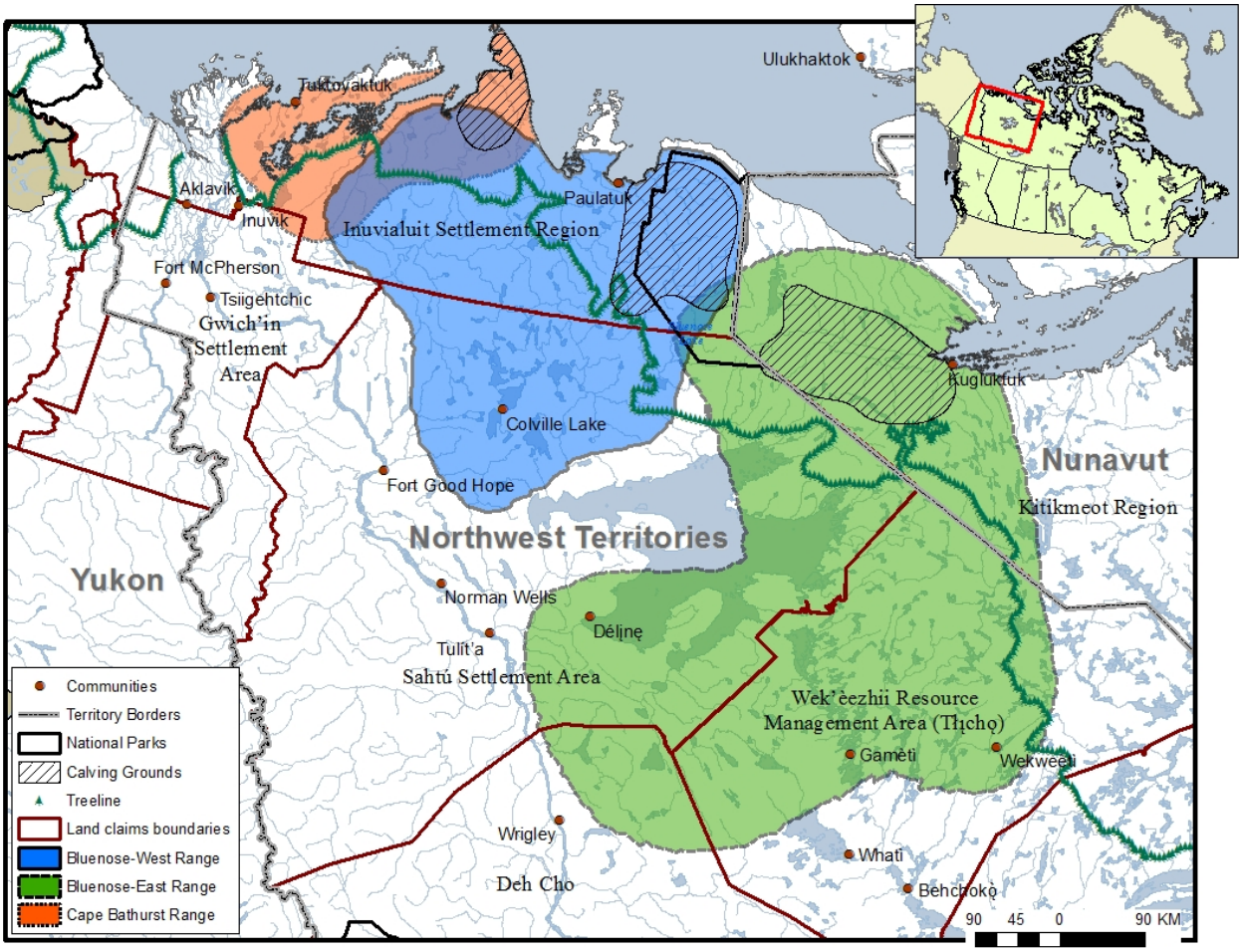

Figure 1.4 The core ranges (90% utilization distributions) of Cape Bathurst (Orange), Bluenose-West (Blue), and Bluenose-East (Green) caribou herds with calving areas (crosshatched) from satellite and GPS radio-collared cow locations between 1996 and 2008 (Nagy et al. 2011).

Although each herd has a distinct calving and post-calving area, the ranges of the three neighbouring herds do sometimes overlap, though this usually happens during seasons other than calving and post-calving. See figure 1.5, 1.6, and 1.7 which show a 90% utilization of Cow collared caribou during Summer, Fall, Winter and Spring. These ranges were developed by CARMA using the following dates; Summer is 1 July to 22 August, Fall is 23 August to 5 December, Winter is 6 December to 14 April and Spring is 15 April to 10 June (CARMA, 2010).

It should be noted that the ranges shown in the figures in this report were created using multiple years of tracking data grouped together. The seasonal range use of caribou in each herd generally varies among years. Although sometimes the herds do mix in some years, it is important to understand that overlap in the ranges of two or more herds as shown on the maps does not

necessarily mean that the herds all use an area at the same time - some of the areas are simply occupied by different herds in different seasons or in different years.

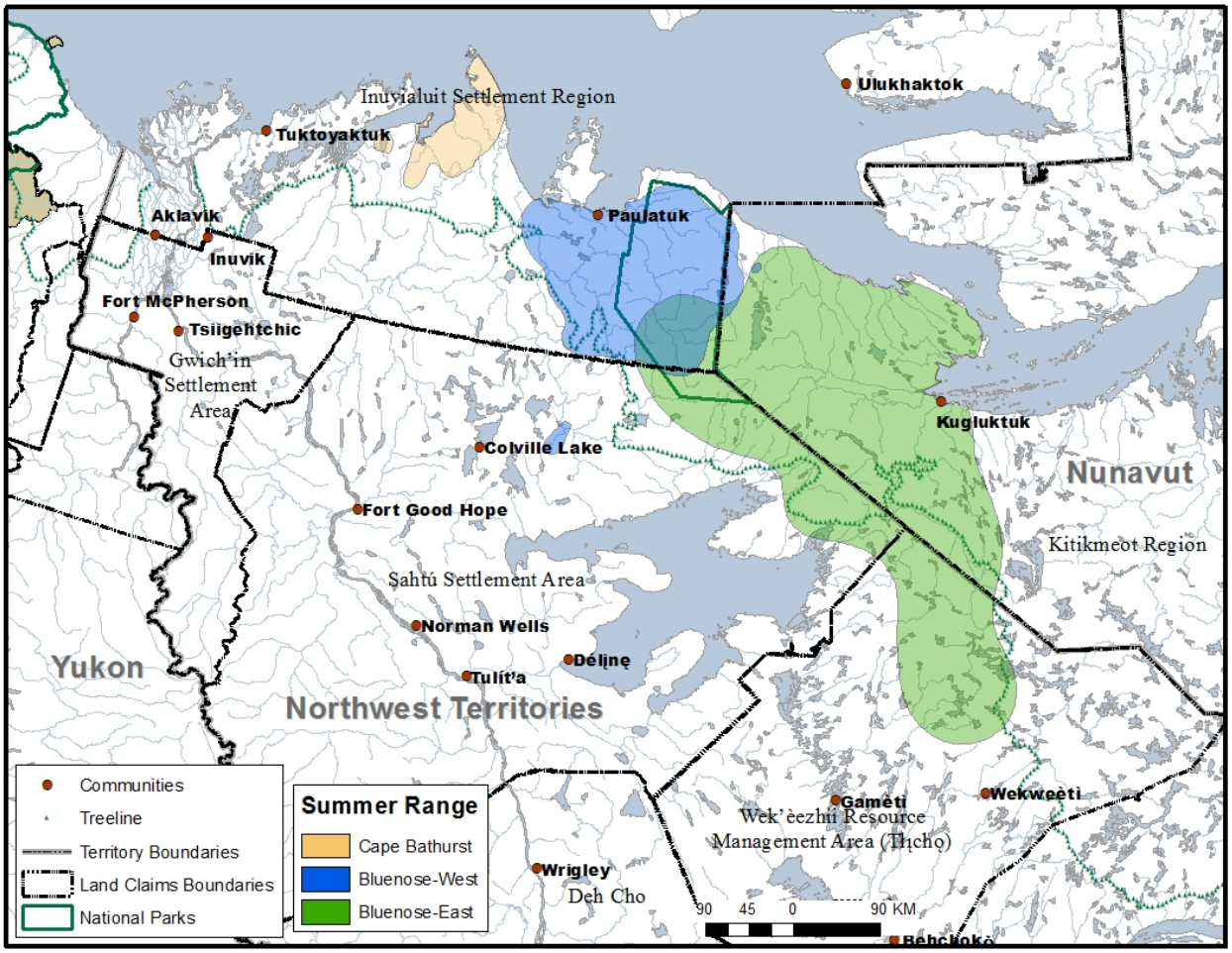

Figure 1.5 The core Summer ranges (90% utilization distributions) of Cape Bathurst (Orange), Bluenose-West (Blue), and Bluenose-East (Green) caribou herds from satellite and GPS radio-collared cow locations between 1996 and 2010 (CARMA2010).

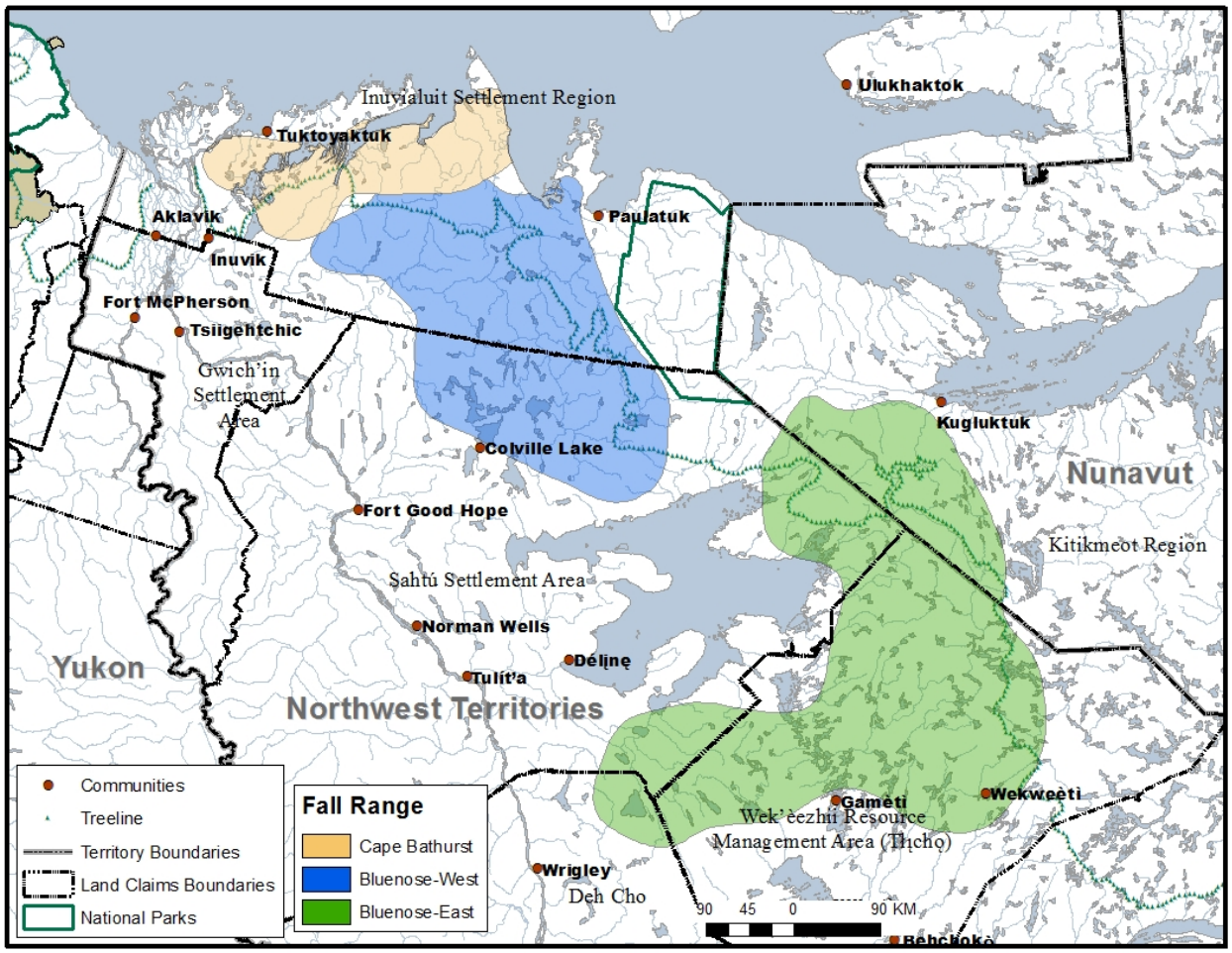

Figure 1.6 The core Fall ranges (90% utilization distributions) of Cape Bathurst (Orange), Bluenose-West (Blue), and Bluenose-East (Green) caribou herds from satellite and GPS radio-collared cow locations between 1996 and 2010 (CARMA 2010).

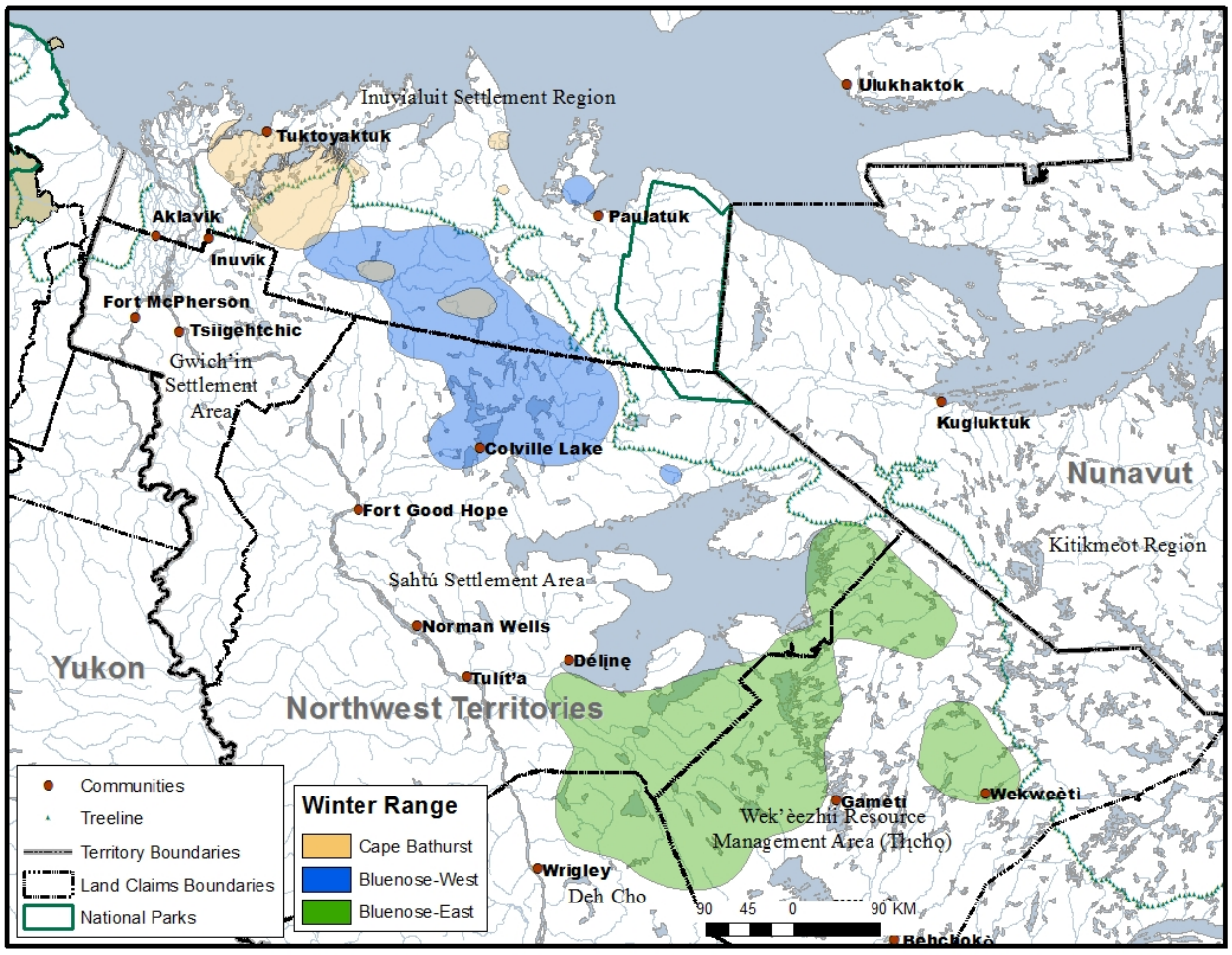

Figure 1.7 The core winter ranges (90% utilization distributions) of Cape Bathurst (Orange), Bluenose-West (Blue), and Bluenose-East (Green) caribou herds from satellite and GPS radio-collared cow locations between 1996 and 2010 (CARMA 2010).

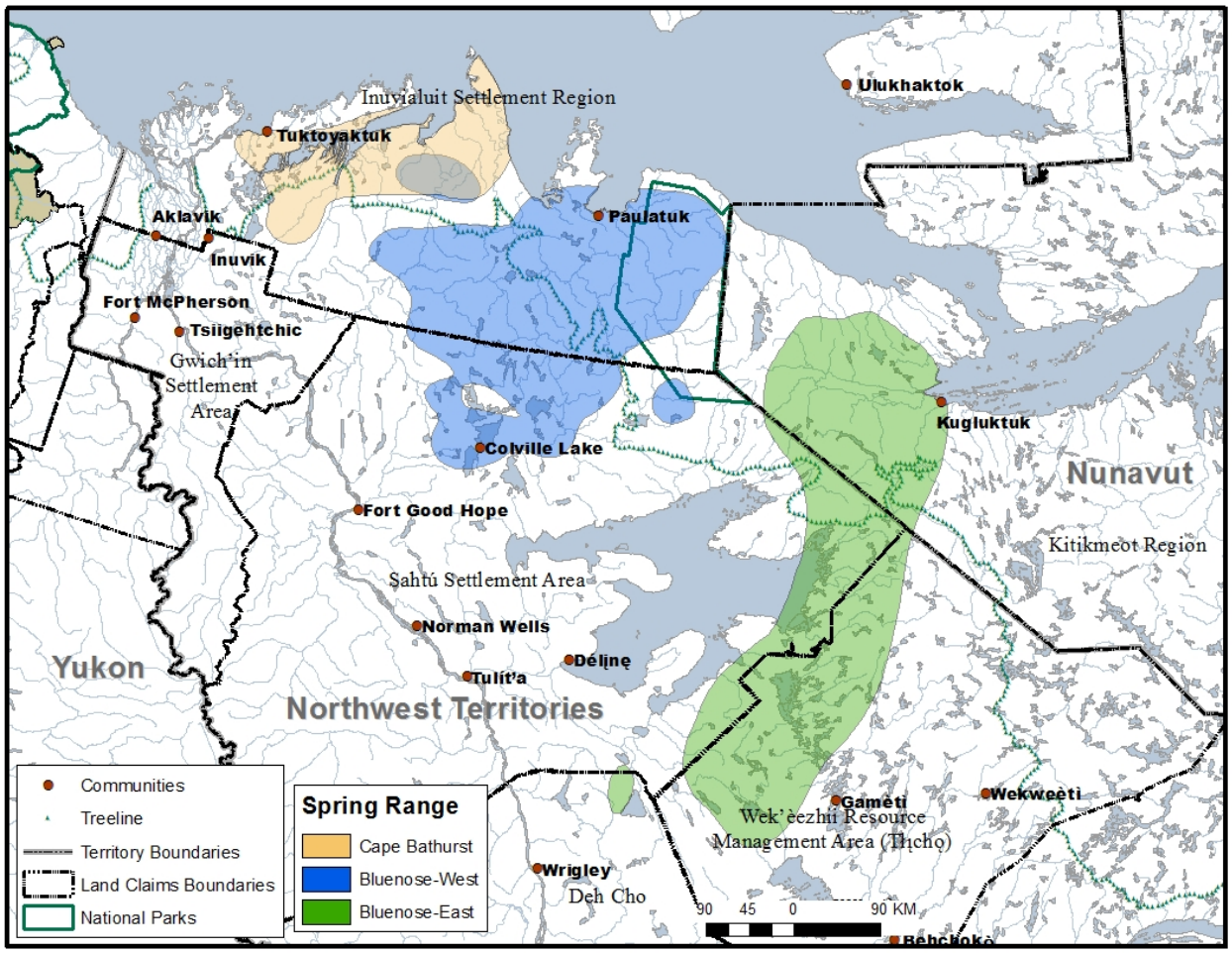

Figure 1.8 The core spring ranges (90% utilization distributions) of Cape Bathurst , Bluenose-West, and Bluenose-East caribou herds from satellite and GPS radio-collared cow locations between 1996 and 2010 (CARMA 2010).

Analysis of the calving and year-round movement data from collared caribou that has been collected over the past two decades continues to provide support for the designation of these three herds (Nagy et al. 2011, Davison et al. 2013).

1.3 Range Use over time and Herd management

Movements of caribou populations are dynamic when looked at over a long term (i.e., centuries), and there is evidence of large scale movements with herds shifting their ranges over time (Skoog 1968, Bergerud et al 2008). Scientific knowledge regarding caribou movements has also changed over time, with survey and tracking methods constantly improving.

The current way of defining barren-ground caribou herds by fidelity to calving grounds and similar demographic characteristics is considered by many biologists to be the best means of managing herds (Fisher 2008). Herds based on calving ground have similar demographic characteristics and allow management actions to be applied appropriately for each herd (Fisher 2008). However, there are some issues with this method of defining herds for management. For example, large shifts in calving locations can occur over long periods of time; e.g., the Bathurst caribou herd have shifted their calving area (Sutherland and Gunn 1996); the Rivière-George (RG) herd and Rivière-aux – Feuilles herd experienced shifts in location of calving grounds over 35 and 15 years, respectively, while calving ground size of the RG herd also significantly declined (Taillon et al 2012). In addition, the areas used by caribou outside of the calving period can overlap among herds (Nagy et al. 2005 and see Figures 1.5 to 1.8).

There are examples of the annual range sizes of barren-ground caribou herds changing over time. Annual range size generally expands when herd numbers are high and becomes smaller as the herd numbers decrease (Messier et al. 1988, Hinkes et al. 2005, Skoog 1968). When caribou numbers are high, herd movements become more complex and generally cover larger areas. It is at this time that emigration into other areas is more likely (Skoog, 1968). Usually, scientifically-documented movements between populations have been relatively small and not significant to the overall status of the individual herds (Valkenburg et al. 2002). Radio-collar and ear-tag studies have shown 'switching' rates between herds were documented to range from around 1% to 6% (Parker 1972, Boulet et al 2007, Heard and Stenhouse 1992).

Between 2005 and 2013, 87 cape Bathurst, 125 Bluenose-West and 108 Bluenose- East collared cow caribou had data obtained from more than one calving period. Of these caribou monitored there were 4 individual collared caribou that switch calving ground while being monitored. One caribou used Bluenose-West calving ground in 2010 and the Bluenose east calving ground in 2011, also between 2010 and 2011 one moved from Bluenose-East to Bathurst. Between 2012 and 2013 one caribou moved from Cape Bathurst to Tuktoyaktuk Peninsula and one Bluenose West to Bluenose East. There were also 54 collared cow caribou of the Tuktoyaktuk Peninsula Herd, of

which 4 switched to the Cape Bathurst herd; one in each of the years 2007, 2011 2012. There was also one Tuktoyaktuk Peninsula caribou that moved from Tuktoyaktuk Peninsula calving ground in 2012 to an area near Cape Bathurst in 2013. Between 2005 and 2013, including the Tuktoyaktuk Peninsula Herd data, 3.6% of the individual collared cow caribou showed switching behaviour (Davison et al. 2013). Between 2010 and 2013 there were also two Bathurst Herd collared cow caribou that moved to the Bluenose-East calving grounds (Boulanger et al. 2014).

Knowledge related to herd movements is limited when considering the time scales involved. Large dispersion of caribou has been documented in Alaska during peak population size (Hinkes et al. 2005, Skoog, 1968). Large unusual movements of collared caribou have been observed in relation to unusual weather conditions; however, caribou seem to return to the typical range if they survive (Adams et al. 2005 and Nagy et al. 2005).

Genetic variation is high in barren-ground caribou, and neighbouring herds are not considered to be genetically distinct; in particular, most migratory herds in Nunavut and NWT were found to be very similar (Yannic et al. 2013). The Porcupine Caribou Herd, which is considered a different subspecies based on earlier taxonomy (Banfield 1961) and is separated from the Cape Bathurst herd by the Mackenzie River and delta, has not been shown to be considerably genetically different from herds to the west (Zittlau, 2004, Yannic et al. 2013). Genetic differences usually occur when populations are separated for extended periods of time and if the populations are small; however, barren-ground caribou usually occur in large numbers and there is generally a low rate of exchange between neighbouring herds. The lack of genetic differences may be a result of recent common ancestry and large population sizes without different selective pressure (Zittlau 2004, Yannic et al. 2013.).

Because of the large and dynamic range of barren-ground caribou, it has been suggested that to allow for management of caribou over large areas and over long time periods, managers should consider not just herds but “metapopulations” (Levins 1969; Hinkes et al. 2005, Fisher et al 2008). A metapopulation is defined as a regional group of connected populations of a species or sub-species that have some degree of interaction among the populations. Nagy et al. (2011)

recommend going beyond looking just at traditional calving ground location for defining and managing herds, and using the total annual use of the landscape by cow caribou who tend to stay together with flexibility for changes in calving ground location over time.

2.0 Herd Size and Demographics

2.1 Herd Size Estimates

A basic piece of information required to understand changes in a barren-ground caribou herd is an estimate of its size – that is, the number of non-calf animals that are in the herd. Generally, biologists obtain this estimate using some form of aerial survey. Population surveys do not need to count every animal in a herd; instead a statistically valid subset (usually the majority of animals within a herd) is counted and then the subset is used to estimate the total size of the whole herd based on characteristics of the known sample and of the sampling method used (e.g. how many caribou were observed compared to how many with collars were observed during the survey and how they were distributed in space and time). Trends can be determined when there are population estimates for at least two or three different years – indicating whether the herd is stable in numbers, increasing, or decreasing. The rate of any increase or decrease of a herd is also very important to estimate and has a major influence on any management actions that might be considered and/or put in place.

Both scientific and traditional knowledge agree that the numbers of barren-ground caribou populations change over periods that span several decades (Bergerud et al. 2008, Morneau and Payette 2000, Parlee et al 2013, Payette et al 2004, Zalatan et al 2006). These changes, known to biologists as population cycles, are a feature of many wildlife populations (e.g., lynx and snowshoe hares, lemmings, and other small mammals). One of the challenges for biologists is the monitoring of these trends and trying to understand the underlying causes for the changes that are seen.

Aerial surveys to estimate the population size and productivity for the “Bluenose” herd were flown in 1978 and 1979 by Brackett et al. (1979) and in 1981 and 1983 by Latour and Heard (1985) and Latour et al. (1986), respectively. These surveys used fixed-wing aircraft flying a ‘strip-transect’

design with the area covered varying somewhat among years. While these strip transect surveys provided estimates of herd size, the estimates had wide 'confidence intervals.' A confidence interval tells us how precise an individual estimate is through giving an upper and a lower limit to the population size estimate; the narrower the upper and lower limits around the estimate, the more precise it is. If the estimate is considered to be precise it means that if the survey were to be repeated that the results would likely be similar. A goal with surveys is to have the narrowest possible confidence intervals so that we have greater confidence in the estimate of the actual number of animals in a particular herd.

In the 1960s and 1970s, an improved aerial survey method was developed specifically for barren-ground caribou in Alaska, the 'post-calving photo-survey' (Valkenburg 1985). These surveys are flown in July when caribou are on the open tundra after calving, which generally happens in June. On hot, sunny, and calm days the caribou form large groupings, known as aggregations, in response to the considerable insect harassment they can experience. Caribou are located with one or more small aircraft and when the large aggregations form, a series of detailed photographs is taken with high-resolution digital or film cameras. Caribou can then later be counted directly from these photographs and a population estimate, along with the associated confidence interval, can be calculated for the herd. Two methods of calculating the population estimates from a post-calving ground survey have been developed. The Lincoln-Peterson is the traditional mark-recapture methodology used (Krebs 1999, Russle et al 1996, Patterson et al 2004) but the Rivest methodology (Rivest et al 1998) has been developed more recently. If all collars are in groups photographed the Lincoln-Peterson method cannot calculate the confidence interval, as it assumes it's 0 as all marked animals were found.

To obtain a good and precise estimate of herd size using the post-calving photo-survey method it is necessary to have sufficient radio-collars on both adult female and adult male caribou (Rettie 2008). Increase in the number of collars increases the accuracy and precision of the population estimate. Collaring, generally done in late winter, is done to provide a sample of animals from across the entire range of the herd. During the photo-survey, the radio-collars help ensure that all

areas where groups of caribou occur are photographed and included in the final population estimate. Collars also reduced the amount of flights needed to locate caribou and GPS or satellite collars reduce that even further as locations can be gathered remotely and groups flown to directly. Collared caribou locations also provide an excellent measure of the degree of mixing among the herds so that we have a relatively high degree of confidence in which caribou are being photographed.

The first estimates of the size of the 'Bluenose" herd using the post-calving photo-survey method were obtained in 1986 and 1987 (McLean and Russell 1992). A similar post-calving photo-survey of the "Bluenose" herd was also conducted in 1992. Although these surveys were focused on what was considered a single herd at the time, by reviewing and mapping capture locations and movements of collared caribou it was possible to derive separate population estimates for the Cape Bathurst and Bluenose-West herds for the 1986, 1987, and 1992 surveys. However, there were not enough radio-collars deployed in the range of the Bluenose-East herd to be able to derive similar estimates for those years (Nagy and Johnson 2006).

Starting in 2000, the three herds were surveyed as separate herds and separate population estimates were obtained. The same post-calving photo method used in 1986, 1987, and 1992 was also used in 2000 (Patterson et al. 2004), 2005, and 2006 (Nagy and Johnson 2006). All three herds were again surveyed in 2009 and estimates of herd size were obtained for the Cape Bathurst and Bluenose-West herds (Table 2.1); however, no estimate was possible for the Bluenose-East herd because of poor weather conditions (Davison et. al 2013).

The Bluenose-East herd was surveyed again in July 2010 using the post-calving photo-census method. However, the herd was also surveyed earlier in June using a different method for estimating herd size, a calving ground photo-survey (Adamczewski et al. 2012) This survey focuses on estimating the number of breeding cows on the calving grounds (Heard 1985). This technique has been used for the Bathurst herd in the NWT, as well as for some other herds across the range of barren-ground caribou in North America, although currently only used in NWT and Nunavut

(Gunn et al 2005, Campbell et al 2010). Once cows have moved up to the calving ground, as indicated by collared caribou movements, fixed-wing aircraft are used to determine where most of the cows are concentrated, and usually using transect lines at 5, 10 or 20km intervals. This information is then used to divide the calving grounds into blocks of high, medium, and low densities of caribou. Transects are then flown in the higher-density blocks at or near the peak of calving using a specialized photographic aircraft that takes large-format stereo photos at about 600 metres (2000 ft.) above the ground. Lower-density blocks are flown visually using strip-transect methods. All caribou at least one year old in the photos and on the visual surveys except newborn calves are counted. The proportion of breeding cows on the photos and from the visual blocks is determined from the results of a composition survey done near the peak of calving. To derive an estimate of overall herd size, corrections or extrapolations are made to account for the caribou not on the calving ground. This includes non-breeding cows and bulls. An estimate of herd-wide pregnancy rate is used to "add in" the non-breeding cows. An estimate of the bull:cow ratio is used to "add in" the bulls. The bull:cow ratio is generally obtained during the fall breeding season in the year before the population estimate, in the fall after the population estimate, or both. The two alternate methods (post-calving photosurvey and calving photosurvey) for estimating populations had only been tested on the same herd during a single year once before – for the George-River Herd of northern Quebec and Labrador in 1996 (Couturier et al. 1996).

A post-calving ground population survey of Bluenose-East was also unsuccessful in 2012 so a calving ground population survey was conducted in 2013. The results of the Bluenose-East post-calving photo-surveys and the June 2010 calving ground survey are provided in Table 2.3 and Figures 2.3. The last post calving photo-survey was conducted for the Cape Bathurst and Bluenose-West herd in 2012. The post calving photo-survey results for the Cape Bathurst are presented in table 2.1 and Figure 2.1 and Bluenose-West results are presented in table 2.2 and Figure 2.2. All estimates of herd size are for caribou that are at least 1-year-old; estimates do not include calves because of the high mortality rate calves usually experience relative to that of adults and the difficulty of accurately counting calves from the survey photos.

Table 2.1: Population estimates for the Cape Bathurst, barren-ground caribou herd, 1986 to 2012 based on post-calving surveys.

Year	Number of collars available	Number of collars in groups counted	Minimum count	Lincoln-Petersen estimate with 95% CI
1986[1]	3	3	13,476	13,476
1987[1]	6	5	10,728	12,516 ± 3,504
1992	6	5	16,524	19,278 ± 5,397
2000[2]	17	15	9,857	11,089 ± 1,756
2005	32	29	2,213	2,434 ±257
2006	33	31	1,714	1,821 ±149
2009	28	22	1,534	1,934 ±350
2012	24	24	2,427	2,427

[1]There was a small number of radio-collared caribou in the herd; however, the Cape Bathurst area is relatively small and was flown extensively. As a result, large groups that did not contain collars were found in the area when searching for radio-collared caribou in 1986 and 1987.

[2] The Cape Bathurst, Bluenose-West, and Bluenose-East herds were first surveyed as separate herds in 2000. Radio collars were deployed throughout the fall (Bluenose-East herd) and winter ranges (Cape Bathurst and Bluenose-West herds) in preparation for this survey.

Table 2.2: Population estimates for the Bluenose-West barren-ground caribou herd, 1986 to 2012 based on post-calving surveys.

Year	Number of collars available	Number of collars in groups counted	Minimum count	Lincoln-Petersen estimate with 95% CI
1986	35	33	86,460	88,369 ± 6,899
1987	44	43	104,512	106,887 ± 4,655
1992	33	22	76,008	112,360 ± 25,566
2000[1]	47	32	52,508	76,376 ± 14,347
2005	63	54	17,875	20,800 ± 2,040
2006	66	65	17,781	18,050 ± 527
2009	54	50	16,595	17,897 ± 1,310
2012	55	38	14,252	20,465 ± 3,490

[1] The Cape Bathurst, Bluenose-West, and Bluenose-East herds were first surveyed as separate herds in 2000. Radio collars were deployed throughout the fall (Bluenose-East herd) and winter ranges (Cape Bathurst and Bluenose-West herds) in preparation for this survey.

Table 2.3: Population estimates for the Bluenose-East barren-ground caribou herds, 2000 to 2013. [1]

			Survey Type:	Post-Calving Survey		Calving-Ground Survey		
Year	Number of collars available	Number of collars in groups counted	Minimum count	Lincoln-Petersen estimate with 95% CI	Rivest estimate with 95% CI	Breeding Females	Extrapolated Calving Ground with 95% CI	Preferred Calving Ground estimate with 95% CI
2000[1]	33	23	84,412	119,584 ±25,419				
2005	43	37	60,524	70,081 ±8,120				
2006	51	47	61,619	66,754 ±5,182				
2010[2]	47	44	92,481	98,646 ±7,125	122,697 ±31,756	51,757 ±11,092	102,704 ±39,964	114,472 ±15,865
2013[2]						34,471 ±3,757	68,295 ±18,040	

[1] In 1992, there were only 5 collars surveyed in the range of the Bluenose-East Caribou Herd and this is insufficient to get a reliable population estimate, so is not included in the table.

[2] In 2010 both a post-calving and calving ground photo survey was conducted. In 2013 a calving-ground photo survey was conducted

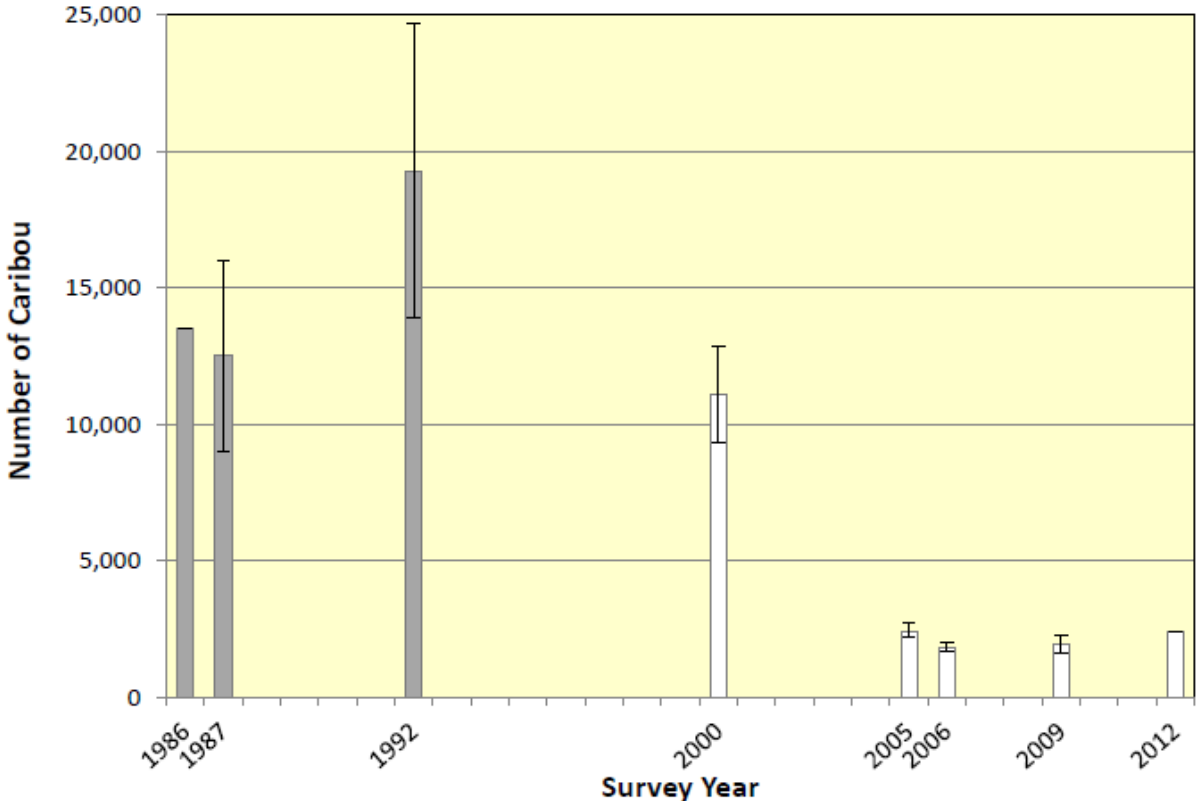

Figure 2.1 Change in population estimates for the Cape Bathurst barren-ground Caribou Herd, based on Lincoln-Petersen estimates from post-calving surveys. Estimates in grey were obtained prior to the Cape Bathurst, Bluenose-West, and Bluenose-East herds being surveyed as individual herds and are a recalculation of data from survey of 'Bluenose' caribou.

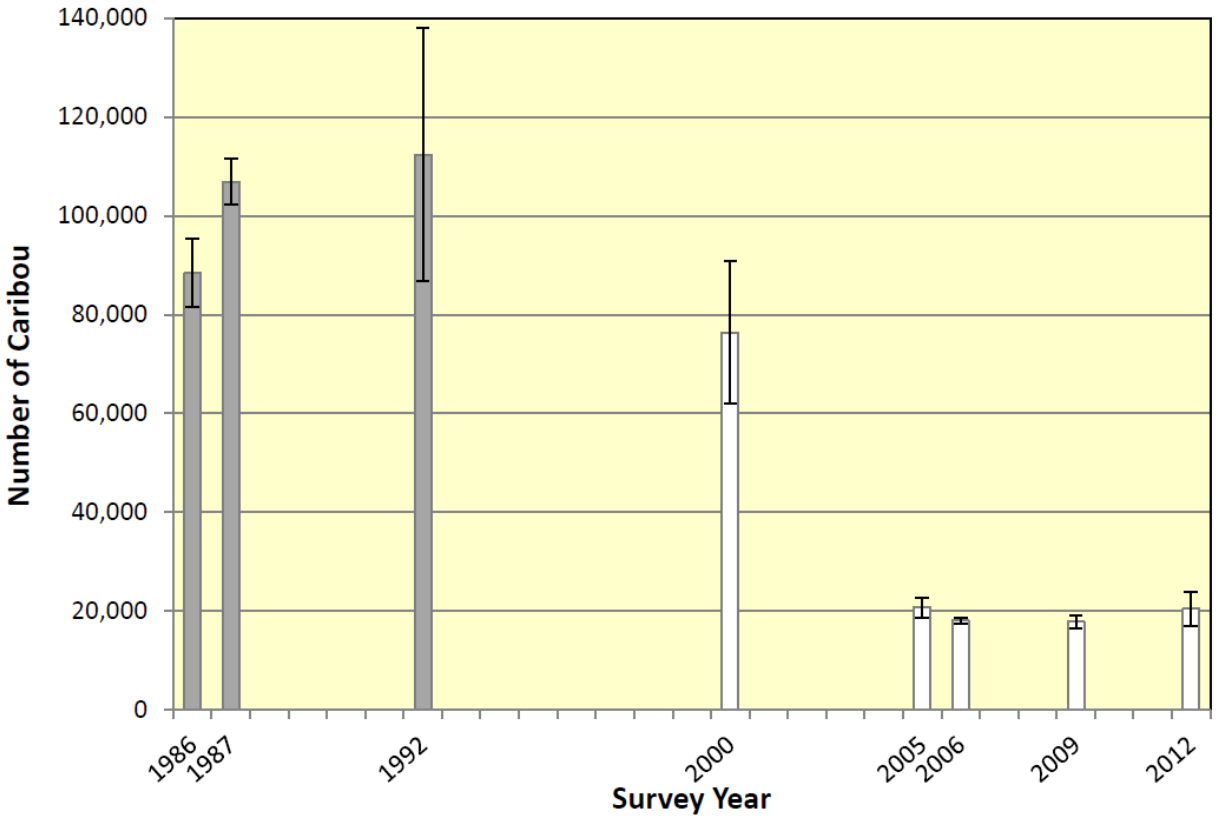

Figure 2.2 Change in population estimates for the Bluenose-West barren-ground Caribou Herd, based on Lincoln-Petersen estimates from post-calving surveys. Estimates in grey were obtained prior to the Cape Bathurst, Bluenose-West, and Bluenose-East herds being surveyed as individual herds and are a recalculation of data from survey of 'Bluenose' caribou.

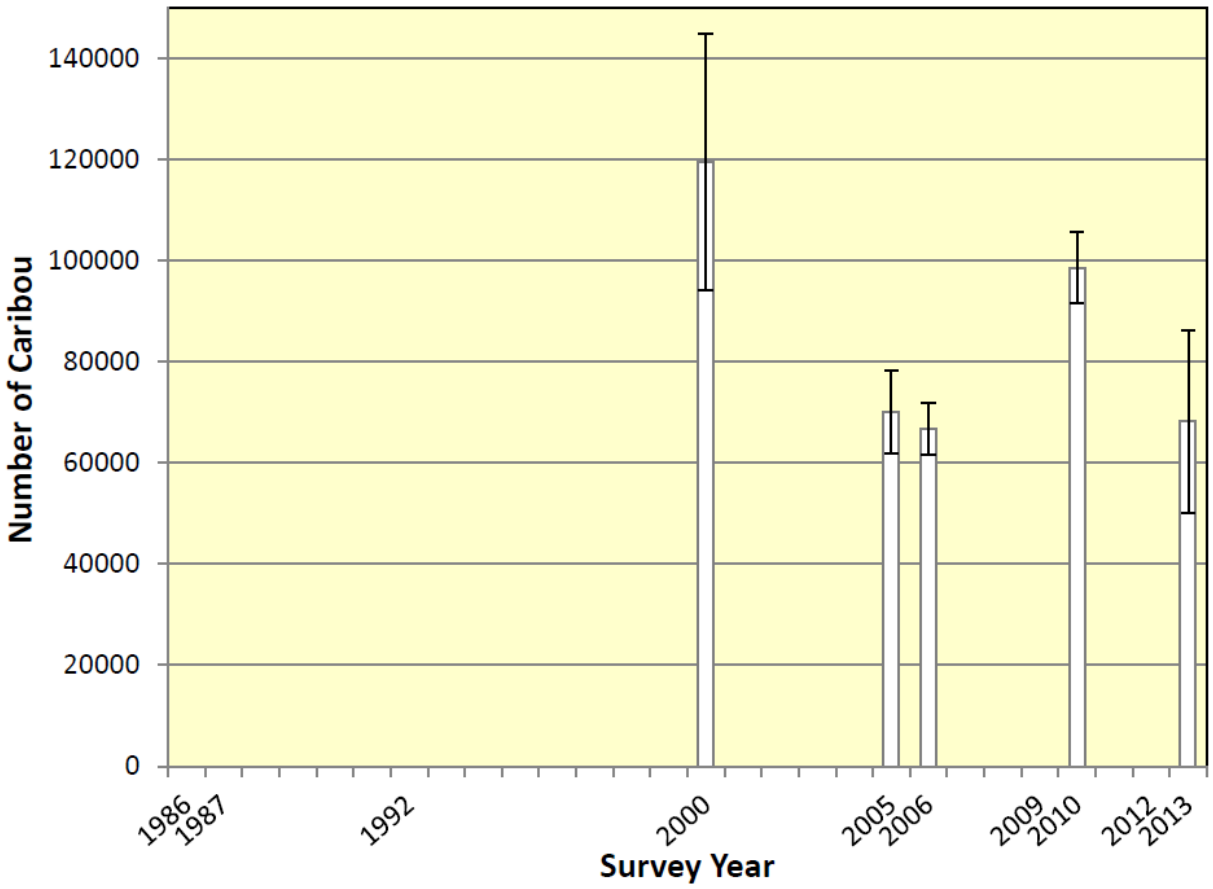

Figure 2.3 Change in population estimates for the Bluenose-East barren-ground Caribou Herd. The population estimate was based on Lincoln-Petersen estimates from post-calving surveys in 2000-2006, the 2010 survey used a Rivest estimate for the post-calving survey and the 2013 survey used the estimate from the calving ground survey.

The estimates of herd sizes clearly show the changes in numbers that occur between surveys, such as was seen between 2000 and 2005, and then in 2006 further confirming the declining trend. For the Bluenose-West and Cape Bathurst herds we see stability in the estimates between 2006 and 2009, which is likely a result of the good recruitment from 2007 to 2009 and management actions taken (see section 8.6). The Bluenose-East herd has not followed the same population trend as the Bluenose-West and Cape Bathurst herds. For the Bluenose-East herd in 2010 all estimates (based on both post-calving and calving ground surveys) showed a recovery in numbers for the herd and indicated a herd numbering more than 98,000. Of the four estimates made of herd size in 2010, the Rivest estimate of 122,697 ± 31,756 (95% CI) was the preferred estimate (Adamczewski et al 2013). However the recovery did not continue and again a decline trend was seen between 2010

and 2013. The current population sizes are low for the three herds, even if current population estimates are combined and compare to historic "Bluenose" herd estimates.

2.2 Adult Female Mortality

The survival of adult females can be the largest factor in the growth of ungulate populations (Langvatn and Loison 1999), including barren-ground caribou and even small changes in adult female survival can have a large influence on herd population size (Prichard 2009, Boulanger et al. 2011). Cow survival is most often estimated for barren-ground caribou herds from monitoring deaths of radio collared animals (Gunn and Russell 2008). The adult female mortality rate for the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds has not been estimated. To obtain a good estimate of adult female survival with a large enough confidence to detect change a large number, over 100, of cows need to be collared and monitored closely (Rettie 2008, Arthur et al 2001). However, adult female survival rates were estimated for the Bluenose-East herd using collared caribou between June 2010 and May 2013 and estimated to be 73% (Boulanger et al 2014). Adult female survival over 80% has been shown to be needed for stability or growth (Boulanger et al 2011, Fancy et al 1994, Mahoney and Schaefer 2002).

2.3 Recruitment

Recruitment is defined as the proportion of calves in a herd that survive their first full year of life. When a calf becomes more than 12-months-old it enters, or is recruited into, the adult segment of the herd and generally can be expected to have a much higher survival rate over the coming years. Having an annual estimate of recruitment (defined as the number of calves estimated per 100 cows) is important because it provides information about the trend and future growth potential of the herd. Recruitment rates can vary greatly from year to year depending on weather and other environmental factors (e.g., snow depth and hardness), predation rates, diseases, and other factors. Sustained low recruitment is a clear signal of a declining natural trend, as in the Bathurst herd 2000-2006 (Boulanger et al. 2011). Sustained high recruitment is indicative of herds that are either stable or increasing. However, because the number is a ratio, it can be affected by both calf mortality and cow mortality. It is also important to have accurate estimates of harvest and adult female survival rates, since adult female mortality rates can influence recruitment rates and the

ratio used to estimate recruitment. If there is a high mortality of adult females (either from harvest or for other reasons), then the estimated ratio of calves to cows (recruitment) may be inflated for the herd for that year making it appear as though more calves enter the adult population than actually did. It is for this reason that good harvest data, particularly sex-specific harvest, is very important when interpreting recruitment survey results and herd trends.

Recruitment surveys are flown in late March or early April, timing that is not too close to calving to disturbed cows during that time but after the majority of the winter mortality has occurred, therefore the survey actually counts calves or "short yearlings" as they are short of their first birthday. Surveys are conducted by helicopter. Areas to survey are identified from locations of satellite radio-collars, local knowledge, and experience gained from previous surveys. Usually at least one observer from the community nearest the area being surveyed is part of the survey crew and helps ensure that all areas where caribou are likely to be are included in the survey. Caribou are classified either from the air or on the ground (if there are large groups and where feasible) and all animals are identified as being a cow, calf, or bull.

The recruitment surveys for 1983-1992 were based out of Inuvik and mostly flown over what is now considered the ranges of the Cape Bathurst and Bluenose-West herds (McLean 1992, McLean and Heard 1991, McLean and Jackson 1992, Williams and Elliott 1985, Fraser and Nagy 1992, Fraser et al 1993). There was also an effort made to cover areas near Coppermine (now Kugluktuk, Nunavut) in 1993 (Fraser et al 1993). Recruitment surveys were not flown for many years, partially due to concerns about the impact of a female dominated spring harvest on the survey results. However, recruitment surveys were reinstated as a regular component of the overall barren-ground caribou research program after declines in the herds were documented in 2005 and 2006. Results of recruitment survey shown in table 3.2.

While recruitment estimates for all three herds are considered to be very good for 2008-2011, it is also important to note that for some years harvest data are lacking for the Bluenose-West and Bluenose-East herds, so impact on the recruitment rate is not known (Davison and Branigan 2008).

However, harvest was closed on the Cape Bathurst herd during this time, so cow harvest should not be a factor influencing the recruitment results.

Table 3.2: Summary of spring (March-April) recruitment surveys for the "Bluenose," Cape Bathurst, Bluenose-West, and Bluenose-East herds of barren-ground caribou, 1983-2010. All values are calves per 100 cows with standard error. Blank fields represent years where no survey was conducted.

Year	Bluenose	Cape Bathurst	Bluenose-West	Bluenose-East
1983	44.0 ± 2.0			
1986	51.8 ± 2.9			
1987	55.0 ± 4.8			
1988	46.0 ± 0.6			
1989	44.7 ± 3.0			
1991	38.9 ± 2.6			
1992	16.6 ± 1.67			
1993	24.9 ± 2.2			
1994	27.0			
2000		63.5	39.8	
2001				25.1
2004				51.7
2007		21.8 ± 3.1	25.7 ± 2.8	48.7
2008		49.0 ± 3.6	41.9 ± 1.4	48.3
2009		41.9 ± 4.1	43.7 ± 2.3	37.5
2010		48.1 ± 3		46.6
2011		47.4 ± 2.8	32.0	41.0
2012				27.2
2013		25.9 ± 3.4		

2.4 Productivity

Productivity is defined as the number of calves per 100 cows either at, or near, the peak of calving, which is generally early to mid-June. This timing for estimating productivity was the standard procedure used from 1981 to 2005. However, due to community concerns about disturbance on the calving grounds, since 2005 productivity surveys for Bluenose-West and Cape Bathurst herds have been flown about one month after calving (Davison et al. 2007). Productivity is estimated by aerial surveys (usually helicopter) with ground-based observations through spotting scopes on large groups also used where feasible. Results of recruitment surveys are shown in table 3.3.

Table 3.3: Summary of productivity surveys for the "Bluenose," Cape Bathurst, Bluenose-West, and Bluenose-East herds of barren-ground caribou, 1981-2010. All values are calves per 100 cows. Blank fields represent years where no survey was flown for that herd. Surveys were flown in June near the peak of calving, except for 2007 and 2008.

Year	Bluenose	Cape Bathurst	Bluenose-West	Bluenose-East
1981	92.0			
1983	82.0			
2000		64.4	38.7	
2001		19.2 ± 8.7	54.1	
2002		32.3 ± 5.0	53.7	
2003		47.0 ± 3.8	53.2	
2004		46 ± 17.6	60.9	
2005		52.6 ± 5.5	59.4	
2006		32.9 ± 7.0		
2007*		52.6 ± 1.6	77.4 ± 7.3	
2008*		49.3 ±1.0	59.6 ± 1.9	

* Surveys conducted in July

2.5 Adult Composition

Both cows and bulls are important parts of a healthy herd. Bulls have consistently higher mortality rates than cows and an adult sex ratio of about 50 bulls:100 cows is common (Bergerud et al. 2008). In NWT barren-ground caribou herds, ratios have varied from 60-70 bulls:100 cows in increasing herds to 31-38 bulls:100 cows in declining herds (Boulanger et al. 2011), in a healthy herd the number of bulls can be lower than the number of cows because one bull can breed with many cows. In some ungulate populations very low male to female ratios (below 25 bulls to 100 cows) have been documented while calving rates remain high (Langvatn and Loison 1999, Noyes et. al. 1996). The age of the bulls is also a factor, with prime bulls (3- to 4- years of age) putting more effort into rutting than younger bulls (Mysterud et al. 2003). This might be because cows can dominate young bulls and not allow them to breed (Bergerud 1974a). The age of bulls in the population can also impact the conception date, with younger bulls influencing the timing of calving, shifting it later in the spring (Holand et al 2003, Noyes et. al. 1996).

The optimum time for surveying barren-ground herds to estimate the adult composition of the herd (i.e., the ratio of bulls to cows) is near the peak of the breeding period (i.e., the rut) in late

October. All animals over 1-yr-old are included as adults in these surveys. Similar to spring recruitment surveys, adult composition surveys are flown in helicopter and local observers are generally involved.

Fall composition surveys were conducted in 2009 for the Bluenose-West and Bluenose-East herd and 2013 for the Bluenose-East herd (Boulanger et al 2014). There was also an attempt to do a survey on the Bluenose-East herd in 2008, however spatial coverage was poor due to weather leading to poor results (Bruno Croff, personal communication).

Table 3.4. Summary of fall composition surveys for the "Bluenose," Cape Bathurst, Bluenose-West, and Bluenose-East herds of barren-ground caribou, 2008-2010. All values are calves and bulls per 100 cows. Blank fields represent years where no survey was flown for that herd.

Year	Cape Bathurst	Bluenose-West	Bluenose-East
2009		70.0	42.9 ± 3.4
2013			42.6 ± 3.5

4.0 Condition and Health

4.1 Body condition

The body condition of an individual caribou is an indication of the amount of fat reserves an animal has. These fat reserves are very important to the animal's survival and the likelihood of reproduction (Kofinas et al. 2002). Body fat of cow caribou of a cow caribou can be used to predict pregnancy, with fatter cows more likely to be pregnant (Gerhart 1997). When the body condition of a sample of animals from a herd is assessed, we can get an idea of the overall health and condition of that herd.

Standardized protocols developed by the CircumArctic Rangifer Monitoring and Assessment Network (CARMA 2008), are used to monitor caribou herds across the Arctic and sub-Arctic in North America and Eurasia. There are 3 levels of CARMA sampling protocols – Levels 1, 2, and 3 (CARMA 2008). Level 1 collections are the most basic, with samples easily collected by a harvester. These can include some of the following samples: teeth or lower jaw, metarsus (lower leg bone),

kidneys and fat, fecal samples and back fat measurements. The collections then get more progressively complex with Level 3 collections being intensive collections carried out by a trained biologist or technician. Level 3 samples and mesuremenst include teeth, body mass, rumen contents mass, jaw, metarsus, liver, blood, fecal, muscle, lungs, urine, kidney and fat along with other fat measurements and for cows fetal, milk and ovaries are sampled. Level 1 collections have been done on the Bluenose-West and Bluenose-East herds since 2007 and 2004, respectively. Level 3 collections were done on Bluenose-West caribou during a fall hunt at Horton Lake in 2007 and 2008. In some cases, sample sizes of collected samples are low; therefore they may not but the best predictors of overall health of the herds.

Samples collected from harvested caribou provide basic information to monitor overall health and condition. Hunters give an assessment of the general health of the harvested caribou: Poor/Skinny (1), Fair/Not bad (2), Good/Fat (3), and Excellent/Very fat (4). Table 4.1 and 4.2 summarizes the general health assessment of Bluenose-West and Bluenose-East caribou harvested. Bluenose-West harvest was conducted from Nov to July. Bluenose-East harvest was conducted January to March.

Table 4.1 Summary of the condition Bluenose-West caribou harvested in the Inuvik Region as assessed by hunters on scale of 1 – 4 with number of samples in brackets (ENR, unpublished data).

Season	**Female**	**Male**	**Unknown**	**Total**
07/08	1.8 (5)	2.79 (14)	4 (1)	**2.6 (20)**
08/09	1.33 (6)	1 (1)	(0)	**1.29 (7)**
09/10	1.9 (10)	2.58 (36)	4 (1)	**2.47 (47)**
10/11	2.5 (2)	3.25 (4)	3 (1)	**3 (7)**
11/12	3.0 (3)	(0)	(0)	**3.0 (3)**
12/13	2.6 (18)	2.3 (17)	2.5 (6)	**2.5 (41)**

Table 4.2 Summary of the condition Bluenose-East caribou harvested as assessed by hunters on scale of 1 – 4 with number of samples in brackets (ENR, unpublished data).

Season	**Female**	**Male**	**Total**
10/11	2.1 (12)	1 (2)	**1.9 (27)**
11/12	2.1 (29)	2 (6)	**2.1 (35)**
12/13	1.9 (20)	1.2 (6)	**1.7 (26)**
13/14	1.9 (61)	1.4 (5)	**1.8 (66)**

Back fat measurement can be taken by hunters. A cut is made approximately 5 cm away from the base of the tail and the spine and the deepest point of fat is measured (CARMA 2007). Back fat measurement from harvested caribou from the Bluenose-West and Bluenose-East herds are summarized in Table 4.3 Table 4.4, respectively. Bluenose-West harvest was conducted from Nov to July. Bluenose-East harvest was conducted January to March.

Table 4.3 Summary of the back fat measurements (in centimetres) of Bluenose-West caribou harvested in the Inuvik Region (ENR, unpublished data).

	Cows		**Bulls**	
	Number of Samples	**Average depth of back fat (cm)**	**Number of Samples**	**Average depth of back fat (cm)**
07/08	5	1.36	18	0.92
08/09	5	0.00	3	2.13
09/10	9	0.33	22	1.20
10/11	4	1.88	19	3.22
11/12	2	0.75	1	1
12/13	16	1.18	16	0.03

Table 4.4 Summary of the back fat measurements (in centimetres) of Bluenose-East caribou (ENR, unpublished data).

	Cows		**Bulls**	
Season	**Number of Samples**	**Average depth of back fat (cm)**	**Number of Samples**	**Average depth of back fat (cm)**
09/10	45	1.02	40	0.23
10/11	5	1.00	1	0.00
11/12	29	0.35	5	0.16
12/13	18	0.42	6	0.07
13/14	44	0.61	5	0.14

The lower leg bone (metatarsus) can be collected and bone marrow fat content is determined. Table 4.5 and 4.6 summarizes the general health assessment of Bluenose-West and Bluenose-East caribou harvested. Bluenose-West harvest was conducted from Nov to July. Bluenose-East harvest was conducted January to March.

Table 4.5 Summary of the percent of fat in the bone marrow of Bluenose-West caribou harvested in the Inuvik region (ENR, unpublished data).

	Cows		**Bulls**		**unknown**	
	Number of Samples	Average percentage of fat in marrow	Number of Samples	Average percentage of fat in marrow	Number of Samples	Average percentage of fat in marrow
07/08	10	90.8%	11	88.5%	14	88.4%
08/09	6	81.2%	2	87.7%		
09/10	11	89.8%	22	86.5%	10	88.1%
10/11	8	91.2%	26	88.0%	8	90.0
11/12	3	92.9%	1	89.4%	---	---

Table 4.6 Summary of the percent of fat in the bone marrow of Bluenose-East caribou harvested (ENR, unpublished data and 2008 and 2009 data from Allaire 2014).

	Cows		**Bulls**		**Unknown sex**	
	Number of Samples	Average percentage of fat in marrow	Number of Samples	Average percentage of fat in marrow	Number of Samples	Average percentage of fat in marrow
2004	---	---	---	---	11	84.8%
2005	17	91.9%	---	---	---	---
2006	---	---	15	86.7%	---	---
2007	---	---	10	89.21%	---	---
2008	1	81.9%	9	82.6%	---	---
2009			3	83.4%	---	---
2013	21	83.0%	7	93.4%	---	---
2014	55	92.8%	5	86.6%	10%	90.9%

Kidney fat index is calculated by weighing the kidney with fat and the kidney without fat. It is calculated using formula: (weight of kidney fat/weight of kidney) X100. Table 4.7 show Kidney fat index from Bluenose-East harvest harvested January to March.

Table 4.7 Summary of kidney fat of Bluenose-East caribou harvested (2009 and 2008 data from Allaire 2014, 2010 to 2014 from ENR, unpublished data)

	Cows			**Bulls**		
	Number of Samples	Kidney Fat Index Average	Kidney Fat Index Range	Number of Samples	Kidney Fat Index Average	Kidney Fat Index Range
2008	1	79.27		9	51.69	12.02 - 77
2009				3	27.23	11.54 – 55.13
2010	38	58.2	0.5-114.1	39	41.5	12.0 – 175.8
2011	12	67.4	36.6 – 155.4	2	28.9	15.8 - 42
2012	30	43.8	12.43 – 92.3	6	32.1	20.0 – 50.8
2013	21	57.3	25 – 105.1	6	33.0	11.5 – 49.3
2014	49	62.0	13 – 129	5	44.0	25.0 – 47.0

4.2 Disease and Parasites

Disease and parasites can affect an individual caribou's health (Huot and Beaulieu 1985), and consequently their reproduction and survival. Disease and parasites have also been found to play a role in the feeding strategies of caribou and other ungulates (Gunn and Irvine 2003). There are a number of diseases and parasites that are found in barren-ground caribou, although their significance to individuals in the herd and the herd overall is not always well understood. An overview of some common diseases affecting caribou is presented in this section. Detailed information on infectious diseases and parasitic diseases in caribou and other wildlife can be found in Samuel et al. (2001) and Williams and Barker (2001).

Currently, sample kits are provided to hunters by ENR, Inuvik, and Sahtú Regions for collecting body condition samples. Hunters provide information on; sex, location of the harvest, and condition of the animals, including back fat measurements. The jaw/lower incisor and lower leg bone (femur) are collected to get age and a measure of body condition by analysis of fat in the marrow. Filter papers are provided to collect blood. The filter paper technique is a new tool that is being investigated to test for brucellosis, *Mycobacterium avium,* and pregnancy (Curry 2009). Hunters are

also encouraged to submit samples of caribou abnormalities to territorial government staff with departments of Environment and Natural Resources (NWT) or Environment (Nunavut).

When caribou are live-captured and collared, blood and fecal samples are collected, which can be tested for diseases and parasites. Important information on the animal can also be collected, such as body condition (index), external injuries / abnormalities and any presence of besnoitiosis in the eyes.

Besnoitiosis is a caused by a very small protozoan parasite (*Besnoitia tarandi***)** that occurs commonly in caribou in the NWT (GNWT 2005). Infected caribou usually look healthy but may lose hair on their lower legs and face. When skinning the lower legs small, hard cysts – which feel somewhat like grains of sand or coarse sand paper - can be found in infected animals. Small, white cysts may also be seen on the eyeballs of infected animals. In 1995 and 1996, of 48 samples taken from harvested Cape Bathurst caribou, 77% had *Besnoitia* cysts (Larter 1999). Of 25 adult male Bluenose-West caribou sampled in the fall between 2007 and 2009, 44% were found to be infected by *Besnoitia*. The prevalence in the Cape Bathurst and Bluenose-West herd is higher than both the Bathurst and Porcupine caribou herds, but lower than the Leaf River Herd of northern Quebec (Ducrocq et al, 2009).

Brucellosis is caused by the bacteria *Brucella suis* and is common in barren-ground caribou in the NWT (Government of the NWT 2005). Leg joints and reproductive organs are usually affected by brucellosis; often infected animals will have swollen leg joints. When butchering a caribou that has brucellosis, pus-filled swellings may be found under the skin, in the meat, and/or internal organs. Brucellosis is a zoonotic disease, which means that it can be transferred to humans. In 1995, 42 Cape Bathurst animals were tested for brucellosis and 2 (4.8%) had evidence of exposure to Brucella (Larter and Nagy 1996). This is somewhat lower (but generally comparable) to the prevalence of brucellosis in other caribou herds across North America.

The bacteria *Mycobacterium avium paratuberculosis*, causes Johne's disease in cattle, sheep, wild ruminants, horses, foxes, and some species of birds. The bacteria has been found in 1 of 13 Bluenose-West caribou sampled, but it was not found in the Cape Bathurst herd (13 samples) (Orsel et al. 2009). The Bluenose-East herd has not been sampled. Symptoms of Johne's disease includes dehydration and wasting and can lead to death. No cases of Johne's disease in caribou have been reported; however, it is not known if this is due to removal of affected animals by predation or if caribou are simply not affected the way other species are (Orsel et al. 2009).

Other diseases and parasites affecting barren-ground caribou include tapeworms, lungworms, and sarcocystosis. The tapeworms, *Taenia hydatigena, Echinococcus granulosus*, *and Taenia krabbei,* commonly occur in caribou in the NWT. Tapeworm cysts are most commonly found in liver, lungs, or muscles of infected animals, but can occur in other organs as well. Lung Worm, including *Echinococcus granulosus Dictyocaulus spp.* and *Protostrongylus,* are found in the lungs of caribou either as a cyct (larva) or adult worm. Tape worms require two or three hosts, usualy a carnivore, a snail and herbivore. *Sarcocystis* is a very small single-celled parasite that causes cysts in muscle tissue; these cysts sometimes look like small grains of white rice in the meat. The prevalence of these parasites in the Cape Bathurst, Bluenose-West, and Bluenose-East herds is unknown

Insect harassment during warm days in summer has been shown to have an effect on caribou condition. Annoyance responses seen during insect harassment include head and body shakes, foot stamping, ear flicking, tail wagging, and biting (Toupin et al 1996). Observation of caribou behaviour shows a significant decrease in the time spent feeding and lying when compared to the pre-insect season (Toupin et al 1996). Caribou increased time spent on insect avoidance behaviour and standing rather than lying or feeding when oestrid flies are present or black flies were at moderate to high levels (Whitter et al 2011). When mosquitoes are active caribou spend more time walking (Whitter et al 2011). Time spent moving increases and time spent moving decreases with weather conditions that increased insect activity (Russell et al 1993). This increased activity and decreased in time spent feeding can have an effect on body condition. A study on reindeer in northern Finland found the majority of cow reindeer weight variations could be explained by insect harassment and

winter weather conditions (Helle and Tarvainen 1989). Studies have shown that grouping up (i.e., aggregating) in tree-less areas is the best strategy to reduce insect harassment (Helle 1992). Changes in climate could cause longer insect seasons in the future.

Warbles, found under the skin of caribou, are parasitic larvae of the warble fly, which are common in caribou in the NWT (Government of the NWT 2005). The adult female warble fly lays eggs on the caribou's lower body, and after hatching the larvae make their way through the skin and travel to the caribou's upper back. In the early summer, the warbles break through the skin and drop to the ground. The caribou are harassed while the flies lay their eggs, which has been suggested to have more impact on the caribou than the larvae under the skin(Thomas and Kiliaan, 1990). The prevalence and intensity of warbles in the Cape Bathurst, Bluenose-West, and Bluenose-East herds is unknown; however, other barren-ground caribou herds have been found to have up to 100% infection (Thomas and Kiliaan, 1990).

Nose bots are parasitic larvae of the bot fly, which are deposited by the female fly inside the nostrils of caribou; the caribou are harassed while the flies lay their eggs. They are common in caribou in the NWT (Government of the NWT 2005), but the prevalence of nose bots in the Cape Bathurst, Bluenose-West, and Bluenose-East herds is unknown.

4.3 Contaminants

There are a wide range of both naturally occurring and human produced components, which can be grouped together as 'contaminants,' that have been detected in northern environments. The Northern Contaminant Program (NCP) was established in 1991 to monitor and reduce the contaminants in country foods and to provide health-related information to communities (NCP 2010). Contaminant levels were monitored in most barren-ground caribou herds across the north during the 1990's under the NCP to provide a baseline of the types and levels of contaminants that are present, to help understand the source of the contaminants, and to consider their significance to caribou and the people that depend on caribou for food.

In 1995, 20 kidney samples were taken from hunter-killed cow caribou on the range of the Cape Bathurst herd. These samples were tested for aluminum, nickel, cadmium, mercury, and lead. The levels measured were similar to other herds, except the level of aluminum, which was lower. Risk to humans from the consumption of caribou is low, adults would have to consume more than 13 whole caribou kidneys a year to exceed the World Health Organization's recommended intake of cadmium (Larter and Nagy 2000).

In 2000 and 2001, 10 kidney samples were taken from hunter-killed caribou on the range of the Cape Bathurst herd. They were tested for arsenic, aluminum, nickel, cadmium, copper, mercury, lead, nickel, selenium, and zinc (Larter et al. 2010). Aluminum was higher in 2000/2001 than in 1995, whereas mercury was lower in 2000/2001 than 1995. Nickel, cadmium and lead levels were constant when compared to 1995 levels. There was no detectable level of arsenic (Larter et al. 2010).

5.0 Harvest

To understand trends in barren-ground caribou populations, we also need to have information on the total harvest from the herds, in addition to estimates of herd size, recruitment, and productivity. Knowing the sex ratio of the harvest is also important, bulls can impregnate multiple cows so the number of cows in a population is importation to the growth potential of the herd (see section 3.5 for more on this). Harvest of barren-ground caribou occurs by five general categories of hunters: Subsistence, Resident, Non-resident (Canadians outside the NWT), Non-resident Alien (non-Canadian), and Commercial. Non-residents and Non-resident Alien hunters are required to hunt with a licensed outfitter and must be accompanied by a licensed guide at all times while hunting.

Through the regional land claims, formal Harvest Studies were done for the Inuvialuit, Sahtú, and Gwich'in regions of the NWT, and in Kugluktuk through the Nunavut Harvest Study. These studies documented community harvests of all species of fish and wildlife on a regular basis, with harvesters contacted as often as monthly to report harvest. Response rates by harvesters were excellent (usually over 90%), although participation was voluntary. Currently, resident hunters

report their harvest to GNWT on a voluntary basis through mail-in forms and the data are summarized in the annual *Resident Hunter Harvest Study*. Submission of Non-resident and Non-resident alien hunter data is mandatory through GNWT legislation, even when a client does not harvest; therefore, we can assume the response rate is 100%.

In addition to harvest numbers there is also possibility of wounding loss, caribou injured accidently and not retreated. This can include a bullet passing through a caribou and hitting another or caribou being hit but not dying till latter due to blood loss. The exact percentage of wounding loss occurring is not known. Hunter education and sight-in your riffle events are used to help ensure lower wounding loss.

As a result of the decline in the population of the herds, management actions were taken to reduce harvest. For the Cape Bathurst herd action include the elimination of commercial harvest in 2005 and the other types of harvest in September 2007. Management actions for the Bluenose-West herd include the elimination of commercial harvest in 2005 and a Total Allowable Harvest of four percent. More information is provided in the following sections. See section 8 for more information on the management of these caribou herds.

5.1 Subsistence Harvest

A total of 14 communities in six land claim/regional areas and two territories are the primary subsistence harvesters from the Cape Bathurst, Bluenose-West, and Bluenose-East herds herds. On the mainland, the Cape Bathurst herd is primarily harvested by Inuvialuit and Gwich'in from 4 communities; Aklavik, Inuvik, Tsiigehtchic and Tuktoyaktuk. The Bluenose-West herd is primarily harvested by Inuvialuit, Gwich'in, and Sahtú Dene and Metis in 13 communities; Aklavik, Colville Lake, Deline, Fort Good Hope, Fort Mcpherson, Norman Wells, Inuvik, Paulatuk, Sachs Harbour, Tsiigehtchic, Tulit'a, Tuktoyaktuk, and Ulukhaktok. The Bluenose-East herd is primarily harvested by Sahtú Dene and Metis, Inuit, Tåîchô, and Dehcho in 9 communities in two territories; Behchoko,

Deline, Gamieti, Kugluktuk, Norman Wells, Paulatuk, Tulit'a, Whati, and Wrigley. However, these caribou may also be harvested by people from other communities with rights to harvest the herds.

5.1.1.Inuvialuit Harvest Study – 1988-1997 (IHS 2003).

The Inuvialuit harvest study was conducted between 1988 and 1997. Throughout the study the response rate varied from 76% to 98%, with a mean response rate of 92%. Harvest was recorded as 'caribou', with no differentiation made between Porcupine, Peary, barren-ground, or woodland (either mountain or boreal) caribou. From the communities of Inuvik, Tuktoyaktuk and Paulatuk the average total annual harvest of caribou was 3,113 (range of annual lowest of 1,978 in 1997 to highest 5,393 in 1988).

Table 5.1 Inuvialuit Harvest Study total caribou estimated harvested by year in the communities of Inuvik, Tuktoyaktuk and Paulatuk.
(Note: harvest total not divided by herd, so likely also contains Porcupine Caribou Harvest from Inuvik). (From IHS, 2003)

Community	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Inuvik	1,589	635	602	490	663	392	470	272	398	275
Tuktoyaktuk	1,003	586	732	1,325	1,358	890	955	691	883	730
Paulatuk	665	405	659	543	546	441	455	279	260	302

5.1.2 Gwich'in Harvest Study – 1995-2004 (GRRB 2009).

The Gwich'in Harvest Study (GHS) study was conducted over a nine-year period from 1995-2001, with a "year" used in the study defined as from July to August. Estimates in the published report were based only on reports made by Gwich'in harvesters, enrolled as participants in the Gwich'in Comprehensive Land Claim agreement (GCLCA), and were calculated based on monthly or study year response rates in each of four Gwich'in communities until the end of the sixth study year in July 2001. Although harvests were reported through July 2004, estimates could not be calculated for those years because of declining participation rates. Reported harvests by harvesters who had not yet enrolled in the GCLCA were also recorded but their harvests were not included in published estimates.

In the GHS, the monthly harvests of caribou were recorded as Porcupine, woodland or 'Bluenose,' and were reported according to age and sex (e.g. cow/bull/calf)' However, their published

estimates did not distinguish between age or sex categories. The GRRB reported in the GHS that it was not known if study participants differentiated between woodland and barren-ground harvest during the time of the survey. However, recent interview with Gwich'in knowledge holders about Gwich'in Traditional Knowledge of boreal caribou suggests those interviewed have a generally good understanding of physical differences between woodland caribou and other caribou types, especially compared when to Porcupine caribou (GSCI 2011). Harvesters reported their monthly harvests of study species by indicating the location of harvest on map grids (~10km by 10km).

The GHS average annual harvester response rate was 90%. The estimated average annual Gwich'in harvest of "Bluenose caribou" over the six-year study period was 104, with a range of 22-153 caribou, and variances on the estimates are included in the published report (GRRB 2009). Gwich'in participants reported most caribou harvests from the neighbouring Porcupine herd (with the average estimated harvest of 1558 annually). Less than 10% of total Gwich'in caribou harvest was recorded as "Bluenose".

To facilitate calculations of overall harvests from all user groups, the estimated and reported harvests from the Gwich'in harvest study are presented in Table 5.2. The harvest estimates are broken down both by calendar year and GHS study year, and are based on the monthly harvester reports and monthly response rates in each community.

Table 5.2 'Bluenose' Caribou Harvest from the Gwich'in harvest Study by year and community. (GRRB 2009)

		Aklavik		Fort McPherson		Inuvik		Tsiigehtchic		Annual total	
		R	E	R	E	R	E	R	E	R	E
Aug-Dec	1995	0	0.0	0	0	44*	49.3*	5	5.2	49	54.6
	1996	30	30.3	0	0	68	75.3	5†	5.0†	103	110.7
	1997	8	8.0	0	0	136	143.7	5	5.0	149	156.7
	1998	6	6.3	0	0	75	81.2	6	6.1	87	93.6
	1999	20	21.0	0	0	64	69.5	7††	7.4††	91	97.9
	2000	1	3.0▪	0	0	81	95.2	10	10.9	92	109.1
Jan-Jul	2001a	0	0.0	0	0	0	0.0	0	0.0	0	0
Aug-Dec	2001b	0	0	0	0	38	38	0	0	38	38
	2002	4	4	0	0	79	79	0	0	83	83
	2003	0	0	0	0	38**	38**	0	0	38	38
Jan-Jul	2004	6	6	0	0	54	54	6	6	66	66
	total	75	79	0	0	677	727	44	46	796	848
	95-01a total	65	69	0	0	468	514	38	40	571	622
Aug-Dec	Year 1	30	30.3	0	0	85*	94.0*	10†	10.2†	125	134.5
	Year 2	0	0.0	0	0	77	84.1	0	0.0	77	84.4
	Year 3	8	8.0	0	0	131	139.2	6	6.0	145	153.3
	Year 4	19	20.0	0	0	69	74.4	7††	7.1††	95	101.5
	Year 5	8	8.3	0	0	93	107.6	11	11.8	112	127.7
	Year 6	0	2.0▪	0	0	13	15.0	4	4.4	17	21.4
	Year 7	4	4	0	0	74	74	0	0	78	78
	Year 8	0	0	0	0	68**	68**	0	0	68	68
Jan-Jul	Year 9	6	6	0	0	67	67	6	6	79	79
	total	75	79	0	0	677	727	44	46	796	848
	Year 1-6 total	65	69	0	0	468	514	38	40	571	622

Note, annual and community totals use unrounded monthly estimates. Shading indicates reported harvests only as no estimates could be calculated after August 2001 because of declining participation.

If the following revisions are made based on a review of the published GHS study and the GHS database, the average estimated annual Gwich'in harvest from study years 1-6 must be modified to be 107 caribou, ranging from 23-153 caribou per study year (K. Callaghan pers comm. 2013):

Error corrections (omissions of harvests by enrolled Gwich'in participants or calculation error):

*	Inuvik	1995	Reported harvest should be 49, Estimated harvest should be 55.2
	Inuvik	Year 1	Reported harvest should be 90, Estimated harvest should be 99.8
**	Inuvik	2003	Reported harvest should be 42
	Inuvik	Year 8	Reported harvest should be 72
▪	Aklavik	2000	Estimated harvest should be 5
	Aklavik	Year 6	Estimated harvest should be 4

If reported harvests of 'Bluenose' caribou made by Gwich'in harvesters prior to the date of their enrolment in the GCLCA were also included in the estimates the following additional corrections should be made:

†	Tsiigehtchic	1996	Reported harvest should be 6, Estimated harvest should be 6.0
	Tsiigehtchic	Year 1	Reported harvest should be 11, Estimated harvest should be 11.2
††	Tsiigehtchic	1999	Reported harvest should be 17, Estimated harvest should be 18.6
	Tsiigehtchic	Year 4	Reported harvest should be 17, Estimated harvest should be 18.3

5.1.3 Sahtú Harvest Study -- 1998-2005 (SRRB)

The Sahtú Renewable Resources Board began a Harvest Study for Sahtú Dene and Métis beneficiaries in 1998, through to 2005. The study involved voluntary monthly interviews of all beneficiaries (or others providing information on behalf of beneficiaries) and included all species harvested. Data were collected on numbers of animals harvested, location, and the month of harvest. For some species, including caribou, data were collected on sex of animals harvested. The caribou harvest data from the Sahtú harvest study have not been adjusted for participation rates and as a result should not be considered total estimated harvests. It is likely that the numbers presented in Table 5.3 underestimate the total caribou harvest in the communities by 10-20%.

Table 5.3 Caribou harvest Data from the Sahtú harvest study by year and community. (SRRB 2002, 2003, 2004, 2006)

Community	1998	1999	2000	2001	2002	2003	2004	2005
Deline	-	1772	1470	1602	1377	947	1307	858
Tulita	67	278	289	228	146	46	266	226
Norman Wells	34	52	62	106	18	26	36	129
Fort Good Hope	349	641	727	505	185	39	153	107
Colville Lake	329	355	245	120	169	42	237	98

Note: In 1998 the harvest study began in April and did not include Deline. In 2003 the harvest study ended in March, although Deline continued until the end of the year. The harvest study continued through 2004 and 2005 but was done quarterly (rather than monthly).

5.1.4 Nunavut Harvest Study – 1996-2001 (NWMB)

The Nunavut Harvest Study was conducted by the Nunavut Wildlife Management Board from June 1996 to May 2001.The purpose of the study was to determine current harvest levels and patterns of Inuit use of wildlife resources. The study had an 82% response rate (Priest and Usher 2004). The annual mean reported caribou harvest in Kugluktuk was 1575 caribou (range 1355-1913). Some hunters did not specify the type of caribou harvested, therefore harvest estimates were calculated with the combined number of barren-ground (Bluenose-East Herd and Bathurst Herd) and Island caribou (Dolphin and Union Herd) (Priest and Usher 2004).

Table 5.4 All caribou harvest in Kugluktuk reported in the Nunavut harvest study (includes barren-ground and Island caribou (Priest and Usher 2004).

Year	96/97	97/98	98/99	99/00	00/01	Mean
All Caribou	1,561	1,462	1,913	1,584	1,355	1,575

5.1.5 Current Harvest

On the range of the Cape Bathurst herd all hunting, including subsistence harvest, was closed in 2007, based on recommendations from WMAC(NWT) and GRRB. The Bluenose-West Herd currently has a total allowable harvest based on the recommendation of the WMAC(NWT), GRRB, and SRRB. The WMAC(NWT), GRRB and SRRB met together to set a Total allowable harvest of four percent for the Bluenose-West herd, with recommendation that the harvest be 80% bulls. The boards also determined the allocation of that harvest between settlement regions, with 48% of the quota going to each the Inuvialuit and Sahtu and the remainder 4% to the Gwich'in. Harvest was reduced based on these recommendations through a quota in the ISR portion of the herd's range (of which the Gwich'in receive tag also) and a reduced harvest in the Sahtú through a Total Allowable Harvest recommended by the SRRB after a Public Hearing in November 2007. Reported harvest is shown in table 5.5

Data collected by the department of Environment and Natural Resources estimate total harvest for the Bluenose-East herd for 2009/2010 season to the 2012/2013 season, they are shown in table 5.6, these estimates include estimates for Nunavut harvest and Sahtu (Deline) harvest. (Sara True, Personal Communication). Sex ratio is not reliably reported but is likely at least 65% cows. These estimates are likely below actual harvest but the degree of under-reporting is not clear.

Table 5.5 Bluenose-West harvest under total allowable harvest 2007/2008 season to 2011-2012 season.

	07/08	08/09	09/10	10/11[a]	11/12	12/13
Inuvialuit Harvest	**268**	**230**	**296**	**341**	**314**	**340**
Inuvialuit Quota	345	345	345	345	345	345
Gwich'in Harvest	**16**	**1**	**13**	**n/a**	**n/a**	**n/a**
Gwich'in Quota	22	22	22	22	22	22
Sahtu Harvest	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Sahtu Quota	345	345	345	345	345	345

[a] In the Inuvialuit Settlement region the season changed from 1 July to 30 June to Sept 1 to Aug 31 in 2010

Table 5.6 Bluenose-East harvest under total allowable harvest 2009/2010 season to 2012-2013 season.

	09/10	10/11	11/12	12/13
Total estimated harvest	**3466**	**2918**	**1766**	**2562**

5.2 Resident Harvest

In the past, there were a variety of tags available to licenced hunters with an interest in harvesting caribou, including; Resident (NWT/Nunavut non-aboriginal resident; meeting residency requirement), Non-resident (Canadian residents), and Non-resident Alien (Non-Canadians). Residents were allowed to harvest up to 5 barren-ground caribou per year (any age or sex) and had to have a hunting licence and sufficient tags for the number of animals taken. As a result of the decline in population estimates for the three herds in 2005 and 2006, these tags were eliminated for the Cape Bathurst, Bluenose-West, and Bluenose-East herds within the ISR, GSA, and Sahtú; Resident tags were reduced in the Tłı̨chǫ to two tags, and then were eliminated in 2009. In Nunavut, there is still a limit of 5 caribou per year for Resident hunters.

Resident harvesters are sent harvest surveys to gather information on hunting success. Response rates from the 1990/91 to 1996/97 resident harvest surveys ranged from 68% to a low in 1991/92 of 32%, due to having only one survey wave instead of three. The mean response rate from 1990/91 to 1996/97 was 58% (D'Hont 2000a, 2000b, 2000c, 2000d, 2000e, 2000f, 2000g). The results of the survey were grouped by herd based on the community of hunter resident and management zone harvested in and presented in Table 5.6. Management zones have not historically followed the range of the herds; therefore, this is an estimate of the harvest based on management zone and community. These are not adjusted for response rates, so they are minimum harvest numbers.

Table 5.7 Estimated minimum resident harvest by herd from July 1990 to June 1997.

	90/91	**91/92**	**92/93**	**93/94**	**94/95**	**95/96**	**96/97**
Bluenose-East	27	402	10	491	108	108	6
Bluenose-West	77	32	147	26	13	26	21
Cape Bathurst	13	2	18	65	49	32	25
Total	**117**	**436**	**175**	**582**	**170**	**166**	**52**

5.3 Non-resident, Non-resident Alien Harvest

Non-resident and Non-resident alien hunters are required under NWT and Nunavut regulations to use the services of a licensed outfitter and be accompanied by a guide at all times while hunting, this harvesting is also referred to as 'sport hunting'. There is no non-resident or Non-resident alien harvest currently allowed in ranges of Cape Bathurst, Bluenose-West, and Bluenose-East herds in the NWT. There is, however, Non-resident and Non-resident Alien (bull only) harvesting allowed in Nunavut.

Table 5.8 Number of "Bluenose" Caribou Harvested by Non-resident and Non-resident Alien hunters in the Inuvialuit Settlement Region from July 1998 to June 2007.

		Quota Year *(1 July to 30 June)*								
		98/99	**99/00**	**00/01**	**01/02**	**02/03**	**03/04**	**04/05**	**05/06**	**06/07**
Aklavik	Sport	0	0	0	0	0	0	0	0	0
Inuvik	Sport	0	0	0	0	0	0	0	0	0
Tuktoyaktuk	Sport	35	38	8	12	5	5	6	30	11
Paulatuk	Sport	47	20	73	72	50	50	58	44	26

5.4 Commercial Harvest

Commercial tags have been available for some wildlife species in the NWT and Nunavut for harvesters that wish to sell meat within the NWT (non-federally inspected) or outside of the NWT (must be federally inspected). Prior to 2006, a total of 950 commercial tags were available for "Bluenose" caribou in the NWT however they were rarely all used (Table 5.7). However, these tags are no longer available and there is no commercial harvest of any kind allowed for the three herds in the NWT.

Table 5.9 Commercial harvest of the "Bluenose" Caribou' in the Inuvik Region from July 1998 to June 2007.

	Season	**98/99**	**99/00**	**00/01**	**01/02**	**02/03**	**03/04**	**04/05**	**05/06**	**06/07**
Aklavik	Harvest	0	0	0	0	0	0	0	0	0
	Quota	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**[a]
Inuvik	Harvest	46	53	27	47	88	88	87	88	8
	Quota	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**[a]
Tuktoyaktuk	Harvest	49	27	74	75	65	65	52	18	40
	Quota	**175**	**175**	**175**	**175**	**175**	**175**	**175**	**175**	**175**[a]
Paulatuk	Harvest	0	0	0	0	?	?	0	0	0
	Quota	**175**	**175**	**175**	**175**	**175**	**175**	**175**	**175**	**175**[a]

[a] Quota was eliminated in March 2006, some communities halted commercial harvest before this due to the results of the 2005 Post-Calving Photo survey

6.0 Ecology

6.1 Habitat and Forge

Barren-ground caribou use large areas as they make their long migrations across the landscape over the course of the year, coming from the Taiga northwards to calve on the Arctic tundra, where they also spend the summer before eventually moving south again in preparation for winter. A portion of the Cape-Bathurst herd will spend winter above or near the tree line, but the Bluenose-West and Bluenose-East caribou herds will spend their winters below tree line. The areas used also vary with the abundance of caribou, with caribou traveling further south in the winter during times of higher population numbers.

There has been relativity little scientific research done on the Cape Bathurst, Bluenose West and Bluenose-East herds' habitat. Information from research on other barren-ground herds is presented

as it is also applicable to the Cape Bathurst, Bluenose West and Bluenose-East herds. Range ecology of the Porcupine herd has been well studied (e.g. Russell et al. 1993, Griffith et al. 2002).

6.1.1 Spring

Characteristics of snow cover seem to influence the timing, direction, and speed of spring migration (Pruitt 1959). It is thought that migration routes are direct routes between feeding areas and traveling in single file during migration allows most of the animals to avoid the cost of travel through deep snow (Duquette 1988). Adverse snow conditions may cause delays in migration because lead caribou are reluctant to "break trail" (Duquette 1988). Migration to calving grounds in the spring seems to be driven by predator avoidance, rather than food availability (Heard et al 1994, Fancy and Whitten 1991). While breeding cows move quickly in the spring to the calving ground; non-breeding cows, bulls and juveniles remain on wintering areas longer, generally following snow melt north (Russell et al 1993).

There is a progressive change in the diet of caribou through the spring period. As the snow melts, areas with exposed lichen and evergreen shrubs are increasingly used by caribou (Miller, 1972). Caribou in Alaska were found to use areas of early phenological development in late May to early June (Griffith et al. 2002). There is intensive, but temporary, feeding on new leaves in spring from a wide variety of shrub species, likely due to the higher nutrient content and lower defensive compounds found in plants at this time (Boertje 1984, Russell et al 1993). Willow leaves and buds, lichens, grasses, and forbs make up the majority of the spring diet of caribou (Boertje 1984). In Norway, it was determined that the total quantity, or amount, of forage for reindeer in the spring/summer is more critical than the quality of that forage (Tveraa et al. 2013).

Energy demands of breeding cows on the calving ground are high. Maximum growth and nutrients of vegetation occurs just after calving (Russell et al 1993). A study of calving ground locations for the Porcupine Caribou Herd between 1983 and 1990 showed that cows select for *Eriophorum* (cotton grass) tussock tundra. Compared to random sites, Porcupine caribou cows chose calving

sites at lower elevations on general slopes and closer to major rivers. Calving sites also had more snow (Fancy and Whitten 1991).

6.1.2 Summer

Insect avoidance influences caribou selection of summer habitat. During insect periods, shrub tundra was used less than expected based on available habitat. Snow patch use increased during times of insect harassment (Toupin et al 1996). Barren-ground caribou group up to form aggregations during periods of high insect activity to avoid insect harassment. Experiments have shown that black flies and midges attack animals on the outside of a group, or aggregation, more than those in the middle of a group (Helle et al 1992). Further, in open habitat, such as the tundra, individuals may be targeted by black flies and midges more than groups (Helle et al. 1992).

Summer forge includes mushrooms, lichens, willows, grasses, sedges, cotton grass, dwarf birch, and horsetails (Banfield 1954). Lichens make up 17 to 22% of the summer diet of caribou (Boertje 1984, Bergerud 1972, Bergerud and Nolan 1970). Deciduous shrubs (mostly willows) are the largest component of summer diet (46%) with other important components of summer diet being mushrooms (12-45%) and graminoids (Boertje 1984). The proportion of the overall summer diet of caribou for each plant type is partially dependent on plant abundance and distribution on the range of a particular herd (Boertje 1984, Skoog 1968, Bergerud 1972).

6.1.3 Fall

In the fall the Bluenose-West and Bluenose-East caribou move below treeline to their wintering areas (Nagy et al. 2005). In the fall the amount of forbs and shrubs available declines, and lichen make up a larger proportion of the caribou's diet (Boertje 1984).

6.1.4 Winter

The Bluenose-West and Bluenose-East caribou herds winter below treeline, while the Cape Bathurst herd stays near the treeline, with many Cape Bathurst animals remaining on the tundra

throughout the winter (Nagy et al. 2005). Winter habitat surveys in the early 1980's for caribou between the Mackenzie River (in the south) and Anderson River (to the North in the Colville Lake area) showed that caribou preferred areas with large numbers of small lakes (Carruthers 1986). This habitat seems to be most favourable for predation avoidance, especially for cow groups (Carruthers 1986), as lakes have harder and shallower snow cover, so are used for escape or resting habitat (Pruitt 1959). Female and males use somewhat different winter ranges, with males being more dispersed and traveling further south (Carruthers 1986). The highest concentration of caribou on winter ranges tends to occur in areas with soft, light snow less than 50 to 60 cm deep. However, caribou also tend to increase their tolerance to hard snow throughout the winter as the snow "matures" (Pruitt 1959).

Cratering, digging through the snow with their hooves, is part of the winter behaviour of caribou. Caribou are grazers (not browsers), that need to access food under the snow layer (Pruitt 1959). Cratering increases the hardness of snow, so caribou tend not to use cratered areas again as the snow becomes too hard and the animals move to a new area (Pruitt 1959). Caribou dig fewer craters and increase the reuse of cratering areas during years of adverse snow conditions (Russell et al 1993).

The percent of lichen ground cover is thought to be the major factor in barren-ground caribou selection of winter feeding sites; other factors are the low volume of conifers and older forests (Barrier and Johnson 2012). Fires can also influence caribou distribution in winter as caribou seek areas with longer intervals between fires and more abundant terrestrial lichens (Barrier and Johnson 2012). It is also important that lichens can be accessed making snow cover and icing events important factors on the caribou winter range.

Lichen becomes increasingly important in the diet of caribou in winter and lichens make up more than half of the total diet (Boertje 1984, Thomas and Hervieux 1986, Russell et al 1993). Other species foraged during winter include horsetails, sedges, and grasses (Boertje 1984, Miller, 1972, Russell et al 1993). Low bush-cranberry was the only species of evergreen shrub that was

consistently found to be part of the winter diet of caribou (Boertje 1984, Russell et al 1993); however, it does not appear to be selected by caribou because its presence and abundance is far greater than the use (Thomas and Hervieux 1986). Labrador tea appears to be avoided by caribou during winter (Thomas and Hervieux 1986).

6.2 Fire

Fire is a natural part of the ecology of the boreal forest (Kelsall et al. 1977). The greatest influence that forest fires have on caribou is on their distribution (Thomas and Kiliaan 1998). Long-term analysis of trampling scars on tree roots as an index of caribou abundance in relation to fire history in Nunavik (northern Quebec) showed that fires have a relatively short-term impact on migration (Payette et al. 2004). Spruce-lichen forests in the range of the Beverly herd were shown to recover 40 to 50 years after a fire, but there are indications that caribou use of forest was greatest in much older forests (151 to 250-years-old; Thomas 1998). There is also evidence that lichen abundance and productivity may actually decrease in forested areas that are 200-years-old (Skuncke 1969). Although fire has a short-term negative effect on forage and caribou movements, it has a long-term positive effect by rejuvenating the forest and maintaining forest diversity by releasing nutrients and 'opening up' the forest canopy (Klein 1982). The "opens up" of the canopy by fire allows sunlight on to the ground cover, which favours lichen growth. In mature forest that has not seen a fire in decades, the trees may out-compete the ground lichens for nutrients.

In the NWT, fires are routinely monitored and mapped by GNWT Forest Management (Dept. of ENR), but usually fires are only fought if they pose a threat to an identified 'value-at-risk', such as cabins, communication tower, roads and communities. Figure 6.1 shows the fire history from 1978 to 2012 related to caribou range. If climate change brings an increase in the frequency of large-scale fires, there could be negative effects on caribou winter ranges (Joly et al. 2012). The decrease in available winter forage due to increased fires could alter the distribution of herds that winter below the tree-line (Gustine et al 2014), such as Bluenose-West and Bluenose-East, more than herds that use tundra areas in the winter such as the Cape Bathurst. This change of distribution

could affect communities if fires shift the distribution of caribou away from harvesting areas (Gustine et al 2014).

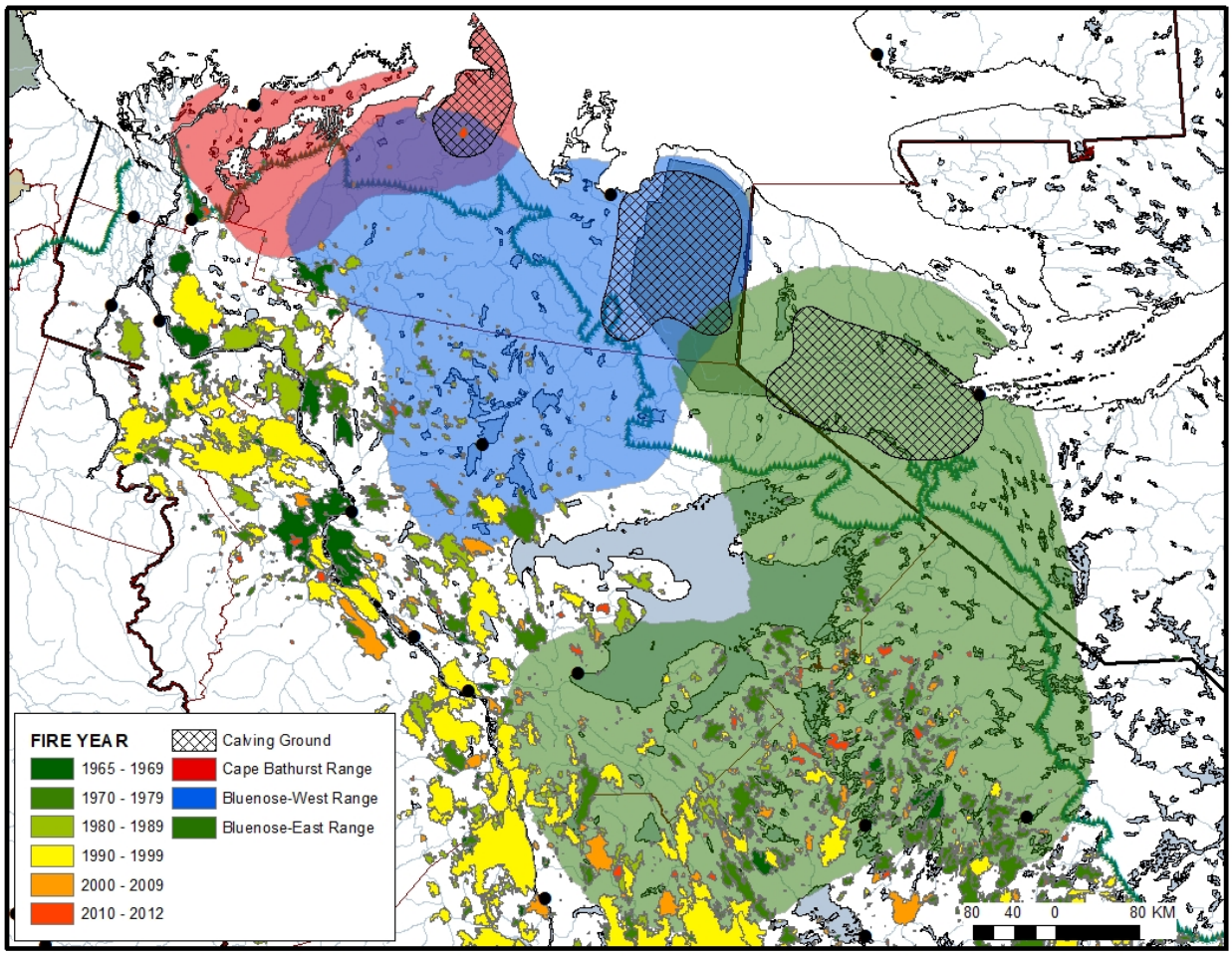

Figure 6.1 Forest fire history from 1978 to 2012 within and near the ranges of the Cape-Bathurst, Bluenose-West, and Bluenose-East Caribou Herds. (Ranges from Nagy et. al. 2011. Fire history from ENR, Forest Management.)

6.3 Predation

Barren ground caribou have evolved in the presence of predators. Bergerud (1994) suggests that the largest influence on seasonal distribution of caribou is the risk of predation, primarily by wolves, but also by grizzly and black bears, wolverines, and golden eagles.

The predation rate of wolves on caribou varies due to such factors as the availability of alternate prey species (e.g., moose and muskox) and the season. During summer, when feeding their pups,

wolves in the Inuvialuit Settlement Region (ISR) were estimated to consume 4.9 to 10.3 kg of caribou per wolf per day (Clarkson and Liepins 1992). In contrast, during spring the consumption rate was estimated to be much lower; 2.7 kg/wolf/day (Clarkson and Liepins 1989). Caribou make up 59-68% of the total diet of wolves in the ISR mainland, with other prey including muskox, and small mammals (Clarkson and Liepins 1992, ENR unpublished data).

The current rates of predation on the Cape Bathurst, Bluenose-West, and Bluenose- East herds are unknown. However, a carcass collection of hunter/trapper-killed wolves to obtain biological information began December 2007 in the ISR and September 2010 across the rest of the NWT. Preliminary results from results show that of 161 stomachs analyzed, 117 wolves had caribou present in their stomach and 66.8% of the contents, by weight of the total content analysed, was caribou (ENR, unpublished data).

Wolves, grizzly bears, and golden eagles are all significant predators of calves (Adams et. al. 1995, Griffith et al. 2002). Wolves are generally considered the most important overall predators of barren-ground caribou, as they prey on caribou year-round, while bear predation is more seasonal (Bergerud et al. 2008). Wolves and grizzly bears prey on all age and sex classes of caribou; golden eagles, wolverines, and black bears are principally predators of calves. Predation can have a significant impact on calf survival. For example, calf mortality during the first month after birth was estimated to be 25% during one study of the Porcupine caribou herd, with almost half of those deaths (48%) attributed to predation (Griffith et al. 2002). Similarly, calf mortality in the first 15 days after birth was estimated to be 39% in Denali National Park, Alaska, and again the majority was attributed to predation (Adams et. al. 1995).

Predator control is often a controversial issue. Predator productivity natural decreases with a decrease in prey, so a predator population will typically decline after prey declines (Boertje & Stephenson 1992). However, predator control has been used by wildlife managers to increase the availability of prey for human uses. There are several methods of reducing wolf predation on caribou, these include: reducing predator birth rates (such as through sterilization programs),

increasing hunting and trapping of predators (often through incentives offered to hunters and trappers), aircraft-assisted wolf harvest, "diversionary feeding" during the calving period, and keeping predators away from the calving grounds with use of fences (Boertje et al. 1995, Farnell 2009). There have been select instances where controlling predators has been successful at increasing numbers of caribou in Alaska and the Yukon when wolf predation was considered to be limiting the ability of herds to recover (Dutler and Dale 2010, Boertje et al. 1996, Farnell 2009). However there are other instances where wolf control has not been successful (Valkenburg et al. 2004).

In order for wolf control to be successful wolf predation needs to be a limiting factor on the caribou population, and the habitat has to be in good enough condition to support more caribou (Russell 2010). The number of wolves removed each year should be 65% to 80% of the total wolf population (NRC 1997). Wolf removal also must occur over a large enough area and for long enough time in order for it to be successful (NRC 1997, Valkenburg et al. 2004). Hunting of the affected caribou herd also has to stop or be limited in order to increase the chance of success of the predator control in raising caribou population (Russell 2010). When wolf control programs are discontinued the wolf populations are able to increase rapidly, sometimes to a level larger than the pre-control population (Boertje et al. 1996, McNay and Delong 1998).

The last government-led wolf control program used to recover caribou populations in the Northwest Territories was in 1977-78. There is currently no formal wolf control for Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds; however subsistence harvest of wolves is encouraged.

6.4 Changing Climate

By nature, climate is inherently complex with large-scale patterns that span continents and move across the planet. However, climate also includes long term local weather trends that influence plants and animals. There are large-scale influences, such as the Arctic Oscillation and North Atlantic Oscillation, which are atmospheric pressure patterns that tend to drive weather on a

continental scale. Since the 1970s, these have resulted in winter and spring warming over northern continents (Serreze et al. 2000). How these large-scale patterns translate into what a caribou herd, or even an individual caribou, experiences is complex and generally not understood completely. However, large-scale weather patterns may play a role in caribou population trends (Joly et. al. 2011).

Direct weather affecting caribou includes snow and icing events. Snow depth and icing events can limit access by caribou to vegetation (Weladji et al. 2002). Caribou on the Beverly herd winter range to avoid snow deeper than 60-70 cm and areas with hard snow or icy layers (Thomas 1998). Winter weather events that cause an increase the hardness and density of snow cover can result in a change in distribution of caribou on their winter ranges (Pruitt 1959). There has been an overall increase in precipitation between 44 and 85 degrees latitude, which includes the entire NWT; however, generally in northern and western Canada there has been a decrease in snow depths and a shorter period in winter when snow covers the ground (Serreze et al. 2000).

Indirect influences of weather affecting caribou can include; insect abundance, the spread of diseases/parasites north, forage quality, and drought causing forest fire. Temperature, wind, and relative humidity all influence insect activity and their harassment of caribou, and one of the most important factors determining body condition may be insect harassment, which increases during warm summer weather (Weladji et al. 2002). Climate also has a role in the ecology of diseases and parasites, as climate changes new diseases could emerge and conditions may be improved for some species of parasites (Kutz 2004, Bradley et al. 2005).

Forage availability and quality varies yearly, in part due to weather. Remote sensing methods using satellites, such as the normalized difference vegetation index (NDVI) that can index plant "greenness," can be used to monitor changes in forage availability and abundance (e.g. Griffith et al. 2002). Increased solar radiation and temperature actually decrease forage quality by increasing phenols and tannins in plants, which inhibit grazing and browsing by animals like caribou, and by decreasing crude protein to dry matter ratios (Weladji et al. 2002). A change in growing season

resulting from changes in climate may mean that caribou do not arrive on the calving grounds during the ideal period of forage growth (Walsh et al. 1997). Earlier springs, which may be more common with climate change, were found to increase fall reindeer calf weights and calf survival rates in Norway (Tveraa et. al. 2013). Earlier green-up was associated with higher June calf survival in Porcupine caribou (Griffith et al. 2002). In Greenland the loss of Arctic sea ice and early, warm springs were linked to increased caribou calf mortality (Post and Forchhammer 2008, Kerby and Post 2013). Rate of green-up is just as important as timing, with rapid green-up cancelling out the positive benefits of early green-up (Tveraa et. al. 2013). Plant growth and nitrogen levels change throughout the growing season. An increase in nitrogen level in caribou forage may also benefit caribou populations (Walsh et al. 1997).

Changes in climate can also lead to changes in vegetation distribution that could affect caribou. Between 1972 and 2004, alder and other tall shrubs increased north of Inuvik, NWT (Lantz et al. 2013). Shrub expansion can also be attributed to tundra fires (Lantz et al. 2013), which may increase with climate change. Climate models in the range of the Western Arctic caribou herd in northwest Alaska suggest the amount of range burnt annually could increase with climate change, particularly tundra (Joly et al. 2012). Increased fire and shrub expansion could also result in an increase in the range and numbers of moose. An increase in moose – an alternate prey for wolves - could then increase numbers of wolves, which could directly have a negative impact on caribou (Joly et al. 2012).

Overall, natural systems are complex, so changes to caribou population with changing climate are hard to predict.

7.0 Pressures

7.1 Anthropogenic Landscape change: Industry/Development

Industrial activities on the range of the Cape Bathurst, Bluenose-West, and Bluenose-East herds include mineral exploration, and oil and gas-related development. In addition, the Tuktoyaktuk-Inuvik Highway will cross through the range of the Cape Bathurst caribou herd and the proposed

extension of the Mackenzie Valley Highway from Wrigley to the Mackenzie Delta is within the range of the Bluenose-East and Bluenose-West herds.

Barren-ground caribou require large areas as they move from treeline to tundra. Development and the associated human activities can have short-term impacts on individual caribou, (such as behavioural changes) as well as longer-term and larger scale impacts on the herd (Vistnes and Nellemann 2008). During calving, cows and their calves and are more sensitive to disturbance from development than other caribou, while during insect harassment periods, all caribou are sensitive to disturbance by development (Wolfe et al. 2000).

There is mineral potential within the range of the Cape Bathurst, Bluenose-West, and Bluenose-East Herds. To date activity has been exploratory but gravity and magnetic anomalies near Paulatuk, in the range of the Bluenose-West herd, suggest mineral potential. Darnley Bay Resources have been conducting exploration in the area since 1997, including recent work between 2010 and 2012 (Reford 2012). The source of the anomalies is not known; however, it potentially includes nickel or copper. Kimberlite pipes have also been found in the region, particularly on the Parry Peninsula and near the Horton River, which could mean future diamond exploration and development (Falck and Gochnauer 2012). Exploration east of Great Bear Lake, in the range of the Bluenose-East herd, for copper and silver is being conducted by Diamonds North Resources Ltd. (Falck and Gochnauer 2012).

If mineral exploration results in a mine, or mines, within the ranges of the Cape Bathurst, Bluenose-West, or Bluenose-East herds there is a potential that caribou will be negatively impacted. Barren-ground caribou were found to avoid open-pit diamond mines on the central barrens with probability of occurrence reduced within a distance of 14 km from the mine site (Boulanger et al. 2012).

There is extensive oil and gas potential in the Northwest Territories. Norman Wells, on the very south edge of the Bluenose- West range, is producing oil with a pipeline connecting it to Alberta.

There are other oil and gas reserves within the Sahtú Settlement Area and Inuvialuit Settlement Region, that if developed will have footprint in more core barren-ground caribou range, such as Colville Hills and Parson Lake. The proposed Mackenzie Gas Project would have connected the natural gas fields of the Mackenzie Delta with southern markets opening the way to extensive development in areas within barren-ground caribou range. The proposed pipeline would have crossed the winter range of the Cape Bathurst herd, mostly the pipelines was proposed to be laid underground but anchor fields would include above ground development. It is unknown if this project will be revitalized in the future.

The Central Arctic Herd grew from approximately 5,000 to 32,000 animals during Prudhoe Bay oil field development. Roads in the oilfield complex were found not to have an effect of the density of calves during calving (Noel et al. 2004). However, the distribution of caribou was altered, especially with increasing road density (Cameron et al 1979, and Nellemann and Cameron 1998). Studies also suggest a general avoidance of the oilfield complex, especially by cow caribou (Cameron et al 1995, Nellemann and Cameron 1998, Cameron et al. 2005). Calving was split into two areas by the oilfield (Cameron et al. 2005).

The all-season road from Inuvik to Tuktoyaktuk, which is being constructed, passes through the wintering range of the Cape Bathurst herd. The proposed Mackenzie Valley Highway extension passes near the range of the Bluenose-West and Bluenose-East caribou herds and through the range of the Cape Bathurst caribou herd. Infrastructure, such as roads, can have a negative impact on the abundance of birds and mammals (Benítez- López et al. 2010). Roads can affect caribou in a number of ways, including : direct mortality due to collisions, changing habitat, and allowing increased human access (Cameron et al. 2005, Wolfe et al. 2000). Recreation and harvesting activities are related to increased human access and can result in further habitat changes from off-road vehicles, direct mortality due to harvesting, and changes in behaviour of caribou due to increases in human presence in the area (Vistnes and Nellemann 2008). Further, the effects of roads on caribou can be variable based on other factors such as purpose and use of road, habitat surrounding the road, season, and age/sex class of the caribou (Wolfe et al. 2000). Animals avoid

infrastructure over greater distances in open habitat (e.g., tundra), habitat through which the Tuktoyaktuk-Inuvik road will pass (Benítez- López et al. 2010). For the Porcupine caribou herd, the zone of influence (area of decreased use) around the Dempster Highway ranged from 30 km to 18.5 km, decreasing over time, possibly as caribou became accustomed to the road (Johnson and Russell 2014).

7.2 Aircraft

Communities in the range of the Cape Bathurst, Bluenose-West, and Bluenose-East have expressed concern about aircraft flights (including those by biologists doing surveys) over caribou ranges, especially during the sensitive calving and post-calving periods. Calves have a greater response to aircraft than other age groups (Calef et al. 1976).

A 1972-73 study on the reaction of caribou to both fixed-wing aircraft and helicopters recommended that flight above 150 m (500') would avoid the most extreme reaction by caribou that might result in direct injury. Flying above 305 m (1000') would avoid all escape responses. It was also found that helicopters at the same altitude caused no more disturbance to the caribou than fixed-wing aircraft (Calef et al. 1976). A study on the Fortymile caribou herd found that short-term effects of military jets flights on caribou was generally mild, and less pronounced than responses to predation (Lawler et al. 2005); however, an experimental study on the impacts of low-level jet flying in Labrador found decreased survival among those collared cows that were regularly overflown (Harrington and Veitch 1992). Low-Level jet aircraft has been shown to cause caribou to move more, and further than other caribou, especially in the post-calving season (Maier et al 1998).

The Inuvialuit Environmental Impact Screening Committee (EISC) conducts environmental screening of development activities in the ISR and has recommendations for overflights (EISC 2004). These include recommendations that; 1) aircraft altitude be greater than 610 m (2000') above ground level when flying point-to-point in the vicinity of caribou and other wildlife species, 2) Caribou calving grounds should be avoided whenever possible, and 3) aeromagnetic surveys should be controlled to prevent disturbance to large mammals by restricting the timing of the surveys, rather

than the elevation at which the flights occur. These surveys should also not take place near or on calving and post-calving areas during May 25 to July 15 and after July 15 they should avoid any areas know to have large aggregations of caribou (EISC 2004). These are guidelines, however, and enforcement of flight altitudes is difficult. Action has been taken for the Bluenose-West herd by restricting flights in to Tuktut Nogait National Park during the calving period while the herd's numbers are low (Parks Canada 2009).

8.0 Management context

8.1 Taking Care of Caribou

Several co-management boards established through comprehensive land claim agreements, along with the Government of the Northwest Territories (GNWT) and Government of Nunavut are responsible for the management (taking care) of the three herds – the Wildlife Management Advisory Council (NWT) for the Inuvialuit Settlement Region, the Gwich'in Renewable Resources Board for the Gwich'in Settlement Area, the Sahtú Renewable Resources Board for the Sahtú Settlement Area, the Wek'èezhìi Renewable Resources Board for the Wek'èezhìi which was set up under the Tåîchô Agreement, the Nunavut Wildlife Management Board for Nunavut, and the Tuktut Nogait National Park Management Board for Tuktut Nogait National Park, and the Department of Environment and Natural Resources for the Government of the Northwest Territories.

Community organizations (Hunters and Trappers Committees/Organizations, Renewable Resource Councils or local aboriginal organizations) are regularly engaged by co-management boards and GNWT when management plans and other wildlife management policies are developed. Results of wildlife studies are regularly reported to the communities, schools, and meetings of co-management boards. Where and when it is possible, local people are directly involved in surveys and other research. In areas where there are no co-management boards, GNWT is responsible for engaging and consulting aboriginal governments and communities on wildlife programs and management.

The co-management boards, communities, and GNWT worked together from 1995 to 1999 to develop the first co-management plan to care for the Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds. It contained Work Plans for 1999/2000 to 2003/2004 and summarized some of what was known at the time about these caribou, their habitat, and harvest levels. A Co-operation Agreement for the herds was also signed among the co-management boards in 2000, which established the Bluenose Caribou Herds Co-management Advisory Committee to make recommendations on the implementation plan.

A number of agencies and boards also screen and review development proposals to determine whether proposed activities may cause negative environmental impacts, including those to caribou and their habitat. Within the range of the Cape Bathurst, Bluenose-West, and Bluenose-East herds, these groups include: the Environmental Screening Committee for the Inuvialuit Settlement Region, Gwich'in Land and Water Board, the Sahtú Land and Water Board, Tåîchô Lands and Culture Protection Department, Nunavut Impact Review Board, Nunavut Water Board, and the Mackenzie Valley Environmental Impact Review Board, Mackenzie Land and Water Board and Parks Canada.

8.2 Advisory Committee for Cooperation on Wildlife Management

The Bluenose Caribou Herds Co-management Advisory Committee was integral in the development of the original Co-management Plan for the three herds, which covered the period 1999/2000 to 2003/2004. In 2008, this committee was restructured and renamed as the Advisory Committee for Cooperation on Wildlife Management (ACCWM). The ACCWM was formed through a signed agreement among the following parties: Gwich'in Renewable Resources Board, Sahtú Renewable Resources Board, Nunavut Wildlife Management Board, Tuktut Nogait National Park Management Board, Kitikmeot Region Wildlife Board, Wek'eedhii Renewable Resources Board and the Wildlife Management Advisory Council (NWT).

The purpose of the ACCWM is to exchange information, help develop cooperation and consensus, and make recommendations regarding wildlife and wildlife habitat issues that cross land claim agreement and treaty area boundaries. It includes the development of a management plan for the Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds and protection of their calving and post-calving grounds.

To assist the ACCWM with the development of a new plan for taking care of the caribou, in January 2009 a Bluenose Caribou Herd Working Group was formed – including representatives from the wildlife co-management boards, GNWT, Government of Nunavut, Parks Canada, Nunavut Tungavik, the Kitikmeot Regional Wildlife Board, and the Tuktut Nogait National Park Management Board. The Dehcho First Nation was also invited to participate.

8.3 Protected Areas

A variety of government agencies and land management boards are responsible for land management, or taking care of the land on which the caribou roam: the Inuvialuit Land Administration, Inuvialuit Regional Council, Gwich'in Land and Water Board, Gwich'in Tribal Council (Department Lands Administration & Resource Management), Gwich'in Land Use Planning Board, Sahtú Secretariat Incorporated, Sahtú District Land Corporations, Sahtú Surface Rights Board, Sahtú Land Use Planning Board, Sahtú Land and Water Board, Nunavut Planning Commission, Nunavut Water Board, Nunavut Impact Review Board, Kitikmeot Inuit Association, Tåîchô Lands and Culture Protection Department, Wek'eezhii Land and Water Board, and the Mackenzie Land and Water Board.

Land Use Planning Boards, such as the Nunavut Planning Commission, Gwich'in Land Use Planning Board, Sahtú Land Use Planning Board are responsible for developing land use plans under the *Mackenzie Valley Resource Management Act*. In those plans, which are submitted to land claim governments, the GNWT, and federal government for approval, important areas can be identified for protection during the life of the plan. Similarly, the Draft Interim Dehcho Land Use Plan identifies areas of protection and is part of the negotiations for the larger Dehcho Process.

Community Conservation Plans (CCP) in the Inuvialuit Settlement Region identifies important wildlife areas and make recommendations for their management. The Cape Bathurst and Bluenose-West calving grounds are identified in the Tuktoyaktuk and Paulatuk CCPs as Category D areas (Site 428D and 731D, Figure 8.1). Category D is "Lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year. These areas shall be managed so as to eliminate, to the greatest extent possible damage and disruption" (Community of Tuktoyaktuk 2008, Community of Paulatuk 2008).

The Gwich'in Land Use Plan, Nan Geenjit Gwitr'it T'agwàa'in / Working for the Land, was officially approved on August 7, 2003 and is currently undergoing a process of revision. It identifies Gwich'in Conservation zones where development activities are not permitted (Figure 8.1)

Within the Sahtú Settlement Area, the Sahtú Land Use Plan (SLUP), which came into effect in August 2013, has identified Conservation Zones that are significant traditional, cultural, heritage, and ecological areas (Figure 8.1). The SLUP prohibits specific land uses in Conservation Zones. There are also Proposed Conservation Initiatives for which formal legislative protection is being pursued, such as National Wildlife Area or National Park status. They have the same protection under the SLUP until protected by other legislation. Conservation Zones prohibit development activity, mineral, and hydrocarbon exploration.

The Tłı̨chǫ Final Agreement gives surface and subsurface protection to Ezǫdzìtì, a Tłı̨chǫ Heritage Area (Figure 8.1). Ezǫdzìtì, was established August 2005 and is within the range of the Bluenose-East herd.

The Nunavut Planning Commission is currently drafting a Nunavut Land Use Plan (DNLUP). This includes a proposed national park in the Bluenose Lake area; contiguous to the existing Tuktut Nogait National Park (Figure 8.1). Also in the draft plan, recommendations are made regarding caribou calving grounds, post calving areas, and migration routes.

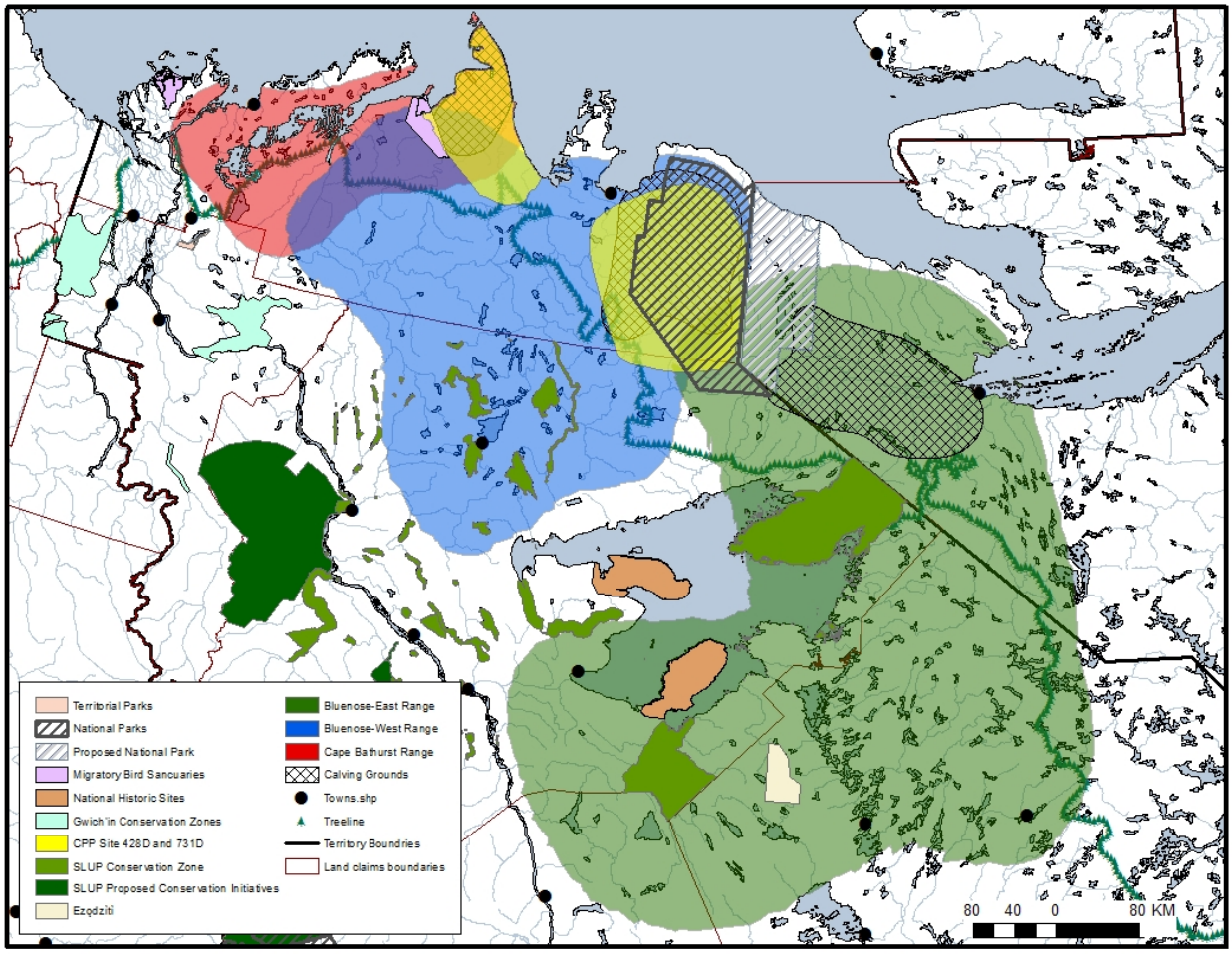

Figure 8.1: Protected Areas in the ranges of the Cape Bathurst, Bluenose-Wests and Bluenose-East barren-ground caribou herds.

8.3.1 NWT Protected Areas Strategy

The NWT Protected Areas Strategy (NWT PAS) was established in 1999 as a community-based means of protecting important areas using existing federal and territorial government legislation (Northwest Territories Protected Areas Advisory Committee 1999). Types of possible protected areas include National Historic Sites, National Wildlife Areas, Territorial Parks, and Critical Wildlife Areas (GNWT). National Parks are established outside the NWT PAS process.

A Mackenzie Valley Five-Year Action Plan (2004-2009) was the first implementation plan for the NWT PAS and was developed for the 16 NWT eco-regions most likely to be directly impacted by the proposed Mackenzie Gas pipeline route and associated hydrocarbon development areas. The

Establishment Action Plan (2010-2015) is the second implementation plan and focuses on actions needed to secure protection of areas identified during the first 10 years of the NWT PAS. Funding the work required under the PAS process is the responsibility of the federal and territorial governments and some of the various non-government organizations that are involved, such as the World Wildlife Fund, Ducks Unlimited Canada, and the Canadian Parks and Wilderness Society.

An important proposed protected area for barren-ground caribou is Edaʝʝla (Caribou Point) on the northeast side of Great Bear Lake (Figure 8.1). Local traditional knowledge (Deline) and satellite radiotracking have shown that Edaʝʝla is used quite extensively by caribou from the Bluenose-East herd in many years, particularly before and during the fall rut and again during spring migration towards the calving grounds. Discussions are ongoing among Deline, GNWT, and the federal government as to the nature of the proposed protected area.The area has also been identified as a Conservation Zone under the Sahtú Land Use Plan (Sahtú Land Use Planning Board 2013).

Saoyú-ʔehdacho – two peninsulas on the west side of Great Bear Lake – are the first areas to go through the complete 8-step NWT PAS process and were declared National Historic Sites in 2009 to be jointly managed (Co-operative Management Board) by the Deline Land Corporation, the Deline Renewable Resources Council and Parks Canada (Figure 8.1). Saoyú-ʔehdacho are not as frequently used by barren-ground caribou as Edaʝʝla, but satellite-tracked caribou from both the Bluenose-West and Bluenose-East herds have periodically used the peninsulas between 1996-2010.

8.3.2 Tuktut Nogait National Park

Tuktut Nogait National Park was established in 1996 within the Inuvialuit Settlement Region with the signing of the Tuktut Nogait Agreement. In 2005, an Access and Benefits Plan was signed to extend Tuktut Nogait within the Sahtú Settlement Area (Parks Canada 2007). The park currently protects the core calving and post-calving grounds of the Bluenose-West herd. With the park extension there would also be protection for a portion of the post-calving grounds of the Bluenose-East herds (Figure 8.1).

9.0 Gaps and Recommendations

Monitoring and research plans must recognize the financial and capacity limitations however standardized monitoring is recommended using consistent methodology. Monitoring must continue in times of abundance and scarcity of caribou. There is also a need to balance the impacts of research and monitoring on caribou with the need for information to manage the herds. Impacts can be reduced by following acceptable protocol such as limiting overhead flight during sensitive times and following standards of animal care during capture. New methodology and technology can also be evaluated to see if they improve data collecting while reducing impacts to caribou.

The monitoring of satellite and GPS collared caribou can be used to track use of the three herd ranges on a yearly basis and to monitor any range use changes over time. New analysis of seasonal ranges should also consider the annual movements of collared bulls in each of the herds. Further analysis of collared caribou data needs to be done including: seasonal movements and changes in sizes of annual ranges with changing population size, a detailed look at collared animals moving between herds, movements of bulls versus cows, and survival rate estimates.

Monitoring of caribou herds need to be frequent and using comparable methodology among the different herds (Fisher et al. 2008). Suggested monitoring includes a regular recruitment survey for each herd every spring, except years that there is a population survey. There is currently a gap in our knowledge about adult survival rates, particularly for adult females. However, in order to obtain this information with precision, there would need to be an increase in the overall number of collars for each herd and more intensive monitoring of collars, including flying to sites within days of a radio-collar becoming stationary. Rettie (2008) recommended more than 80 collars per herd in order to detect even moderate changes in adult female survival rates.

Additional monitoring of the herd is recommended such as periodical monitoring of health and contaminant levels and in the Cape Bathurst, Bluenose-West, and Bluenose-East herds.

Future research project could provide more information on population dynamic and ecology. New genetic techniques can be applied to caribou to look at gene flow between herds, and meta-population analysis to further inform our understanding of how populations are defined. There are gaps in the understanding of caribou predators and habitat. Research to understand this complex system would also be beneficial to understand caribou population cycles and what drives them.

Systematic and comparable harvest data are not available for all user groups of the herds. Collection harvest data in a standardized way across all user groups is recommended.

There is also a need for the systematic collection of Traditional Knowledge on these caribou in addition to scientific information.

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Appendix I: List of Commonly Used Acronyms

ACCWM: Advisory Committee for Cooperation on Wildlife Management

CARMA: CircumArctic Rangifer Monitoring and Assessment Network

ENR: Department of Environment and Natural Resources

ISR: Inuvialuit Settlement Region

GCLCA: Gwich'in Comprehensive Land Claim Agreement

GIS: Geographical information Systems

GN: Government of Nunavut

GNWT: Government of the Northwest Territories

GPS: Global Positioning System

GRRB: Gwich'in Renewable Resources Board

NCP: Northern Contaminant Committee

NWMB: Nunavut Wildlife Management Board

NWT: Northwest Territories

NWT PAS: NWT Protected areas Stratigy

SRRB: Sahtu Renewable Resources Board

WMAC(NWT): Wildlife Management Advisory Council (Northwest Territories)

WRRB: Wek'èezhìi Renewable Resources Board

Appendix II: Recommending Harvest for Barren-Ground Caribou based on herd Risk Status: A Rule of Thumb Approach

Harvest recommendations for barren-ground caribou based on herd risk status: A rule of thumb approach

GNWT ENR, November 2013

1. Background

The Advisory Committee for the Cooperation on Wildlife Management (ACCWM)'s draft management plan for the Cape Bathurst, Bluenose-West and Bluenose-East caribou herds identifies an approach to hunter harvest management that assumes each herd will cycle between high and low numbers. Four coloured zones are defined for each herd as (a) low (red), (b) decreasing (orange), (c) increasing (yellow), or high (green). Thresholds for transitions between these zones are defined based on the range of estimated herd sizes for the three herds, and harvest recommendations are proposed based on which zone the herd is in.

This approach is intuitive and pragmatic. However, there are two potential issues with this approach: (1) herds do not always cycle predictably, and (2) at best, reliable population estimates for the three herds only extend back to the late 1980s. Consequently, the basis for defining historic high and low levels and the associated thresholds between zones is limited[1]. Environment and Natural Resources (ENR) has developed additional rules of thumb to help refine harvest recommendations based on a herd's risk status, particularly its size and trend. The harvest recommendations are meant to be revisited as new information on a given herd's risk status becomes available.

2. Harvest management context in the NWT

In the NWT, management of barren-ground caribou harvest is a shared responsibility between governments, co-management boards and communities. Recommendations and decisions about caribou harvest should in part reflect biological realities; that is, what the herd can tolerate. Management plans may also define varying priorities or goals for a herd; for example, recommended harvest for a herd might be different if the priority is maximizing hunting opportunities than if the priority is herd growth. The purpose of the approach described here is to help define a range of acceptable harvest options for a caribou herd based on its risk status. These options should be revisited in an adaptive manner when new information on the herd's risk status becomes available.

[1] The Fortymile herd in Alaska/Yukon numbered an estimated 568,000 in 1920, then declined rapidly and between 1940 and 1990 (50 years) remained between about 6,000 and 50,000 (Valkenburg et al. 1994). Bergerud et al. (2008) re-constructed approximate numbers of the George River (GR) herd in Labrador/Quebec from various sources and concluded that the herd reached high numbers around 1800, 1890, and 1990. Between 1890 and 1950, the GR herd was thought to have had two smaller peaks in numbers in about 1910 and 1925, with successively lower low numbers around 1900, 1920 and then 1940-1950. What constitutes a "high" and "low" herd size is less easily defined under these conditions.

Recommendations and decisions on harvest management will ultimately reflect a range of considerations, in particular the requirements of land claims and treaties, and management priorities defined through co-management.

3. Harvest modeling for caribou

Population modeling was conducted to help guide general rules of thumb for harvest depending on a herd's risk status. This included assessing the effect of various levels and sex ratio of harvest on caribou herd size and trend. Some modeling was specific to the Bluenose-East and Bathurst herds while other modeling was for a generic herd (Boulanger and Adamczewski 2010, Boulanger 2013, Adamczewski and Boulanger 2013).

4. Significance of harvest to barren-ground caribou herds

How harvest affects a caribou herd depends on a number of factors. Key ones are:

a) the herd's trend (increasing, stable, declining);
b) the rate (%) of the harvest in relation to herd size;
c) the sex ratio of the harvest (proportion of cows in the harvest).

Herd trend: Increasing herds usually have high calf productivity and high adult survival rates; consequently, they are best able to withstand substantial hunter harvest. Modeling suggests that herds with high cow survival, sustained high calf productivity, and rapid rates of increase can tolerate annual harvest rates of up to 5-8% and continue to grow or be stable. These demographic conditions have not been observed in NWT's herds since the early 1980s. Conversely, herds with a declining natural trend usually have low calf productivity and low adult survival; consequently, mortality rates already exceed the rate at which yearling caribou are added to the herd. Under these conditions, harvest rates as low as 1-2% may increase the rate of decline.

For example, modeling of the Bluenose-East herd suggested that if the herd's increasing trend and good calf recruitment continued, a harvest of 3,000 (2.5% of the 2010 herd size estimate of
122,000) was likely compatible with a stable herd. However, a decline in herd size was likely with a harvest of 5,000-6,000 (4-5% of estimated herd size in 2010).

***Harvest as % of herd size*:** A harvest of 5,000 cows from a large and stable herd of 350,000 caribou is expected to have relatively little impact on the herd, since only a small fraction of the herd is harvested (just over 1%). However, a harvest of 5,000 cows from a herd of 30,000 would be 16.7% of the herd. A caribou herd could never produce enough young to sustain this level of harvest.

Harvest management plans or actions taken for a number of herds across Canada (e.g., Porcupine, George River, Cape Bathurst, Bluenose-West, Bluenose-East, and Bathurst) include harvest closure at very low numbers for conservation to allow the herd its greatest opportunity to recover.

Harvest of cows and bulls: Harvest of cows affects herds more strongly than harvest of bulls. Removing a breeding cow takes out the cow, the calf she is carrying, and all future calves she may produce. Although over-harvesting bulls is also not desirable, a healthy bull can breed many cows, while each cow typically only carries one fetus. The effect of harvesting a high proportion of cows is strongest in declining herds and the least in increasing herds with high calf productivity. Emphasis on bull harvest over cow harvest should be greatest in declining herds and/or herds at low numbers, and least in herds increasing and/or at high numbers.

Sustainable and acceptable harvest: Sustainable harvest from wildlife populations can be defined as harvest that does not cause a population to decline. By this definition, no harvest is sustainable from a caribou herd that has a declining natural trend. A limited harvest may be still be considered acceptable for declining caribou herds, with the understanding that substantial harvest (particularly that of cows) from a declining herd increases the risk of more rapid and extensive decline.

5. Rule of thumb approach to harvest based on herd risk status

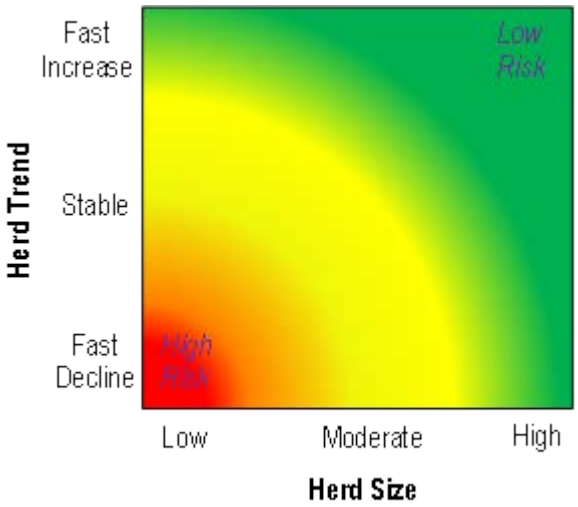

Figure 1. Assessment of risk status based on herd size and trend.

Herd risk status based on size and trend: Figure 1 shows how risk status of a caribou herd could be defined based on its size and trend (red - high risk; yellow - medium risk; green - low risk). A herd at relatively high numbers and increasing rapidly is at low risk of significant decline (green), while a herd already at low numbers and declining rapidly is at high risk of further significant decline (red). Recommendations on harvest would begin with a risk assessment of the herd.

Other measures of herd risk status: As described in the draft ACCWM caribou management plan, monitoring of caribou includes other indicators such as late-winter calf:cow ratios, fall bull:cow ratios, health and condition assessment, harvest, and

information about predator numbers, herd accessibility, environmental indicators, and disturbance on the landscape. Information from people on the land is often the first indicator of change on the caribou range. These indicators could serve as additional ways of assessing the herd's risk status after herd size and trend are considered. Sustained low calf:cow ratios, caribou in consistently poor condition, high wolf numbers and increased levels of disturbance might be used to assess a herd as being at greater risk.

***Basing harvest level and sex ratio on herd risk status*:** Figure 2 (below) shows how the rate (% of herd) and sex ratio of harvest could be adjusted to the herd's risk status. Acceptable harvest as a percentage of the herd should be limited in high-risk herds (1% or less of the herd) and increase to 2, 3 and 4% of the herd in lower-risk herds. In herds at very low risk and high numbers, harvest of 5% or greater would be acceptable. Emphasis on harvest of bulls-only or a high percentage of bulls in the harvest would be greatest in high-risk herds, while either-sex harvest would be acceptable in low-risk herds. A higher overall harvest rate could be considered in medium-high risk herds if it is predominantly a bull harvest; for example, this approach was used in harvest recommended for the Bluenose-West herd in 2007 (harvest rate of 4% and a bull biased harvest (80% bulls)).

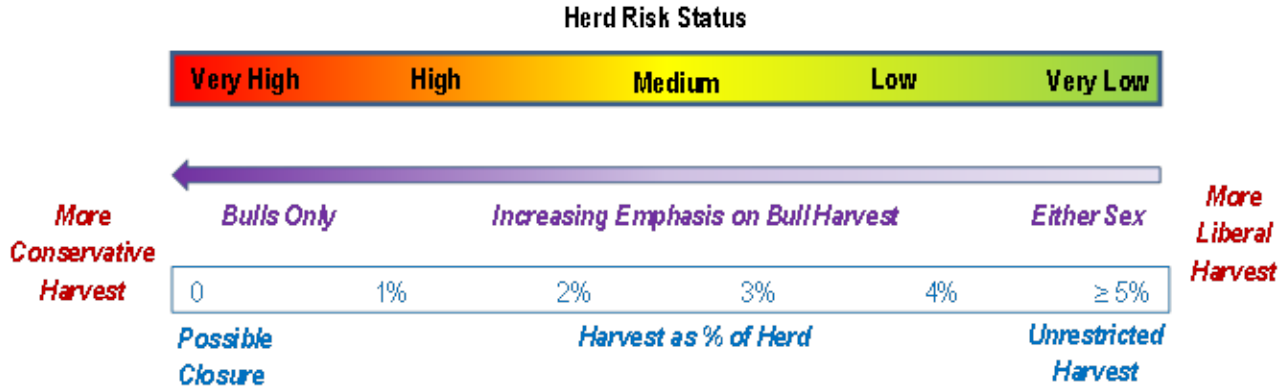

Figure 2. Suggested approach to recommending rate and sex ratio of harvest depending on a herd's risk status.

This approach could be used to define a range of options for harvest rate (% of herd) and harvest sex ratios appropriate to a herd of a particular size and trend, with consideration of other indicators. Additional indicators suggesting high risk might be low calf recruitment, poor condition assessed by hunters, accessibility of the herd's range to hunters, and substantial disturbance on key parts of the herd's range. In addition, consideration should be given to objectives for the herd: an emphasis on herd growth would be consistent with a lower harvest rate and a higher emphasis on bull harvest. An adaptive approach would include regular reviews of up-to-date information on herd status and reported harvest, and adjusting recommended harvest as needed. This approach would rely on on-going reliable reporting of

harvest (numbers and sex ratio) by all hunters, whether the herds are large or small, and increasing, stable or declining.

6. Examples of rule of thumb approach applied to harvest recommendations:

In 2009, the Cape Bathurst herd was at very low numbers compared to earlier estimates (less than 2,000), with a stable trend and improving recruitment. All harvest had been closed for this herd in 2007. The herd's range is small and easily accessed by hunters. This herd's status could be assessed as High Risk given its very low numbers or Very High Risk based on its very low numbers and continued high accessibility. Continued harvest closure would help maximize the herd's opportunity to recover. If harvest was considered, it would likely be at a low rate (1% or less of the herd) with a high emphasis on a bull-only or predominantly bull harvest.

In 2010, the Bluenose-East herd was estimated at about 122,000 with an increasing trend and good recruitment. Based on the herd's trend and relatively large size, it would likely be assessed as being at Low-Medium Risk. If the management goal was to give priority to a stable trend and a strong chance of continued herd growth, a conservative approach to harvest would be 2-3% of herd size with strong promotion of bull harvest. A more liberal approach to harvest would be 4% of the herd with a sex ratio including a substantial percentage of cows. This approach would give priority to maximizing harvest opportunities but would carry a higher risk of population decline.

Table 1 (below) includes a summary of the rule of thumb approach that includes possible approaches to resident and commercial harvest of caribou. The underlying elements of the summary are borrowed from management plans or proposed harvest management for the Porcupine, George River,Bathurst, Beverly, Qamanirjuaq, Bluenose-West, Bluenose-East and Cape Bathurst herds, and harvest modeling carried out by ENR for the Bathurst and Bluenose- East herds.

Table 1. Rule of thumb approach to recommending rate and sex ratio of harvest for barren-ground caribou based on risk status, with possible approaches to aboriginal, resident and commercial harvest.

Suggested Acceptable Harvest (% of herd)	Recommended Aboriginal Harvest	Recommended Resident Harvest	Recommended Commercial/Outfitter Harvest
5 % or higher	Unrestricted, Either Sex	≥ 2 bull tags/hunter	Limited commercial tags
3-5 %	Unrestricted, Promote Bull Harvest	2 bull tags/hunter	Limited commercial tags
2-3 %	Unrestricted, Promote Bull Harvest	1 bull tag/hunter; possible limit on tags	Either no commercial tags or small numbers of tags
<2 %	Promote Conservation, Voluntary Bulls Only	1 bull tag/hunter; possible limit on tags	No commercial tags
<1 %	Consider Mandatory Bulls Only	No resident tags	No commercial tags
0.01 %	Consider Closure; Harvest for Social/Ceremonial Reasons	No resident tags	No commercial tags

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