Wek'èezhìi Renewable Resource Board (WRRB)
Management Proposal

1. Applicant Information
Project Title: Government of the Northwest Territories and Tłı̨chǫ Government Joint Proposal on Caribou Management Actions in Wek'èezhìi: 2014 – 2019
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2. Management Proposal Summary: provide a summary description of your management proposal (350 words or less).	
Start Date: Fall 2014	**Projected End Date:** Fall 2019
Length: 5 years	**Project Year:** 1 of 5

This management proposal carries forward the recommendations that arose from the "Revised Joint Proposal on Caribou Management Actions in Wek'èezhìi", which was submitted to the WRRB in May 2010 by the Tłı̨chǫ Government (TG) and the Department of Environment and Natural Resources, Government of the Northwest Territories (ENR-GNWT). Overall, the main objective in the 2010 proposal, which was to halt the Bathurst barren-ground caribou herd's rapid decline from 2006-2009, has been achieved. This proposal is meant to apply to 2014-2019, although it is recognized that it may need to be adapted in the interim pending new information.

This proposal's focus is to promote recovery and growth of the Bathurst herd. The specific goal of the proposal is to increase the number of breeding females in the herd, which will be

measured during the next two calving ground surveys (scheduled for 2015 and 2018). Management actions will focus on improving adult female survival through continued harvest management and by implementing a community-based wolf harvest program to reduce caribou mortality on the Bathurst winter range. Increased wolf harvest on the Bathurst range will also be promoted by allowing resident hunters to participate in the Mackenzie Valley Fur incentive program. Biological monitoring of the herd will continue, and, if approved, enhanced, by increasing the number of collared caribou in the herd.

This proposal builds on three key management and monitoring options identified in the May 2010 proposal and subsequent WRRB recommendations for the herd:

1) Hunter harvest: since the harvest target approach was initiated in 2010, the estimated annual harvest of Bathurst caribou has been less than 300 per year and is biased towards bulls. The recommendation is to maintain the current harvest target of 300 animals for the Bathurst herd and for the harvest to continue to be bull focused (80% bulls). Additional effort will be needed to promote respect for caribou, which includes limiting meat wastage and educating harvesters about the need for a bull-focused harvest if the rate of herd recovery is to be maximized.

2) Predator management: Management efforts to increase the annual harvest of wolves on the winter range of the Bathurst herd to 80-100 per year have not been successful. Consequently, it is recommended that a hunter-based wolf management approach be developed with Tłı̨chǫ hunters and communities. Using this approach, mobile wolf-hunter camps will be established in early or late winter, with the objective of removing 80-100 wolves from the Bathurst range annually. Resident hunters will also be allowed to access incentives administered under the Mackenzie Valley Fur Program for prime wolf pelts.

3) Monitoring: Monitoring of the Bathurst herd from 2010 to 2013 included a calving ground photographic survey in 2012, fall and late winter composition surveys, and the tracking of up to 20 caribou cows fitted with satellite radio-collars. In collaboration with ENR-GNWT, the DCLP also initiated an extensive caribou condition monitoring program, which including the training and participation of Tłı̨chǫ hunters. Harvest monitoring in winter was conducted by community monitors and incorporated a check-station and aerial and ground-based patrols by wildlife officers. Demographic monitoring, caribou condition monitoring, and harvest monitoring will continue in 2014-2019.

   It is also recommended that the number of satellite collars on Bathurst caribou be increased from 20 to 50 in total with 30 on Cows and 20 on Bulls. Increasing the number of collars on the Bathurst herd will: i) allow for more precise monitoring of adult female caribou survival and better understanding of the main causes of mortality and when/where mortality occurs; ii) result in a more refined understanding of the distribution of the herd during the fall and winter harvest season, which will improve understanding of the number of Bathurst caribou that are hunted within different management zones; iii) encourage hunting of bulls over cows by directing hunters to areas with bulls; and iv) result in improved understanding of caribou response to mines, roads and other industrial development and human activities. Some collars will need to be replaced annually in late winter (i.e., March/April) to offset mortalities.

Please list all permits required to conduct proposal.

NWT and Nunavut Wildlife Research Permits will be required annually to conduct monitoring

recommended in this proposal.

3. Background (Provide information on the affected wildlife species and management issue)

A. Bathurst caribou decline to 2009

There were an estimated 16,600 breeding cows and 32,000 caribou in the Bathurst herd in 2009, which represented a 70% decline based on 2006 estimates (Figure 1). As a result of this rapid decline, ENR-GNWT held meetings and workshops in fall 2009 to discuss management actions that might be taken to halt the decline and allow the herd to stabilize and recover. Evaluation of the Bathurst decline from peak numbers in the 1980s suggested that a large part of the decline was likely the result of natural factors. Natural factors have caused herd fluctuations to occur many times in the past.

Sustained low calf recruitment in this herd from 2000 to 2006 indicated a naturally declining trend, similar to concurrent declines and low calf productivity documented in two other NWT herds (Cape Bathurst and Bluenose-West, summarized in Adamczewski et al. 2009). Hunter harvest of the herd was documented in 2008-2009 and annual harvest estimates ranged from 4000 to 7000, with most harvested animals being cows (Boulanger et al. 2011). This level of harvest would have had a limited effect on the herd when it was large and numbered more than 300,000. However, a consistent harvest rate of 4000 to 7000 caribou per year would became an increasingly important factor as the herd naturally declined because proportionally more of the herd would have been harvested. This consistent harvest may have accelerated the natural decline, resulting in the dramatic decrease from 2006 to 2009 (see Boulanger et al. 2011). Many factors, including weather in all seasons and natural mortality from predation, likely contributed to the Bathurst decline. Attention in 2009-2010 was focused on managing factors which could be controlled directly to stop and reverse the decline, including hunting and management of predators such as wolves. Potential impacts of land-use and industrial development were also considered important, but development of specific recommendations was left to be addressed through a broader longer-term planning and management process.

B. Previous Bathurst caribou management proposals and actions from 2010 – 2013

An initial joint management proposal for caribou was submitted to the WRRB by TG and ENR-GNWT in November 2009. While TG and ENR-GNWT agreed on most of the management and monitoring actions described in the proposal, they did not agree on management of Aboriginal harvest. In January 2010, the ENR Minister used emergency powers to close all harvest of Bathurst caribou (resident, commercial and Aboriginal) in the NWT until a co-management approach to managing harvest and other factors could be developed. The WRRB held a 5-day hearing in March 2010 to consider the joint management proposal and submissions from many other concerned parties. The hearing was adjourned following a request from TG and ENR-GNWT to re-convene and work toward agreement on managing Aboriginal harvest.

A revised joint proposal on caribou management was submitted to the WRRB in May 2010. The main recommendation in the proposal was to establish an annual harvest target of 300 ± 10% Bathurst caribou with a sex ratio of 80% bulls. The target would be shared, with 150 caribou available to Tłı̨chǫ hunters and 150 for Yellowknives Dene First Nation (YKDFN). The WRRB issued a report in October 2010 with 60 recommendations for management of Bathurst caribou and adjacent barren-ground caribou herds (Bluenose-East, Beverly, and Ahiak; WRRB 2010). Those recommendations generally agreed with measures in the revised

TG – ENR-GNWT joint management proposal. In October 2010, ENR signed an agreement with YKDFN that included tags for 150 Bathurst caribou, also with a sex ratio of 80% bulls. In spring 2013, WRRB recommended that short-term harvest of Bathurst caribou remain limited to 300 caribou and 80% bulls, and extended its 2010 recommendations for Bathurst caribou through the 2013-2014 hunting season.

C. Bathurst caribou status in 2013

Based on a calving ground photo-survey conducted in June 2012, there is an estimated 35,000 caribou in the Bathurst herd. This is similar to the 2009 estimate of 32,000 caribou (Figure 1). The estimated number of breeding females was similar but slightly lower in 2012 (~15,900) compared to 2009 (~16,600).

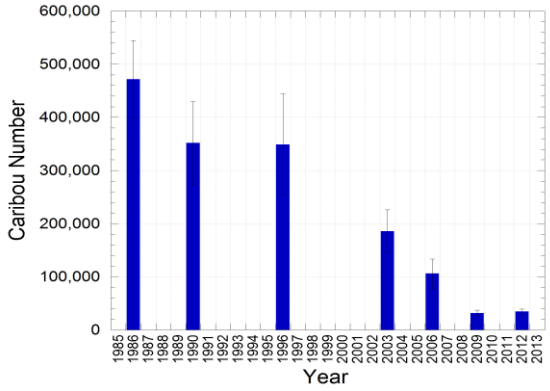

Figure 1. Population trend of Bathurst herd

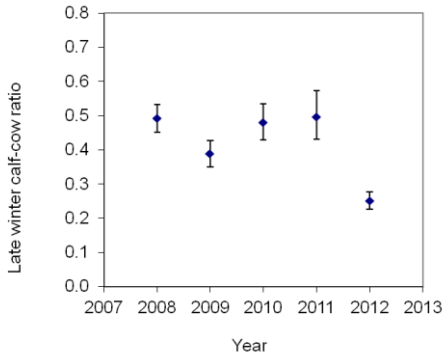

Figure 2. Trend in calf:cow ratios

Demographic analysis and simulation modeling of field data estimated that the 2012 cow survival rate was about 78%, which is improved compared to 2009, when survival was inferred to be ~ 67% (Boulanger et al. 2011). Late winter calf:cow ratios were relatively high from 2008 to 2011 (35-50 calves:100 cows) but below 30:100 in 2012 (Figure 2). Overall, the 2012 calving ground survey suggests that the Bathurst herd has stabilized but is not yet showing any clear signs of population growth and recovery. In fact, the low estimates for both cow survival and calf recruitment in recent years suggests a slow decline in abundance of breeding females (Boulanger 2013; Appendix 3), and little potential for population growth over the short term.

D. Effectiveness of management actions 2010-2013

The goal and objectives established in the 2010 joint TG-ENR management proposal (pp. 13-14) are listed below.

> ***Goal:*** *For the Bathurst herd, the short-term goal is to shift from a declining trend (2006-2009) to a stable trend from 2010 to 2012, by maximizing survival of cows and calves. TG and ENR-GNWT recognize that some factors affecting caribou numbers are not readily subject to management control. In the longer-term, the goal is to promote the herd's recovery to a size and trend where sustainable harvesting sufficient to meet all interests is again possible.*

Objectives for the Bathurst herd:

1. A stable trend in numbers of breeding cows on the calving grounds 2010-2012, based on annual reconnaissance surveys in 2010, 2011 and 2012, and a population photo-survey in 2012.

2. An average late winter (March-April) calf:cow ratio between 2010 and 2012 of at least 40 calves: 100 cows.

3. A total hunter harvest target of 300 ± 10% in any year, with at least 80% bulls, for the entire herd.

4. A total wolf kill of 80-100/year in the Bathurst range.

While the main objective of a stabilized trend in the size of the herd population was achieved, population indicators do not yet suggest that recovery is occurring so the herd is still vulnerable. Two important lessons from detailed analyses of the Bathurst herd data are: a) the herd may decline further even with no harvest, if it is subject to subsequent years of low productivity (number of calves born to breeding females) and recruitment (number of calves surviving to become yearlings); and b) the herd has little chance of stabilizing or recovering with substantial and continual harvest of breeding females. Nevertheless, a stable population trend is a vast improvement over the rapid decline observed from 2006 to 2009. This stability suggests that short-term management actions recommended by TG & GNWT-ENR and enacted following WRRB recommendations, and the harvest agreement with YKDFN were effective. This is primarily due to implementing the harvest target, which reduced mortality from hunting and improved cow survival. Improved calf recruitment for some years also contributed to the stabilizing trend. Although stabilization of herd trend is good, herd recovery will require continued harvest management and multiple years of good adult female survival, calf production and calf survival.

The objective of sustained high calf recruitment of at least 40 calves per 100 cows between 2010 and 2012 was not met; the trend from 2008-2011 was positive but ratios were lower in 2012 and 2013 (Figure 2). Calf productivity and recruitment are influenced by environmental factors such as timing of spring green-up, biting insect harassment levels through summer, and condition of cows during the fall breeding season and so may not reflect the harvest or predator management actions taken since 2010.

The objective of reducing the total harvest of Bathurst caribou to 300 or less was met. The reported NWT harvest of Bathurst caribou was below 300 in each of the winters of 2009-2010, 2010-2011, 2011-2012 and 2012-2013 (Appendix 1). Harvest was bull focused. This is greatly reduced from an estimated 4000-7000 cow-focused harvest in 2008-2009 (see Boulanger et al. 2011). However, there is uncertainty around the true level of harvest of the Bathurst herd and it is likely that the reported harvest is an under-estimate. A limited Bathurst harvest occurs annually in Nunavut, with an allocation of 70 bulls for sport hunters each year. In addition, there is likely wounding loss, some unreported winter harvest and some wastage. The low number of Bathurst collars (all on cows) added to the uncertainty around harvest on the winter range, particularly in areas of overlap with the Bluenose-East herd.

The objective of an annual kill of 80-100 wolves on the Bathurst range was not met between 2010 and 2013. In the winters of 2009-2010, 2010-2011, 2011-2012, and 2012-2013, incentives of $400 for well-handled wolf pelts and $200 for wolf carcasses resulted in totals of 19, 41, 80, and 56 wolves taken, with most of these near community dumps and elsewhere in the NWT (east of Great Slave Lake). It is highly unlikely that enough wolves that prey on Bathurst caribou were killed to improve survival of Bathurst caribou cows and calves.

In addition to the goal and objectives specific to the stabilization of the Bathurst herd, the 2010 TG-ENR joint management proposal recognized the need to manage the Aboriginal harvest in a manner respectful of the Tłı̨chǫ Agreement and traditional ways, and to engage Tłı̨chǫ and other Aboriginal harvesters in monitoring and managing the harvest.

> *Although the main focus of the original and revised proposals remains on actions to stabilize declining caribou herds, TG and ENR-GNWT through their joint meetings reviewed and recognized the importance of the long-standing cultural and social relationship between caribou and Tłı̨chǫ and other northern Aboriginal peoples. Management of the Aboriginal harvest must happen in ways that re-build traditional respect for caribou, other wildlife, and the land itself, and in a manner that empowers Tłı̨chǫ communities to implement the Tłı̨chǫ Agreement through self-regulating and monitoring their collective hunting behaviour.*

Some progress was made toward these goals through close collaboration between ENR-GNWT and TG that focused on implementing community-based monitors, check-stations, health and condition monitoring, and a continuing series of workshops and meetings. Over the past two years, the Tłı̨chǫ Government has been building community capacity to work on caribou co-management and increase hunter participation in caribou sampling and health monitoring. The DCLP held an on-the-land training workshop with 12 community members and conducted a follow-up workshop in winter 2013 to finalize monitoring protocols. This was followed by a second 'train the trainer' on the land camp in April 2014. With technical support from ENR-GNWT, the DCLP has established and maintained strong communication with community members about the results of the work. Complementary traditional knowledge studies on caribou health have also been conducted in the past two years by the DCLP. These activities remain works in progress, but are an important priority and should be continued.

E. Management context and proposal scope for 2014-2019

When short-term management actions for the Bathurst herd were undertaken in 2009-2010, neither a management plan for the herd across its range in Nunavut, NWT and Saskatchewan nor an overall governing board were in place. This remains true in 2014. The herd's range encompasses many communities and includes areas with and without settled land claims. The Tłı̨chǫ Agreement has a requirement for the WRRB, TG, GNWT, and Canada to develop an overall long-term management planning process for the herd. This process is to be developed with those that have jurisdiction over any part of the Bathurst range and with Aboriginal peoples who traditionally harvest the herd. Initial organizational meetings to define this long-term process were held in 2012 and work continues to develop a comprehensive approach to managing the Bathurst herd. TG and ENR-GNWT are committed to continued collaboration with the WRRB and other partners to develop the comprehensive management proposal. That process may include provisions for monitoring and management of harvest and predators, as well as for management of development, caribou habitat, and other factors affecting caribou. Other management proposals like this one may contribute to and should directly align with the comprehensive management process, but are not intended to pre-empt any part of the comprehensive planning process for the Bathurst herd.

In recognition of the importance of habitat conservation and management, and in light of the scale of current and proposed development on the Bathurst herd's annual range, work to develop a range plan for the Bathurst herd was initiated by ENR-GNWT in 2013. The range plan will provide specific guidance on how to monitor, assess and manage cumulative effects

of human disturbance on the historic range of the Bathurst herd. This plan is being developed through a multi-partner collaborative process that will eventually need to be included under the comprehensive process required by the Tłı̨chǫ Agreement. In addition, ENR has begun work with partners to develop a cumulative effects monitoring program for wildlife and wildlife habitat in the Slave Geological Province (GNWT 2013; also see Greig et al. 2013). This program is caribou focused and will support the range plan, environmental assessments, and cumulative effects assessments related to the Bathurst herd.

This proposal and the 2010 proposal were undertaken to address key short-term monitoring and management needs, primarily resulting from the Bathurst herd's rapid decline to 2009 and subsequent stabilization in 2012. The timeframe for this proposal is 5 years (2014 to 2019) with the understanding that management may be adapted as new information becomes available (e.g., release of population updates based on scheduled calving ground photographic surveys in 2015 and 2018). In particular, recommendations on harvest will be re-assessed following results from population surveys.

Guidance for the management and monitoring of the Bluenose-East herd is primarily found within the Advisory Committee for the Cooperation on Wildlife Management's draft management plan for the Cape Bathurst, Bluenose-West and Bluenose-East herds. Similarly, guidance for the management and monitoring of the Beverly herd is primarily found within the Beverly and Qamanirjuaq Caribou Management Board's draft management plan for the Beverly and Qamanirjuaq herds. If management proposals to the WRRB are needed for these herds, they will be made separately.

4. Description of Proposed Management Action

- **Describe the proposed management action, including implementation, location and Tłı̨chǫ Citizen involvement.**
- **What are the desired outcomes of the proposed management action?**
- **What, if any, outcomes may be incidental to the management action?**
- **What monitoring, if any, will be conducted to assess the effectiveness of the management action?**

This proposal continues the general management and monitoring recommendations for barren-ground caribou in Wek'èezhìi that were described in the May 2010 proposal (see Table 1), but its specific focus is to continue and improve short-term management and monitoring actions for the Bathurst herd. Resilience of the Bathurst herd is low, due to a combination of small population size and relatively low rates of adult female survival (< 80%) and calf recruitment (<30 calves per 100 cows) (Boulanger 2013, Boulanger et al. in press).

This proposal's focus is to promote recovery and growth of the Bathurst caribou herd. The specific goal of the proposal is to increase the number of breeding females in the herd, which will be assessed following the next two calving ground surveys (scheduled for 2015 and 2018) and via other monitoring. The sections that follow describe the three main elements of this proposal: (A) hunter harvest, (B) wolf harvest, and (C) monitoring.

A. HARVEST RECOMMENDATIONS FOR THE BATHURST CARIBOU HERD

Rationale in the May 2010 proposal for reducing total harvest of Bathurst caribou (including Aboriginal harvest) and recommending a harvest target of 300 animals was based on detailed analyses and modeling of field data that indicated the decline of the herd was driven by

increasing negative trends in adult female and calf survival rates and possibly reduced fecundity (Adamczewski et al. 2009, Boulanger et al., 2011). Boulanger et al. (2011) also concluded that the estimated annual harvest (~4000-7000 caribou) may have accelerated the decline because a constant total harvest from a declining herd actually increases proportionally over time. *"The modeling also raised the possibility that the Bathurst herd might decline further even with no harvest, as shown by low productivity parameters in recent years. In addition, the herd had almost no chance of stabilizing or recovering with any substantial continuing harvest of breeding females"* (Boulanger et al., 2011, p. 894).

The suspension of all harvesting in 2010, followed by implementation of a harvest target of 300 caribou (80% bulls), likely played a key role in halting the steep population decline by improving the survival of adult cows. Although the direct estimate of adult female survival is imprecise due to small sample size, modeling of demographic data suggests that the survival rate increased from ~69% in 2009 (Boulanger et al. 2011) to ~78% in 2012 (Boulanger 2013). Based on recent analyses of Bathurst herd data (Boulanger 2013, Boulanger et al. in press; and see Adamczewski et al. 2009 and Boulanger et al. 2011), TG and ENR-GNWT recommend that harvest of Bathurst caribou should continue to be managed conservatively:

- Current Bathurst cow survival rates appear to be ~78% which is below the desirable level of ~85% for a healthy and stable herd. High adult female survival is a key parameter for herd recovery. Causes of lower female survival rates in the Bathurst herd are unknown.
- The ability of a caribou herd to grow and recover also depends on productivity and recruitment, which are a function of the number of calves born and their survival rate during the first year of life. Herd growth requires that the number of healthy young caribou recruited into the herd each year is greater than the annual rate of mortality. The annual rates of pregnancy in breeding-aged females and calf survival are strongly influenced by environmental conditions and can vary from year to year. More-likely-than-not, the Bathurst herd is in a slow decline given the estimated low adult female survival and low calf recruitment observed from composition surveys in recent years.
- Stochastic model simulations suggest that large increases in adult female survival and calf recruitment will be needed for the herd to recover. Thus, in combination with harvest management, a concerted effort to improve caribou survival through predator management is also warranted to improve the likelihood of recovery and hasten the rate of recovery.
- More-likely-than-not, the time period required for meaningful recovery and growth of the Bathurst herd (e.g., for the herd to grow to double the size of the 2009 calving ground estimate) will require favorable conditions for 10 years or longer. It is important for all people with an interest in hunting the Bathurst herd to understand that management actions and a conservative hunting strategy will be required for many years. This suggests that governments, Aboriginal communities and other stakeholders will need to continue to work collaboratively to ensure conservation and recovery of the herd, and address the tradeoffs and hardships that accompany harvest management restrictions.

In consideration of these key points, and based on the updated technical review of Bathurst herd data (see Adamczewski et al. 2009, Boulanger et al. 2011, Boulanger 2013, and Boulanger et al. in press), we suggest that the current harvest target of 300 Bathurst caribou – 80% bulls (240) and 20% cows (60) – be maintained until the next calving ground survey is conducted (scheduled for 2015) and data are re-evaluated (estimated for early 2016). The

proposed allocation would be 150 for Tłı̨chǫ Citizens and 150 for other Aboriginal harvesters with Aboriginal or treaty rights who traditionally harvest in the area. Estimates of the number of breeding females, herd size, and other factors will be considered to explore potential changes in harvest recommendations following release of survey results.

The scope of the harvest management recommendations outlined in this proposal is based upon technical review of available data for the Bathurst herd and consequently is limited to consideration of a total harvest target and the sex composition of the harvest. However, any future increase of the recommended harvest will have to consider allocation among all Aboriginal peoples who traditionally hunted the Bathurst caribou in Wek'èezhìi' (i.e., Tłı̨chǫ, YKDFN, and others). It will likely be contingent on TG and ENR-GNWT to develop a strategy for addressing caribou harvest allocation through consultation with appropriate representatives from Aboriginal groups.

Respecting the Caribou

As part of harvest management for the Bathurst herd, ENR and TG suggest that an area where further effort is needed is hunter education, with an emphasis on promoting traditional practices of using all parts of harvested caribou and minimizing wastage. Below are a few extracts from the consultation meetings that took place leading up to the Draft Bathurst Caribou Management Plan of 2004.

> *"People do not do things without the caribou being aware of it. We depend on the caribou and so, when we will kill a caribou, we show respect to it. If we don't do that and we don't treat them really well, the caribou will know about it."* (Rosalie Drybones, Gameti. 1998).

- *"People should know how to think and talk respectfully about caribou."*
- *"People should respect caribou as gifts from the Creator."*
- *"All people should have knowledge of the caribou to respect caribou. This means knowing caribou behavior as well as how to think and talk about caribou."*
- *"Hunters should not be too particular when hunting caribou."*
- *"Caribou should not suffer in death."*
- *"Hunters must not boast about their harvest."*
- *"It is important to use all parts of the caribou and waste nothing."*
- *"People must care for the stored meat and discard bones and other unused parts in a manner that will not offend the caribou."*
- *"The relationship between the people and the caribou is based on mutual respect."*
- *"The rules about caribou respect are meant to be obeyed."*

Under the GNWT Wildlife Act

> **57.** (1) Subject to the regulations, no person shall waste, destroy, abandon or allow to spoil
>
> (a) big game, other than bear, wolf, coyote or wolverine, or an upland game bird that is fit for human consumption; or
>
> (b) a raw pelt or raw hide of a fur-bearing animal or bear.

Suggested Education/Public Awareness Initiatives:

- ENR and TG will work with the communities, in particular working more closely with the school systems, on promoting Aboriginal laws and respecting wildlife, including how to prevent wastage.
- Invite elders to work with the youth to teach traditional hunting practices and proper meat preparation.
- Posters, pamphlets, media and road signs will be used to better inform the public about respecting wildlife, traditional hunting practices, wastage, poaching and promoting bull harvest.

B. WOLF HARVEST

The May 2010 proposal recommended increased harvesting of wolves on the Bathurst range to reduce mortality of caribou due to predation by wolves. Financial incentives for prime pelts ($400) and carcasses ($200) were used to increase harvest of wolves on the Bathurst winter range by 80 to 100 wolves. Wolf harvest was monitored annually. This program had limited success in meeting the 2010 joint proposal objective and it is unlikely that survival rates of adult and calf caribou were meaningfully altered. The total numbers of wolf carcasses reported in the North Slave Region in 2009-2010, 2010-2011, 2011-2012, and 2012-2013 were 19, 41, 80, and 56 respectively (average 49/year; Appendix 2). Of the 196 wolves harvested in total, 47 were associated with dumps or sewage lagoons, 49 were taken from where collared Bathurst cows have not occurred in recent years (i.e., east of Great Slave Lake in areas near Artillery Lake, Reliance and Lutsel K'e), and 20 were in the Yellowknife area (Appendix 2).

Despite the limited success of wolf harvesting efforts to date, TG and ENR-GNWT continue to recommend management actions to increase and sustain an elevated annual harvest of wolves on the Bathurst winter range. If conducted effectively and for multiple years in combination with harvest management, management actions that sufficiently reduce predator density are predicted to increase caribou survival and calf recruitment, which would contribute to increased herd growth and recovery (Gasaway et al. 1993, Hayes et al. 2003). In additional to addressing concerns about wolf predation on caribou, this recommendation will also address concerns from Tłı̨chǫ people who report that wolves are abundant and increasing in and around communities (workshop discussions in Gameti, February 2013, and Yellowknife, December 2013).

Community-based wolf harvesting program

Recognizing the general principle that "communities should play an important role in the management of wolves, including sharing local and traditional knowledge about wolves" (Yukon Government 2012), initial discussion among staff from TG and ENR-GNWT and Tłı̨chǫ community representatives have resulted in the following elements being proposed for developing and implementing a community-based wolf harvesting program to address the real and perceived aspects of this human-wildlife conflict.

- The basic premise is that Tłı̨chǫ communities will have meaningful input into deciding how to hunt and trap wolves in a culturally respectful manner, selecting candidates (including interested youth) who will be trained in effective field techniques for hunting/trapping wolves, skinning, and fur preparation, and identifying appropriate locations away from communities for skinning and processing wolf carcasses. Selected individuals will receive training from recognized expert wolf hunters/trappers and/or potential expert instructors. GNWT would develop, coordinate, and provide the training workshops.

- The program will be attempted as a pilot project in winter 2015 with the community of Wekweeti, where 3 to 6 selected individuals will participate in one or more training workshops. Alternatively, or in addition to training workshops, an expert wolf hunter/trapper would be hired to come to the community for a specified time and mentor Tłıchǫ harvesters in the field. Wolf harvesting would initially focus on areas close to the community, with harvest effort extending further from the community and directed according to the known distributions and movements of collared Bathurst caribou and locations of collared wolves. Financial resources (from TG and GNWT) would be made available to support purchase of fuel and supplies for trained wolf hunters only, with mandatory reporting of wolf harvesting effort and success. Financial incentives for harvested wolves would be maintained, i.e., $400/wolf pelt (prime pelts, properly skinned and prepared) & $50/skull for all GHLs.

- Depending on available resources, an additional workshop could be held in one other Tłıchǫ community in fall 2015 or winter 2016, with remaining Tłıchǫ communities completing the training by winter 2016. This would result in a core group of trained and experienced wolf hunters in each of the Tłıchǫ communities who would be active and effective in the field and capable of training other interested hunters and trappers in the community.

- Based on the level of success, interest, and capacity developed through the community-based wolf harvesting program, a more extensive wolf management program involving Tłıchǫ wolf hunters and trappers may be developed with TG and ENR-GNWT to increase wolf harvesting over the winter range of the Bathurst herd for multiple years, as part of an adaptive management project to reduce wolf densities and improve Bathurst caribou survival and recruitment.

In addition to training Tłıchǫ hunters as part of a community-based wolf harvesting program, recommendations from the communities and governments were made to extend wolf hunting opportunities and incentives to Northwest Territories residents and non-residents (i.e., guide-outfitters). Changes will be made to the Mackenzie Valley Fur Program to allow licenced NWT resident hunters to be eligible for wolf fur incentives to encourage wolf harvesting. The opportunity for guided outfitters to hunt wolves on the Bathurst range is already in place.

C. MONITORING OF BATHURST CARIBOU HERD

1) Monitoring under 2010-2013 Tłıchǫ-ENR caribou proposal

Monitoring proposed in the 2010 joint Tłıchǫ-ENR caribou proposal is summarized in Table 1. Monitoring consisted of three main components: (1) biological monitoring of the Bathurst caribou herd, (2) monitoring of caribou harvest, and (3) wolf monitoring. 2010 WRRB recommendations generally supported the proposed monitoring actions. In this proposal, the three monitoring components are summarized in following sections, each with an assessment of monitoring 2010-2013 and modified monitoring proposed for 2014-2019.

2) Biological monitoring for the Bathurst herd 2014-2019

Biological monitoring of the Bathurst herd 2010-2013 included 6 main elements:

(a) Annual reconnaissance surveys on the calving grounds in June as an index of the numbers of breeding females;
(b) Estimates of the number of breeding females & herd size every 3 years;

(c) Annual composition surveys in late winter (Mar/April) to estimate recruitment of calves;
(d) Fall composition surveys during the rut (October) every 3 years to estimate bull:cow ratios, and to estimate calf:cow ratios as relative index of summer mortality of calves;
(e) Composition surveys on the calving grounds every 3 years (part of population surveys) to estimate female productivity; and
(f) Annual assessments of condition in hunter-killed caribou.

Although not specifically listed in Table 1, the information provided by 12-20 satellite-collared female caribou was also a key element in monitoring the herd.

In general, these monitoring actions were carried out successfully. Estimates of herd size and numbers of breeding cows were derived in June 2012 from a calving ground photographic survey and reconnaissance surveys provided an index of breeding cow numbers in 2010 and 2011. Late-winter recruitment surveys were carried out in 2010, 2011 and 2012, and fall composition surveys in 2011 and 2012. A composition survey on the calving ground in June 2012 was carried out as part of 2012 population survey. Some condition assessment from hunter-killed Bathurst caribou has been collected each winter via Tłıchǫ hunters and community-based monitors but sample numbers have been small.

A similar schedule of population surveys and other surveys is proposed for 2014-2019 (Table 1), with the understanding that monitoring may be changed in an adaptive manner as new information becomes available. The Tłıchǫ Government is leading a program to collect more comprehensive information annually on condition in hunter-killed caribou.

A key change in monitoring proposed for 2014-2019 is an increase in the number of satellite-collared Bathurst caribou from a maximum of 20 cows to 50 in total with 30 collars on cows and 20 collars on bulls. The placement of collars has always been a controversial issue with the Tłıchǫ (and other Dene) with a decision being made in 2007 under the guidance of Elders, to maintain 20 collars on the herd. The Tłıchǫ are particularly concerned with collars on cows and how this 'disrespects' the animal and may affect their ability to reproduce. After extensive consultation with the Tłıchǫ communities and Chiefs Executive Council, agreement has been reached to increase the number of collars on cows to 30 and 20 on bulls. The rationale is that increased collars on bulls will help to reduce harvest of cows by directing hunters to where the bulls are. There is also recognition (in science) that our understanding of bulls is limited, and more collars may help to provide some insight in their movement and behavior. A detailed rationale for an increased number of Bathurst collars is provided in a supporting document (Appendix 4) and summarized as follows:

Most of the harvest of Bathurst caribou and harvest of caribou from the neighbouring Bluenose-East herd has been in winter, and in some winters (e.g., 2012-2013) the overlap of collared caribou from these two herds has been substantial. Collar locations of Bathurst caribou and caribou from neighbouring herds have also shown substantial variability from year to year (Figure. 3). Locations of collared caribou in relation to locations of hunter harvest of caribou have been essential for defining where the herds are and in assigning harvested caribou to an individual herd. In addition, a key focus of harvest management in the Bathurst herd has been to emphasize bull harvest over cow harvest. Numbers of radio-collared Bluenose-East caribou have varied but there have been up to 60 collars, including 12-15 on bulls, and have provided a more reliable definition of the herd's distribution. The ability to

define where the Bathurst herd is and assign and manage harvest reliably would be greatly improved if the number of collars on the herd increases from 20 to 50[i], and some of the collared caribou are bulls (20).

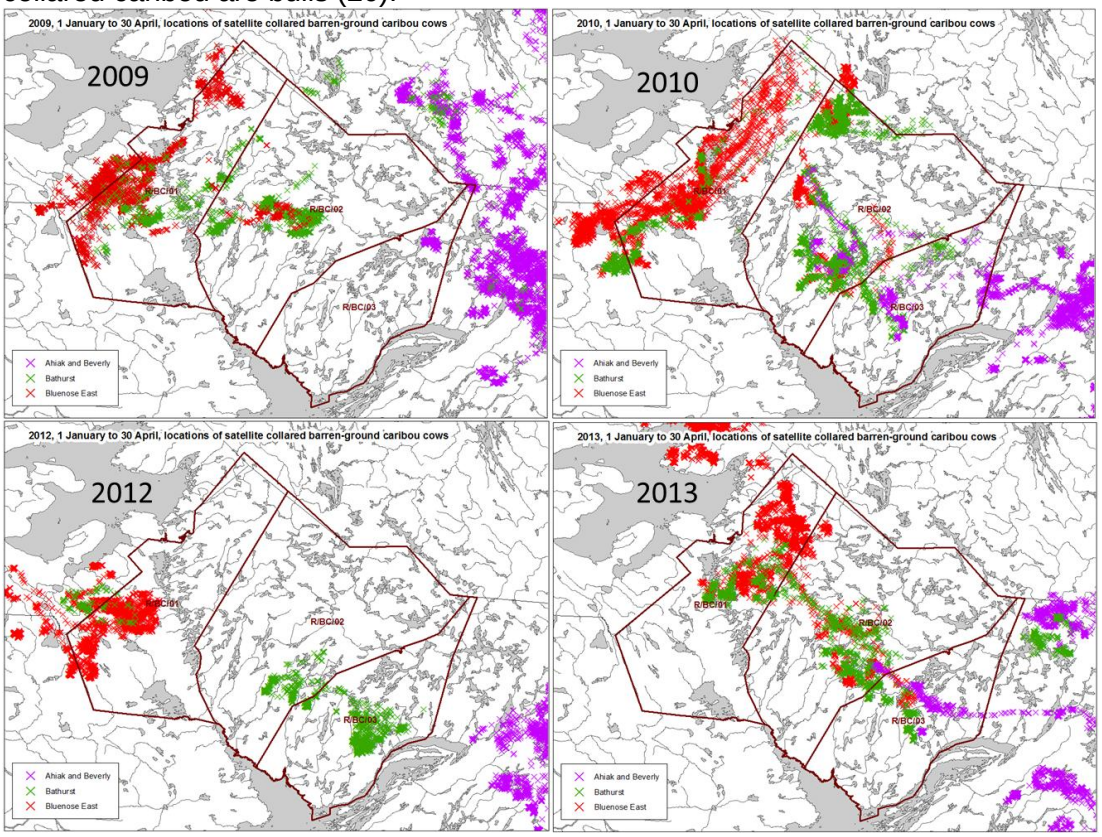

Figure 3. Cumulative winter distribution of radio-collared caribou in RBC01, 02 and 03 from 3 herds (Jan-April) in four years. Red=Bluenose-East, Green=Bathurst, Purple=Beverly and Ahiak. Maps A. D'Hont, ENR.

(a) Population trend in a caribou herd is strongly influenced by the survival rate of cows. Estimated cow survival rate in the Bathurst herd in 2012 was ~78% based on modeling (Boulanger 2013). In herds with larger numbers of radio-collars (e.g. Alaskan herds with 70-100 collared caribou), cow survival rates are estimated annually from radio-collared animals. Monitoring cow survival rate from the fates of radio-collared caribou, and understanding mortality patterns of cows, would be substantially improved if based on a larger number of collared female caribou (vs. the 12-20 Bathurst collars of recent years).

Estimates of cow survival from collars can be used to improve reliability of age ratio data collected during composition surveys. If increased numbers of collars are used to monitor adult female survival directly, the rate of population growth can be calculated annually when integrated with late winter calf recruitment data (see Decesare et al. 2011 and Hervieux et al. 2013). Annual estimates of population growth could then be used to confirm or modify harvest management decisions if it drops below some agreed upon threshold level.

3) Harvest monitoring for the Bathurst herd 2014-2019

Since 2010, monitoring of hunter harvest of Bathurst caribou has been carried out by a combination of community monitors, ground and aerial patrols by ENR wildlife staff, and estimates from Department of Environment staff in Kugluktuk, Nunavut. Much of the harvest has been during winter (December to April). The annual harvest target has remained at 300 caribou, with a bull focus (80%). Reported harvest has been mapped in combination with locations of collared caribou to assign harvest to the Bathurst, Bluenose-East, Beverly and Ahiak herds. An example of mapped harvest and collar information is provided in Figure 4. Reported harvest of the Bathurst herd was 213 in 2010-2011 (43% cows), 170 in 2011-2012 (19% cows) and 216 in 2012-2013 (38% cows) (Appendix 1).

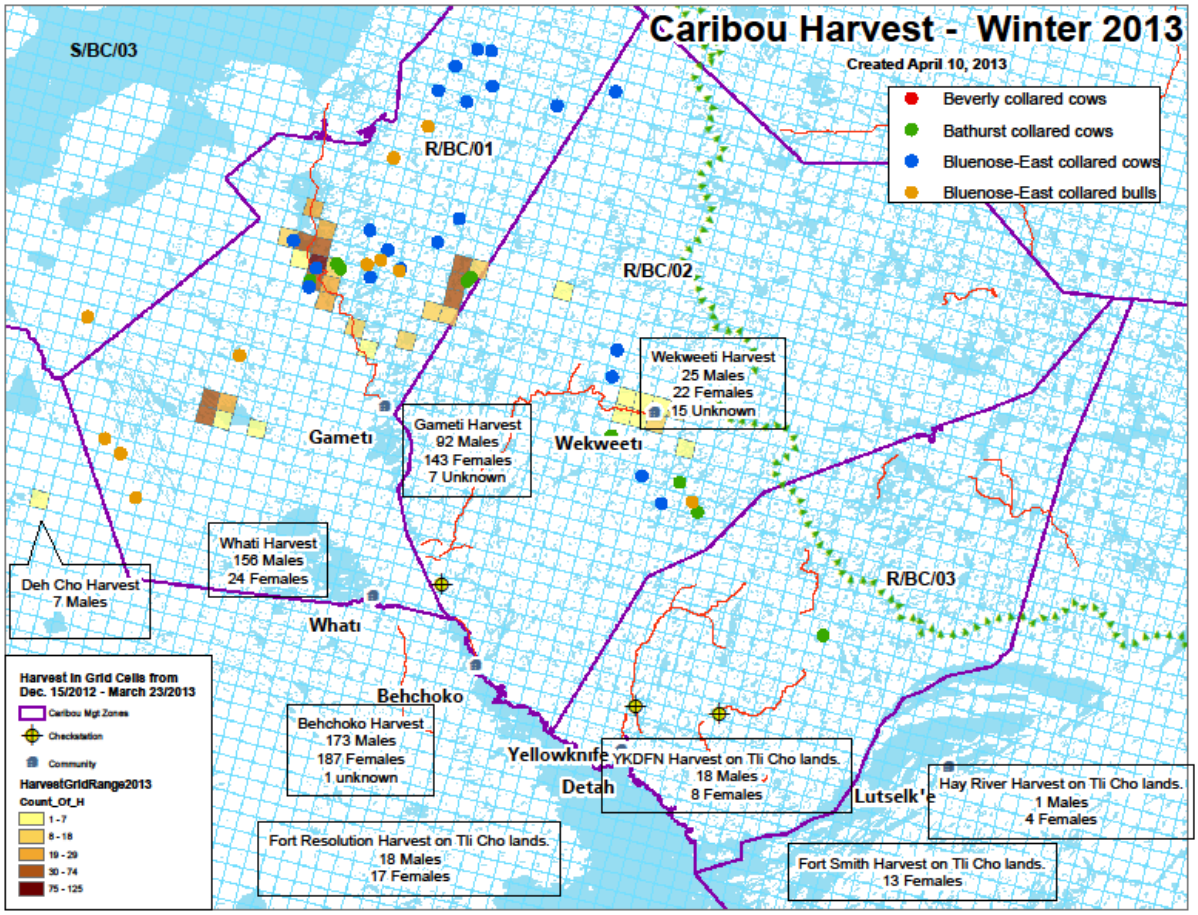

Figure 4. Distribution of collared caribou and distribution of hunter harvest in Wildlife Management Units RB/C/01, RB/C/02 and RB/C/03 in early April 2013. Map courtesy of B. Croft, ENR N. Slave Region.

Overall, the harvest monitoring and reported harvest numbers suggest that the objective of reducing the Bathurst harvest from an estimated 4000-7000 to 300, with an emphasis on bull harvest, was achieved. However, there is likely some unreported winter harvest and wounding loss in the NWT, and the sex ratio may not always be reliably reported. In addition, winter harvest of Bathurst and Bluenose-East caribou was estimated in large part based on collar locations, and the two herds have overlapped substantially on the winter range in some winters. Variability in winter distribution of the three herds has been substantial in recent years (Figure 4), and some collared Bathurst caribou have wintered in RB/C/01, where Aboriginal harvest is not restricted, in addition to RB/C/02 and RB/C/03 where the harvest target of 300 Bathurst caribou applies. The low number of Bathurst collars and the lack of collars on Bathurst bulls means that portions of the herd's distribution have not been reliably identified, and an unknown harvest may be occurring in winter.

In order to improve harvest monitoring, ENR and TG commit to developing a *Comprehensive Monitoring and Education Training Program.* Though further development of the program is required, the intent is for ENR and TG to further train Tłı̨chǫ people to take the lead on monitoring and where appropriate, enforcement on the land. This would include:

- Evaluation of current monitoring approach through a workshop with monitors and technical staff;
- Development of a more refined and detailed harvest monitor training program;
- More consistent communication between monitors and ENR and also TG, before, during and after hunting season;

A substantial increase in collar numbers would allow the herd's distribution to be defined more reliably. A more refined and flexible approach to managing the harvest, including revised management units defined with community involvement, could be developed if the distribution of the three herds was more definitive. Focusing on bull harvest would be enabled if areas with bulls were defined spatially.

4) <u>Wolf monitoring for the Bathurst herd 2014-2019</u>

Wolf monitoring for the Bathurst range 2010-2013 included continued monitoring of wolf abundance and productivity at dens on the southern edge of the Bathurst summer range, initiated in 1996 when the herd was at much higher numbers. These surveys suggest that wolf numbers on the Bathurst range, and the average number of pups at traditional den sites have declined substantially since 2005, likely as a result of the herd's decline, and remained low 2010-2013. ENR North Slave Region, in collaboration with University of Northern British Columbia, deployed 15 satellite collars on female wolves in 2013 to better understand movements and ecology of collared wolves.

ENR is planning to conduct a review of methods used in the NWT and elsewhere to monitor wolf abundance and distribution over time. One of the main objectives will be to explore the feasibility of a more robust and improved wolf monitoring program for the NWT. The review will include an assessment of the den survey methods in use since 1996.

A revised approach to increase wolf harvest on the Bathurst winter range by increasing hunting and trapping by residents of the four Tłı̨chǫ communities is described earlier in this proposal. Monitoring will involve reporting on the details of the program, including the numbers and locations of wolves taken and the effort made to harvest wolves.

5) Other monitoring and management actions related to Bathurst caribou

As with the 2010 joint TG-GNWT caribou management proposal, the current proposal is focused on relatively short-term monitoring and management actions for the Bathurst herd. TG and GNWT recognize that a more comprehensive approach to monitoring and management of the herd is needed. This approach may consider monitoring and studies of environmental and habitat variables that affect caribou abundance, and monitoring and management of cumulative effects of disturbance. While the initiatives described below are outside the scope of this proposal, they are referenced to signal the importance TG and GNWT place on them.

Monitoring and research on key environmental and habitat variables

Climate change, weather in all seasons, and other environmental variables affect caribou abundance and distribution. A better understanding of these factors and their effects on caribou is needed. Approaches to this could include the following:

- Annual monitoring of environmental and habitat conditions from remote sensing and climatology datasets. Identifying and tracking key variables for habitat, environmental and climatic conditions on the Bathurst range. Environmental conditions should be monitored as they may affect caribou population dynamics through reduced calf recruitment or adult survival especially in years with severe winter conditions or poor summer growing conditions (Hegel et al. 2010a and 2010b; Hebblewhite 2005; Chen et al. 2012). Indices of insect harassment (Witter et al. 2012) can be developed from summer weather indices. Climatic indicators collected at Bathurst range scale could build upon the analyses by Chen et al. (2012), with specific consideration given to the 25 candidate indicators that Russell et al. 2013, described as a 'caribou-relevant' dataset. The selected covariates could be included in OLS model analysis to further explore the effects of the environment and other factors on demography.
- Supporting current (Chen et al. 2012) and further research on environmental factors affecting caribou.
- Developing an overall strategy for caribou monitoring built around environmental and cumulative effects assessment. The impact hypothesis diagrams by Greig et al. 2013 (p. 50 and p. 70), provide a starting point and framework that links impact pathways of natural environmental and human-caused stressors to population demography in migratory barren-ground caribou. ENR initiated a process in 2013 to develop a cumulative effects monitoring program for wildlife and wildlife in the Slave Geological Province (GNWT 2013). Included in the process is identifying key monitoring and research needs, including those for Bathurst caribou and their range.

Range management planning

In 2013 ENR initiated a process to develop a range management plan for the historic range of the Bathurst herd, based on collaboration among governments, boards and other partners with responsibility for management of this herd. This process may include the following components:

- Creating or regularly updating geospatial databases on roads, mines, and other footprints along with a measure of activity (disturbance levels). Analyses may consider use of resource selection functions and step selection functions to test the influence of habitat conditions and anthropogenic footprint and industrial land-use activities on distribution, movement and migration of collared caribou.
- Defining management objectives (i.e., thresholds) for anthropogenic disturbance and habitat intactness (including fire management). Achieving these objectives may be

important for sustaining caribou herds in regional landscapes and across their historic ranges. This strategic perspective also recognizes that landscape planning has to include the likelihood that caribou will re-occupy larger areas as their abundance increases.

Comprehensive management process for the Bathurst herd

The Tłı̨chǫ Agreement has a requirement for the WRRB, TG, GNWT, and Canada to develop an overall long-term management planning process for the Bathurst herd with those that have jurisdiction over any part of the range and with Aboriginal peoples who traditionally harvest the herd. Initial organizational meetings to define this long-term process were held in 2012. TG and ENR-GNWT are committed to continued collaboration with the WRRB and other partners to develop the comprehensive management proposal. That process may include provisions for monitoring, and management of harvest, predators, development, caribou habitat, and other factors affecting caribou.

Table 1. Summary of monitoring actions and adaptive management options for Bathurst caribou herd proposed for 2014-2019 (updated from May 2010 'Revised Joint Proposal on Caribou Management Actions in Wek'èezhìi' – p. 21)

Part 1: Biological monitoring of Bathurst herd

Note: Items 1-6 similar to 2010 proposal (updated slightly). Item 7 has been used 2009-2012, but was not listed in 2010 table. Item 8 is new and would depend on increase in collar numbers.

Action	Indicator(s)	Priority	Rationale	Desired Response	Adaptive Management Options	How Often	Notes
1. Reduce annual cow harvest to <60	1. Numbers (density) of 1+ year old caribou on calving ground from reconnaissance surveys	1	Provides index of number of breeding cows on calving grounds; number of 1+ year old caribou correlated with number of breeding females.	Increasing trend in numbers of 1+ year old caribou on annual calving ground.	If trend in 1+ year old caribou is increasing, continue as before; if trend stable-negative, re-consider harvest and wolf harvest.	Annual (between photo-surveys)	Precision improved 2013 using 5-km spacing between flight lines.
	2. Estimate of breeding cows from calving ground photo survey	1	Most reliable estimate for abundance of breeding cows & can be extrapolated to herd size based on pregnancy rate and sex ratio.	Increasing trend in numbers of breeding cows by 2018.	If trend in breeding cows increasing, continue as before; if trend stable-negative, re-consider harvest and wolf harvest.	Every 3 years	Last surveys 2009, 2012, next in 2015, 2018. Trend in breeding females is most important for herd trend.
	3. Cow productivity; composition survey on calving ground in spring (June)	2	Relatively low calf:cow ratio in June 2009 – many sub-adult cows not yet breeding; establishes basis for potential calf recruitment through fall & winter.	High calf:cow ratio (80-90 calves:100 cows).	Low ratio indicates poor fecundity and poor nutrition in previous summer; survey data integrates fecundity & neonatal survival.	Every 3 years	Essential component of calving ground photographic survey.
	4. Fall sex ratio; composition survey (October)	2	Tracks bull:cow ratio; Bathurst ratio increased from 31-38 bulls/100 cows 2004-2009 to 57-58/100 in 2011-2012; prime bulls key for genetics, migration.	Maintain bull:cow ratio above 30:100.	If bull:cow ratio below target, reduce bull harvest. Fall calf:cow ratios indicate spring & summer calf mortality relative to June ratios.	Every 3 years	Needed for June calving photo survey – extrapolation to herd size. Provides fall estimate for calf:cow ratio.
	5. Calf:cow ratio in late winter (March-April); composition survey	1	Herd can only grow if enough calves are born and survive to one year, i.e., calf recruitment is greater than mortality.	>40 calves:100 cows on average.	If average calf:cow ratio ≥ 40:100, continue as before; if average ratio ≤ 20:100, herd likely declining; re-evaluate management.	Regular	Calf productivity & survival vary widely year-to-year, affected by several variables, including weather.
	6. Caribou condition assessment/pregnancy rate	2	Condition assessment provides overall index of nutrition/environmental conditions, estimate of pregnancy rate	High hunter condition scores (average 2.5-3.5 out of 4)	Poor condition or low pregnancy rate may indicate poor environmental conditions, possible decline	Annual	Sample numbers to date limited (2010-2013). TG working to improve program, sampling.
	7. Cow survival rate (estimated from OLS model - see Boulanger et al. 2011)	1	Cow survival estimated 67% in 2009, 78% in 2012 (from model). Need survival of 83-86% for stable herd.	Increase to 83-86% by 2018	If cow survival increases to 83-86%, continue as before; if survival stays below 80%, re-assess harvest & wolf management.	Regular	Population trend highly sensitive to cow survival rate; recovery will depend on increased cow survival.
	8. Cow survival rate (estimated from collars on 30 cows)	1	Cow survival estimated from 30 collared cows. Will improve knowledge of mortality patterns. A more robust and direct estimate of cow survival improves interpretation of age/sex ratio data from composition surveys.	Increase to 83-86% by 2018	If cow survival increases to 83-86%, continue as before; if survival stays below 80%, re-assess harvest & wolf management.	Annual	Population trend highly sensitive to cow survival; recovery depends on increased cow survival. Requires timely investigation of mortality sites of collared caribou to determine cause of death.

Part 2: Harvest monitoring of Bathurst herd & monitoring of wolves and wolf harvest

Note: Items 9, 10, 11 similar to 2010 proposal (updated slightly). Item 9a is new; confidence in accurate harvest reporting and management would depend on increase in collar numbers.

Action	Indicator(s)	Priority	Rationale	Desired Response	Adaptive Management Options	How Often	Notes
2. Track caribou harvest accurately	9. Numbers of cows and bulls taken by all hunters	1	Cannot assess effectiveness of management if harvest is poorly tracked; harvest well over target could lead to further decline.	Accurate harvest reporting & numbers within target limits (300 total & 80% bulls)	If harvest reports accurate & within target limits, continue as before; if harvest not tracked well or over limit, review/revise harvest reporting & management immediately	Annual	Reported harvest to date within/near targets. Uncertainty in true harvest due to wounding, unreported harvest, limited collars to define herd distribution and harvest, overlap with other herds.
	9a. Increased number of collared caribou from 20 to 65 (50 cows & 15 bulls)	1	Reduce uncertainty in defining winter herd distribution; improve confidence in assigning herd identity to hunter-kills and improve overall harvest management; provide a direct & more precise estimate of adult female survival	More reliable harvest management & improve datasets for OLS model analysis of population demography and key co-variables.	Develop options for implementing new management zones in collaboration with Tłı̨chǫ communities; has potential for improved zoning strategies that permit more flexible and effective harvest management.	Annual deployment of collars to maintain 50 on the herd	Tracking movements and locations of collared bulls (n=20) would assist in directing hunters to areas with bulls.
3. Reduce wolf predation on adult and calf caribou	10. Numbers of wolves killed/year	1	Wolves are main non-human predator on caribou; natural cow and calf survival rates should increase at low wolf numbers.	Increasing # of breeding caribou cows, increased cow survival. Annual wolf harvest increased to 80-100.	If cow numbers, survival increasing, continue as before; if trend stable-negative, re-assess harvest & predator management.	Annual	Experience in Alaska & elsewhere indicates need to remove significant numbers of wolves for several years to affect caribou survival rates.
	11. Wolf abundance	2	Index of relative wolf abundance	Declining trend in wolf abundance		Regular, pending wolf monitoring program review	ENR to review methods of monitoring wolf abundance. Input & collaboration from Dean Cluff.

5. Consultation

Describe any consultation undertaken in preparation of the management proposal and the results of such consultation.

The following communities will need to be engaged before the proposal is submitted to the WRRB. Consultation will also take place following the release of the WRRB recommendations and prior to implementation of the new proposal's recommendations.

The Tłı̨chǫ government has consulted with the 4 Tłı̨chǫ communities on the draft proposal (spring 2014), and the current draft reflects those consultations.

- North Slave: YKDFN, NSMA, LKDFN, Mountain Island Metis
  Sahtu: Deline.
- South Slave: Fort Resolution and Fort Smith, NWT Metis Nation
- Co-management boards: SRRB and WRRB.

6. Communications Plan

Describe the management proposal's communications activities and how the Tłı̨chǫ communities will be informed of the proposal and its results.

7. Relevant Background Supporting Documentation

List or attached separately to the submission all background supporting documentation, including key references, inspection/incident reports and annual project summary reports.

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8. Time Period Requested

Identify the time period requested for the Board to review and make a determination or provide recommendations on your management proposal.

Fall 2014 – Fall 2019 following the analysis of the scheduled June 2015 and June 2018 Bathurst calving ground photographic surveys.

9. Other Relevant Information

If required, this space is provided for inclusion of any other relevant project information that was not captured in other sections.

10. Contact Information

Contact the WRRB office today to discuss your management proposal, to answer your questions, to receive general guidance or to submit your completed management proposal.

John McCullum
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Wek'eezhii Renewable Resources Board
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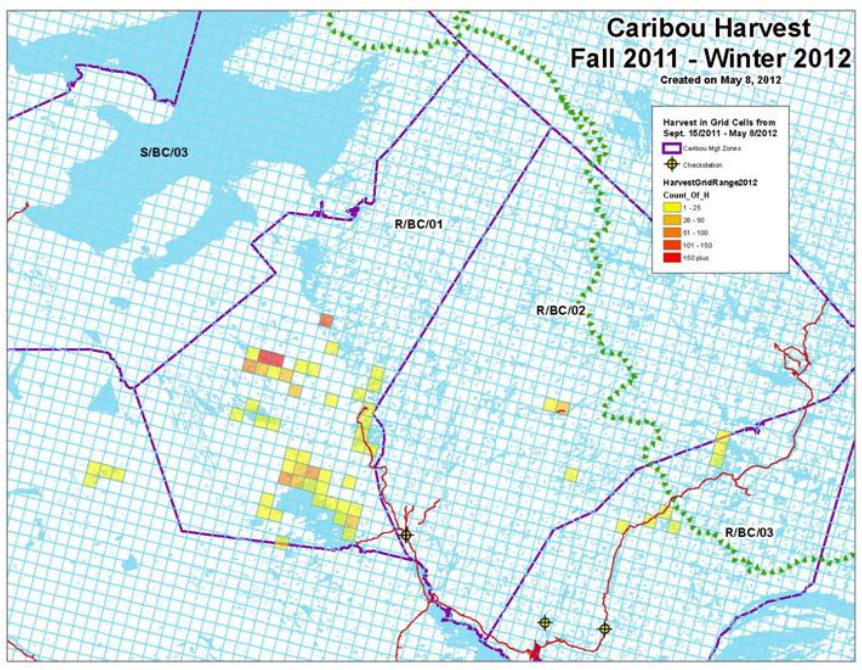
Appendix 1. Reported harvest of barren-ground caribou

(2010-2011 From Kerri Garner's PowerPoint)

Region	Bathurst 2010-11				Bluenose East 2010-11			
	M	F	C&U	**Total**	M	F	C&U	**Total**
Tłı̨chǫ	80	59	13	**152**	643	469	0	**1,112**
YKDFN	33	28	0	**61**	11	4	0	**15**
Sahtu							1200	**1,200**
Deline							600	**600**
Total	113	87	13	**213**	654	473	1800	**2,927**

Region	Bathurst 2011-12				Bluenose East 2011-12			
	M	F	C&U	**Total**	M	F	C&U	**Total**
Tłı̨chǫ	**29**	19	0	48	408	570	172	1150
YKDFN	**81**	6	0	87	35	97	0	132
Sahtu				0	9	110	181	300
Dehcho				0	27	7	0	34
Nunavut			35	35			150	150
Total	110	25	35	**170**	479	784	503	**1766**

Region	Bathurst 2012-13				Bluenose East 2012-13			
	M	F	C&U	**Total**	M	F	C&U	**Total**
Tłı̨chǫ	**25**	**22**	**15**	**62**	**743**	**540**	**123**	**1,406**
YKDFN	**54**	35	15	**104**	18	8	0	**26**
Sahtu					173	192	0	**365**
Dehcho					7	0	0	**7**
South Slave					19	34	0	**53**
Nunavut	**70**			**70**			705	**705**
Total				**236**				**2,562**



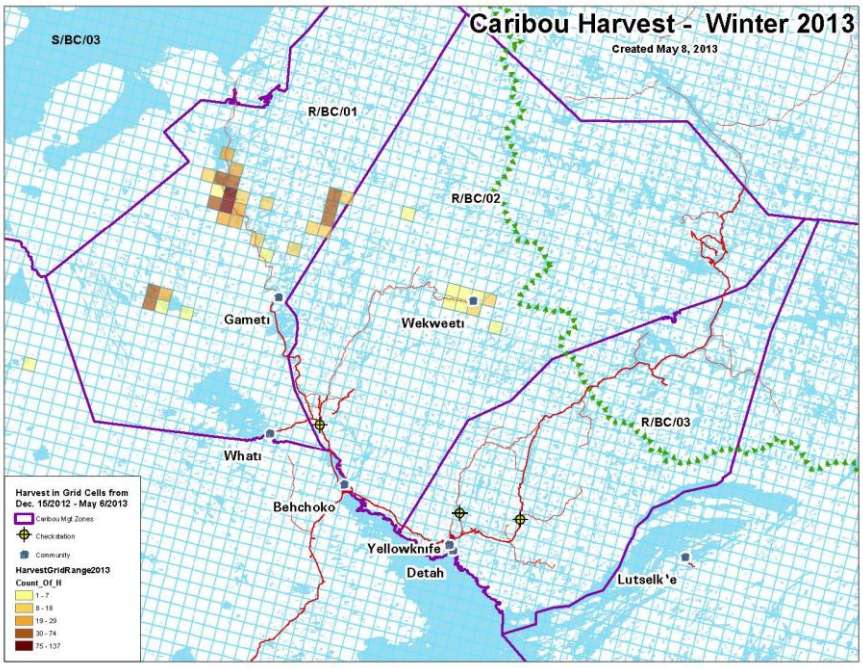


Fig. 5a and b. Mapped caribou winter harvest for 2011-2012 and 2012-2013. Darker 10x10km squares show higher harvest numbers. Maps B. Croft, ENR N. Slave Region.

Appendix 2. Wolf harvest monitoring

Wolf pelts harvested are reported through the Genuine Mackenzie Valley Fur Program on an annual basis as per the existing ongoing fur trapping assistance protocol. Wolf carcasses are either deposited at the local community wildlife office and/or provided directly to the ENR North Slave Regional Biologist for necropsy and basic health, condition and productivity analysis.

The wolf harvest results between 2010–2013 compiled by ENR North Slave Region are shown in Table 1. The previous Revised Proposal incorporated incentives to promote more wolf hunting. The effectiveness of the wolf harvest incentives are discussed under the Rationale section of this proposal.

Table 1: Wolf Carcass Collection in the North Slave Region

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

* harvest year occurs from 1 July to 30 June

Appendix 3. Supplemental Information

Boulanger, J. 2013. Simulations of bull-dominated harvest for the Bathurst caribou herd based on demographic projections from the 2012 calving ground survey. Draft Report, 23 January 2013. Submitted to Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

Simulations of bull-dominated harvest for the Bathurst caribou herd based on demographic projections from the 2012 calving ground survey

Draft January 23, 2013

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1. Introduction

The main objective of this report is to re-assess harvest strategies for the Bathurst herd based upon the results of the 2012 calving ground survey and subsequent reanalysis of the demographics of the Bathurst herd. The 2012 Bathurst calving ground survey documented a stabilization of breeding female estimates relative to results from the 2009 survey. Overall there was a slight decrease of estimated breeding females on the Bathurst calving ground, however, the reduction was within confidence limits of both the 2009 and 2012 estimates (
Figure 1) (Boulanger et al. 2013).

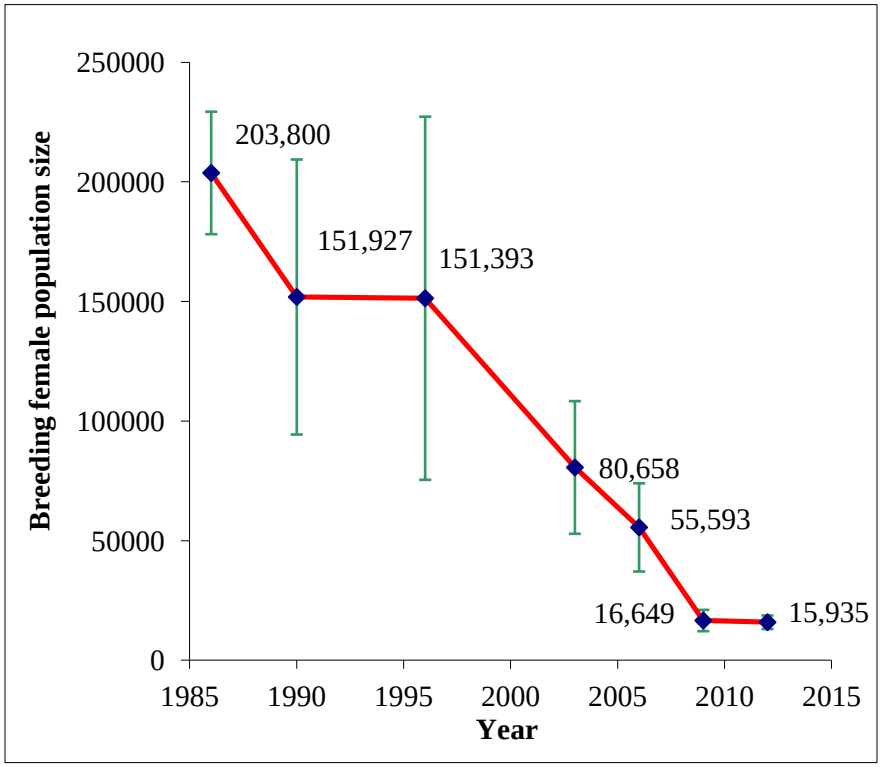

Figure 1: Estimates of breeding females on the Bathurst calving ground

During the interval between the 2009 and 2012 calf-cow ratios were measured each spring to estimate relative productivity of the herd (Figure 2). The calf-cow ratios that most directly correspond to the potential increase of breeding cows from 2009 to 2012 is the interval of 2008-2010 due to the period of

time it takes calves to mature to adult females. Calf-cow ratios suggested high productivity during this period.

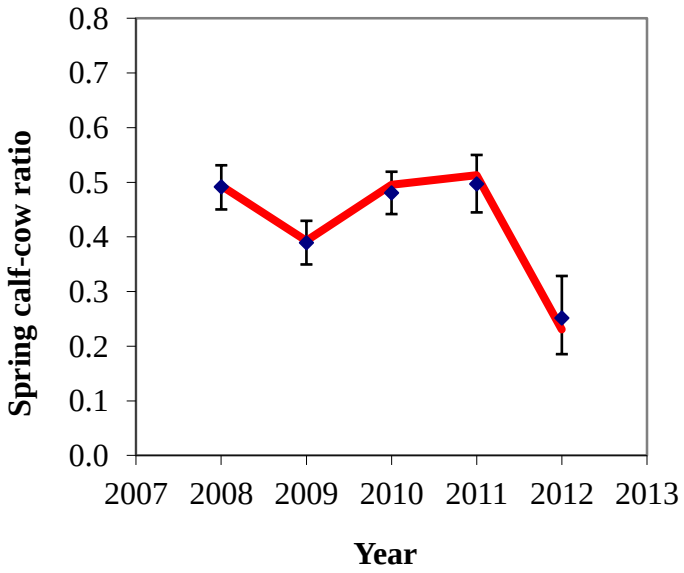

Figure 2: Calf-cow ratios from 2008 to 2012 for the Bathurst herd. OLS model predictions from Boulanger et al (2013) are shown as a red line.

An immediate question was why more breeding females were not observed on the calving ground given the relatively high productivity levels. This question was addressed using an OLS model which basically estimated the most likely adult survival level that would result in the 2012 breeding female estimate given observed levels of adult female productivity as detailed in (Boulanger et al. 2013).

Estimates of parameters from the most supported OLS model demonstrated temporal variation in calf survival and constant values for other parameters. Most notably, adult female survival was estimated as 0.78. Yearling survival was estimated also at 0.78, adult male survival at 0.71, and fecundity at 0.84 Calf survival varied from 0.68 in 2010 to 0.06 in 2012. Further analyses suggested that adult survival values from 0.75 to 0.82 were possible given uncertainty in the 2012 estimate.

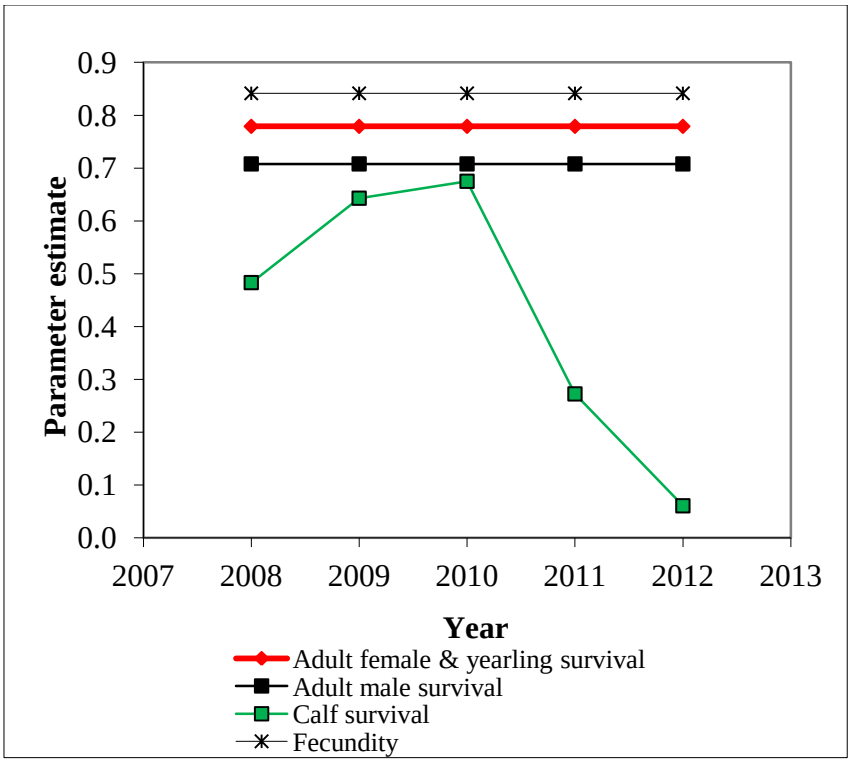

Figure 3: Estimate of demographic parameters from the OLS model (Boulanger et al. 2013)

The estimated cow survival rate of 0.78 was lower than the assumed cow survival of 0.87 used in the 2010 harvest model. The adult survival value of 0.87 assumed that once harvest levels (that approximated 3000-5000 cows per year) were removed there would be no further compensatory mortality of caribou resulting in survival values increasing to pre-harvest levels.(Boulanger and Adamczewski 2010, Boulanger et al. 2011).

Therefore, a key objective of the model was to re-assess dominant herd trend, and re-assess the relative effect of harvest on herd size.

1.1. A review of the stochastic model

A stochastic model is basically a simulation model that is run hundreds of times with variation in demographic parameters simulated. The advantage of using a stochastic approach is that the outcomes include a range of possible "futures" for the herd. In the natural world, calf survival, pregnancy rate, and other variables change from year to year. The outcomes of stochastic modeling identify the most likely trends under a particular set of conditions, but they also make clear that there is uncertainty around those likely trends.

The main objective of this exercise was to use the stochastic model as an aid in setting management targets (i.e. herd sizes), and objectives while appropriately considering the uncertainty caused by natural variation in population parameters. Given uncertainty in Bathurst demography, any management of the Bathurst caribou herd should be adaptive with management goals that respond to future information on productivity, harvest, and other demographic indicators. Therefore, the model also generates predictions

of all applicable demographic indicators as well as ranges of future herd sizes. The specific objectives of this exercise were as follows:

- Assess overall risk associated with various management actions and population level targets as a function of natural variation in herd productivity and hypothetical harvest levels.
- Assess the probability of future herd sizes as based upon management objectives as well as the power to detect changes in population size. The monitoring interval between surveys is explicitly considered since this affects the power to detect population change.
- Predict field-based estimates of fall bull-cow ratios, calf-cow ratios, and breeding female numbers to be used in an adaptive management context to further refine management goals and simulations as more data become available.

2. Methods

The methods used for the stochastic model are detailed in earlier reports (Boulanger and Adamczewski 2010) and manuscripts(Boulanger et al. 2011). In this report I review the main methods but suggest that earlier reports are reviewed for details.

2.1. Estimates of base survival based upon 2012 OLS model survey results.

For the purpose of simulations, the point estimate of 0.78 for adult female survival was used, with sensitivity analyses conducted in which adult female and yearling survival was set at values from 0.75 to 0.82. In general, OLS model estimated yearling and adult female survival to be similar. Bull survival was set

2.2. Scenarios of adult productivity

Productivity of the herd was estimated using estimates of fecundity and calf survival from the OLS model (Table 2 and Figure 1). The 2007-12 period corresponded to the overall productivity in the past 5 years, whereas the 2007-10 and 2011-12 period corresponds to the recent lower and higher estimated productivity levels.

Table 2: Productivity scenarios considered in simulation based on estimates of OLS model from Boulanger et al 2013.

Period	Fecundity	Calf survival	Productivity
2007-12	0.842	0.452	0.380
2007-10	0.842	0.606	0.510
2011-12	0.842	0.166	0.140

Monitoring of productivity is an essential step of adaptive management. If productivity levels that are substantially different than levels simulated are observed in the next few years than further productivity scenarios could be run to further focus simulation model outcomes.

2.3. Process variation in demographic parameters

Boulanger et al. (2010) estimated biological or process variation in demographic parameters (Table 3). Process variance is basically the amount that parameters vary by individual and on a yearly basis. For example, factors such as weather and range condition will influence fecundity and calf survival. By

analyzing the time series of productivity estimates from the Bathurst herd it was possible to estimate both yearly and individual variation. These estimates were also used for the harvest simulation. Directional change in parameters was not simulated beyond the effect of constant harvest on adult male and female survival rates.

Table 3: Process variation for demographic parameters as detailed in (Boulanger et al. 2010). This is the natural variation that occurs in these parameters as estimated from field data.

Parameter	CV (individual)	CV (time)
Adult female survival (S_f)	0.10%	3.15%
Adult male survival (S_m)	0.10%	3.15%
Fecundity (F_a)	8.50%	1.39%
Calf survival (S_c)	12.70%	36.79%
Yearling survival (S_y)	12.70%	3.15%

2.4. Initial population sizes for simulations

The estimated population size for the Bathurst herd for 2012 and associated confidence interval was used as a starting point for simulations. For each simulation, an initial herd population size was generated based upon the point estimate ($\hat{N}$ =34,690, SE=4691.1, CI=24,934 to 44,445) and the associated standard error to generate a random normal variable that was centered on the point estimate and was distributed similar to the confidence limit of the estimate. This random normal variable was then subdivided for adult cows and bulls based upon the 2012 estimated fall sex ratios. The proportion of the population that was yearling and calves was then estimated using an assumed stable age distribution that was a function of initial demographic parameter values. POP-TOOLS (Hood 2009) in excel was used to estimate stable age distributions for simulations.

2.5. Harvest levels simulated

The effect of harvest was explicitly considered for these estimates. For example, it is assumed that harvest occurs in mid-winter so that fall based measurements will not be affected as much as spring based measurements. Subtracting harvest from population sizes between the fall and spring estimates simulated this effect.

I considered two harvest scenarios that were proposed as part of the Bathurst joint management plan. First, the current allocation of 240 bulls and 60 cows was simulated. A second simulation in which the number of bulls harvested was double (480) was simulated. These were compared to simulations in which no harvest was simulated.

2.6. Assessment of simulation outcomes

2.6.1. Evaluation using short-term management-based population size levels

The goal of these simulations was not to forecast the exact time of recovery or the exact future population size of the Bathurst herd, but instead, to inform management on the probabilities of change in herd size based upon sets of management scenarios. To further this objective, simulations were evaluated in terms of the proportion of simulations that met specified management and monitoring-based herd population size ranges (Table 4). The proportions of simulations in this context could be interpreted as the relative probability of meeting a given management target.

Target levels were based upon the ability to detect changes in breeding female population size and management objectives. To estimate the power to detect change I assumed the level of precision of breeding female estimates from future surveys would be similar to the average of the 2009 and 2012 surveys (coefficient of variation=11%). I then estimated the difference in breeding female population sizes required to detect change in population size using a 2-tailed t-test with an α level of 0.1. In this case, the hypothesis would be a change in population size as opposed to a directional (negative or positive increase). Degrees of freedom for the t-tests were estimated using the formulas of (Gasaway et al. 1986).

As discussed later, the t-test is not necessarily the most efficient method to compare estimates, however, this analysis was mainly intended to provide a general estimate of the power to detect trends which could be used to determine the appropriate intervals for calving ground based population estimates. An alternative is trend analysis from visual surveys of calving grounds. As discussed later, a power analysis on this approach is planned to compare with the t-test based method.

Breeding females are the best segment of the population to use for trend estimates, however, management targets, especially when harvest sex ratio is favored towards males, is based upon overall herd size. The t-test power analysis provided estimates of a lower breeding female population size needed to detect a decline and a higher breeding female population size needed to detect and increase based upon the 2012 estimate of 15,935 breeding cows. These lower and upper estimates of breeding females were then extrapolated to herd size using the 2012 bull-cow ratios and assumed proportion of females pregnant to set corresponding herd size targets.

Note that an inherent assumption with these targets is that sex ratio will not change appreciably in the short term so that breeding female population size can approximate future herd size. This may not be the case, however, and I suggest that these targets should be considered *incrementally as new information about herd status is collected.* For example, the relationship between breeding female population size and herd size can be incrementally adjusted as new data on bull-cow ratios (from fall composition surveys) is collected. In addition, once another calving ground photo survey is conducted, these targets could be changed.

Table 4: Levels of target populations for management used for simulations with corresponding color codes. Detectability is based upon the assumption that future spring calving photo surveys have the same level of precision as the average of the 2009 and 2012 surveys. The correspondence of breeding female and total herd size is based upon the estimate 2012 fall sex ratio.

Management scenario and objectives	Target herd size range	Breeding female range	Comments
Detectable increasing herd size	>44,500	>20,500	Statistically detectable increase
Potential increase (not detectable)	34,700-44,500	16,000-20,500	Potential increase but not statistically significant
Potential decline (not detectable)	27,000-34,700	12,500-16,000	Potential decline that is not statistically detectable
Decline first detected	17,000-27,000	8,000-12,500	Decline becomes detectable
Herd in severe decline (detectable)	<17,000	<8,000	Approximately half the 2012 estimated size suggesting herd is still declining sharply.

Another pertinent question for management was the timelines in which the herd might meet target herd sizes and the corresponding intervals in which management strategies should be evaluated. As time progresses, the herd size changes therefore making apparent increases or declines more evident. Therefore, the interval for evaluation of population size (i.e. a spring calving ground survey) was of interest in evaluating management targets as proposed in Table 4. The probabilities of the management targets were therefore evaluated at 3, 6, and 9 years which correspond to possible intervals in which subsequent calving ground surveys might be conducted. These result help determine the optimal monitoring intervals needed to ensure detection of various herd size levels.

2.7. Predicted demographic trends and field based estimates

A key use of this model is not just predictions in terms of population size but also predictions of field based measurements to further assess herd status. Therefore, I also generated predictions of most of the field-based measurements such as calf-cow ratios and bull-cow ratios. Breeding female population size was also predicted given that it was influenced by both overall herd size and the assumed productivity scenario, and level of fecundity.

An excel sheet with simulation outcomes including predicted estimates of all applicable field measurements was supplied to NWT.

3. Results

3.1. General results

In general, all simulations with adult female survival set at 0.78 resulted in decline of herd size regardless of level of productivity simulated. If productivity based on the 2007-10 average was used (0.51) the herd declined slowly at a rate of approximately 5% per year. If average productivity from 2007-12 (0.38) was simulated, decline became more pronounced, with the largest decline occurring if recent productivity (0.14) observed from 2011-12 was simulated.

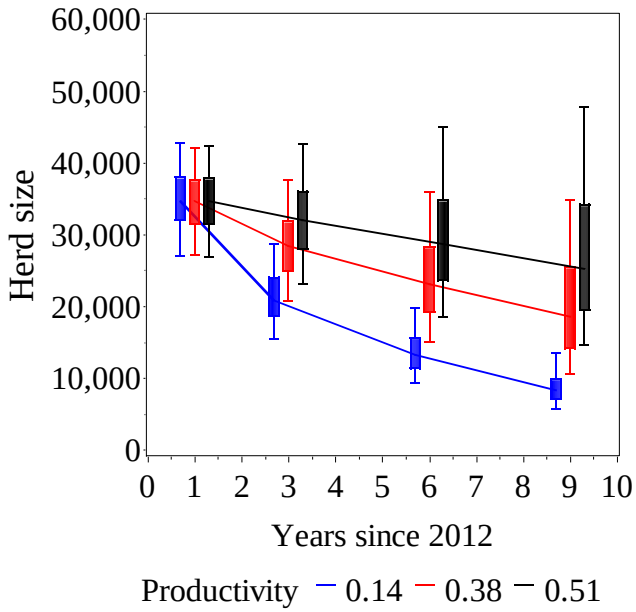

Figure 4: Herd population trajectories with 0 harvest and various levels of productivity as summarized in Table 1. Error bars represent 5th and 95th percentiles of estimates and boxes represent 25th and 75th percentiles.

3.2. Results defined by relative probability of decline

I used stacked bar charts that displayed the simulation outcomes in terms of productivity scenarios (Table 1), management targets (Table 4), and monitoring intervals (years until next calving ground survey) for the most applicable simulations. The idea of the bar-charts is to convey the probabilistic nature of the stochastic model outcomes in a graphical fashion. The colors of the stacked hopefully convey the relative risk of each outcome (red="very high risk" and green="less risk").

There is a lot of information displayed when variation in productivity, monitoring interval, population target levels, and harvest levels are considered simultaneously. The stacked bar-charts efficiently summarize the range of simulation outcomes across a range of assumed productivities and monitoring intervals. *While these contain a lot of detail, they can also be viewed with less detail.* Basically, a graph that has a lot of red means that the given harvest scenario has a high risk of rapid decline compared with a graph that is mainly yellow or green. Some combinations of higher calf productivity and low harvest can result in a stable or increasing herd; these could serve as estimators of a sustainable harvest under those conditions So, this allows interpretation of risk of management strategies without detailed attention to individual simulation outcomes.

3.2.1. Simulations with no harvest.

The general result for simulations with no harvest (at cow survival values of 0.78) is that there is a high probability of a gradual decline in population size regardless of levels of productivity. It is important to note that unless productivity is low (0.14), the change in breeding female or herd size would not be detectable in 3 years for approximately 60% of the simulations when average (2007-12) productivity was simulated. In most cases, decline would be detectable in 6 years unless productivity is high (0.51) where it would be detected in 70% of simulations.

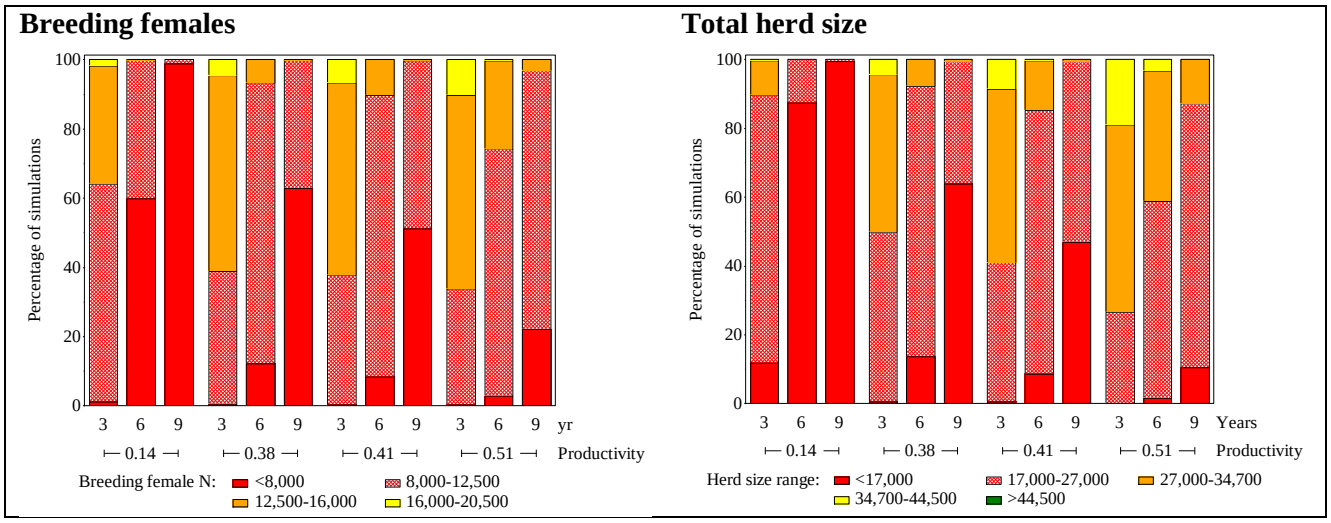

Figure 5: Results of simulations with no harvest (male or female) as a function of mean productivity and years since 2009. Each color on the bar denotes the relative proportion of simulations that resulted in a given range of herd sizes/management targets with the estimates of 16000 cows and 32000 caribou as a baseline. Declines that are colored red and increases that are colored green are statistically detectable. For these simulations adult female survival was 0.88 since no harvest was simulated. Productivity estimates correspond to productivity scenarios as listed in Table 1.

Figure 5 also illustrates that the breeding female and herd size status are almost identical. This is because the no harvest simulations have constant survival rates and therefore there is minimal change in the population sex ratio. Also, female mortality predominantly drives the herd size (in comparison to bull mortality) given that no effects of sex ratio on breeding success were simulated.

3.3. Sensitivity of simulations to adult survival

3.3.1. Adult female survival

Simulations with no harvest were run across a range of adult survival values to explore the sensitivity of herd trajectory to assume adult female survival. Assuming average (2007-12) productivity, it can be seen that adult survival of 0.87 and above result in a herd that has longer term stability for the majority of simulations. Lower values, including the assumed value of 0.78 result in larger scale declines.

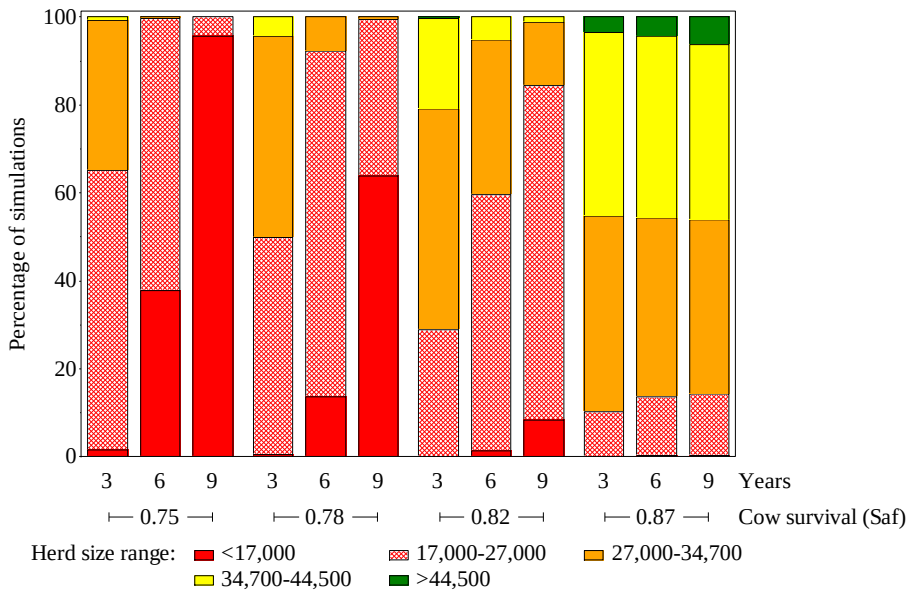

Figure 6: Simulations of herd trajectory under various levels of adult female survival assuming average 2007-12 productivity.

In terms of the OLS model results, the most likely adult survival range is 0.75 to 0.82. Therefore, it can be concluded that a slow decline is most likely given this level of adult survival even in the absence of a harvest. This contrasts with higher adult survival values of 0.87 which would create a stable to increasing caribou herd size.

3.3.2. Cow survival versus bull survival

In general, simulation results are most sensitive to adult female survival compared to male survival. This is demonstrated by the rate of change of the population with varying levels of adult male or female survival (Figure 6). The adult female survival rate used in the simulations (0.88) assumes that "natural" factors influencing mortality are similar in 2009 when compared to 1986. If factors such as predation have increased then survival values will be lower. There is no data available to estimate current "natural" adult survival.

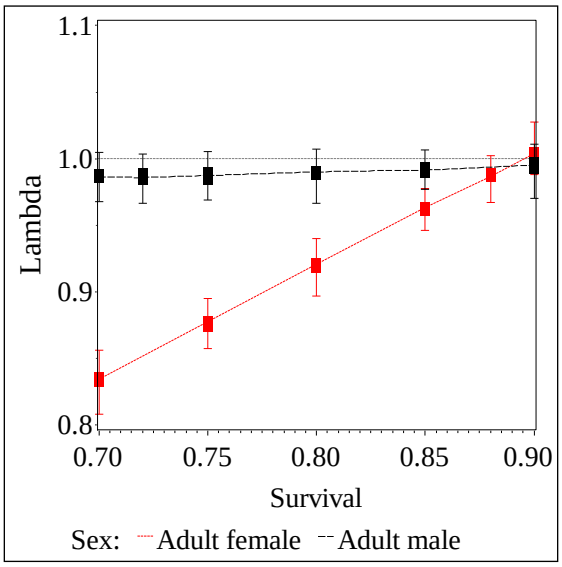

Figure 7: Population rate of change (λ) as a function of varying adult male and female survival rates with 0 harvest. Productivity was set at 0.29 for simulations. Higher values of productivity would result in the adult male and adult female survival lines crossing λ=1 line at lower survival values.

3.4. Evaluation of bull dominated harvest strategies

3.4.1. Evaluation using short-term population sizes

Simulations of harvest levels of 300 (240 bulls, 60 cows) and 540 (480 bulls, 60 cows) show little difference in terms of relative risk of decline (Figures 8 and 9). In both cases, a decline was detected in 60% of simulations at 3 years if average (2007-12) productivity was simulated.

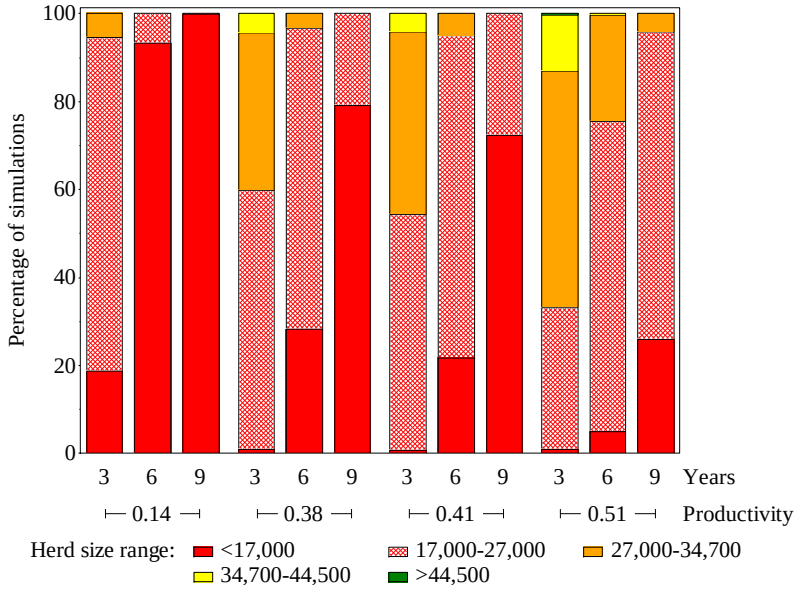

Figure 8: A harvest of 300 caribou composed of 60 cows and 240 bulls.

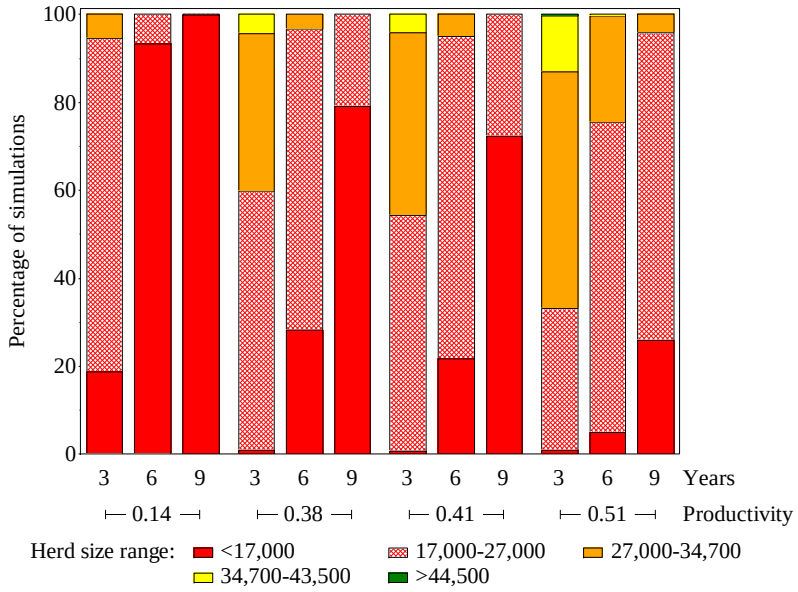

Figure 9: A harvest of 540 caribou composed of 60 cows and 480 bulls.

The results of simulations at 3 and 6 years assuming average (2007-12) productivity can also be displayed in simpler bar charts (Figures 10 and 11). These graphs illustrate that there is minimal sensitivity of simulation outcomes to harvest, and that if adult female survival rates do not increase, detectable change in population size will occur in 40-50% simulations in 3 years, and 70-80% of simulations in 6 years.

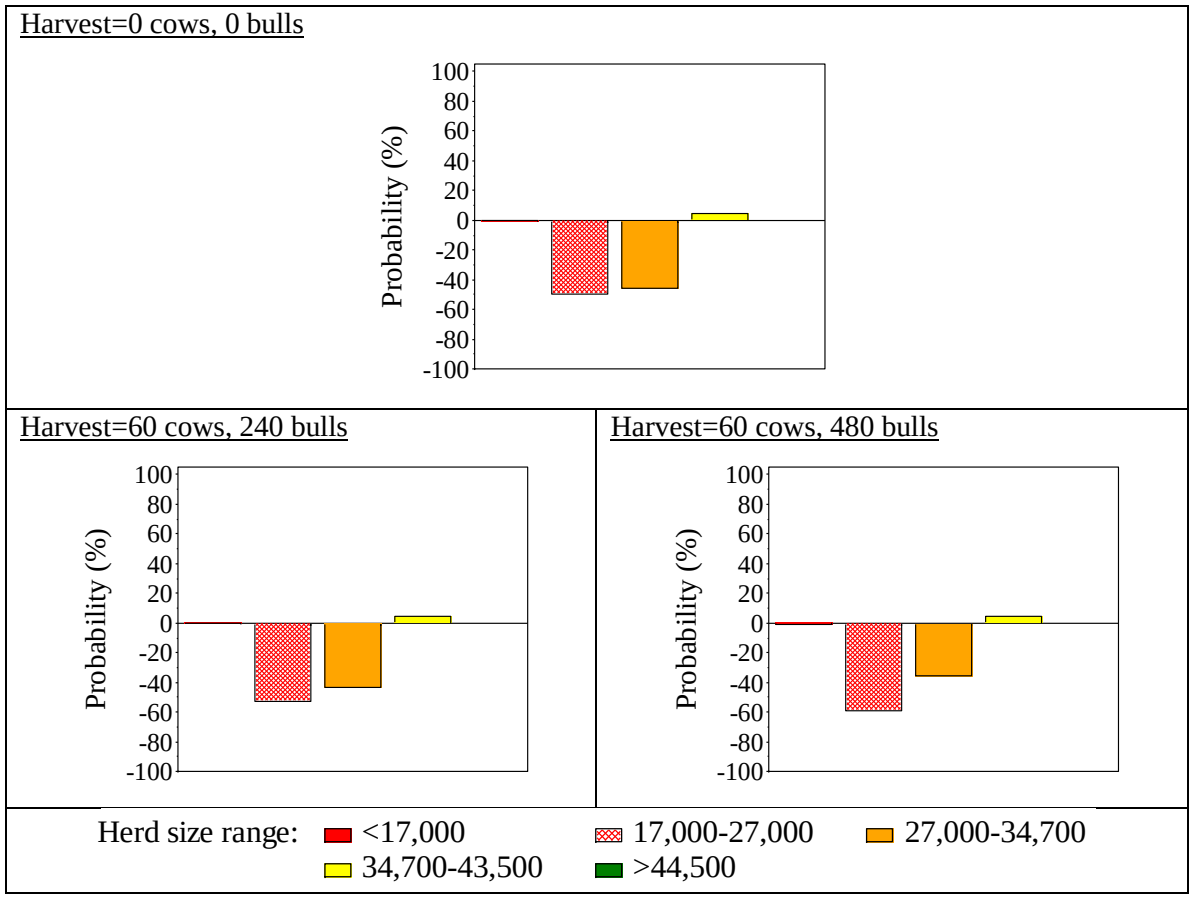

Figure 10: Probabilities of different herd levels assuming average productivity (2007-12) evaluated at 3 years with adult female survival =0.78.

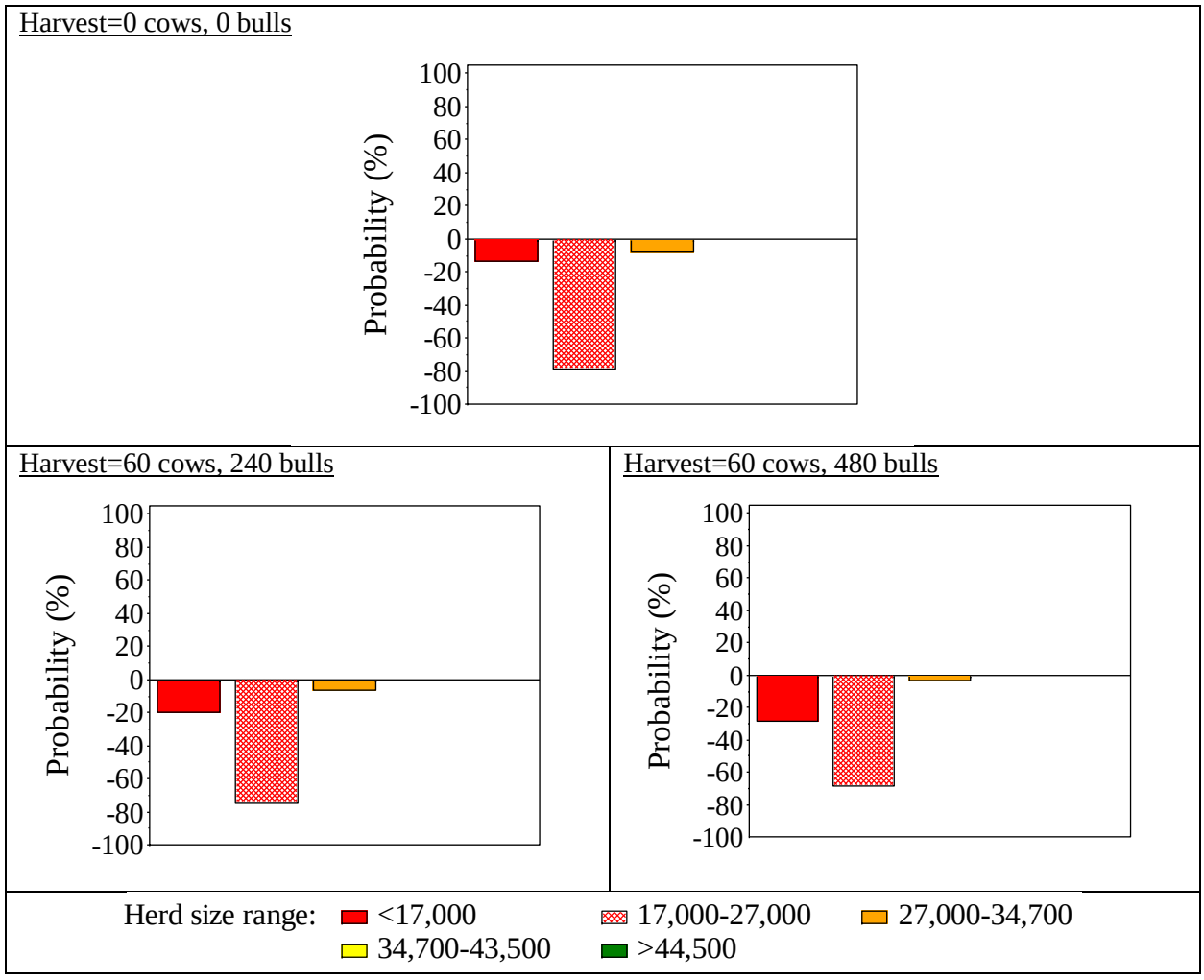

Figure 11: Probabilities of different herd levels assuming average productivity (2007-12) evaluated at 6 years with adult female survival =0.78.

3.4.2. Assessment of bull-cow ratios

Given that the population is potentially in a slow decline due to reduced adult female survival, regardless of bull harvest level (Figure 12), the next question is how bull-cow ratios may respond to a bull-dominated harvest given the demography of a declining population.

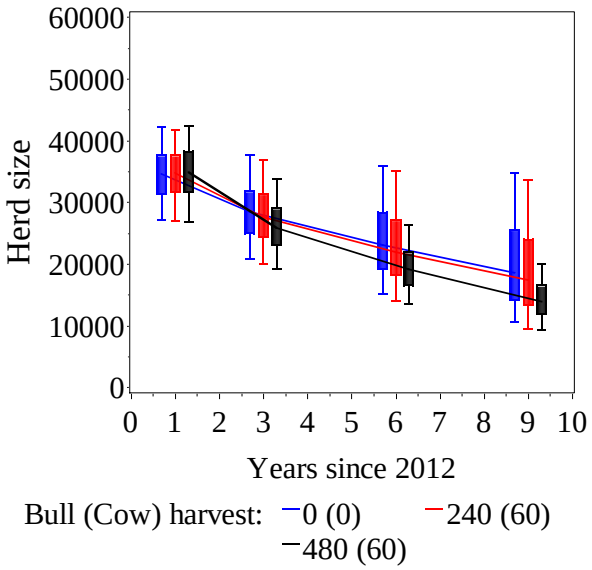

Figure 12: Herd population trajectories with average 2007-12 productivity as a function of different harvest regimes.

To explore this further I plotted bull-cow ratios under the 3 harvest scenarios under average (2007-12) productivity (Figure 13), high (2007-10) productivity (Figure 14), and low (2011-12) productivity (Figure 15). I also plotted the accompanying bull and cow population sizes to allow better inference as to the causes of changes in the ratio.

The general conclusion was that if productivity was high (2007-10) (Figure 12), bull cow ratios were affected minimally by bull harvest level. As productivity decreased, bull-cow ratios decreased with increasing bull harvest (Figure 13). This result makes intuitive sense given that when productivity is low there would be less recruitment into the bull class to offset lower bull survival rates and therefore the bull cow ratio would be expected to decrease with additional harvest mortality. Of greater concern under the low productivity scenario is the reduction of both bull and cow population size to fairly low levels after 6 years, a result also illustrated in previous simulations.

One additional observation from simulations is that bull cow ratio is minimally sensitive to actual change in population size of the herd and therefore it is essential that productivity and relative population size be monitored in unison with bull cow ratios.

The actual trigger of a reduction of bull harvest should be based upon bull cow ratios in unison with calf-cow ratios, and results of calving ground surveys. The OLS model provides yearly estimates of bull population size based upon observed productivity levels. I suggest that a lower bull population size be considered as a trigger for reduction of bull harvest rather than complete reliance on bull cow ratios as a management trigger.

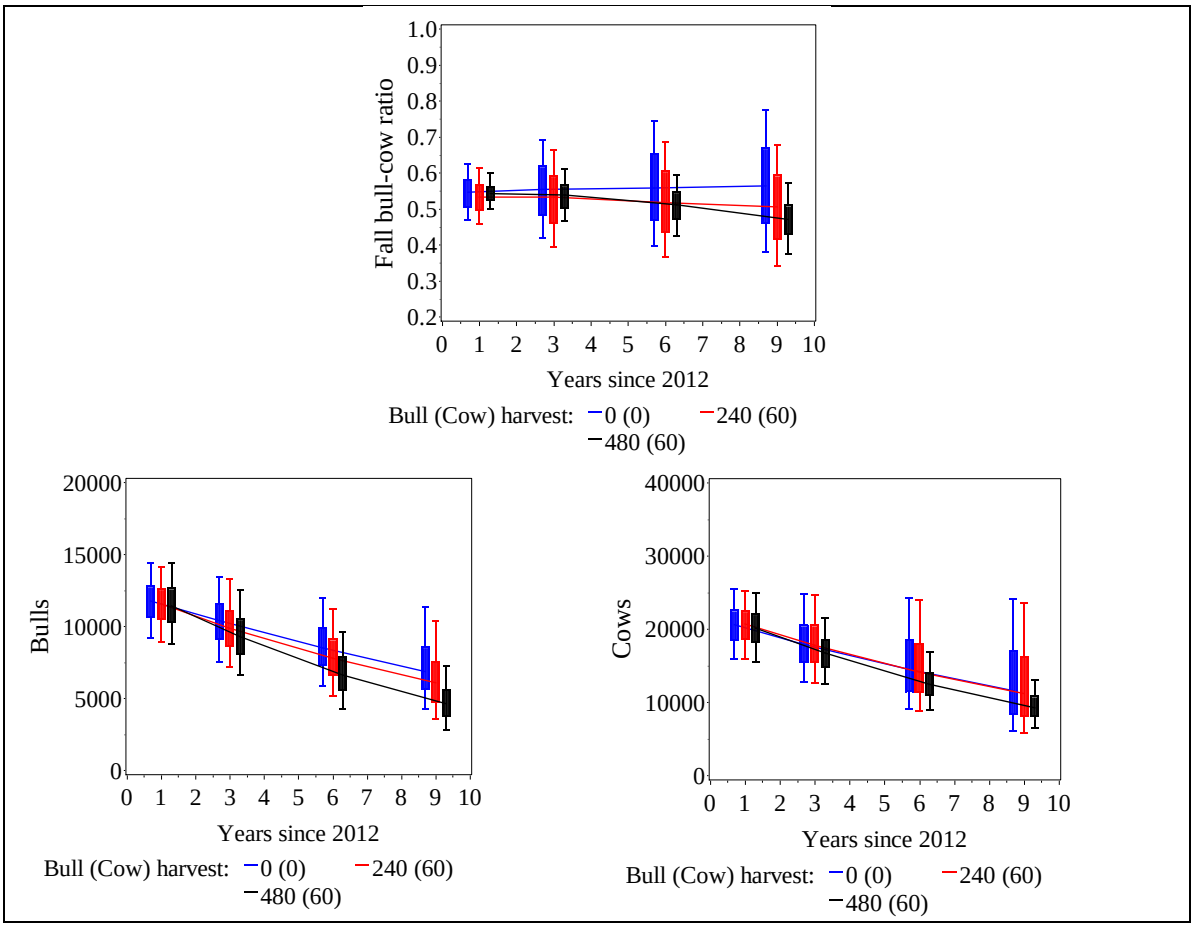

Figure 13: Fall bull cow ratios and accompanying cow and bull population sizes with varying levels of harvest with 2007-10 productivity.

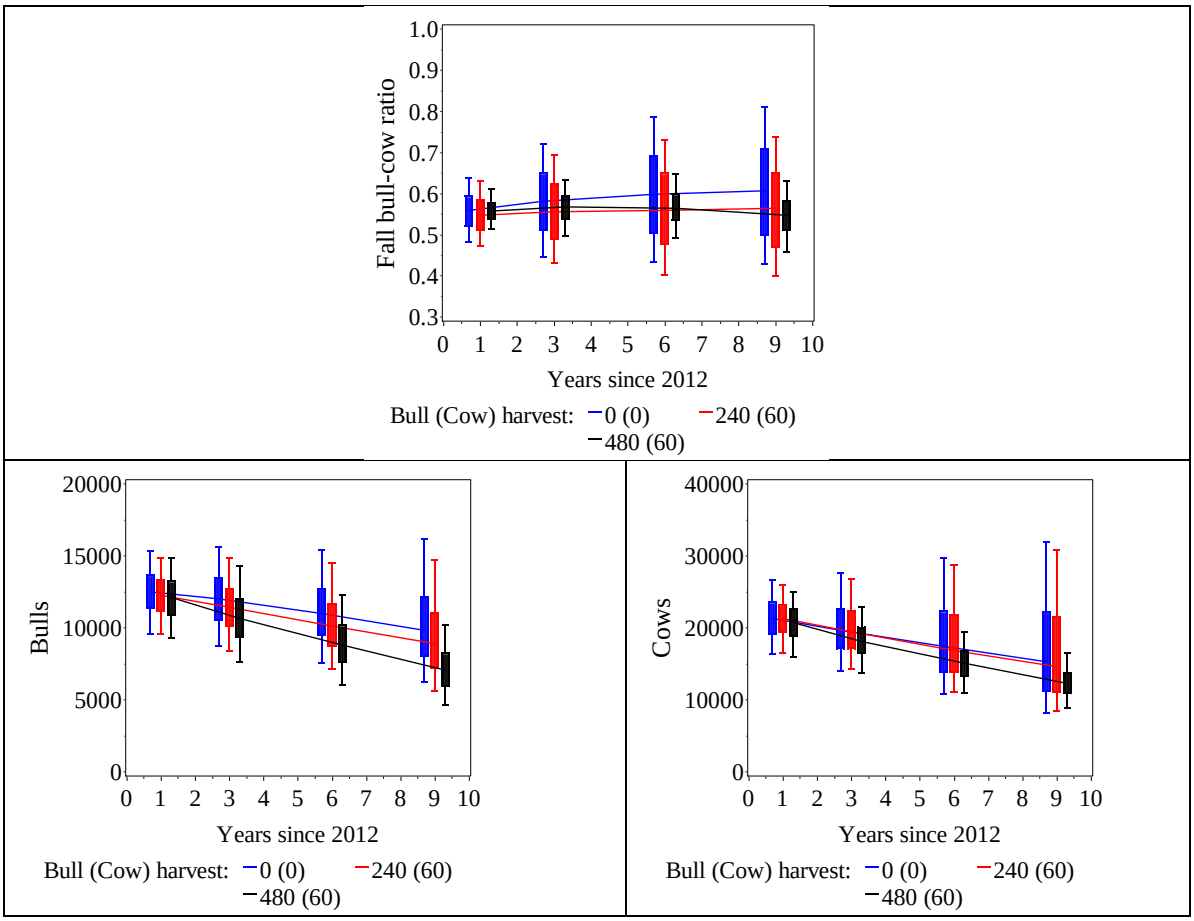

Figure 14: Fall bull cow ratios with varying levels of harvest with high (2007-10) productivity.

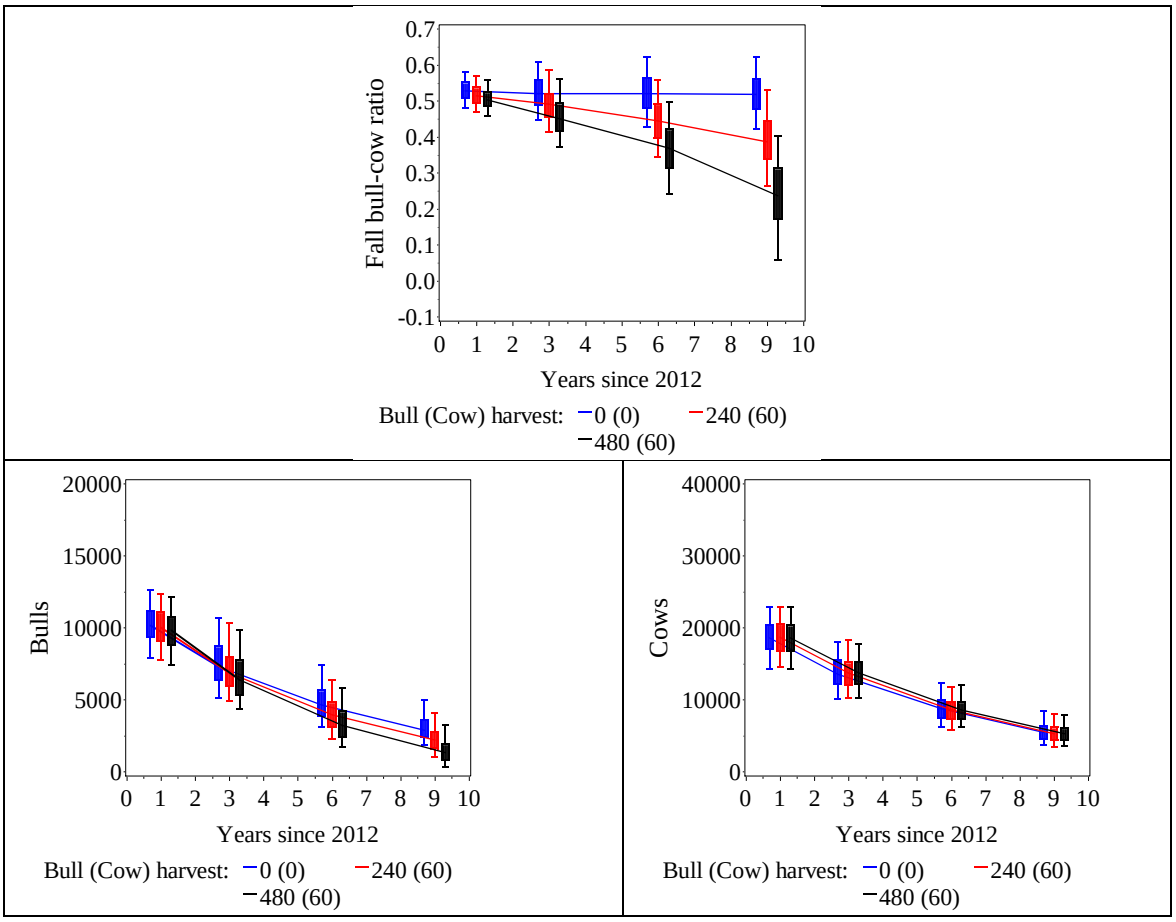

Figure 15: Fall bull cow ratios with varying levels of harvest with low (2011-2) productivity.

3.5. Other field indicators

For the sake of brevity, calf-cow ratios are not shown in this report. However, excel sheets with these predictions were supplied to ENR for further assessment.

4. Discussion

One of the main conclusions of simulations is that the herd is potentially in a slow decline given lower adult female survival values. Simulations suggest that low levels of bull-dominated harvest will not influence overall population trend. Higher cow harvest levels were not considered given that higher levels of cow harvest are not justifiable as long as the population is declining.

The OLS model uses an indirect method to estimate adult female survival given that low sample sizes of collared caribou prevent useful estimates based upon collars alone. In terms of management, further investigation of reduced adult female survival through the increase of collared caribou should be considered in unison with conservative harvest strategies. Many of the demographic indicators such as calf cow ratios, and bull cow ratios, are based upon ratios and will not necessarily indicate a declining population. Therefore these ratios should be interpreted cautiously.

This report presents an overview of the inputs and outputs of the stochastic simulation model. The following points should be considered when interpreting the simulations in this report.

- *This model does not simulate any effects of reduced breeding success based on bull-cow ratios.* Given this, threshold levels of bull-cow ratios should be also established to ensure reasonable sex ratios as discussed in (Mysterud et al. 2002). The model can generate predicted bull-cow ratios that can then be used to evaluate the relative risk of male dominated harvest strategies to the overall population. As mentioned earlier, power analyses can be used to determine the relative power to detect a threshold bull-cow ratio for a given harvest sex ratio, productivity, and management regime.

- *Simulations illustrate that the ability of the herd to recover is very much influenced by productivity, not just by harvest levels.* Harvest can be managed, while productivity is strongly influenced by weather and is less subject to human control. Given this it is difficult to forecast recovery just based on harvest management. Any harvest management strategy should be ***adaptive*** in which goals/targets/harvest are set based upon levels of productivity observed from field-based estimates.

- *Better estimates of true harvest level are essential to help refine herd recovery scenarios and determine the relative impact of harvest on adult female survival.* It would be possible to use harvest as a direct model input to allow better assessment of harvest levels on herd recovery. In this case, model runs could be focused on exact harvest levels rather than being run across a wide range of potential harvest levels. Basically, reporting of harvest rates is one of the fundamental requirements of an adaptive management program. Harvest levels should be a model input rather than a model estimate.

- *The appropriate interval to evaluate herd status (i.e. spring calving ground surveys) should be considered in the context of observed productivity levels, relative risk, and power to detect change in population size.* The simulation model outcomes and the OLS deterministic model can be used to further refine management strategies as more information becomes available.

- *Power analyses demonstrate limited power to detect moderate changes in herd size and therefore herd status should be evaluated also using productivity and survival rate estimates.* This also demonstrates that herd size along with productivity and adult survival should be simultaneously used to evaluate herd status through the framework of a population model. Model based methods (Boulanger et al 2010) can help interpret calf-cow ratios, bull-cow ratios that are influenced by many demographic factors. Note that the OLS model will generate a predicted population size as new data such as calf-cow ratios are produced. The model in this exercise generates predictions of all field based estimates. Power analyses can be used to further optimize appropriate intervals to sample for composition or sex ratio based upon assumed demographic/management scenarios.

- *Biological variation creates uncertainty in many outcomes and recovery scenarios are best interpreted as probabilities rather than estimated future population sizes.* It should be evident that estimation of exact future population sizes is not possible given uncertainty in various current aspects of herd demography.

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Appendix 4. Supplemental Information

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

Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

Updated
20 January 2014

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.

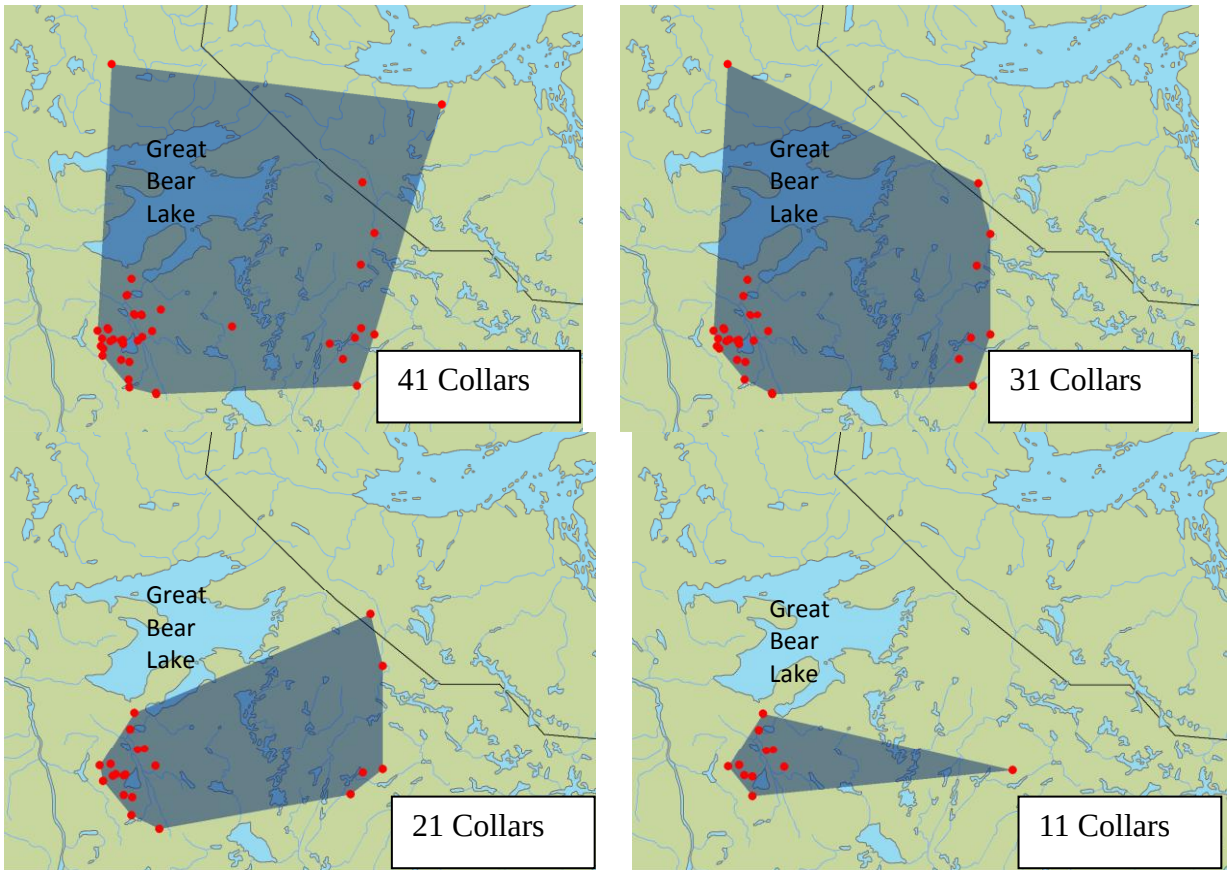

Fig. 1. Minimum Convex Polygon (MCP) derived from 41 caribou collar locations, Bluenose-East herd, on one day in early winter 2009, and then reduced randomly to fewer collars (J. Williams, ENR, maps).

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.

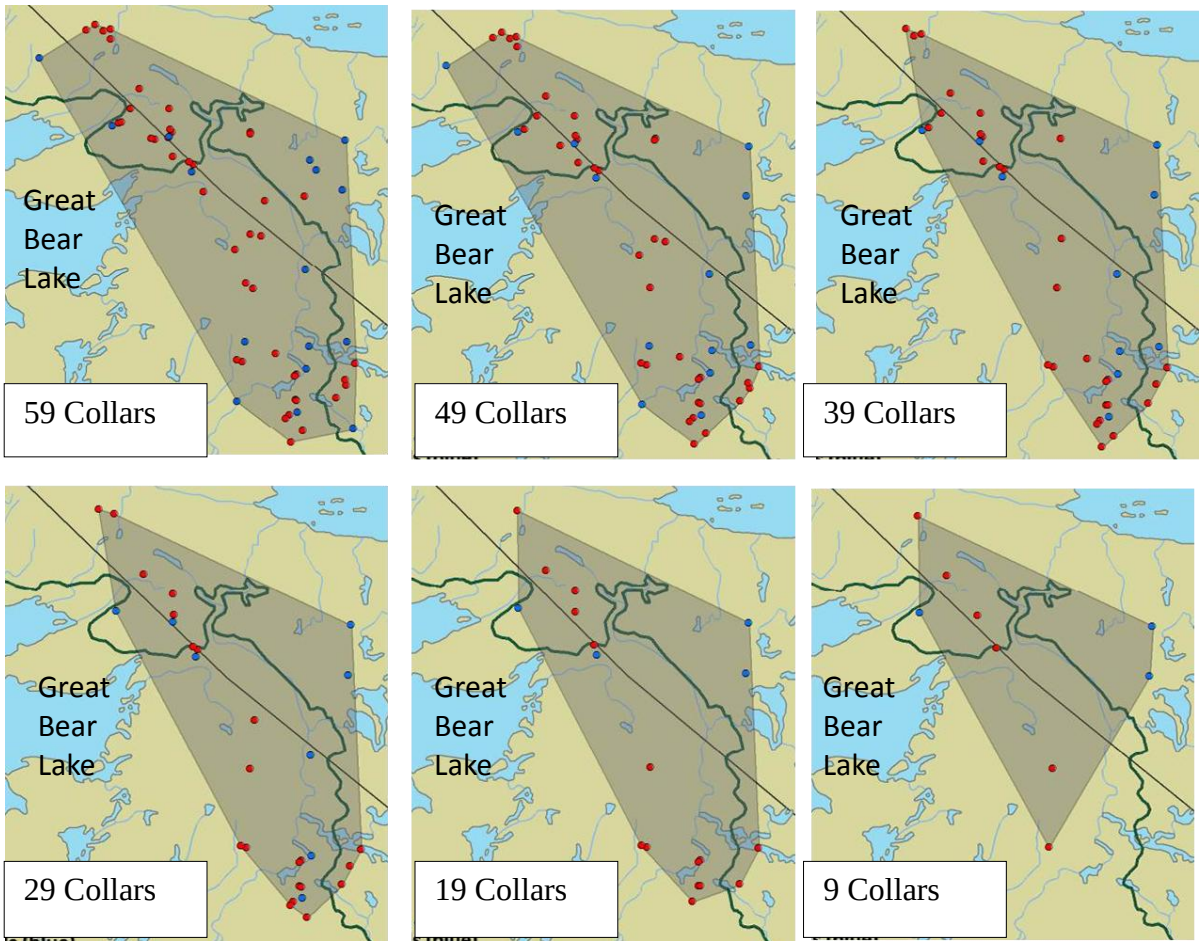

Fig. 2. Minimum Convex Polygon (MCP) from 59 caribou collar locations, Bluenose-East herd, on Aug. 17, 2012, then reduced randomly sequentially to 9 collars (J. Williams, ENR, maps). Red dots are cows and blue dots are bulls.

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.

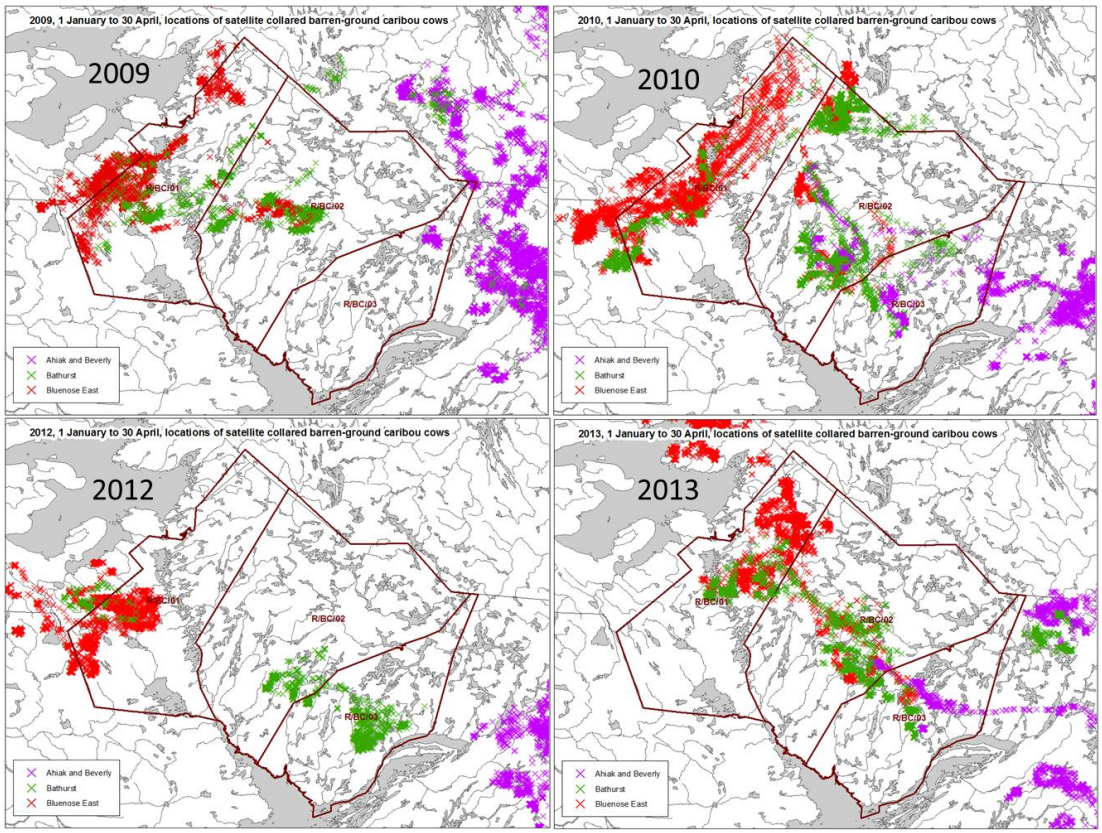

Fig. 3. Cumulative winter distribution of radio-collared caribou in RBC01, 02 and 03 from 3 herds (Jan-April) in four years. Red=Bluenose-East, Green=Bathurst, Purple=Beverly/Ahiak. Maps A. D'Hont, ENR.

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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