Technical rationale to increase the number of satellite collars on the Bathurst caribou herd

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1. Summary

Satellite and/or GPS-satellite radio-collars are used for many applications in monitoring of all herds of migratory barren-ground caribou in North America. To date (2014), a maximum of 20 collars have been used on the Bathurst herd, all on cows, and at times there have been as few as 8-9 collared caribou in the herd. This document briefly reviews the uses of radio-collars in caribou monitoring and management, outlines recommended numbers of collars/herd for particular uses, and provides a rationale for increasing the number of collars on the Bathurst herd to 65, with some of these being on bulls (ca. 15). The areas of greatest priority in management for this herd are in assigning and managing harvest from this herd in the winter, and in monitoring survival rates of cows. All applications of collar information would benefit from higher collar numbers, including greater confidence in monitoring surveys and in assessing caribou range use in relation to development such as mines and roads.

2. Introduction

Satellite and GPS collars have been used since 1996 on the Bathurst caribou herd to monitor seasonal distribution and migratory movements. To date (Jan. 2014), the number of collars on the Bathurst herd of barren-ground caribou at any one time has not exceeded 20, and all have been placed on adult cows. While capturing, handling and attaching a collar to caribou is challenging to Tłıchǫ values of respect for wildlife, elders gave their approval to initially place 10 collars on Bathurst caribou and then later 20 collars to monitor the herd due to concerns over potential effects of the diamonds mines, something the Tłıchǫ were very concerned about.

VHF-radio, satellite and GPS-collars are used as tools for monitoring all migratory herds of barren-ground caribou in North America. They provide key information on caribou throughout the year. Applications include monitoring herd movements, detecting timing of birth, defining seasonal ranges, assessing habitat preference, estimating survival rates, assessing movement between herds, assessing caribou responses to development, designing & modifying surveys, and monitoring and managing hunter harvest. A larger number of collared caribou on the Bathurst herd would increase confidence in monitoring and particularly in monitoring and managing the hunter harvest on the winter range. This document provides rationale for increasing the number of collars on the Bathurst herd from 20 to 65, with up to 15 placed on bulls, to achieve many of the research and monitoring objectives for the herd. A decision to increase the number of collars on the herd must be balanced with the need for respectful behavior towards caribou.

3. Meeting barren-ground caribou research and monitoring objectives with satellite and GPS-collars

Currently, collar location data are used to achieve many of the research and monitoring objectives for barren ground caribou herds in the NWT. These include:

- describing seasonal and annual ranges and how these might shift year to year;
- monitoring movements and responses of caribou to roads and industrial activities;
- when associated with plant communities, revealing selection for preferred habitats and avoidance of others;
- showing where and when caribou are congregating for calving and post-calving (to increase confidence in calving and post-calving population surveys);

- locating animals and appropriately allocating sampling during fall and spring aerial composition surveys;
- assessing rates of exchange or movement between neighbouring herds;
- assessing cow fidelity to calving grounds and other seasonal ranges; and
- tracking deaths of collared animals for estimating adult cow survival.

Collar location data have also been used by communities when planning their community hunts. Recently with harvest limits on the Bathurst herd due to its severe decline to 2009, collar data have been used to assign harvest to either the Bathurst herd or neighbouring herds, and to direct harvest to adjacent herds such as the Bluenose-East caribou herd, that do not currently have harvest targets in place. Because of variation year to year in winter range use and substantial overlap in the winter in some years between the Bathurst and Bluenose-East herds, collar locations are currently the only way to assess which herd is being hunted in particular areas.

The Government of the Northwest Territories (GNWT) recently commissioned studies to assess the numbers of collars needed per herd for various applications, including J. Rettie (2008) and J. Boulanger (2011). An independent review of the GNWT barren-ground caribou monitoring program, recommended increased numbers of collars on all herds, and particularly in herds where collar numbers were low, such as the Bathurst herd (Fisher et al., 2009). Recommended numbers of satellite and GPS-collars from these analyses are listed in Table 1, along with the source of the recommendation, the advantages of more collars, and the limitations of using few collars.

Recommended numbers of collars per herd vary from about 30 to about 100, depending on the objective. Numbers of collars used on caribou herds elsewhere also vary, with the maximum number used being about 100/herd in the Western Arctic and Porcupine herds. Analyses carried out for the George River herd in Quebec/Labrador showed that between 36 and 184 collars were required at different seasons if a 95% probability of defining the herd's distribution was desired (Otto et al., 2003). Of greatest relevance to the Bathurst herd in winter, Otto et al. (2003) found that 64, 49 and 34 collars were associated with 95%, 75% and 50% confidence in defining the George River herd's distribution in winter. Boulanger's analyses similarly showed that at least 40 collars were needed to reliably define a herd's winter range. Most of the analyses suggested that a minimum of 40-50 collars (in Table 1) are needed on a caribou herd to adequately address the research and monitoring objective with an acceptable level of certainty, and up to 100 or more collars were needed for some applications. Although concerns about collars remain, the value of the information gained by monitoring individual caribou from the Bathurst and other herds is substantial.

4. Applications of collar data and advantages of increased numbers of satellite and GPS-collars on the Bathurst herd

4.1. Improved monitoring of Bathurst caribou cow survival rates

Studies of several barren-ground caribou herds, including the Bathurst herd (Boulanger et al. 2011) have shown that population trend is very sensitive to cow survival rate. A stable trend in population size generally depends on cow survival being at least 83-87% (Boulanger et al. 2011). Demographic analysis and simulation modeling of field data by J. Boulanger (pers. comm.), suggested that the cow survival rate was ~67% in 2009 during the rapid decline of the Bathurst herd, with an increase to ~ 78% in 2012. Although, the survival rate appears to have

improved, the current estimate is still too low for the herd to increase. Thus adult cow survival is a key demographic indicator that needs to be tracked directly and more precisely. Biologists in Alaska maintain approximately 100 collars annually on the Porcupine and Western Arctic caribou herds, in part to be able to monitor cow survival and detect small changes in mortality rates with a high degree of confidence (see Alaska Department of Fish and Game 2011). In contrast, detecting changes in cow survival in the Bathurst is not possible with 10-20 collars because the survival estimates are simply too variable due to the small sample size. However, a substantial improvement in estimating survival of Bathurst cows would be achieved by increasing the sample size of collared caribou cows to 50 individuals. In recent years, there appears to have been an increase in mortality of collared Bathurst cows in the summer. However, because of the low collar numbers on the herd, it is difficult to know whether this trend is truly representative of mortality patterns in Bathurst cows or whether the trend reflects low sample numbers and random chance. An increase to at least 50 cow collars would substantially improve our understanding of this apparent trend.

4.2. Defining caribou winter range and assigning caribou harvest to herd

Following the rapid decline in the Bathurst herd from 2006 to 2009, harvest was reduced in 2010 by about 95% to an annual limit of 300, with 80% of the harvest to be bulls (Boulanger et al. 2011). The harvest target of 300 Bathurst caribou was to occur only within R/BC/02 and R/BC/03. Although the population has stabilized, herd size was still at relatively low in 2012. Herd size and trend continues to be monitored closely via surveys and other indicators, and the harvest is monitored and managed closely. Accurate and representative data on the seasonal movements and locations of Bathurst and neighboring caribou herds is key to managing the winter harvest; thus, harvest management requires frequent locations of caribou from known herds that is most effectively provided by satellite and GPS-collars. In some winters (e.g. 2010-2011 and 2012-2013), overlap between the Bathurst and Bluenose-East herds on the winter range has been substantial. Determining whether Bathurst or Bluenose-East caribou were being hunted, and directing hunters to areas where they could hunt was determined from as few as 8-10 Bathurst collars and a similar number of Bluenose-East collars. But due to the small sample size of collared Bathurst caribou, we are unable to confidently assign herd identity to all hunted caribou, which results in a variable and potentially large source of error when monitoring locations of hunter-kills and trying to assign herd identity to kill locations. In addition to increasing the total number of collars on cows, maintaining some collars (i.e., 15) on Bathurst bulls would also improve overall harvest management especially if the overall strategy continues to emphasize bulls to be hunted in lieu of cows.

Defining the wintering range of a caribou herd of thousands is difficult when significant portions of the herd have no collared caribou among them. For the George River herd, 64 collared caribou resulted in a 95% probability of the herd's winter range being identified, and 49 collars resulted in a 75% probability (Otto et al. 2003). These probabilities can be interpreted as confidence levels; confidence in the George River winter range being well defined was lower at 49 collars than at 64 collars. Boulanger's analyses in 2011 similarly suggested that at least 40 collars were needed to define the winter range of the Bluenose-West and Bluenose-East herds with confidence. The risk to management of Bathurst harvest in winter is that significant portions of the herd are not defined spatially; hence harvest may be assigned to the wrong herd or undefined. An increase to 65 collars would increase confidence that harvest of caribou from the Bathurst herd and its neighbours is reliably assigned.

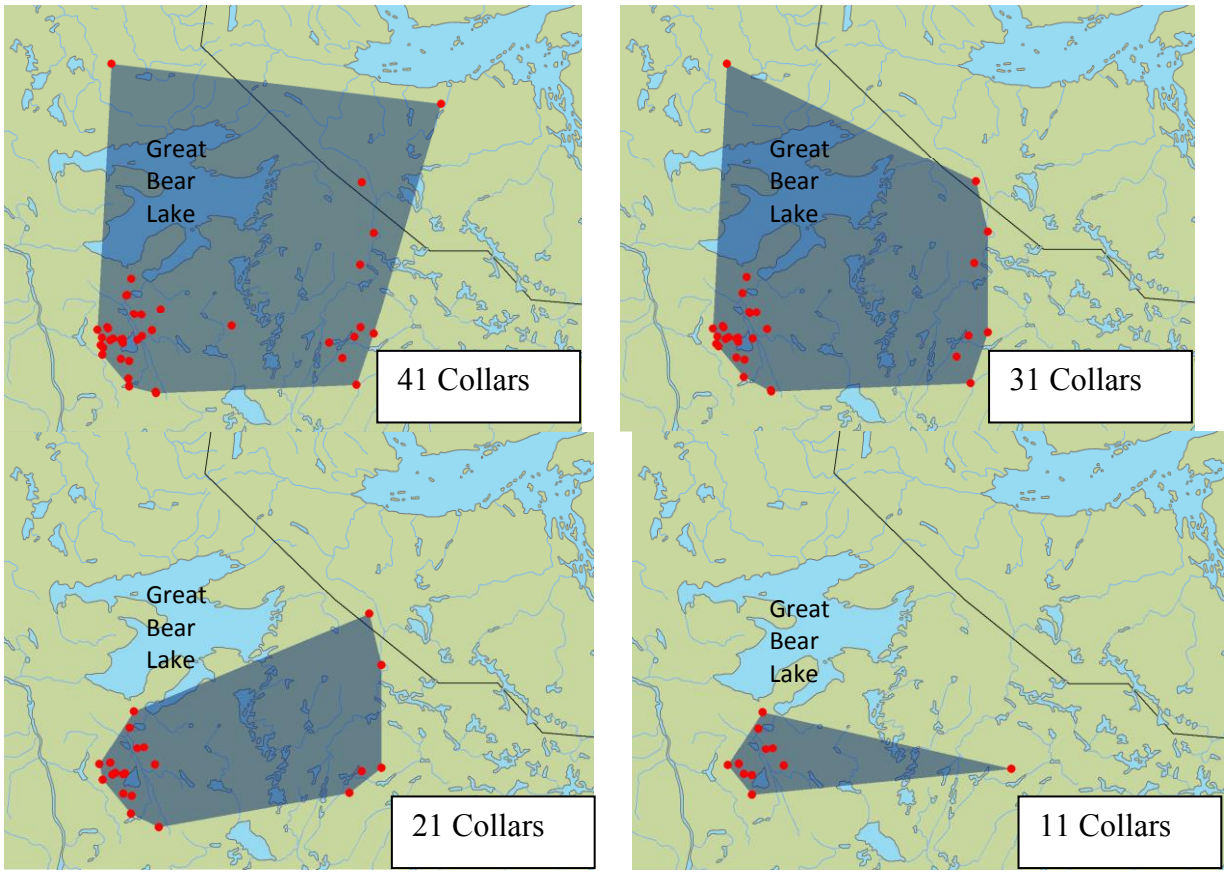

Fig. 1. Minimum Convex Polygon (MCP) derived from 41 caribou collar locations, Bluenose-East herd, on one day in early winter 2009, and then reduced randomly to fewer collars (J. Williams, ENR, maps).

To assist in visualizing the value of larger numbers of radio-collars and the limitations of low collar numbers, a series of maps is shown in Figures 1 and 2. The actual locations of 41 Bluenose-East collars on one day in early winter 2009 are shown in Fig. 1. Thereafter, by a random draw, the numbers of collars were reduced sequentially to 31, 21, and 11 collars. The location of a single larger aggregation of caribou with collars was still identifiable with 11 collars, but other collars and thus the caribou associated with each of those collars were no longer identified.

Figure 2 shows a similar series starting with 59 actual Bluenose-East collars (cows and bulls) on Aug. 17, 2012, reduced sequentially and randomly to lower numbers. In this case there was no main grouping of collars, rather a scattered distribution over the entire range. Assigning harvest to a herd could be done confidently with 49 or 59 collars, but with far less confidence with 9 or 19 collars. All uses of collars would be carried out with greater confidence with 65 collared caribou in the herd.

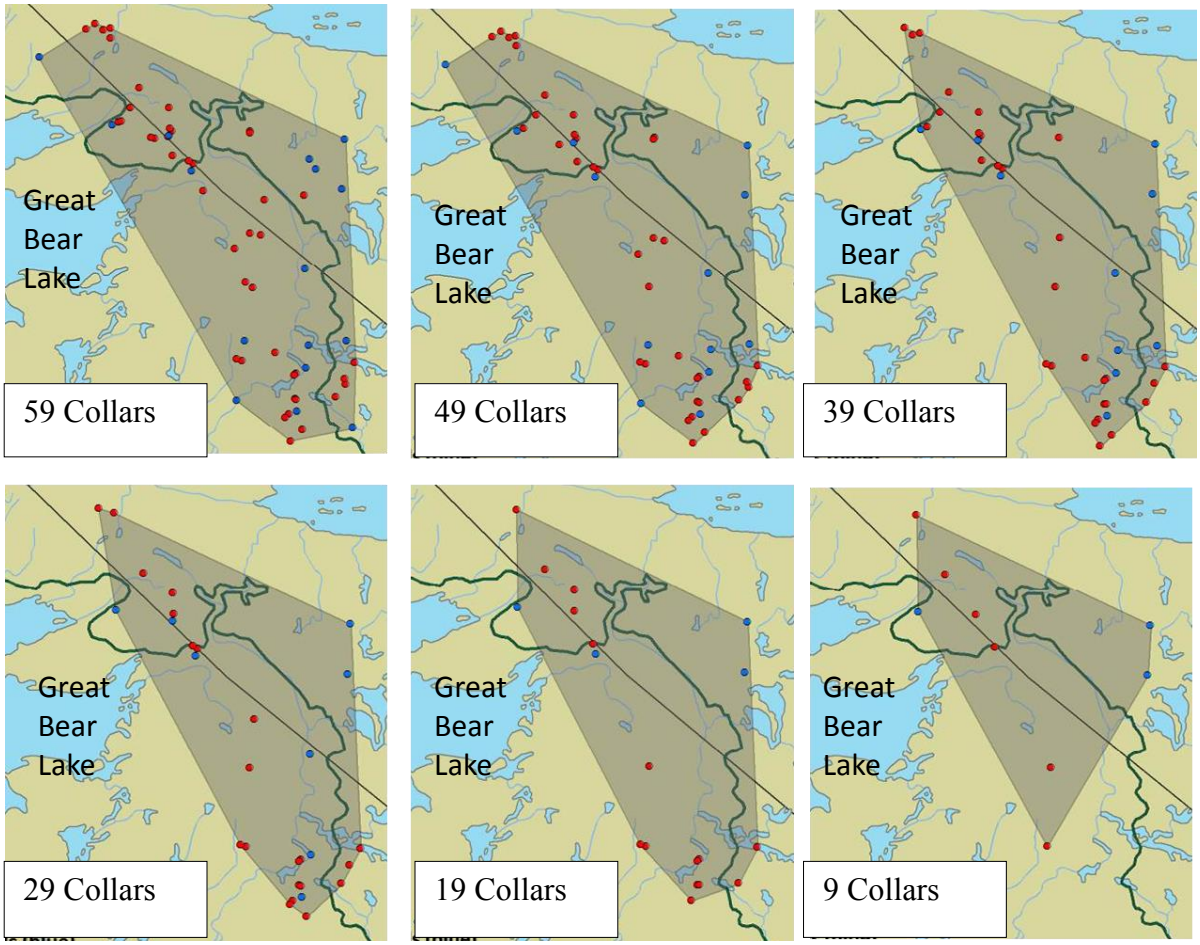

Fig. 2. Minimum Convex Polygon (MCP) from 59 caribou collar locations, Bluenose-East herd, on Aug. 17, 2012, then reduced randomly sequentially to 9 collars (J. Williams, ENR, maps). Red dots are cows and blue dots are bulls.

4.3. Managing caribou harvest on the winter range

If the winter range used at any point in time by the Bathurst herd and neighbouring herds is well defined, then the possibility arises of a more flexible approach to harvest management. At present, three large zones with fixed boundaries for the Bathurst winter range were defined in late 2009 based on range use over a number of years by collared caribou (RB/C/01, RB/C/02, and RB/C/03 in Figure 3). However, there is year-to-year variation in caribou winter range use, collared Bathurst caribou have wintered in zone RB/C/01 where Aboriginal harvest is unrestricted, and overlap with neighbouring herds has been substantial in some winters (Fig. 3). With adequate collar representation on Bathurst, Bluenose-East and Beverly/Ahiak caribou, a more flexible approach to harvest zones could be developed. The two current Bathurst zones could be divided into sub-zones with boundaries using natural and/or locally known topographical features, and the regulated harvest zone for the Bathurst herd could be defined each winter, by a combination of sub-zones identified by collared caribou locations that winter.

4.4.

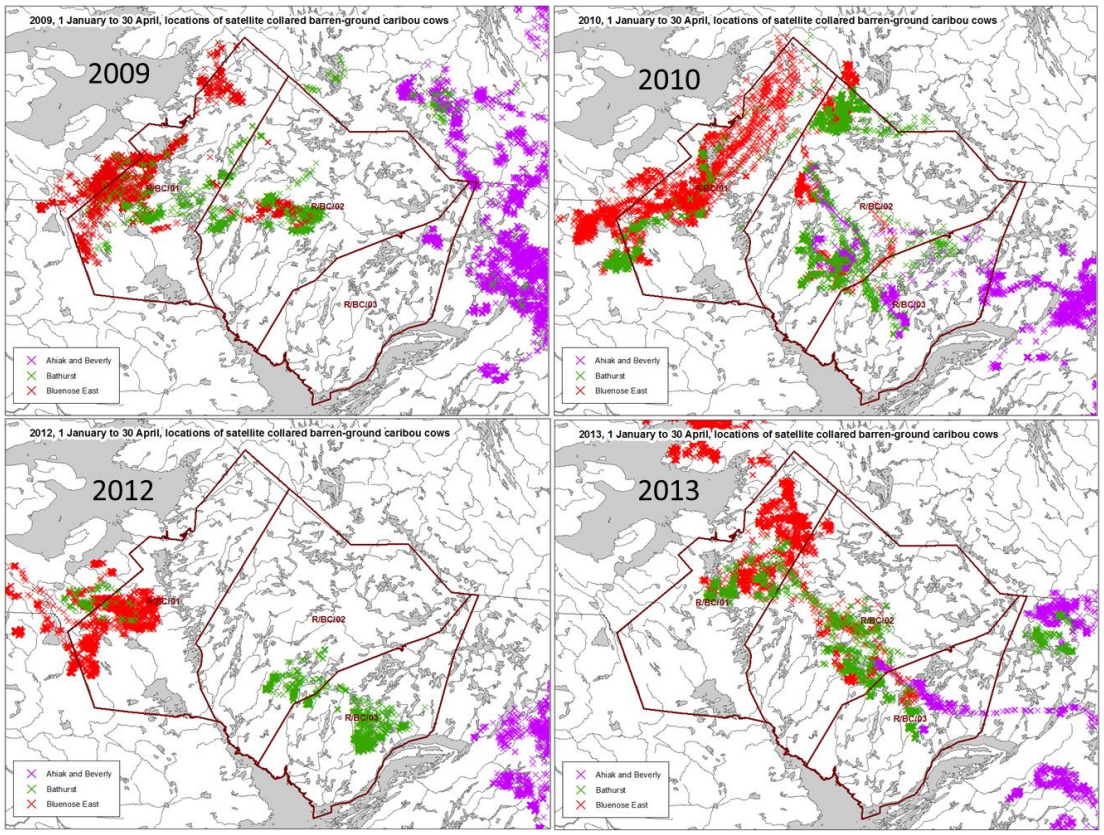

Fig. 3. Cumulative winter distribution of radio-collared caribou in RBC01, 02 and 03 from 3 herds (Jan-April) in four years. Red=Bluenose-East, Green=Bathurst, Purple=Beverly/Ahiak. Maps A. D'Hont, ENR.

4.5. Delineating winter range of bulls

Collars are placed on bulls from the Bluenose-West, Bluenose-East and Cape Bathurst herds in population survey years, because of the requirement of post-calving surveys for substantial collar numbers to identify all portions of the herd. This makes it possible to define seasonal movements and range use by bulls in these herds. Caribou are known to segregate during much of the year, thus winter ranges used by bull-dominated groups will likely be different from those used by mostly cow-calf groups. There have been no collars on Bathurst bulls to date. However, because of the Bathurst herd's decline, recommended hunter harvest has been at least 80% bulls in the accepted 300 annual caribou harvest. A harvest of primarily bulls may continue to be recommended for the Bathurst herd, depending on herd size and trend. Directing hunters to winter range where bulls from the Bathurst herd are concentrated would be enabled by an adequate sample of collars on Bathurst bulls (n = 15).

4.5.1. Improved reliability of caribou surveys

Composition surveys are used for the Bathurst and other caribou herds to assess recruitment of calves (calf:cow ratio in March) and sex ratio (bull:cow ratio; October). These are important secondary indicators of the herd's health and population trend. Collared caribou are key to defining the survey area for composition surveys. In particular, the calf:cow ratio and the

bull:cow ratio may vary according to the spatial dispersion of the herd, so an appropriate spatial stratification of survey effort is needed to collect a representative sample of caribou groups across their seasonal range. In this way, sufficient numbers of collared caribou, including bulls, can help ensure that the herd's distribution is well identified and that a composition survey is based on a representative sample of the herd. Similarly, a larger number of collared caribou during population surveys (calving or post-calving) increases confidence that the herd's distribution has been reliably defined.

4.6. Increased capability of assessing caribou responses to development and minimizing disturbance.

The first study to document a Zone of Influence (partial avoidance) by caribou around the diamond mines in the Bathurst range used satellite collar locations (Johnson et al. 2005). More recently Boulanger et al. (2012) confirmed this avoidance by caribou to a distance of about 14 km from each active mine, using both aerial survey observations and collar locations. Other studies of caribou relying on collar locations have shown altered movements near linear corridors and declines by woodland caribou in southern Canada (e.g. Dyer et al. 2001). Additional mines and roads in the Bathurst range are proposed, under review or recently reactivated; these include Jericho, Izok Lake, High Lake, Bathurst Inlet Port and Road, Gahcho Kue, and Fortune Minerals. Several other known mineral deposits in the Bathurst range are in exploration phases. In all environmental assessment and impact statements focused on caribou, collar information has been the basis for defining caribou seasonal ranges and movements and caribou responses to roads, mines and other disturbed areas. Adequately defining movements and habitat use by Bathurst caribou will depend heavily on being able to define where the caribou are. A renewed Caribou Protection Measures program (used primarily in the 1980s to monitor movements of the Beverly and Qamanirjuaq caribou herds and limit industrial activity near caribou) has been proposed for the Sahtu region, and would depend on recent collar locations for the Bluenose-West and Bluenose-East herds. The study by Otto et al. (2003) was carried out to assess how many collared caribou were needed to reliably define the distribution of George River caribou so that low-level jet flights could be directed elsewhere. Knowing where the Bathurst caribou herd is, with confidence, will require an adequate number of Bathurst cow and bull collars to ensure that responsible development can be managed to minimize impacts on the herd.

5. Conclusion

Satellite and/or GPS-collars are used to monitor all migratory herds of barren-ground caribou in North America. Collars are able to provide key information on locations and movements of caribou throughout the year. Increasing the number of collared caribou on the Bathurst herd to 65 (includes 15 bulls) would greatly improve the overall herd monitoring program. The larger sample size of collared Bathurst caribou would improve confidence in harvest management and improve our understanding of mortality rates and causes in adult cows. A decision to increase the number of collars on the herd must be balanced with the need for respectful behavior towards caribou.

Table 1. Recommendations for radio-collar numbers in barren-ground caribou herds for various uses, advantages of higher collar numbers and limitations of low collar numbers. Tan shaded cells indicate specific objectives and priorities for monitoring Bathurst caribou with satellite & GPS collars.

Radio-Collar Application	Recommended Collar Number	Source	Advantages of More Collars	Limitations of Few Collars	Priority for Management
Defining Location of Caribou Herd Seasonally & Managing Harvest					
Defining Calving Range, George River herd	36 (95% probability) 23 (75% probability)	Otto et al. 2003	High probability that location of large percentage of cows is known; low probability of missing main groups of breeding cows	Increased likelihood that location of significant percentage of cows not known, especially if in unusual locations	High
Defining Winter Range, George River herd	64 (95% probability) 49 (75% probability)	Otto et al. 2003	High probability of larger and smaller aggregations of caribou identified	Increased likelihood that location of significant parts of herd, especially smaller aggregations, not known	High
Defining Winter Range, Bluenose-West & Bluenose-East herds	At least 40/herd	Boulanger 2011	Good confidence that larger and smaller aggregations of caribou in herd are known	Increased likelihood that location of significant parts of herd are unknown	Moderate
Assigning harvest in winter to herd in overlap areas between herds	At least 40/herd	Boulanger 2011	Good confidence that known harvest locations are assigned to correct herd, including overlap areas	Increased likelihood of harvest being assigned to wrong herd	High
Defining & managing mobile harvest zones	At least 40/herd	Boulanger 2011	Ability to define sub-zones to correct herd with confidence, and change if needed	Low confidence in assigning sub-zones to herd(s)	High
Monitoring Cow Survival Rate					
Monitoring cow survival rate (closely tied to population trend)	100/herd to detect slow decline in 10 years	Boulanger 2011	Ability to detect changes in cow survival, hence in herd trend, in a timely manner	Inability to detect change in cow survival rate, hence less ability to detect change in herd trend	High
Monitoring cow survival rate (closely tied to population trend)	60/herd to detect rapid decline in 3-5 years	Boulanger 2011	Ability to detect changes in cow survival, hence in herd trend, in a timely manner	Inability to detect change in cow survival rate, hence less ability to detect change in herd trend	High
Monitoring cow survival rate (closely tied to population trend)	100/herd to detect 7% decrease in survival in 3 years	Rettie 2008	Ability to detect changes in cow survival, hence in herd trend, in a timely manner	Inability to detect change in cow survival rate, hence less ability to detect change in herd trend	High
Monitoring cow survival rate (closely tied to population trend)	40-60/herd to detect 10-13% decrease in survival in 3 years	Rettie 2008	Ability to detect changes in cow survival, hence in herd trend, in a timely manner	Inability to detect change in cow survival rate, hence less ability to detect change in herd trend	High
Monitoring cow survival rate (closely tied to population trend)	100 collars (each) on Porcupine & Western Arctic Herd	N/A	Ability to detect changes in cow survival, hence in herd trend, in a timely manner	Inability to detect change in cow survival rate, hence less ability to detect change in herd trend	High
Land Use & Disturbance Studies					
Land Use – defining seasonal ranges &	No specific recommendations –	ENR staff experience	Ability to define where large proportion of herd is seasonally & on migration, in	Increased likelihood of locations of significant proportions of herd not	Moderate (increasing)

Radio-Collar Application	Recommended Collar Number	Source	Advantages of More Collars	Limitations of Few Collars	Priority for Management
movements	see Section 1		relation to proposed developments	known	
Land Use – assessing caribou response to roads, mines, camps					
Designing caribou surveys & assessing movement between herds					
Post-calving population surveys	Cape Bathurst 30, Bluenose-West 60, Bluenose-East 40-60	Rettie 2008	Critical for post-calving surveys to find caribou groups; need collars on bulls also	Potential to miss significant portions of herd; inaccurate surveys	High
Composition Surveys	No specific recommendations – see Section 1	ENR staff experience	Key to defining areas where larger and smaller numbers of caribou are, and to identify overlap areas between herds	Poor representation of herd composition; potential for inaccurate calf:cow and bull:cow ratios	Moderate
Calving photo surveys, George River herd	36 (95% probability) 23 (75% probability)	Otto et al. 2003	Confidence in breeding cows being concentrated on the calving ground at time of survey; ability to find cows calving in unusual areas - e.g. late spring or low pregnancy rate	Less confidence in survey result being representative of herd; less ability to find cows calving in unusual areas - e.g. late spring or low pregnancy rate	Moderate

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