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Technical Rationale to Increase the Number of Satellite Collars on the Bathurst Caribou Herd

Jan Adamczewski
Environment and Natural Resources, Government of the Northwest Territories

John Boulanger
Integrated Ecological Research, Nelson, BC

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ABSTRACT

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. Until 2015, a maximum of 20 collars had been used on the Bathurst herd, all on cows, and at times there have been as few as eight to nine collared caribou in the herd. An independent review of the Government of the Northwest Territories barren-ground caribou program in 2009 recommended increases in radio collar numbers for all herds, and particularly for herds like the Bathurst where the collar numbers were low. In 2015, the number of Bathurst collars was increased to 50 (30 on cows and 20 on bulls) with approval of the Tłı̨cho Government. This document briefly reviews the main 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. Areas of high priority in management for this herd in 2016 were in assigning and managing harvest from this herd in the winter, in monitoring mortality pattern rates in cows, and in designing reliable population surveys in June. 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.

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INTRODUCTION

Satellite and GPS collars have been used since 1996 on the Bathurst caribou herd to monitor seasonal distribution and migratory movements. Initially ten collars were placed on cows and after a few years the maximum number of collars increased to 20. Until 2015, the number of collars on the Bathurst herd of barren-ground caribou at any one time had not exceeded 20, and often there were 12-13 or fewer (Boulanger et al. 2011). While capturing, handling and attaching a collar to caribou is challenging to Tłı̨cho and other Aboriginal values of respect for wildlife, Tłı̨cho elders gave their approval to initially place ten collars on Bathurst caribou and then later 20 collars to monitor the herd due to concerns over potential effects of the diamond mines, something the Tłı̨cho were very concerned about. In early 2015, the Tłı̨cho Government (TG) approved a further increase to Bathurst collar numbers to 50 (30 on cows and 20 on bulls) and additional collars were placed on Bathurst caribou in March 2015 to reach these totals.

VHF-radio, satellite and GPS-collars have been used as tools for monitoring all migratory herds of barren-ground caribou in North America. Up to 100 collars are maintained on some herds as essential on-going monitoring. Collars 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 mines and other development, designing and 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 a 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 behaviour towards caribou.

We note – a number of previous versions of this document have been used since 2011-2012, including review and discussion by a technical working group with representatives of the Tłı̨cho Government, Department of Environment and Natural Resources, and the Wek'èezhìi Renewable Resources Board. The report was updated in 2016 by the two lead authors and was finalized as a Government of the Northwest Territories manuscript report to make it more widely available.

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 Northwest Territories (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.

In addition, in the past, collar location maps have been used by communities when planning their community hunts. In 2007, however, the GNWT was requested to cease making maps of satellite collared caribou widely available due to widespread caribou declines and the need to limit harvest (ENR 2007). Since 2010, managing harvest limits on the Bathurst herd has relied heavily on collar locations to assign harvest to either the Bathurst herd or neighbouring herds (Bluenose-East and Beverly/Ahiak). 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 and to direct hunters to areas where harvest is permitted.

An independent review of the Government of the Northwest Territories (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). The GNWT commissioned studies to assess the numbers of collars needed per herd for various applications, including J. Rettie (2008) and J. Boulanger (2011). 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 varied from about 30 to about 100, depending on the objective or use of the collars.

Numbers of collars used on caribou herds elsewhere vary, with the maximum number used being about 100/herd in the western Arctic, Porcupine, and George River 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 (2011) 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 information gained by monitoring individual caribou from the Bathurst and other herds is critical to monitoring and management of herds.

APPLICATIONS OF COLLAR DATA AND ADVANTAGES OF INCREASED NUMBERS OF SATELLITE AND GPS-COLLARS ON THE BATHURST HERD

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 (Boulanger et al. 2011), suggested that the cow survival rate was ~67% in 2009 during the most rapid decline of the Bathurst herd, with an increase to ~78% in 2012 (Boulanger et al. 2014). Although the survival rate appeared to have improved from 2009 to 2012, the current estimated cow survival rate is still too low for the herd to stabilize or increase. 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 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 with confidence 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.

Defining caribou winter range and assigning caribou harvest to herd

Following the rapid decline in the Bathurst herd from 2006-2009, 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 appeared to have stabilized 2009-2012, herd size was still relatively low in 2012 (Boulanger et al. 2014). Herd size and trend continued to be monitored closely via surveys and other indicators in 2016, and the harvest was monitored and managed closely. Accurate and representative data on the seasonal movements and locations of Bathurst and neighbouring caribou herds is key to

managing the winter harvest; thus, harvest management requires frequent locations of caribou from herds that are 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 eight to ten Bathurst collars and a somewhat larger number of Bluenose-East collars. Due to the small sample size of collared Bathurst caribou, it was difficult to confidently assign herd identity to all hunted caribou. In addition to increasing the total number of collars on cows, maintaining some collars (e.g. 15) on Bathurst bulls would also improve winter harvest management as bulls tend to winter further south than cows, thus the herd's full distribution is more reliably defined when there is an adequate sample of bull collars.

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.

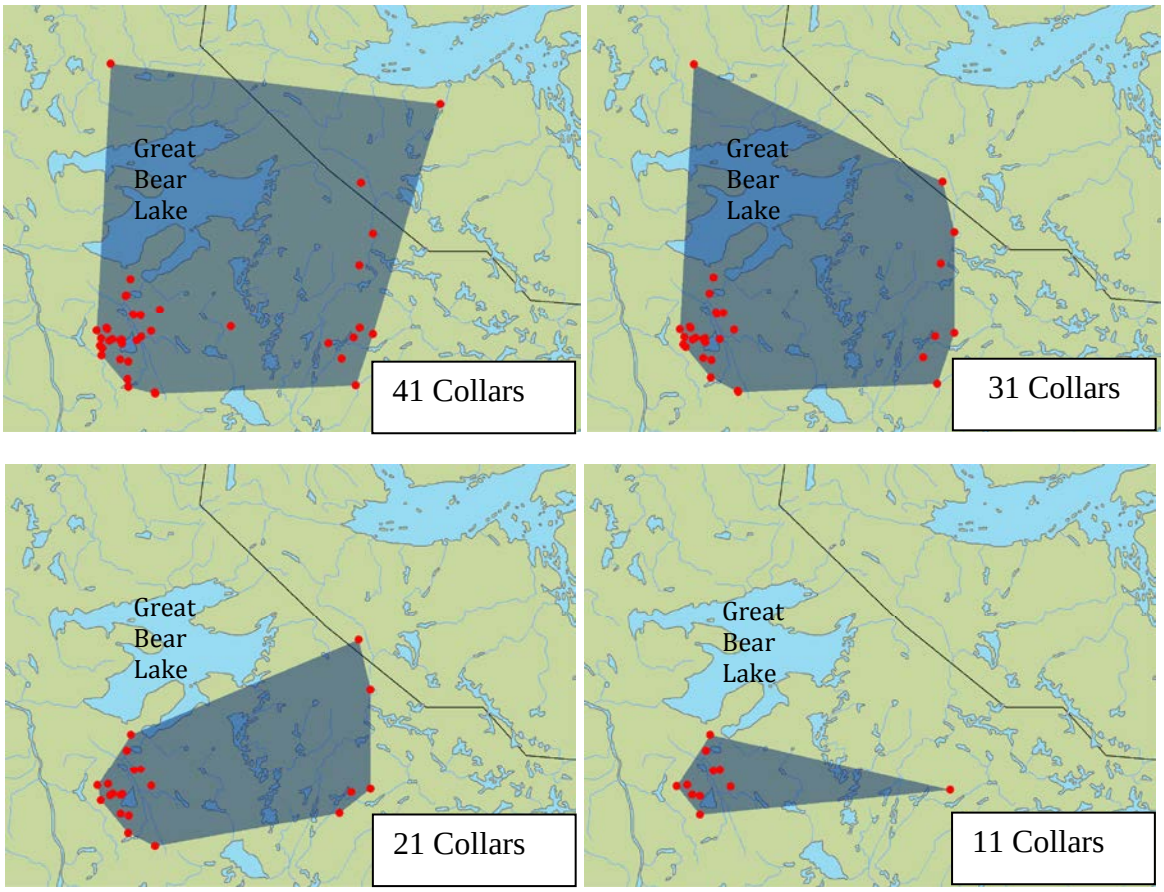

Figure 1. Minimum Convex Polygon (MCP) derived from 41 caribou collar locations, Bluenose-East herd, on one day in early winter 2009, and then reduced randomly to fewer collars (GNWT/J. Williams, ENR).

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 Figure 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 August 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 nine or 19 collars. All uses of collars would be carried out with greater confidence with 65 collared caribou in the herd of interest.

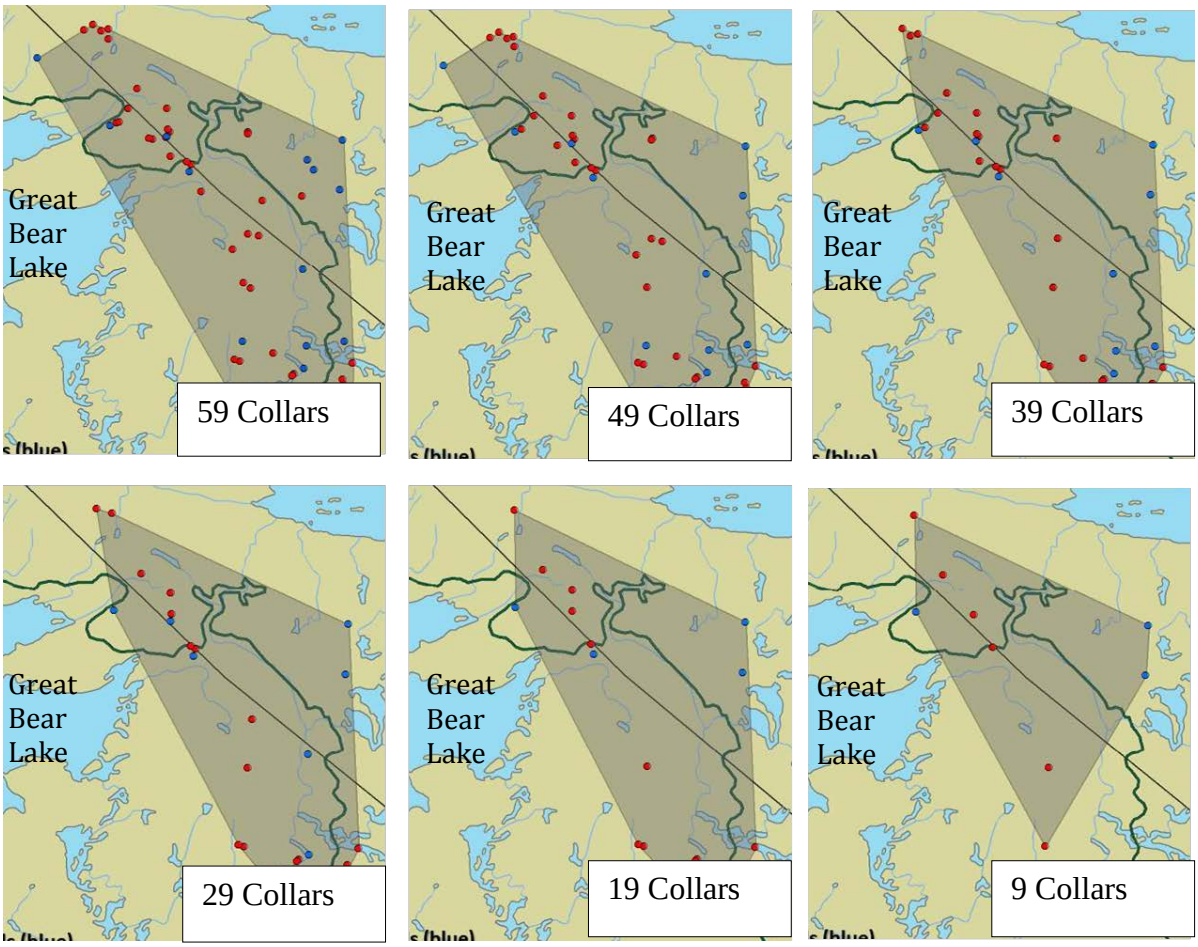

Figure 2. MCP from 59 caribou collar locations, Bluenose-East herd, on August 17, 2012, then reduced randomly sequentially to nine collars (GNWT/J. Williams, ENR). Red dots are cows and blue dots are bulls.

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. 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). Harvest of Bathurst caribou was limited to 300 in R/BC/02 and R/BC/03 as the herd had generally wintered in those areas. However, there is year-to-year variation in caribou winter range use, collared Bathurst caribou have sometimes wintered in zone RB/C/01 where Aboriginal harvest was unrestricted until 2015, and overlap with neighbouring herds has been substantial in some winters (Figure 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.

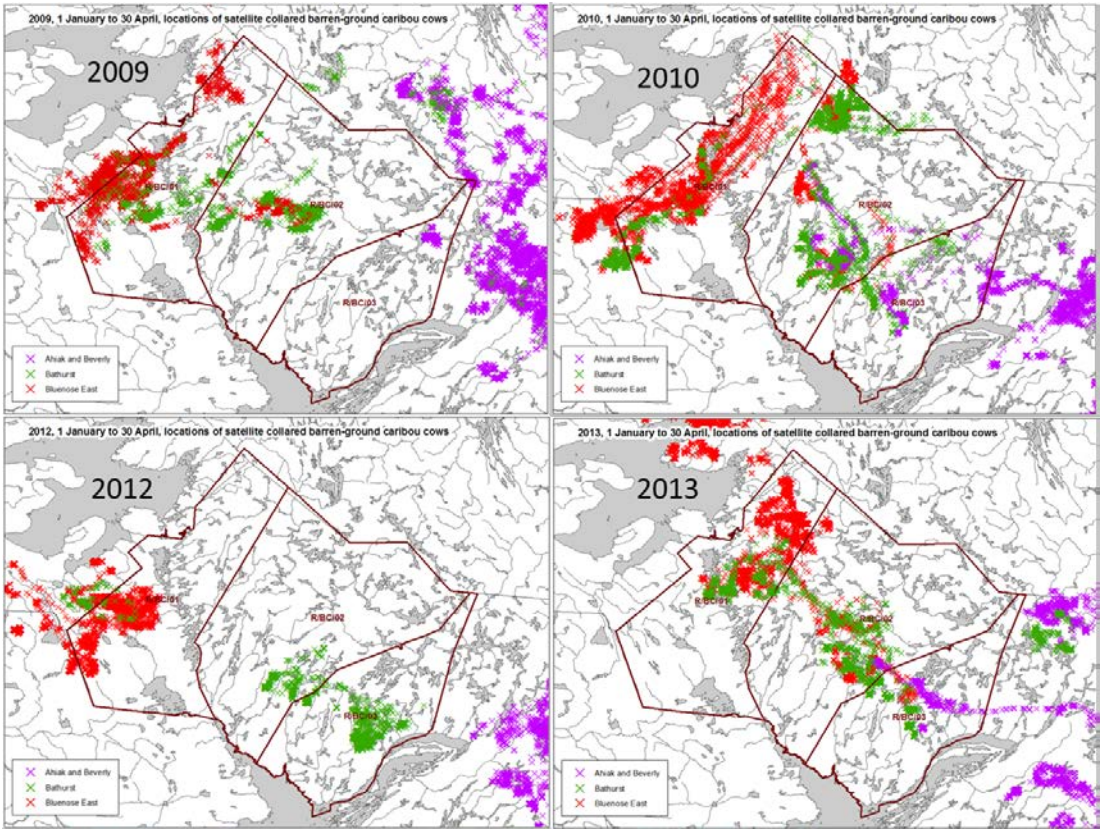

Figure 3. Cumulative winter distribution of radio collared caribou in R/BC/01, 02 and 03 from three herds (January-April) in four years. Red=Bluenose-East, Green=Bathurst, Purple=Beverly/Ahiak. (GNWT/A. D'Hont, ENR)

More recently, in winters 2014-2015 and 2015-2016, a no-harvest mobile conservation zone was used to define the Bathurst herd's distribution based on collars (see GNWT and TG 2015a); an example map is provided in Figure 4. In both these winters, the Bathurst collared caribou tended to form one large group that overlapped very little with the neighbouring herds. This mobile conservation zone meant that limiting Aboriginal harvest to conserve the Bathurst herd was limited to a much smaller area than the two large zones (R/BC/02 and R/BC/03) that had previously been used, and conservation efforts could be directed to the winter range known to be used by the herd at that point in time. This management application of collared caribou data was entirely dependent on the existing collared caribou from the Bathurst herd and from neighbouring herds. Confidence that the Bathurst herd's distribution was well defined was much increased in 2015, after the number of collars was increased from 20 or fewer collared cows to a total of 30 collared cows and 20 collared bulls.

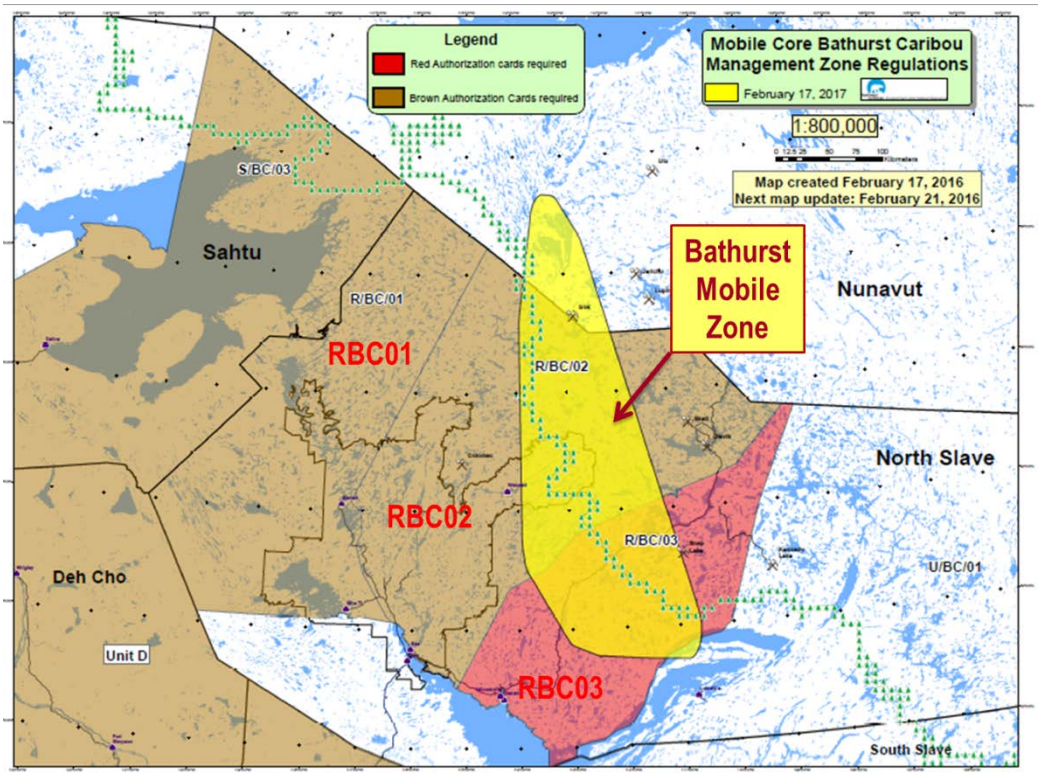

Figure 4. An example of the Bathurst mobile conservation zone from February 2016. The mobile zone was defined by locations of the collared Bathurst cows and bulls as a MCP with a 30 km buffer. No harvest was permitted within this zone. Previously (2010-2014), the large zones R/BC/02 and R/BC/03 had been used to limit annual Bathurst harvest to 300 or fewer, but portions of these large zones were used by neighbouring herds and in some winters Bathurst caribou wintered outside them. (See GNWT and TG 2015a.)

Delineating winter range of bulls

Collars have in the past been placed on bulls from the Tuktoyaktuk Peninsula, 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 (Rettie 2008). 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 were no collars on Bathurst bulls until 2015. However, because of the Bathurst herd's decline, recommended hunter harvest for 2010-2014 with at least 80% bulls in the accepted 300 annual caribou harvest. More recently (December 2015), harvest of Bluenose-East caribou has been proposed to be limited to 950/year and all bulls (GNWT and TG 2015b). Directing hunters to winter ranges where bulls are concentrated, and cows are scarce, would be enabled by an adequate number of collars on bulls.

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.

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 Qamanirijuaq caribou herds and limit industrial activity near caribou) has been proposed for the Sahtú 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.

In an April 2016 hearing under the Nunavut Impact Review Board on the proposed Sabina gold and silver mine near Bathurst Inlet (see documents on Sabina Back River Project, www.nirb.ca), contingency mitigation measures were proposed in the event that caribou cows with calves approach the site. Caribou could be from either the Bathurst or Beverly and Ahiak herds. The company planned to use near-real-time caribou collar data so that reductions in mine activity could be prepared. In this case, use of the collar data allows for advance warning of caribou in the vicinity of the proposed mine and associated roads and other infrastructure. This consideration would also apply to other herds where Caribou Protection Measures or contingency plans for managing industrial activity depend on knowing reliably where the herds are (see Otto et al. 2003).

CONCLUSION

Satellite and/or GPS-collars are used to monitor all migratory herds of barren-ground caribou in North America, with up to 100 collars maintained on some herds. Collars provide key information on locations and movements of caribou throughout the year. Increasing the number of collared caribou on the Bathurst herd to 65 (including about 15 bulls) would greatly improve the overall herd monitoring program. The larger sample size of collared Bathurst caribou would improve confidence in harvest management, understanding of mortality rates and causes in adult cows, survey design and applications to land use and mitigation of disturbance to 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 and 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 unpublished 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

Radio Collar Application	Recommended Collar Number	Source	Advantages of More Collars	Limitations of Few Collars	Priority for Management
Monitoring cow survival rate (closely tied to population trend)	60/herd to detect rapid decline in 305 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 & movements	No specific recommendations – see Section 1	ENR staff experience	Ability to define where large proportion of herd is seasonally & on migration, in relation to proposed developments	Increased likelihood of locations of significant proportions of herd not known	Moderate (increasing)
Land Use – assessing caribou response to roads, mines, camps	No specific numbers; larger numbers of collars preferable	See Otto et al. 2003	Increased probability of some collared caribou encountering mines or roads to allow analysis of their responses.	Not enough collared caribou encountering developed sites to assess responses	Moderate (increasing)
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

Radio Collar Application	Recommended Collar Number	Source	Advantages of More Collars	Limitations of Few Collars	Priority for Management
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, Bathurst and Bluenose-East 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	High

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