SPECIES STATUS REPORT

Porcupine Caribou and Barren-ground Caribou

(Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds)

Rangifer tarandus groenlandicus

Tuktu, Tuktuvialuit, Tuttuvialuk (Inuvialuktun – Inuinnaqtun, Siglitun, and Ummarmiutun dialects)
Vadzaıh (Gwich'in)
Ekwǫ̀, hozıʔekwǫ̀ (Tłıchǫ)
ʔekwę́, ʔepę́, ʔedə (Sahtú Dene – Dél̨ne, Tulít'a, and Fort Good Hope/Colville Lake dialects)
Nódi (South Slavey - Kátł'odehche dialect)
ʔetthén (Chipewyan)
Atihk (Cree)
Caribou de la toundra (French)

in the Northwest Territories

NORTHWEST TERRITORIES SPECIES AT RISK COMMITTEE

NOT AT RISK – Porcupine caribou
THREATENED – Barren-ground caribou
April 2017

Species at Risk Committee status reports are working documents used in assigning the status of species suspected of being at risk in the Northwest Territories (NWT).

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ABOUT THE SPECIES AT RISK COMMITTEE

The Species at Risk Committee was established under the *Species at Risk (NWT) Act*. It is an independent committee of experts responsible for assessing the biological status of species at risk in the NWT. The Committee uses the assessments to make recommendations on the listing of species at risk. The Committee uses objective biological criteria in its assessments and does not consider socio-economic factors. Assessments are based on species status reports that include the best available aboriginal traditional knowledge, community knowledge and scientific knowledge of the species. The status report is approved by the Committee before a species is assessed.

ABOUT THIS REPORT

This species status report is a comprehensive report that compiles and analyzes the best available information on the biological status of Porcupine caribou and barren-ground caribou in the NWT, as well as existing and potential threats and positive influences. Full guidelines for the preparation of species status reports, including a description of the review process, may be found at www.nwtspeciesatrisk.ca.

Northwest Territories Environment and Natural Resources

Environment and Natural Resources, Government of the Northwest Territories, provides full administrative and financial support to the Species at Risk Committee.

Cover illustration photo credit: John Nagy

Production note:

The drafts of this report were prepared by John Blyth and Adam Bathe (traditional and community knowledge component) and Kim Poole and Anne Gunn (scientific knowledge component), under contract with the Government of the Northwest Territories.

A group of traditional knowledge holders and specialists from the Species at Risk Committee (SARC) met on January 9, 2017 to initiate discussion of the draft status report. As a result of that discussion, a targeted review of the traditional and community knowledge component was undertaken by SARC's appointed traditional knowledge holders and specialists to verify and ensure the accuracy, completeness, and cultural appropriateness of this status report.This represents a new effort by SARC to support balanced consideration of traditional and community knowledge and science.

Extensive revisions to the scientific knowledge component was also undertaken by SARC in January 2017.

This status report benefitted from the simultaneous drafting of a status report for the assessment of barren-ground caribou under the federal *Species at Risk Act* (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2016). Many of the sections in the scientific knowledge component of this report and the COSWIC (2016) report were drafted simultaneously and therefore contain the same content. SARC acknowledges the help of the Terrestrial Mammal Sub-committee of COSEWIC for their work.

Assessment of Porcupine Caribou Herd

The Northwest Territories Species at Risk Committee met in Fort Smith, Northwest Territories on April 5, 2017 and assessed the biological status of the Porcupine caribou herd, a geographically distinct population of barren-ground caribou in the Northwest Territories. The assessment was based on this approved status report. The assessment process and objective biological criteria used by the Species at Risk Committee are available at: www.nwtspeciesatrisk.ca.

Assessment: N**ot at risk in the Northwest Territories**

The species has been assessed and is not currently at risk of extinction given the current circumstances.

Reasons for the assessment: The Porcupine caribou herd fits criterion (a) for not at risk.

(a) The species has been assessed and it does not qualify for designation as Extinct, Extirpated, Endangered, Threatened, Special Concern, or Data Deficient.

Main Factors:

- The Porcupine herd's population has been increasing over the past three caribou generations and the current population estimate is the highest since standardized population techniques started being used in the early 1970s.
- Since 2001, Porcupine herd birth rates, June calf survival, and post-calving survival have remained relatively strong in most years.
- Specific international and interjurisdictional co-management structures are well-established and functioning to address concerns with the Porcupine herd. Harvest for the Porcupine herd is led by a Harvest Management Plan.
- The main threats are:
    - Human activity within Porcupine caribou habitat, such as increased hunting access and potential future mineral and oil and gas exploration and development.
    - Climate change-related habitat changes have been noted (e.g., deep snow, melting permafrost, changes in the timing of spring green-up, increase in shrub cover).

Additional Factors:

- Most caribou herds in the circumpolar north are in decline. Currently, Porcupine caribou are an exception as the herd has shown an increase over the last three caribou generations (about 25 years). Caribou populations are known to fluctuate, so future declines in Porcupine caribou population are anticipated. Such declines may be exacerbated by changes in climate and habitat interactions that are not fully understood. Caribou

populations are in decline globally and there is concern that there is an overarching cause exerting its influence globally that could impact Porcupine caribou in the future.

- Currently, their calving grounds in Alaska are protected by the Arctic National Wildlife Refuge. However, the potential for oil and gas development on the calving grounds has increased substantially following the 2016 presidential election in the United States. The current United States' administration has indicated support for opening onshore and offshore leasing for energy projects.

Positive influences on Porcupine caribou and their habitat:

- In addition to the effective management mentioned previously, the calving grounds of the Porcupine caribou herd are currently protected by the Arctic National Wildlife Refuge.

Recommendations:

- Given the importance of Porcupine caribou to the people of the NWT and what's happening with other barren-ground caribou herds in the circumpolar north, the Species at Risk Committee recommends that the Porcupine herd be closely monitored and that management continue. If evidence emerges in the future that it is following the same trajectory as the other eight barren-ground caribou herds, the Species at Risk Committee recommends it be considered for re-assessment. If potential threats to the Porcupine calving grounds become reality, for example, the opening of the Arctic National Wildlife Refuge to oil and gas development, then re-assessment may be needed.

- Given that the Porcupine caribou herd seems to be an exception to the global decline in barren-ground caribou herds, consideration should be given to increasing traditional knowledge and scientific research into the underlying causes of barren-ground caribou population dynamics and habitat changes.

Assessment of Barren-ground Caribou

The Northwest Territories Species at Risk Committee met in Fort Smith, Northwest Territories on April 5, 2017 and assessed the biological status of barren-ground caribou in the Northwest Territories (including the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds).The assessment was based on this approved status report. The assessment process and objective biological criteria used by the Species at Risk Committee are available at: www.nwtspeciesatrisk.ca.

Assessment: **Threatened in the Northwest Territories**

Likely to become endangered in the Northwest Territories if nothing is done to reverse the factors leading to its extirpation or extinction.

Reasons for the assessment: Barren-ground caribou fit criterion (a) for Threatened.

(a) There is evidence that the population is declining in such a way that it could disappear from the Northwest Territories in our children's lifetime.

Main Factors:

- This means that there is a 10% chance that barren-ground caribou could disappear from the Northwest Territories within 75 years.
- Although about 530,000 barren-ground caribou still reside either entirely or partially within the NWT, overall, the numbers have declined by more than 85% for all herds where we have trend information, except the Qamanirjuaq herd, during the past three caribou generations (about 25 years).
- Overall trend demonstrates a continued population decline even though two herds (Cape Bathurst and Bluenose-West) appear to have recently stabilized at very low numbers.
- The main threats are:
    - Climate change may act as a continuing threat to barren-ground caribou through a complex mechanism involving shifts in timing of green-up, changes in summer forage quality, rain-on-snow and icing events on the winter range, longer fire seasons, melting permafrost and erosion, changes to freeze-up and thaw timing, and increasing shrub cover. Parasites and diseases are a potential and complex threat under a warmer climate.
    - Predation can affect survival and reproduction and therefore abundance, and there are reports of increasing predator populations in some areas.
    - Industrial development is considered to be one of the most significant factors affecting barren-ground caribou. It can disturb caribou and affect their behaviour,

the quality of habitat and forage, and ultimately, the survivability of the species. It can also facilitate access for both humans and predators.

- Forest fires represent the most visible factor driving habitat fragmentation and change, impacting forage availability and movement. This threat is particularly important in the winter range. Climate change may lead to even hotter and drier summers in the NWT, possibly increasing the frequency and intensity of fires.

Additional Factors:

- Barren-ground caribou populations undergo large fluctuations over several decades. The causes of these fluctuations in abundance are complex and likely driven by climate interacting with forage availability, predation, and parasites. Harvest and predation play a stronger role when barren-ground caribou are at low numbers.
- The threats mentioned above are acting in addition to these large fluctuations. The cumulative effects from multiple interacting threats are considered unprecedented.

Positive influences on barren-ground caribou and their habitat:

- Collaborative co-management has led to management planning for caribou and resulted in measures to reduce harvest in response to low numbers. Range planning has been initiated for the Bathurst herd.
- Application of traditional laws and harvesting protocols (e.g., respectful harvest, sharing, avoiding wastage, etc.) have, and will continue to have, a positive influence on caribou health, population numbers, and habitat.
- There are community-based conservation measures and community support for management actions.
- Calving grounds of the Bluenose-West and Beverly herds are provided partial protection from development by inclusion in protected areas and sanctuaries. Habitat protection is also offered through land use planning instruments.

Recommendations:

- Complete and implement herd management and action plans.
- Complete or initiate range planning where needed.
- Improve harvest reporting.
- Work with interjurisdictional partners to achieve effective protection of all calving grounds and other key habitat components (e.g., water crossings).

- Consideration should be given to increasing research into causes of barren-ground caribou population decline and habitat changes to better inform effective management actions.

- Climate change is an underlying driver of many of the threats facing barren-ground caribou and their habitat. Action to reduce greenhouse gas emissions is required for the long term conservation of barren-ground caribou. Actions should be taken to ensure that the impact of climate change on caribou is highlighted through the appropriate regional, national, and international fora and that effects of climate change on caribou are monitored and mitigation actions taken where possible.

Executive Summary

Traditional and Community Knowledge Component	Scientific Knowledge Component
Preamble This traditional and community knowledge component executive summary presents a summary of the key findings as described in the body of the report (see *Traditional and Community Knowledge Component*, p. 5). The major sources were from traditional and community knowledge accessible to the Species at Risk Committee (SARC) in a published and publicly available format at the time this report was written. It also incorporates the input of SARC members who are traditional knowledge holders.	**Preamble** This scientific knowledge component executive summary presents a summary of the key findings as described in the body of the report (see *Scientific Knowledge Component*, p. 93). The major sources of knowledge were from peer reviewed papers, original studies, and expert opinions.
Description Barren-ground caribou are mid-sized land mammals. Barren-ground caribou are slightly smaller than the closely related boreal woodland caribou. Both males and females have light-coloured hair around their tail and on their stomach, and their coats become progressively darker towards the spine. Females have smaller antlers, shorter necks, and smaller bodies, and are typically lighter in colouration than the males. Barren-ground caribou have the largest antlers relative to their size of any species of deer. Variation in colour and flavour exists between different herds in the Northwest Territories (NWT). Barren-ground caribou often form large herds and will be seen travelling with numerous other individuals.	**Description** Barren-ground caribou are a medium-bodied cervid (deer family). They are highly gregarious, travel in large groups, and exhibit long-distance migrations between wintering and calving grounds. Mature males have a striking white neck and mane, a brown back, and a distinct band along the flank separating the brown back from the white belly. Females and juveniles show a more muted version of the males' colours. Wide variation in colouring from light to dark can often be seen in caribou groups. Both sexes are antlered and breeding males may have large antlers for display and contest during the rut (breeding season).
Range In the NWT, barren-ground caribou are located	**Range** Barren-ground caribou in Canada are primarily

in the northern half of the territory, roughly following the treeline, such that herds found further east in the territory also range further to the south. Barren-ground caribou are highly migratory and travel along their migration route several times a year. They will migrate northwards in the spring to their calving grounds and southwards in the fall to their winter range. Their massive migration is a response to seasonal changes in the suitability of the habitat within the range.

Current winter ranges of barren-ground caribou of the eastern and central NWT have contracted somewhat and have shown a general shift northwards. Historically, the winter range in the NWT extended much further to the south. In the southeastern portion of the territory in the past, barren-ground caribou were known to occur much closer to the communities of Fort Smith, Fort Resolution, and Rocher River in the NWT and Fort Fitzgerald and Fort Chipewyan in Alberta. In the central portion of the territory, winter range was also known to be located further to the south, with caribou coming in close proximity to the communities of Behchokǫ̀, Yellowknife, Dettah, and Ndılo.

In the NWT, some people appear to be able to distinguish among different herds, or groups, of barren-ground caribou using a variety of techniques: their direction of travel, their range, their colour/size/body condition, and even the effect that varying habitat has on the taste of the meat itself. Even though it is possible to recognize individuals from different groups, it is very clear from traditional and community knowledge that there is mixing and movement among neighbouring herds of barren-ground caribou. In other instances, traditional knowledge located in the NWT, Nunavut (NU), and the Yukon. The Porcupine herd is primarily located in Alaska, with wintering range in the northern Yukon and NWT. The barren-ground caribou herds other than Porcupine caribou (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, and Qamanirjuaq) calve in tundra barrens near the Arctic coast in the NWT and NU and winter below the treeline of the NWT and in northern regions of Manitoba, Saskatchewan, and (historically) Alberta.

The Porcupine herd range includes Alaska, Yukon, and the NWT. The ranges of the Tuktoyaktuk Peninsula, Cape Bathurst, and Bluenose-West herds are almost entirely within the NWT. The ranges of the Bluenose-East, Bathurst, Ahiak, and Beverly herds currently include the NWT and NU. The Qamanirjuaq herd's range is mostly in NU and Manitoba, with a small portion in the NWT and Saskatchewan.

holders and communities assert that barren-ground caribou form larger intermixed, less isolated populations.	
Habitat Barren-ground caribou habitat includes a broad set of environmental conditions, which ensure their survival. These include the space in which they live, predators, snow depth, ice depth, pests and insects, vegetation, water, landscape, human activity, climate, and fire. Many of the items in the above list are not static over time, nor are they evenly distributed across the landscape. As a result, barren-ground caribou must undertake large-scale migrations to reach habitat appropriate for the season. The most essential aspect of barren-ground caribou habitat is the presence of good quality forage with abundant grasses, sedges, mushrooms, and most importantly lichens. Barren-ground caribou use broad open areas where such forage is available, where there are no disturbances, and, especially in their preference for calving grounds, where they may see and smell predators from long distances. Habitat fragmentation and degradation is occurring in the barren-ground caribou range as a result of numerous factors: the destruction to habitat caused by forest fires, climate change, access roads, pipelines, mining and mineral exploration projects, hydroelectric developments, disturbances from vehicles and machines, seismic lines, and utility corridors. Available traditional and community knowledge sources have highlighted decline in the amount of suitable habitat in the NWT.	**Habitat** Habitat requirements are partly driven by the need for forage, which depends on the timing of the caribou's annual breeding cycle and its nutritional costs relative to the brief plant growing season and long winters of the subarctic and Arctic regions. Barren-ground caribou are generalist foragers and select for nutrient content according to the stage of plant growth more than plant species. Habitat requirements for calving vary among calving grounds, and include reducing the risk of predation while obtaining adequate nutrient intake. On summer ranges, reducing exposure to insect harassment while obtaining high quality forage are key habitat requirements. Winter habitat varies among herds and can be tundra or taiga; lichens are the preferred winter forage in the taiga and on the tundra. The most conspicuous cause of natural fragmentation and change of caribou habitat other than the large lakes and major rivers is from forest fires. Habitat fragmentation caused by human activities has not been documented on a large scale within barren-ground caribou ranges, although reduced use near active mines, communities and roads represents a degree of functional habitat loss.

Biology

Female barren-ground caribou will reach maturity between the ages of two and three and will typically have one calf—and in very rare cases two calves—every year. Barren-ground caribou males reach maturity at the age of four but may not begin breeding at the onset of maturity.

Barren-ground caribou follow an annual cycle from the calving grounds to their winter habitat. Calves are typically born eight to nine months after the fall rut (breeding), in late May or the first two weeks of June, after the spring migration northwards to the barrens. Caribou young are taught which foods to eat and trails to travel by the older caribou. Many of the barren-ground caribou herds seek refuge on or near more windswept coastal areas and hilltops, not only for the good foraging opportunities they provide, but also as a mechanism to avoid insects and to reduce their exposure to high temperatures.

Barren-ground caribou are incredibly hardy and well adapted to the environments they inhabit. Typically, barren-ground caribou prefer colder temperatures: in winter, cold weather prevents icing conditions and inaccessibility of forage, while in summer it reduces insect activity, resulting in less stress for the caribou and a better body condition overall. High numbers of insects cause caribou to run around in an attempt to seek refuge, resulting in decreased body condition and, in extreme cases, mortality from heat exhaustion.

Wolves are considered the primary predators of barren-ground caribou, though grizzly bears, wolverines, and possibly lynx and eagles also prey on barren-ground caribou. Caribou appear

Biology

Caribou usually calve at three years of age, although under high forage availability and a corresponding high rate of body growth, females can calve at two years of age. The females typically have a single calf every year, although breeding pauses may occur when females are in poor condition. Synchrony during the rut likely leads to birth synchrony. Calving is highly synchronized with most calves born within a few days of each other.

Intra-specific interactions (interactions among barren-ground caribou) are an important factor in the life cycle of barren-ground caribou, given their social nature. Predators figure in a large way in caribou ecology. An array of predators and scavengers depend on barren-ground caribou. The role of predation in caribou dynamics probably differs among herds, and has a stronger role in caribou population dynamics during declines and the phase of low numbers. Grizzly bears may have a greater impact on newborn caribou on calving grounds than wolves in some herds, but wolves are effective year-round predators of all sex and age classes of caribou. Parasites and diseases are also an important part of caribou ecology, although their role at the population level and the effects of climate change have been less studied.

to avoid muskoxen, generally moving away from areas where muskoxen may be found. In certain areas, boreal woodland caribou and barren-ground caribou have been observed intermingling and foraging in the same groups.	
Population It is thought by traditional knowledge holders that barren-ground caribou have always been relatively abundant compared to other large land animals. Regular changes in barren-ground caribou abundance are the result of a natural population cycle. Across the NWT, there is no clear agreement on the length of this cycle, although it appears to last somewhere between 10 and 60 years. Recent cyclical peaks have not reached the same levels as past ones. Thus, with respect to relative abundance, though there is variation across the herds, traditional and community knowledge holders indicate that there are likely declines in barren-ground caribou. The exceptions are the Porcupine and Tuktoyaktuk Peninsula herds. Various forms of disturbance are currently adding to the pressures that barren-ground caribou may be facing as a part of their natural cycle of decline and recovery.	**Population** In 2013, the Porcupine herd was estimated at approximately 197,000 animals (including calves). The most recent estimates for the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, and Qamanirjuaq herds indicate approximately 530,000 animals (excluding calves). Given approximately 530,000 barren-ground caribou within herds that reside either entirely or partially within the NWT, the NWT could be considered home to approximately 45 percent (%) of the global population of migratory caribou and reindeer. By the mid-1980s to mid-1990s (timing varied among herds), most NWT herds were peaking in abundance; declines were underway during the late 1990s and into the 2000s. Most were at low numbers by 2013 and showed further declines by 2015. Monte Carlo analyses for the six herds with enough survey data showed declines over three generations (1989-2016) ranging from 4-96%. The only herd that increased during those three generations was the Porcupine herd, which increased by 31%. Barren-ground caribou populations undergo large fluctuations over several decades. The causes of these fluctuations in abundance are complex, likely driven by climate interacting with forage availability, predation, and parasites. Harvest and predation play a stronger role in the decline phase of the cycle

	and at low numbers. Variability in the strength of age classes (cohorts) can be a factor in population declines and recoveries.
Threats and limiting factors What follows is a listing of all threats to barren-ground caribou, organized in no particular order. The loss of winter range and forage from forest fires has a significant impact on barren-ground caribou. The number, intensity, and duration of forest fires appears to be increasing in the NWT. Traditional knowledge holders generally agree that fires dramatically impact habitat, often leaving it unsuitable for decades, if not centuries, and forcing barren-ground caribou to relocate to more desirable habitat. These large-scale impacts to habitat reduce survivability of calves, reduce physical condition of adults, and also influence migration patterns. The threat from forest fires is seen as imminent and likely to increase in the future. Industrial resource extraction is largely considered to be one of the major factors affecting barren-ground caribou. Examples of effects include sensory disturbances such as noise or light, the introduction of contaminants, disruption of migration routes, injury and loss of forage opportunities, increase in predation, and fragmentation or degradation of caribou habitat. Resource extraction is considered one of the most immediate and imminent anthropogenic factors affecting barren-ground caribou. This is largely due to the scale of impacts from mining and oil and gas operations. Resource exploration and development have increased in some regions of the NWT and Nunavut and	**Threats and limiting factors** What follows is a listing of all threats to barren-ground caribou, organized in no particular order. For the Porcupine herd, activity on the winter range, improved access as a result of the Dempster Highway (NWT and Yukon), and potential future mineral exploration in the Peel River watershed represent potential threats. Of more significance however, will be a decision on oil and gas exploration and development on the coastal plains of the Arctic National Wildlife Refuge in Alaska. A decision to open the area to development could potentially impact critical calving habitat used by the herd. Industrial development activities vary over time, in a boom and bust cycle dependent upon the global economy. Since the 2008 market crash and resulting lower commodity prices, exploration and development activities have, for the most part, been declining in the NWT. Of the NWT's barren-ground caribou herds, the Bathurst herd likely faces the most pressure from human activities. With respect to linear disturbance, some projects currently under construction (e.g., 28 kilometer (km) all weather road through the central barrens, construction of the Mackenzie Valley Highway) and some proposed future construction (e.g., all-weather road connecting a deep-water port to the interior territory, extension of Highway 4) represent possible threats to barren-ground caribou by acting as potential barriers to movement, sources of

there is concern about the ability of certain herds to withstand current and future pressures.

Current and proposed access roads—both winter and all-season—are a serious concern. Barren-ground caribou are stressed by the noise, the roads provide easier access to remote areas of caribou range for industry, they alter migration patterns, and they increase hunter access and the number of caribou harvested.

Climate change is another factor that traditional knowledge holders have observed to be impacting barren-ground caribou in numerous ways. Increased variability in weather patterns includes hotter, drier summers that increase the chances of large forest fires and an increasing number of freezing rain events that make it very difficult for caribou to access winter forage. Additionally, changing climatic conditions are causing habitat alterations resulting from melting permafrost and erosion.

Although current harvest is low, it has been noted that when barren-ground caribou population numbers are low, any threats are exacerbated and recovery is slower. Non-traditional harvest practices are also considered a threat to barren-ground caribou; these activities include reckless shooting, overuse of motorized vehicles, wasting meat and leaving carcasses on the ground, not sharing meat, and not using the entire carcass.

Wolves, wolverines, and grizzly bears are known predators of barren-ground caribou. Predation by wolves and other predators is a limiting factor. It has been documented that wolf and other predator numbers are increasing due to a decrease in hunting pressure and the influx of alternate prey species such as

disturbance (noise and dust from roads), and increasing access for hunters.

Harvest plays a greater role in caribou population changes during the decline and low phases of cyclic abundance. Hunting is likely not a current threat for herds where harvest restrictions have been implemented or where recent population estimates indicate stable to increasing populations.

Climate change may act as a continuing threat for barren-ground caribou through a complex mechanism involving shift in timing of greening, lower summer forage quality, and subsequent lower calf production and reproductive potential of females, then population declines.

Forest fires are the largest driving factor in habitat fragmentation and change, impacting forage availability and movement. Regeneration of lichen-supporting forest stands can take 70-230 years. It is predicted that climate change will result in an increase in the frequency and intensity of fires, due to hotter, drier summers.

Predation is known to affect survival and reproduction. However, while there are some reports of increasing predator populations, recent information suggests a declining trend in the population of wolves and active den sites. Predator control has been considered as a tool for short-term recovery of caribou populations, but there is little evidence of effectiveness over the long term.

Contaminants are not currently considered a threat.

Parasites and diseases are a potential and complex threat under a warmer climate.

In the NWT, caribou management involves

muskoxen. Barren-ground caribou physical condition and productivity may be negatively affected by disease and parasites. The degree to which they impact caribou varies across the NWT. Caribou collaring projects impact barren-ground caribou through hair loss, icing, interference with feeding, and irritation or strangulation if the collar shifts.	interaction among many government agencies, co-management boards, various organizations, and industrial interests. Caribou seasonally migrate through extensive ranges and this can lead to inter-jurisdictional complexity between political, land management and wildlife management agencies. Most barren-ground caribou herds are now at low points in their abundance and they are facing cumulative effects from multiple interacting threats that are unprecedented.
Positive influences The calving grounds of the Porcupine, Bluenose-West, and Beverly herds are provided partial protection from development by their inclusion in Yukon, NWT, and Nunavut national parks and wildlife sanctuaries. Additional habitat may be protected by a proposed national park—Thaidene Nene—in the ranges of the Bathurst, Beverly, and Ahiak herds. Habitat protection is also offered through land use planning instruments, including the Gwich'in, Sahtú, and Tłı̨chǫ land use plans and the six community conservation plans in place in the Inuvialuit Settlement Region. The draft Nunavut Land Use Plan may provide some habitat protection following its approval. There are a number of measures for reducing harvest in place for aboriginal harvesters in the NWT. These restrictions apply to the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, and Bathurst herds. Relative to harvests 30 or 40 years ago, the total number of barren-ground caribou harvested by both subsistence hunters and resident hunters has decreased across the	**Positive influences** Collaborative co-management has allowed for cooperative/joint management planning for caribou. In some cases, agreement among management authorities has resulted in management actions, including harvesting restrictions for commercial, outfitted, resident and aboriginal hunting, which contribute to addressing caribou declines, as well as the development of co-management plans for barren-ground caribou herds in the NWT. Harvest of the Porcupine caribou herd is led by a harvest management plan. This plan establishes a total allowable harvest based on the status of the herd and requires harvest reporting for all Parties to the plan. There are various measures for reducing subsistence and resident harvest in place for the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds. Currently, there is no commercial harvesting of any NWT barren-ground caribou herd. Specific co-management structures have been built to address concerns with some barren-ground caribou herds. These structures include

NWT. The reduction in harvest coincides with the adoption of the skidoo, as hunters no longer need to provide meat for their dog teams. Declines in harvest also stem from various socioeconomic barriers such as the increased costs associated with utilizing motorized transport in accessing caribou herds. Harvest and use of barren-ground caribou is seen as a sign of respect; as such, there are rules, in the form of traditional laws and harvesting protocols, associated with hunting caribou, many of which have and will continue to have a positive influence on caribou health, numbers, and habitat. These traditional laws and harvesting protocols will help curb overharvest, wastage, and disrespectful harvest for profit. Harvest of caribou may have a positive influence on caribou populations, as it helps prevent the dramatic population cycles resulting from overpopulation.	the Advisory Committee for Cooperation on Wildlife Management, the Porcupine Caribou Management Board, the International Porcupine Caribou Board, and the Beverly and Qamanirjuaq Caribou Management Board. Under development is a Bathurst Caribou Herd Cooperative Advisory Committee. Current and proposed habitat protection for barren-ground caribou in the NWT can be found through existing protected areas (Thaidene Nene, Ezodzıtı, Thelon Game Sanctuary, Edaǰǰla, Saoyú-ʔehdacho National Historic Site, Tuktut Nogait National Park, Yambahti, Queen Maud Gulf Bird Sanctuary), range planning processes, and through regional land use planning processes (Gwich'in, Sahtú, Tłı̨chǫ, and Nunavut land use plans, Inuvialuit community conservation plans). Restrictions on development vary among land management regimes, but many include some form of restriction on resource development. Portions of the Porcupine caribou herd in the Yukon are also offered some protection from Ivvavik National Park and Old Crow Flats Special Management Area.

Technical Summary

Question **TK/CK**; Science	Traditional & Community Knowledge	Scientific Knowledge
Population trends		
Generation time (*average age of parents in the population*) **(indicate years, months, days, etc.).**	Information not available; caribou females begin to have calves at 2-3 years of age and may have calves every year after that.	Eight to nine (8-9) years, based on adult survival and fecundity.
Number of mature individuals in the NWT (or give a range of estimates).	Information not available.	• Porcupine: 197, 228 (2013) Roughly 530,000 barren-ground caribou exist either always or sometimes within the NWT.[1] • Tuktoyaktuk Peninsula: 1,701 (2015) • Cape Bathurst: 2,259 (2015) • Bluenose-West: 15,274 (2015) • Bluenose-East: 38,592 (2015) • Bathurst: 19,769 (2015) • Ahiak: 71,340 (2011) • Beverly South[2]: densities of breeding females too low to survey further (2011) • Beverly North: 124,189 (2011)

[1] Please refer to *Abundance* (p. 122) for more details on herd population estimates.
[2] See *Systematic/taxonomic/naming clarifications* (p. 93) for more information on Beverly herd naming.

		• Qamanirjuaq: 264,718 (2014)
Amount of change in numbers in the recent past; *Percent change in total number of mature individuals over the last 10 years or 3 generations, whichever is longer.*	Population trends vary among herds. The Porcupine herd is clearly increasing and there is some indication that the Tuktoyaktuk Peninsula herd may also be increasing. The Bathurst and Bluenose-East herds are likely decreasing and there is some evidence of recent declines in the Beverly and Qamanirjuaq herds. Trends for the Cape Bathurst and Bluenose-West herds are not clear based on available resources and there is no available trend information for the Ahiak herd.	Based on Monte Carlo analysis between 1989-2016. • Porcupine: +31% • Tuktoyaktuk Peninsula: n/a • Cape Bathurst: -85% • Bluenose-West: -87% • Bluenose-East: -89% • Bathurst: -96% • Ahiak: n/a • Beverly: n/a • Qamanirjuaq: -4%
Amount of change in numbers predicted in the near future; *Percent change in total number of mature individuals over the next 10 years or 3 generations, whichever is longer.*	Information not available; see *Threats and limiting factors* (p. 59).	The Porcupine herd is currently at the highest recorded level and the predicted change in numbers is unknown. Based purely on previous population fluctuations, there is the expectation that for herds currently at low numbers, the population should increase over the next three caribou generations. However, there is uncertainty in this prediction due to unknown management actions going forward, and the effect of environmental variation, particularly with climate change. Fluctuations may not follow the same pattern as

		previously observed.
Amount of change happening now; *Percent change in total number of mature individuals over any 10 year or 3 generation period which includes both the past and the future.*	Not available; however, it is implied that changes in the recent past are still occurring now.	See above. Information as recent as 2015 indicates declines are continuing in these herds (Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst).
If there is a decline (*in the number of mature individuals*)**, is the decline likely to continue if nothing is done?**	The overall decline in the caribou herds is exacerbated by anthropogenic and natural factors. It is likely that the negative trend will continue if these impacts are allowed to continue, or if they increase in duration, magnitude, or intensity.	Declining herds are vulnerable to unprecedented cumulative effects. Conceivably, current severe declines could continue if nothing is done. Management actions would likely reduce the risk of continuing decline.
If there is a decline, are the causes of the decline reversible?	Anthropogenic causes of the decline may be reversed. Attempts may be made to limit the natural causes of decline.	Some likely causes of the decline (primarily human harvest and industrial development) are reversible.
If there is a decline, are the causes of the decline clearly understood?	The causes of the decline are complex and include habitat loss, forest fires, reduced forage, climate change, unfavourable weather conditions (icing, extremely hot summers), industrial development, increased access, increased predation, increased disturbances, hydroelectric regulation of reservoir levels, land use in the calving (and rutting) grounds, increased insect activity, overharvest,	Causes of declines are complex, likely driven by a combination of climate change, forage availability, predation, human harvest, and pathogens. Predation and human harvest play a greater role in caribou population changes during the decline and low phases of fluctuating abundance.

	overharvest of females, habitat fragmentation, and competition from other animals such as muskoxen. Lack of hunter knowledge of and compliance with traditional laws and protocols is also considered to be a possible cause of declines.	
If there is a decline, have the causes of the decline been removed?	Although the causes of the decline are not clearly understood, effort to control the decline is being made. For instance, some harvesting restrictions and predator programs have been put in place.	Some likely contributors to decline have been mitigated in recent years (e.g., harvest has been reduced) but other causes, including natural causes, remain.
If there are any fluctuations or declines, are they within, or outside of, natural cycles?	Uncertain.	Insufficient information on magnitude of previous cycles to answer.
Are there extreme changes in the number of mature individuals?	The available material suggests that over time, caribou populations undergo large changes, with numbers being high and caribou being very accessible, to caribou numbers dramatically dropping and being very difficult to access or having disappeared.	Populations fluctuate greatly in abundance.
Distribution trends		
Where is the species found in the NWT? *Estimated extent of occurrence in the NWT (in km^2).*	Barren-ground caribou are found in the northern half of the NWT, roughly following the treeline. Much of the winter range of the various	The Porcupine herd is primarily located in Alaska with wintering range in the northern Yukon and NWT. Extent of occurrence for the

	herds is located in the NWT; however, many herds have summer ranges that extend into neighbouring regions (Nunavut, Yukon, and Alaska).	Porcupine herd, excluding the portions of its range not within in the NWT, is 21,337 km^2. The range of the Tuktoyaktuk Peninsula, Cape Bathurst, and Bluenose-West herds is almost entirely within the NWT. The range of the Bluenose-East, Bathurst, Ahiak, and Beverly herds currently includes the NWT and Nunavut. The Qamanirjuaq herd is mostly in Nunavut and Manitoba, with a small portion in the NWT and Saskatchewan. Extent of occurrence for these eight herds, excluding portions of their range not within the NWT, is approximately 787,473 km^2.
How much of its range is suitable habitat? *Index of area of occupancy (IAO) in the NWT (in km^2; based on 2 × 2 grid).*	Much of the range is suitable. See *Habitat fragmentation and trends* (p. 51).	The area of occupancy for the Porcupine herd, calculated based on the smallest area essential for the survival of existing populations (calving grounds), either within the NWT or outside the NWT, is 23,952 km^2. The area of occupancy for the eight central/eastern herds, calculated in the same manner, is 161,852 km^2, excluding calving ground overlap between the Beverly and Ahiak herds.
How many populations are there? To what degree would the different	There are at least two populations; the Porcupine herd forms one distinct	Nine (based on extant calving grounds). It is possible that one threat could impact each

populations be likely to be impacted by a single threat? *Number of extant locations in the NWT.*	population, while barren-ground caribou (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq) may form a single, large, mixed population. The most important threat is unknown; therefore, it is not possible to say to what degree the populations would be impacted by a single threat.	calving ground independently.
Is the distribution, habitat or habitat quality showing a decline that is likely to continue if nothing is done? *Is there a continuing decline in area, extent and/or quality of habitat?*	Yes; range and the amount of habitat for barren-ground caribou have shown declines that are likely to continue if nothing is done.	Range size has decreased as population numbers have declined. Habitat is changing (e.g, forest fires, climate change, disturbance), but the effects of these changes on caribou ecology and population dynamics are poorly understood.
Is the number of populations or amount of occupied area showing a decline that is likely to continue if nothing is done? *Is there a continuing decline in number of locations, number of populations, extent of occupancy and/or IAO?*	The amount of occupied area has declined due to anthropogenic and natural factors and is likely to continue declining if nothing is done.	The number of locations and herds has remained constant, notwithstanding changes in herd definitions over time. Range size fluctuates with abundance, thus recent annual areas in some herds are reduced from peak abundance.
Are there extreme fluctuations in the range or the number of populations? *Are there extreme fluctuations (>1 order of magnitude) in number of locations, extent of occupancy and/or IAO?*	See above.	No. The number of herds has remained the same.

Are most individuals found within small and isolated populations? *Is the total population severely fragmented (most individuals found within small and isolated populations)?*	No.	No.
Immigration from populations elsewhere		
Does the species exist elsewhere?	Yes, barren-ground caribou exist in neighbouring circumpolar regions: Nunavut, Yukon, and Alaska.	Caribou (including wild reindeer) are also in Scandinavia, Greenland, the Russian Federation, Svalbard and Jan Mayen, the continental United States, Alaska, and in the mountain, tundra and taiga habitats in the rest of Canada. In North America, domestic reindeer exist in the NWT on the Tuktoyaktuk Peninsula and in Nunavut on the Belcher Islands. In North America, barren-ground caribou also exist in Nunavut on the central mainland (Lorillard, Wager Bay herds) and on Southampton, Coates, and Baffin islands.
Status of the outside population(s)?	Information not available.	Most barren-ground caribou herds in North America have shown declines in recent decades.
Is immigration known or possible?	Immigration between populations is known to occur. Uncertainty exists with respect	Possible among herds, but observed immigration rates are low (<5%) based on

	to the degree of immigration/emigration between groups.	exchange rates of collared females among neighbouring herds.
Would immigrants be adapted to survive and reproduce in the NWT?	Yes.	Yes.
Is there enough good habitat for immigrants in the NWT?	Uncertain; it is thought by traditional and community knowledge holders that the current decline is, in part, the result of decreases in the amount of suitable habitat.	Yes.
Is the NWT population self-sustaining or does it depend on immigration for long-term survival?	Although not expressly stated in the available traditional and community knowledge literature, it is generally implied that as a whole, barren-ground caribou in the NWT are self-sustaining, independent of immigration from outside populations.	Herds that are covered in this report do not depend on immigration for long term survival.
Threats and limiting factors		
Briefly summarize the threats and indicate the magnitude and imminence for each.	What follows is a listing of all threats to barren-ground caribou, organized in no particular order. The loss of winter range and forage from forest fires has a significant impact on barren-ground caribou. The number, intensity, and duration of forest fires appears to be increasing in the NWT. The threat from forest fires is seen as imminent and likely to increase in the future.	For the Porcupine herd, activity on the winter range, improved hunting access, and potential future mineral exploration are key threats. A threat of a greater magnitude will be the decision on oil and gas exploration and development on the coastal plains of the Arctic National Wildlife Refuge in Alaska which would impact critical calving habitat. Of the NWT's barren-ground

	Resource extraction is considered one of the most immediate and imminent anthropogenic factors affecting barren-ground caribou. This is largely due to the scale of impacts from mining and oil and gas operations. Resource exploration and development have increased in some regions of the NWT and Nunavut and there is concern about the ability of certain herds to withstand current and future pressures. Current and proposed access roads—both winter and all-season—are a serious concern. Climate change is another factor that traditional knowledge holders have observed to be impacting barren-ground caribou in numerous ways. Although current harvest is low, it has been noted that when barren-ground caribou population numbers are low, any threats are exacerbated and recovery is slower. Non-traditional harvest practices are considered a threat, including reckless shooting, overuse of motorized vehicles, wasting meat, and leaving carcasses on the ground.	caribou, the Bathurst herd likely faces the most pressure from human activities including linear disturbances and mining-related activities. Unsustainable harvest can affect all herds but is likely less of a current threat due to harvest restrictions. At low populations, harvest can have a significant impact on population dynamics. Climate change interacts with other threats through complex mechanisms including shifts in timing of greening, and lowering summer forage quality which may exacerbate population declines. Forest fires are predicted to increase in frequency and intensity impacting forage availability and movement patterns. Predation, which affects all herds, is known to affect survival and reproduction rates. At low populations, predation can have a significant impact on population dynamics. Parasites and diseases are an unknown but potential and complex threat with a changing climate. In the NWT, caribou management involves interaction among many

	Predation by wolves and other predators is a limiting factor. Wolf and other predator numbers may be increasing due to a decrease in hunting pressure and the influx of alternate prey species such as muskoxen. Barren-ground caribou physical condition and productivity may be negatively affected by disease and parasites. The degree to which they impact caribou varies across the NWT. Caribou collaring projects impact barren-ground caribou through hair loss, icing, interference with feeding, and irritation or strangulation if the collar shifts.	government agencies, co-management boards, various organizations, and industrial interests. Caribou seasonally migrate throughout extensive ranges and this can lead to inter-jurisdictional complexity between political, land management and wildlife management agencies Most barren-ground caribou herds are now at low points in their abundance and they are facing the cumulative effects from the multiple interacting threats that are unprecedented.
Positive influences		
Briefly summarize positive influences and indicate the magnitude and imminence for each.	The calving grounds of the Porcupine, Bluenose-West, and Beverly herds are provided partial protection from development by their inclusion in national parks and wildlife sanctuaries. Gwich'in, Sahtú, and Tłı̨chǫ land use plans and the six community conservation plans in place in the Inuvialuit Settlement Region are instruments offering habitat protection. The draft Nunavut Land Use Plan may provide some habitat protection	Harvest of the Porcupine caribou herd is led by a harvest management plan. This plan establishes a total allowable harvest based on the status of the herd and requires harvest reporting . Various forms of subsistence and resident harvest restriction are in place for the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds.

	following its approval. There are a number of harvesting restrictions in place for aboriginal harvesters in the NWT. Relative to harvests 30 or 40 years ago, the total number of barren-ground caribou harvested by both subsistence hunters and resident hunters has decreased across the NWT. Traditional laws and harvesting protocols have and will continue to have a positive influence on caribou health, numbers, and habitat. These traditional laws and harvesting protocols will help curb overharvest, wastage, and disrespectful harvest for profit. Harvest of caribou may have a positive influence on caribou populations, as it helps prevent the dramatic population cycles resulting from overpopulation.	Currently, there is no commercial harvesting of any NWT barren-ground caribou herd. Specific co-management structures have been built to address concerns with some barren-ground caribou herds (Advisory Committee for Cooperation on Wildlife Management, Porcupine Caribou Management Board, International Porcupine Caribou Board, Beverly and Qamanirjuaq Caribou Management Board). Under development is a Bathurst Caribou Herd Cooperative Advisory Committee. Current and proposed habitat protection for barren-ground caribou in the NWT can be found through existing protected areas (Thaidene Nene, Ezodzıtı, Thelon Game Sanctuary, Edaííla, Saoyú-ɂehdacho National Historic Site, Tuktut Nogait National Park, Yambahti, Queen Maud Gulf Bird Sanctuary), range planning processes, and through regional land use planning processes (Gwich'in, Sahtú, Tłı̨chǫ, and Nunavut land use plans, Inuvialuit community conservation plans). Restrictions on development vary among land management regimes, but many include some form of

		restriction on resource development. Portions of the Porcupine caribou herd in the Yukon are also offered some protection from Ivvavik National Park and Old Crow Flats Special Management Area.

Glossary

ACCWM	Advisory Committee for Cooperation on Wildlife Management
ACIA	Arctic Climate Impact Assessment
BQCMB	Beverly and Qamanirjuaq Caribou Management Board
CARMA	Circum-Arctic Rangifer Monitoring and Assessment Network
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ENR	Environment and Natural Resources
GLUPB	Gwich'in Land Use Planning Board
GNWT	Government of the Northwest Territories
GRRB	Gwich'in Renewable Resources Board
GSA	Gwich'in Settlement Area
GTC	Gwich'in Tribal Council
HTC	Hunters and Trappers Committee
IGC	Inuvialuit Game Council
IPCB	International Porcupine Caribou Board
ISR	Inuvialuit Settlement Region
IUCN	International Union for the Conservation of Nature
LKDFN	Łutsel K'e Dene First Nation
MVRB	Mackenzie Valley Review Board
NIRB	Nunavut Impact Review Board
NSMA	North Slave Métis Alliance
NWT	Northwest Territories
NU	Nunavut
PCMB	Porcupine Caribou Management Board

RRCs	Renewable Resource Councils
SARC	Species at Risk Committee
SLUPB	Sahtú Land Use Planning Board
SRRB	Sahtú Renewable Resources Board
SSA	Sahtú Settlement Area
WMAC (North Slope)	Wildlife Management Advisory Council (North Slope)
WMAC (NWT)	Wildlife Management Advisory Council (NWT)
WRRB	Wek'èezhìı Renewable Resources Board

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Traditional and Community Knowledge Component

PREAMBLE

> *"Our history is written on the land, in the placenames and stories, in the language. ...And unless you speak the language, you will not fully understand the stories. I'm always searching for stories. That's where our knowledge comes from. That's how knowledge in my area is passed on." (Walter Bayha [Tulít'a] in Bayha 2012: 26)*

The people of the Northwest Territories (NWT) are intrinsically linked to barren-ground caribou. For indigenous peoples and many NWT communities, no other animal has such a large influence socially, culturally, or economically on their way of life, in the past and for future generations. The nomadic life of indigenous peoples was historically intertwined with the caribou herds and their seasonal migration. Caribou provided essential resources to survive in the harsh northern environment, including food, clothing, tools, shelter, and connections to the land, animals, community and ancestors. Even with the documented changes in harvesting in recent years, the importance of barren-ground caribou to indigenous peoples and NWT communities cannot be understated in this report. At present, individuals from nearly every community in the NWT are involved in the harvest of barren-ground caribou.

> *"The caribou from around Łutsel K'e feed the people of Łutsel K'e and Fort Resolution." (Danny Beck [Northwest Territory Métis Nation] pers. comm. 2017)*

> *"As Dene people it's not looking too good for us. Without caribou, it would be difficult to survive." (Leon Andrew [Norman Wells] pers. comm. 2017)*

Caribou have historically been a key resource for people in the NWT (SENES Consultant Ltd. 2010; Beaulieu 2012; Zoe 2012; Tłı̨chǫ Government 2013; Polfus *et al*. 2016; Tłı̨chǫ Research and Training Institute [TRTI] 2016); in some cases so important that families would follow their migration (Benson 2015).

Traditional knowledge

Over the years, different traditional knowledge policies have been developed (see *Appendix A*, p. 246).

According to traditional and community knowledge, barren-ground caribou range throughout the large majority of the NWT, with most herds passing through multiple regions during their annual migrations. Their history is integrally tied to the cultural history of the NWT, with indigenous

peoples having interacted closely with barren-ground caribou for thousands of years (Beaulieu 2012; Tłı̨chǫ Government 2013; Polfus *et al*. 2016) and their identity (SENES Consultants Ltd. 2010; Zoe 2012) and even social organization sometimes being attributed to their long-term interactions with barren-ground caribou (Smith 1978; Zoe 2012; TRTI 2016).

The consideration of this experience is of vital importance for the accurate assessment of barren-ground caribou. While all reasonably available traditional and community knowledge was solicited for inclusion in this status report, limitations are acknowledged. First, in the completion of these reports, the Species at Risk Committee (SARC) is not able to conduct any primary research or information gathering activities (e.g., interviews). Understanding that the transcription and verification of traditional and community knowledge is often complex and resource-intensive, not to mention sometimes controversial (Bayha 2012), only a small portion of the traditional and community knowledge that exists has actually been transcribed. This limits the completeness, and perhaps also accuracy, of the status report. Second, it is important for us to recognize that the traditional knowledge that has been transcribed and was available for inclusion in this status report, is, in many respects, removed from the cultural, spiritual, linguistic, and ecological context in which it was intended to be heard (Berkes *et al.* 2000; Thorpe 2004; SENES Consultants Ltd. 2010; TRTI 2016). Translation, in particular, can result in generalizations and the loss of sometimes subtle descriptions of inter- and intra-specific variation, interactions, and patterns (TRTI 2016; Polfus *et al*. in review). As noted by Polfus *et al.* (in review: 17), "words are used in context and convey different meaning depending on who is speaking, what dialect is being used, what questions are being addressed, where on the land the speaker is located, and the dialect or background of the audience." Although traditional knowledge and its transmission is ultimately grounded in practice, language is integral to its interpretation (Bayha 2012; Polfus *et al.* 2016). Ultimately though, understanding the environment (animals, plants, land, water, air, etc.); that is, practicing one's culture, is equally important in understanding the stories and legends.

Traditional laws and protocols

Hunting is often viewed by Elders as fundamental to the continued survival of the caribou and their relationship with the land. Harvest and use of caribou is seen as a sign of respect; as such, there are rules, in the form of traditional laws and harvesting protocols, associated with hunting caribou, many of which currently have and will continue to have a positive influence on caribou health, numbers, and habitat (Wray 2011; Sangris 2012; Wray and Parlee 2013; Benson 2015; Denesuline Né Né Land Corp. 2015). The traditional laws and harvesting protocols surrounding taking only what you need, using everything you take, and not wasting anything will help keep populations strong, as fewer caribou will need to be harvested and caribou will continue to be respected. The principle or law of respect is foundational to the interaction between humans and caribou, and is even incorporated into plans such as the Inuvialuit Community Conservation Plans (Community of Aklavik *et al.* 2008; Community of Inuvik *et al.* 2008; Community of

Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008; Nahanni Butte Dene Band, no date).

> *"One of the first things I was taught as a child is to respect and honour ekwǫ̀, because without this herd many of my ancestors would have perished and would be gone. Ekwǫ̀ give us life, so in return we have to do our best to guard and protect them." (Fred Sangris [Ndılo] in Sangris 2012: 76)*

Many youth and young hunters today are unaware of these laws, or are not practicing them. However, increasingly these traditional laws and harvesting protocols around caribou harvesting and management are being taught to younger members of communities around the NWT. An increase in awareness and use of these traditional laws and harvesting protocols has the potential to increase respectful behaviour to caribou and to reduce wastage and overharvest. Traditional laws and harvesting protocols about respect for caribou will be key positive influences in the present and the future for barren-ground caribou and their habitat.

> *"Aboriginal people are very careful. We have been managing our resources for generations, way before the arrival of the Europeans. If we didn't manage them, there would be no ekwǫ̀, there would be no buffalo, there would be no animals on earth. The same thing goes with the fish. We don't fish out the whole lake. When one lake is fished out we move on to the next one. So we're very careful. We have to manage the animals because this is our food source. We still make sure that our stock are not thinned out. We make sure that the food source is going to be there for many generations after we're gone. For example, one time my grandfather said, "Go hunting in this area. Get some moose, get some ekwǫ̀. But once you've hunted there, don't go there again for a while. Go to another place, and harvest other animals too as well. Because if you stay in one area too long you continue to harvest the same animals, eventually they're going to thin out and disappear." So as Aboriginal people we've learned to manage our wildlife. We've learned to take care of our food source. We've depended on these animals for thousands of years, and we still continue to depend on them today. What's happening today in my community is that the young people, my young generations are not following those protocols. They're not being taught. So I'm trying to push a hunter education program in my community to bring back the old traditional ways and the cultural ways, and teach the young people about respect and only taking what you need. I see young people bringing in many ekwǫ̀ come down, fifty or sixty. I see no reason why such great numbers are taken. I'm not a leader in my community, but as a hunter I take responsibility. I step forward and I'm going to try to do my best to work with young people to bring back education in our culture, hunting skills and the traditional laws of the people and wildlife. We need to go back to these laws because ekwǫ̀ said, "If you don't keep the laws I will go away, and I might not come back." This is what we've got to think about: respect, and bringing the laws back, and trying to protect the*

sacred animal." (Fred Sangris [Ndılo] in Sangris 2012: 77)

Source summary, gaps, omissions, and understandings

Barren-ground caribou in the NWT travel across numerous provincial and territorial boundaries. To ensure adequate coverage, this report uses the best available information from across the NWT, Yukon, Nunavut, Alberta, Saskatchewan, and Manitoba. Within the NWT, the Tłı̨chǫ and Gwich'in areas were best represented by the materials used, with the Sahtú, Inuvialuit, and North Slave regions reasonably well-represented. The Dehcho and South Slave regions had the fewest available resources for use in the report.

The publicly available information tended to be from four main sources: renewable resource boards, local hunters and trappers committees, government reports, and academic research initiatives. Throughout the report, quotes of knowledge holders have been drawn from published, publicly available literatures. These quotes are cited in the text and a list of knowledge holders whose thoughts were used are included in *Authorities cited* (p. 84).

It is important to understand that traditional knowledge holders speak about caribou; they don't tend to speak about specific herds (e.g., Qamanirjuaq, Cape Bathurst, etc.). When traditional knowledge is attributed to a given herd in published sources (e.g., Bluenose-East caribou hearing transcripts), this is often the result of the parameters that the people hosting the meeting have outlined.

Overall, the report represents the best available information on the status of barren-ground caribou throughout the NWT and surrounding jurisdictions as described in traditional and community knowledge sources.

SPECIES OVERVIEW

Names and classification

All of the languages in the NWT have a word for the iconic barren-ground caribou: tuktu/tuktut (Inuvialuktun), tuktuvialuit (Innuinaqtun and Siglitun), tuttuvialuk (Ummarmiutun), vadzaıh (Teetł'it and Gwichya Gwich'in), ʔekwǫ̀ or hozıʔekwǫ̀ (Tłı̨chǫ)**,** ʔekwę́, ʔepé, ʔedə (Sahtú Dene – Délı̨nę, Tulít'a, and Fort Good Hope/Colville Lake)**,** nódı (South Slavey - Kátł'odehche dialect), Ɂetthe̓́n (Chipewyan – Denínu Kuę́ and Łutsel K'e), etthén (Dënesųłiné), atihk (Cree), caribou de la toundra (French) (Tłı̨chǫ Community Services Agency 1996; Gwich'in Elders 1997; LeClaire and Cardinal 1998; Auld and Kershaw 2005; Wildlife Management Advisory Council [WMAC] (North Slope) and Aklavik Hunters and Trappers Committee [HTC] 2009; South Slave

Divisional Education Council [SSDEC] 2009, 2012, 2014; Wek'èezhìı Renewable Resources Board [WRRB] 2010g; Inuvialuit Joint Secretariat and Species at Risk Secretariat [SARS] 2011; Sahtú Renewable Resources Board [SRRB] and SARS 2013; Advisory Committee for Cooperation on Wildlife Management [ACCWM] 2014b).

For the purposes of this report, the nine herds included in this assessment of barren-ground caribou include: Porcupine, Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq. The Porcupine caribou herd, as a geographically distinct population, was assessed separately from the other eight herds. SARC (2016) considers geographically distinct populations to be populations that are 'naturally disjunct' (substantial portion of the range is separate and disconnected from the rest of their species or subspecies) or occupy a different ecological region than the rest of their species or subspecies.

Description

Barren-ground caribou are mid-sized land mammals. They are slightly smaller than the closely related boreal woodland caribou (Benson 2011; Polfus *et al.* 2016) and can be distinguished from mountain caribou by the large size and strong mountain association of the latter (Polfus *et al.* 2016) (Fig. 1, below). These three types of caribou can also be distinguished by their tracks and perhaps also by the taste of their meat (Polfus *et al.* 2016).

Figure 1. Generalized physical differences (relative size, colouring, antlers) between the three types of caribou resident of mainland NWT. From left to right: boreal woodland caribou, mountain caribou, barren-ground caribou (Polfus *et al*. in review). Illustrations by Jean Polfus. Used with permission.

Both male and female barren-ground caribou have light-coloured hair around their tails and on their stomachs, and their coats become progressively darker towards the spine. Both also grunt in similar ways (Benson 2015) and have hooves that make a unique clicking sound when running (Gwich'in Elders 1997). Females have smaller antlers, shorter necks, and smaller bodies than males, and are typically lighter in colour (Gwich'in Elders 1997).

"In size [the males have] bigger horn…The horn is real tall, and the cow, they got smaller horns. That is the only way you can tell, is different size of horns. If you see caribou is big and has got real tall horn, that's bull…And a small little horn is a cow…They look dark [in] colour as a bull,…and white one – they're just like white colour, that's [a] cow. [Both have a tuft of hair, but]…the bull's is really long…[You can tell from] maybe one quarter of a mile, I guess. You can tell what they are if they're smaller and they're [a] lighter colour, but if you see bull they're dark…dark and bigger." (Gabe Andre [Tsiigehtchic], Gwich'in Environmental Knowledge Project [GEKP] in Benson 2015: 21)

Slight variations in pelage colour and taste of the meat exists between different barren-ground caribou herds in the NWT. Barren-ground caribou often form large herds and will be seen travelling with numerous other individual caribou (Gwich'in Elders 1997; Auld and Kershaw 2005).

Range

NWT Range

Barren-ground caribou range widely throughout circumpolar North America. According to traditional and community knowledge, the range of barren-ground caribou covers a large portion of the NWT as well as neighbouring regions (Fig. 2, p. 11).

"In northern Canada we have ekwǫ̀ [caribou] all over northern parts of the Arctic Ocean, all the way from Alaska, Yukon, NWT, and then Quebec, Innu, Labrador, even as far as Newfoundland. There's ekwǫ̀ all over the place." (Fred Sangris [Ndılo] in Sangris 2012: 78)

Figure 2. Historic maximum barren-ground caribou range, compiled based on spatial data and written descriptions of range (Thorpe *et al*. 2001; Parlee *et al.* 2005; Inuuvik Community Corporation [ICC] *et al.* 2006; Dumond 2007; Community of Aklavik *et al*. 2008; Community of Paulatuk *et al.* 2008; Benson 2011; Beaulieu 2012; Kavik-Stantec 2012b; ACCWM 2014b).

Barren-ground caribou are highly migratory and travel along their migratory route twice a year. They will migrate northwards in the spring to their calving grounds and southwards in the fall to their winter range (more detail on their migration can be found in *Migration routes and movement*, p. 17).

> *"The herds in these areas would have traveled in a south and southwesterly direction across the barrens to the boreal forest during the fall time and then returned in a north and northeasterly direction across the barrens in late March." (Northwest Territory Métis Nation 2012: 3)*

> *"Since it's their land [tundra], that's where they roamed around in that area until fall time. Just when they become wedziaa [small male] and fat, they roamed back into the bush. They do*

that every year and that's what they do with themselves. They don't roam in this area only, they roamed all over to Łutselk'e … that's how far they travelled to… They travelled to here and to Sahtì and towards treeline and that's what the ʔekwǫ̀ does." (Joe Zoe Fish [Whatì] in Legat et al. 2001: 33-34)

Some knowledge holders appear to be able to distinguish between caribou of different herds based on factors such as their direction of travel, colour/size/body condition, or by the taste of the meat (because different kinds of forage produce meat with distinct flavours) (Gwich'in Elders 1997; Thorpe *et al.* 2001; Kendrick 2003; Kendrick *et al.* 2005).

"You can tell which herd animals may belong to based on their hide colour, size and body shape, and the direction the cows are migrating to." (James Marlowe [Łutsel K'e] in Kendrick 2003: 172)

For instance, caribou of the Cape Bathurst and Bluenose-West herds may have different sized antlers than those of the Porcupine herd: "I think the cows [antler's] on the Bluenose…are a little bigger than the antlers on the Porcupine cows" (James Firth [Inuvik] *in* Benson 2015: 21). Similarly, caribou of the Beverly herd are often considered to be shorter and stockier than animals of the Bathurst herd, and often also display paler head and flank pelage (Kendrick *et al*. 2005). Knowledge holders note other examples as well:

"Some herds will be in better condition than animals from other herds. The animals towards Yellowknife (McKinley Point) are skinnier and darker in colour, than those caribou over by Łútsël K'é." (August Enzoe [Łutsel K'e] in Kendrick 2003: 172)

"It is well known that Vadzaih from the Porcupine herd never cross to the east of the Mackenzie River, nor do Vadzaih from the Bluenose ever cross to the west side." (Gwich'in Elders 1997: 20)

"Vadzaih from these two herds [Bluenose and Porcupine] also taste different. The meat of Bluenose vadzaih is more tender than Porcupine vadzaih meat, probably because they travel in different country and eat different foods." (Gwich'in Elders 1997: 20)

"They [Bathurst & Ahiak] winter down there (south) in the treeline, and get all spruced up. They taste like spruce when they start to come back north again, spring time. Taste the trees. You shoot a caribou, is like shooting down a tree and eating it, it tastes like spruce…." (Bobby Algona [Kitikmeot community unidentified] in Thorpe et al. 2001: 72)

"I have seen quite a bit of caribou in the Queen Maud Gulf, and the Bathurst Inlet (Kingauk) caribou… It is on the north side of upper Garry Lake where I have seen caribou. They are much bigger than the caribou from the upper mainland, say from the Queen Maud Gulf area. The caribou down here in Garry Lake are a lot bigger that the Queen Maud caribou and the Victoria Island caribou. I noticed they are much darker, darker and bigger. Those caribou I

really like the meat (niqi) and I like the skin. They are really good for clothing, say for pants (qarliik), inner parkas, (ilupaaq) or mitts (pualuk) or outer parkas (qulittaq). I notice the caribou are much darker colour, south, upper from Garry Lakes than the Queen Maud Gulf caribou and the Victoria Island. I have seen both kinds, the island caribou and the barren land caribou." (George Kavanna [Kitkmeot community unidentified] in Thorpe et al. 2001: 81)

However, other individuals and communities assert that barren-ground caribou form larger intermixed (less isolated) populations (Thorpe *et al.* 2001; WRRB 2010g; Beaulieu 2012; Judas 2012; Barnaby and Simmons 2013; ACCWM 2014b).

"Our members view caribou as one meta-population. They're not genetically, behaviourally or spatially distinct, and they should be managed as a meta-population." (Sheryl Grieve [North Slave Métis community unidentified] in WRRB 2010e: 13)

"They do not always go in one direction; they are all over the land around here and here. The land is full of caribou. They would walk in all directions." (May Algona [Kugluktuk] in Thorpe et al. 2001: 100)

In Tuktoyaktuk, for example, some individuals do not consider the Cape Bathurst, Tuktoyaktuk Peninsula, and Bluenose-West herds to be separate (Kavik-Stantec 2012b; ACCWM 2014b) and Gwich'in harvesters do not tend to distinguish between caribou of the Cape Bathurst and Bluenose-West herds, referring to them simply as Bluenose caribou (ACCWM 2014b; Benson 2015). Of the Bluenose caribou, one Gwich'in harvester says, "there's not too much difference. I didn't see any difference" (Morris Blake *in* Benson 2015: 8). There is likewise also little distinction between the Bluenose-West and Bluenose-East herds among harvesters (SRRB 2007).

"Why have we split the herd when it is one big herd? The Cape Bathurst herd mixes with the other herds. We should manage the caribou as one herd." (Anonymous [Tuktoyaktuk] in ACCWM 2014b: 24).

Search effort

Search effort is not a concept that typically appears in traditional and community knowledge sources. Traditional knowledge holders go out on the land to find caribou; they know where the caribou are at any given time of the year. They know when to hunt them and when not to hunt them.

The range of barren-ground caribou in the NWT is well known and is well represented by the extensive network of trails (as evidenced by the Dene Mapping Project, which documented traditional land use) (Auld and Kershaw 2005; ICC *et al.* 2006; Community of Paulatuk *et al.* 2008; AREVA Resources Canada Inc. 2012; Benson 2015; TRTI 2016; Polfus *et al*. in review). With such an extensive network of harvesting trails across the NWT, there are few places where

harvesters have not searched for caribou, and it is highly unlikely that barren-ground caribou exist where land users haven't looked for them.[3]

"People made a lot of effort to find caribou as they had to walk around on snowshoes looking for them…." (A. Vittrekwa [Gwich'in community unidentified] in Wray and Parlee 2013: 73)

"Our harvesting practices are very much community driven. The direction comes from the hunters and the people that go out on the land and observe the wildlife. Hunters go out in different areas and report back what they are seeing. Sometimes we hear that there are a few caribou over there, the east or south. And that is one of the ways we observe wildlife…." (Phillip Kadlun [Kugluktuk] in Barnaby and Simmons 2013: 15)

"There is no limit to where we can go [when hunting caribou]." (Anonymous [Rankin Inlet] in AREVA Resources Canada Inc. 2012: 4–7)

"…one must consider the amount of time the Tłı̨chǫ people have lived on their land. For millennia, the ancestors studied and understood, in great detail, the cycles of the land and animals through each season, in order to know where and how to obtain necessary resources at any given time of the year. These understandings of people's relationship with the land do not only apply to the sub-arctic but are generally true for indigenous peoples worldwide." (TRTI 2016: 12)

BIOLOGY AND BEHAVIOUR

Caribou habitat

In the indigenous cultures and languages of the NWT, habitat is generally thought of holistically, including ecosystem components such as physical habitat, predators, snow depth, ice depth, pests and insects, vegetation, water, landscape, humans, climate, fire, etc. (Berkes *et al*. 2000; Legat *et al*. 2001; Thorpe 2004; SENES Consultants Ltd. 2010; TRTI 2016). In this sense, habitat is variable and dynamic.

As noted in *Range*, p. 10, the migrations undertaken by barren-ground caribou each year (northwards in the spring to their calving grounds/summer habitat on the barrens and southwards in the fall to their winter range in the taiga) are in response to seasonal changes in the suitability of the habitat (food becomes unavailable, movement becomes difficult, etc.) (Legat *et al.* 2001; Benson 2015). Similarly, when migration begins is dependent upon the weather.

[3] It should be noted however that traditional land use data is often considered proprietary, particularly in areas of unsettled claims, and is therefore not included for analysis in this report (Parlee *et al*. 2013).

"Caribou do not stay in one place; they are always moving and grazing wherever food can be found." (ICC et al. 2006: 11–45)

"Wherever there is good lichen, that is where they (the ʔekwǫ̀) ... roam." (Adele Wedwin [Behchokǫ̀] in Legat et al. 2001: 45)

"... Because there's no trees in the barrenlands and the ʔekwǫ̀ are not so cold in the bush, they will move into the bush (during the winter)." (Jimmy Martin [Behchokǫ̀] in Legat et al. 2001: 45)

"It depends on the weather conditions, when they start moving, like in the fall time. They wouldn't go to lakes until they were frozen." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 34)

Perhaps the most important habitat feature required by barren-ground caribou is good quality forage, although safety from predators, relief from flies, resting areas, and good visibility are also considered important, especially in calving grounds (Gwich'in Elders 1997; Thorpe *et al.* 2001; TRTI 2016). Typically, they consume lichens, grasses, rock plants, mushrooms, willow tips, cranberries and cranberry flowers, moss, and sedges (Legat *et al.* 2001; WMAC (North Slope) and Aklavik HTC 2009; Denesuline Né Né Land Corp. 2015).

"[Herd health] depends on the lichens and stuff like that. Migration in the fall time, when vegetations freeze up when it's green, it's a good sign they eat good on the vegetation. Grass and stuff like that, when it's green like that it's a good year. But when they're dry, not good for them. I mean for any animal, rabbits and muskrat that eat off the ground. Always watch that in the fall time ... Vegetation is still green it's good food for animals." (Donald Avuigana [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 89)

Caribou forage varies across the seasons; during the fall and summer when they are on the barrens, they have access to a broader range of plant types than when they are in their winter range at or below the treeline (Legat *et al.* 2001; WMAC (North Slope) and Aklavik HTC 2009; TRTI 2016). Caribou put on a lot of fat in the summer and fall (August, September, October) (TRTI 2016) when moist conditions increase the availability of their preferred foods (ACCWM 2014b), including willow, alder, Labrador tea, moss, grasses, lichens and mushrooms (Thorpe *et al*. 2001; Katz 2010). This period allows them to build up enough fat to get through the winter (TRTI 2016). Excessively dry years reduce the quality of summer forage (Jacobsen 2013).

"When it rains, the food kwetsį (rock tripe) gets moist and swells. That's the caribou's best food because they get very fat on it." (Adele Wedawin [Behchokǫ̀] in Legat et al. 2008: 19)

"In the summer when there is bad weather the ground is kind of moist. The ɂadzìì, especially ɂadzìidegoo (white lichen) gets soft, that is what the ɂekwǫ̀ really like. They get fat with it." (Rosalie Drybones [Behchokǫ̀] in Legat et al. 2001: 42)

"Whenever it rains, ékwę feeds good, and that's how ékwę gets fat. Like if we ate dry food, for example, we wouldn't like it! But if the food is boiled, it is very good for us." (William Sewi [Délįne] in Auld and Kershaw 2005: 47)

"Well, in summertime, [grass,] that's all they eat. They don't eat moss. That's all they eat is grass. And that's why a lot of people don't really care for the caribou in the summer, because it tastes grassy. Come mid-August, from then on, they really try to put lots of fat on…And a lot of it is on the land, but a lot of it is in the lakes too." (James Firth [Inuvik] in Benson 2015: 25)

"Caribou mostly eat lichen in the spring. Their stomachs are always full of lichen." (Mary Kaniak [Bay Chimo] in Thorpe et al. 2001: 134)

The coastal areas of the Arctic Ocean and Hudson's Bay provide refuge for barren-ground caribou seeking relief from insects and high temperatures. These areas also provide good forage opportunities (Thorpe *et al*. 2001; WMAC (North Slope) and Aklavik HTC 2009).

"Some years it's so hot down there, the caribou go along the coast and eat in the bays and stuff like that. They go to the cooler places rather than staying in the Delta, and then they migrate back in the fall time." (Donald Avuigana [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 29)

Important winter foods include grass, caribou moss (lichen), muskrat push-ups, small willows, aquatic vegetation, sedges and spruce bark (Thorpe *et al.* 2001; Benson 2015). The caribou are also known to scratch at the lake ice to get a chemical in the lakes that helps their antlers grow (Benson 2015).

"It's moss…white moss, they call them uhdeezhù', and then short grass…anywhere on the land… Grass – they eat that, then they go to edge of the lake…eat lots of grass there too. In summer time they just eat it, but in winter time they dig it out…they dig out grass or else white moss." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 24)

"…[push-ups are] all roots and plants, so that's what [caribou] eat. I don't think…they don't eat the mud. But if you look at a rat house, it's just all plants." (James Firth [Inuvik] in Benson 2015: 24)

On their winter range, caribou require conditions where the snow cover is easily swept aside when feeding; this is one of the reasons they head into the boreal forest, where snow is lighter and more easily cratered than on the barrenlands, where the snow is windswept and dense.

"In the boreal forest, even if it snows, the ɔekwǫ̀ will kick away the snow and get to the ground and that's how they eat and have their fill." (Jimmy Martin [Behchokǫ̀] in Legat et al. 2001: 31)

Deep snow and icing conditions from freezing rain have a distinctly negative impact on body condition and health.

"As I remember, I was trapping with my dad on a migratory route and he said this year the caribou would be having a hard time. A lot of caribou might die of starvation. I said, Why? Why is that? He said you look at the weather. The weather affects the caribou, he said. He said first it snowed and then there was freezing rain and then the cold -- cold -- cold weather, cold -- cold weather. He said that the caribou when they eat they have to remove snow from the ground to eat. But this -- the -- because of the freezing rain the caribou will be having a hard time." (Edward Chocolate [Gamèti] in WRRB 2010b: 53)

"Back in the days used to be wind, so the snow wasn't that deep because the wind would blow the snow away, so it is harder for caribou to eat now, snow is now four feet deep. Back in the days, people can walk on the hard snow, now people will fall in, because it is not so hard. That is why it's harder for caribou to travel because they fall through the snow." (Charlie Zoe-Chocolate [Whatì] in Jacobsen 2013: 13)

Migration routes and movement

As noted in *Range* (p. 10) and *Caribou habitat* (p. 14), one of the defining characteristics of barren-ground caribou is their twice yearly seasonal migration (Legat *et al.* 2001).

Migration is led by experienced leaders of the group (Benn 2001; Legat *et al.* 2001; Kendrick *et al.* 2005; WMAC (North Slope) and Aklavik HTC 2009; Padilla and Kofinas 2010; BQCMB 2011b; Benson 2015) and is directed by the excellent memories and extraordinary sense of smell of the barren-ground caribou (they can smell the old caribou trails on the landscape) (Padilla and Kofinas 2010).

"Since vadzaih are herd animals, there are usually at least two or three travelling together. A vadzaih herd has one or several leaders, usually a large older bull or cow that everyone follows. If one leader is killed, another one immediately takes its place. Older vadzaih know where to travel and where the food is, so the rest of the herd follows them. A large herd also has up to six animals that are scouts. The scouts are usually young vadzaih sent to look for food. They may travel long distances from the herd in search of a safe place with good food before returning to lead the rest of the herd back to the place. A hunter who finds the group of scouts should follow them because they will lead him to the main herd." (Gwich'in Elders 1997: 20)

"Sometimes…lots of them travel together because of the trail through the ground. Like not only one… [They all follow one behind one another] so that way they know. [T]here is always one caribou [to] lead them. Maybe old one. Old man and old women." (Joan Nazon [Tsiigehtchic],

GEKP in Benson 2015: 36)

"…the pregnant cows are getting larger, they would go back to their calving grounds, start moving back to their calving grounds. So once the boss of the caribou herd feels that it's the right time now to go back to the calving ground, they all have to travel quite a distance. And so all the caribou within the bush area -- it's not like today where we have phones, but in the past, the caribou managed to communicate somehow and gather together in groups. They would gather into group -- into a large group on a big lake. There were hundreds and hundreds as we watched this happen. And as they all gather in groups, they would all travel in a large herd back to the calving ground. The larger bulls, called Yagu (phonetic), even though the snow could be thick, that Ekwoh (phonetic) would be very powerful and travel -- and travel ahead of the herd, and -- and so they would all follow back up to the Bathurst area where the calving grounds...."(Jimmy Martin [Behchokǫ̀] in WRRB 2010b: 193)

"Our parents used to tell us stories about how the ʔekwǫ̀ migrate and roam around on the land. First of all, we start when the ʔekwǫ̀ live in the barrenlands. Later, when it starts to freeze-up, they start to migrate into our land. It is said, the ʔekwǫ̀ have k'aowo [a leader, who is the mother of a large bull]. When many ʔekwǫ̀ are migrating, she goes ahead of them and they follow her. That is the way they roam on the land." (Rosalie Drybones [Behchokǫ̀] in Legat et al. 2001: 33)

"Ɇkwɇ (caribou) migrates to the barrengrounds, even though it doesn't have navigating tools. It still travels straight. It migrates to change its clothing, just the way a man would change his clothing when it wears out. There is a kind of ɇkwɇ known in the Délı̨ne dialect as bele yah (eselǝa in the K'ahsho Got'ıne dialect). It looks like a two year old ɇkwɇ. Bele yah scouts up ahead of the herd. When it finds a good feeding ground it goes back and rounds up the herd, it is amazing how straight it travels. They say it is as intelligent as humans." (William Sewi [Délı̨ne] in Auld and Kershaw 2005: 47)

Well-known trails and water crossings are used repeatedly by migrating barren-ground caribou (Charlebois 1999; Legat *et al.* 2001; Stewart *et al.* 2004; Gwich'in Land Use Planning Board [GLUPB] 2003; Parlee *et al*. 2005).

"Vadzaih have been following the same migration routes for thousands of years. There are old trails cut deep into the ground along these routes…Vadzaih never forget their old trails and come back to them after many years of traveling through other places…." (Gwich'in Elders 1997: 20-21)

The annual migration cycle begins each year on the tundra where barren-ground caribou congregate to have their calves. The movement to the calving grounds typically takes place between January-May (Judas 2012; Benson 2015; Denesuline Né Né Land Corp. 2015; TRTI

2016). The previous year's calves will follow their mothers, but upon arrival at the calving grounds, they will leave their mothers (Gwich'in Elders 1997).

"... When it gets warm, the snow melts and it gets warmer, that is when the smaller cow called ts'ıdaa start migrating. They move first. When the fetuses start to get big, they [the females] start to migrate before the wedzıh (bull caribou)... The cows migrate to the great barrenlands, back to their calving grounds. They travel back there, back to the barrenlands and that's what the cows do. That is where they probably give birth to their calves, in spring or in the summer. As for the wedzıh, they start to migrate when all the snow melts and turns really slushy... And they have leaders for themselves as well. They have a leader for themselves just like we have leaders for us, right here. That's the way it is and when they feel that it is time, and when snow starts to melt and it gets really slushy, that is when they start to migrate last. As for ɂekwǫ̀ antlers, their antlers get really long and it's all covered with velvet… They have here all winter and migrate in the spring (when snow melts and gets slushy) and their antlers grow all the time. Their antlers grow about a foot and it's usually covered with velvet. The wedzıh (bull caribou) start to migrate to the barrenlands when that happens. When they feel that it's time, they go back to their country in the barrenlands and live there all summer. They probably roam around and feed in the barrenlands…" (Rosalie Drybones [Behchokǫ̀] in Legat et al. 2001: 35–36)

"In summer, they mostly move back to [the] calving grounds, that is way down…Bluenose Lake, I guess…they…start back down maybe in May. A lot of time I see them going back around to [Travaillant] lake, sometime I see about three or four bunch crossing the lake, and head straight for east…steady like that for couple days, maybe more. I been there only during that time. Steady going, never…they're not full blast going, they just walk, walk, walk…Sometime they don't come this way, they come by around the Coast and then they go by around Good Hope area, sometime around Bear Lake. Sometime they go further than Bear Lake too, around close to Yellowknife but they always know to go back…Some of them, they calve before they get there, you know, but the young one…a little while [after they are born,] they start walking. They follow their Mom until [they are] back to the calving ground. [They] stay around there all summer and in the fall time, in October, they start back." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 32)

"During the three cold months, January, February, March, ɂekwǫ̀ are heading back to the barren-grounds. Some of the bulls stop halfway, and others follow the females to protect them as they travel to the calving grounds." (Joseph Judas [Wekweètì] in Judas 2012: 50)

Barren-ground caribou will stay at their calving/summer grounds for the summer and fall (July-October), and will then start their southward migration to the wintering grounds (TRTI 2016). This movement south in the fall is likewise led by an experienced leader and includes the calves

born earlier in the year.

> *"In the summer or in the autumn, they return to this land as they done before. And they do this by following their k'àowo. That's the way it is and for them to head back this way again, their minds turn this way. So that is why it is said, when it's the autumn, the ɂekwǫ̀ migrate back this way all together. That is what they do. The dets'è (cow caribou) calves that were born in the barrenlands, migrate with all the other ɂekwǫ̀'s, along with the cows and they all travel this way. They come to our land. They come to our land again for all winter. The calves are two feet high when you see them and they follow their mothers. They are small but they still manage to travel great distances here with their mothers, the cows. And so, they come back here again, to have here all winter. As for the antlers that grow about a foot long… they grow all summer and in the autumn they get really huge... So they continue to migrate down this way and arrive into the tree line. They have velvet on their antlers so, they scrape their antlers in the bushes to get them off. Later their antlers become clean of the velvets and they come off. It is said, that is the reason why the bull caribou's with big antlers start migrating into the treeline. Afterwards they have here all winter. From recalling where they roamed the year before and places they know of or where they know of good feeding areas, they return there again. They have there too. They travel around and when there's no food there, they go to a different place. They travel to places where they know it's a good area for feeding and that's how they travel around." (Rosalie Drybones [Behchokǫ̀] in Legat et al. 2001: 35–36)*

> *"In falltime, August, September, that's when they come back this way and meet the other bulls halfway." (Joseph Judas [Wekweètì] in Judas 2012: 50)*

The rut occurs annually in September-November, during the fall migration south to the wintering grounds (Gwich'in Elders 1997; Thorpe *et al.* 2001; WMAC (North Slope) and Aklavik HTC 2009; Benson 2015; Denesuline Né Né Land Corp. 2015; WMAC (NWT) pers. comm. 2015). Post rut, the males begin to leave the group and are gone by November, but it is unclear from the available sources whether this kind of immediate split of males is consistent across all herds; for instance, Benson (2015) notes that the Bluenose herd (no sex-specific information provided) splits or fans out after arriving at the treeline.

During the winter months, barren-ground caribou will typically disperse into smaller groups ranging from 15-100 animals (Benson 2015). Caribou form these smaller groups in order to decrease competition for forage. It is unclear from the sources whether these groups more typically occur as segregated or mixed-sex groups (Benson 2015).

> *"When I was small, we used to see about maybe up to 15 in one group. It would be all mixed [bulls and cows, during their migration north at Travaillant Lake]." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 27)*

"Bluenose, where you might get 20 or 30 in a bunch…Like, right now,…you'd see cows, you'd see bulls, or cows and calves and bulls. But they spread out, afterwards they're done their mating…But like, when we used to fly out there [north towards the treeline in August-September], they're all mixed up. Everybody is together until they get into the treeline. And then they go their own ways." (James Firth [Inuvik] in Benson 2015: 27)

"Sometime…bulls are in one bunch, sometime cow is in one bunch." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 27)

Preference for particular areas and migration routes seems to depend upon the scale at which it is being considered. This is to say that barren-ground caribou may not be found in exactly the same spot every year, and may even undertake somewhat unexpected movements (Bayha 2012; Benson 2015; Polfus *et al.* 2016), but that when viewed over a larger period of time at a larger scale, they are generally faithful to a larger region (Legat *et al*. 2001; Kendrick 2003; WMAC (North Slope) and Aklavik HTC 2009), although significant shifts in range have been documented (Polfus *et al.* 2016). In one particular instance, Fort Good Hope knowledge holders note the crossing of a large number of barren-ground caribou across the Mackenzie River into the foothills of the mountains many years ago. This crossing, as well as their continued residence in the foothills, was recently affirmed through genetic studies (Polfus *et al.* 2016).

"The border [of their range]… it depends on which way they travel. Sometimes they're further down, sometimes they're further up." (Dennis Arey [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 18)

"ɂekwǫ̀ have unpredictable migration patterns, but when they migrate to particular areas they are more likely to use certain trails and water crossings. ɂekwǫ̀ return to the same birthing grounds. ɂekwǫ̀ follow the same general annual cycle each year." (Legat et al. 2001: 69)

Calving and rutting grounds

It is important to note that calving and rutting grounds are closely linked to migration routes (see *Migration routes and movement*, p. 17) and habitat (see *Caribou habitat*, p. 14). Where possible, calving grounds and rutting grounds for each herd are described below using the information available in the traditional and community knowledge literature. If no written information was available for inclusion, it is not mentioned below.

Porcupine

The calving grounds of the Porcupine herd vary from year to year, shifting back and forth from Alaska to the Yukon on the coastal plain, although the area of 'Caribou Mountain', locally called Edigii Kak ('young calf hill') was also identified, at least as an area where the Porcupine herd historically calved (Katz 2010). Snow and climatic conditions may delay the spring migrations of

the Porcupine herd. As such, the herd may calve in the Yukon, along the coast or in the mountains, prior to reaching their typical calving grounds further to the west (Parks Canada 2007a; WMAC (North Slope) and Aklavik HTC 2009).

Tuktoyaktuk Peninsula

In the limited sources available, the calving grounds for the Tuktoyaktuk Peninsula herd were described as being located on the northeast portion of the peninsula as well as around the Horn River area (ICC *et al*. 2006; Community of Tuktoyaktuk *et al*. 2008; Kavik-Stantec 2012b).

Cape Bathurst

This herd utilizes the northern portion of Cape Bathurst west of Paulatuk as the location for its calving grounds (Community of Paulatuk *et al.* 2008; ACCWM 2014b), although regular shifts in the calving ground have also been observed (ACCWM 2014b).

> *"We have gone through cycles. The calving ground around Cape Bathurst was known before my grandfather's time – the area was named for that. They are back again. My grandfather never saw caribou calving in Cape Bathurst. Our traditional knowledge tells us the calving moves away from Cape Bathurst, but the future it will come back." (Anonymous [Tuktoyaktuk] in ACCWM 2014b: 23)*

Bluenose-West

The Bluenose-West herd's calving grounds are located east of the community of Paulatuk and to the northeast of Colville Lake, in the Inuvialuit and Sahtú portions of Tuktut Nogait National Park (Parks Canada 2007b; Community of Tuktoyaktuk *et al*. 2008; SLUPB 2010; Benson 2011).

Bluenose-East

The Bluenose-East herd's calving ground is located in Nunavut in the region west of Kugluktuk and around Bluenose Lake (Dumond 2007; Benson 2011; Tłı̨chǫ Government 2013). The Bluenose-East herd has been known to rut in the area near McTavish Arm on Great Bear Lake (SRRB 2007).

Ahiak (Queen Maud herd)

Describing the location of the Ahiak herd's calving ground is complicated by the lack of available traditional and community knowledge and variances in herd nomenclature. Additionally, the sources that do contain a description of the calving ground consider the Ahiak, Bathurst, and Beverly herds to all be part of the same population (the Ahiarmiut). Ultimately complicating information around the location of the calving grounds, Thorpe *et al.* (2001)

describe the calving ground as being around both sides of Bathurst Inlet, but they imply the location of another herd to the east near the Queen Maud Gulf (and yet do not mention this as a calving ground). The Queen Maud group, as described in Thorpe *et al*. (2001), may refer to what the Government of the Northwest Territories (GNWT) calls the Ahiak herd.

Bathurst

The Bathurst herd's calving grounds are in the area of Bathurst Inlet in Nunavut (Thorpe *et al.* 2001; Tłı̨chǫ Government 2013; TRTI 2016). As with the Ahiak herd's calving ground, the location in the traditional knowledge literature (Thorpe *et al.* 2001) considers the Ahiak, Bathurst, and Beverly to all be part of the same group (the Ahiarmiut). Breeding appears to take place on Tłı̨chǫ lands ("The herd generally returns to Tłı̨chǫ lands in the fall for the breeding season… .") (Tłı̨chǫ Government 2013: 29).

Beverly

Describing the location of the calving grounds for the Beverly herd is complicated by the apparent presence of two different calving grounds. Utilizing both traditional knowledge and western science in their updated management plan, the Beverly and Qamanirjuaq Caribou Management Board (BQCMB) (2014a, b) describe the calving grounds as being in two locations, one on the east side of Bathurst Inlet and the other near Beverly Lake and Gary Lake.

Qamanirjuaq

The Qamanirjuaq herd's calving ground is centered approximately 150 kilometres (km) west of Rankin Inlet and approximately 100 km south of the east end of Baker Lake near Qamanirjuaq Lake (AREVA Resources Canada Inc. 2012; BQCMB 2014a, b).

Caribou life cycle

Traditional and community knowledge sources describe barren-ground caribou going through multiple life stages: calves, one-year-olds, young mature animals, and large, old mature animals. Knowledge holders in the Gwich'in region describe roles for each of these age classes (large males = teachers and leaders; young males = guards and trailbreakers; old females = teachers; single females with calves = scouts) (Padilla and Kofinas 2010: 15-17).

As noted in *Migration routes and movement* (p. 17), breeding, or the 'rut' as it is commonly known, takes place in the fall during the southward migration to the taiga. During this time, caribou males begin to lose fat and their body condition begins to worsen as they focus on mating. During the rut, males will fight in an attempt to exclude other males from mating with the females and may breed with a single female or a group of them (Thorpe *et al.* 2001).

Calves are typically born eight to nine months after the rut, in late May or the first two weeks of

June (Denesuline Né Né Land Corp. 2015; TRTI 2016); some variation in timing may occur due to weather conditions. Calves that are born earlier may be exposed to colder temperatures and sometimes risk freezing to death (Thorpe *et al*. 2001; WMAC (North Slope) and Aklavik HTC 2009). Calves are vulnerable to predation and only some survive to adulthood (Benson 2015).

> *"You can't tell really [if the timing of calving is the same] ... When they're born, it might be a bit different every year. It depends on the weather. They follow the weather." (Jack Goose [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 55)*

After the calf goes off its mother's milk, it begins to forage on plants, lichens, and other vegetation and does so for the remainder of its life.

> *"When ... [the calf] is about to go off its mother's milk, ... the month of July ... Is when they start moving again…." (Jimmy Martin [Behchokǫ̀] in Legat et al. 2001: 33)*

> *"By October, caribou calves can eat the same food as adults. While still feeding on their mothers' milk." (Gwich'in Elders 1997: 23)*

> *"[At the] end of October they have to quit [nursing], because bull chase them away from their mother. That is when they start to stop feeding from their mother." (Gabe Andre, GEKP in Benson 2015: 37)*

As described in the quote below, caribou calves are taught what to eat by their mothers.

> *"... When a calf is about to go off milk, it will eat whatever its mother eats. Its mother will teach it." (Jimmy Martin [Behchokǫ̀] in Legat et al. 2001: 31)*

> *"...just go only where it go, and follow his mother, that way they know what to do." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 37)*

Calves typically stay with their mothers for approximately one year; separating after returning to the calving ground, after their first winter (Benson 2015).

Female caribou will reach maturity between the ages of two and three and will have calves every year until they reach old age and stop breeding (Gwich'in Elders 1997; Thorpe *et al.* 2001; Benson 2015).

> *"They calve, then [the young ones] come out here. They stay around here and they go back [to the coast]. They come back, and next year they go back to have young ones. The second year they calve." (Gabe Andre [Tsiigehtchic], Tom Wright [Inuvik] and John Jerome [Inuvik] all in Benson 2015: 37)*

Females will typically have one calf per year; however, if conditions are excellent they may have two (Gwich'in Elders 1997; ACCWM 2014b; Benson 2015). Likewise, if conditions are poor, a female may not produce a calf at all (Benson 2015).

"Sometimes if…[the] caribou [herd is] going to be increasing, they have lots. They have maybe two to each caribou, but if they're not going to increase, sometime they have one, sometime they have nothing. Lots of them have nothing, it's just the way they're going to be is going to be no calf, that means there is going to be no caribou…Some years they…they don't have that many calves, that means they going to be less than the other years. But if they really calve [lots], they will increase pretty fast you know." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 37)

Barren-ground caribou are somewhat unique in that both males and females have antlers.

"And you know how they find out if the caribou had a baby or not? If [a cow] had a baby, it's got no horns [in the spring]. It seems kind of backwards, wouldn't it? You'd think…she would need horns to protect [herself], but they don't. And that's how you tell if they had one, they have horns or not…They drop them after [they calve]." (Tom Wright [Inuvik] in Benson 2015: 38)

Caribou males reach maturity between the ages of two (Benson 2015) and four (Thorpe *et al*. 2001) but may not begin breeding at the onset of maturity (Benson 2015).

"[Caribou] become bulls after four years… maybe after six years they start mating." (Mary Kaniak [Bay Chimo] in Thorpe et al. 2001: 66)

"The bulls, they fight for that right. And it's the biggest, or the toughest one, he's the one." (Tom Wright [Inuvik] in Benson 2015: 38)

Caribou in northern regions

Barren-ground caribou are incredibly hardy and are well-adapted to the environments they inhabit. Migration is the principal adaptive behaviour that barren-ground caribou display. During the summer when temperatures begin to increase and insect activity becomes intense, barren-ground caribou will migrate towards the coast or other windy locations in order to escape the excessive heat and bugs (WMAC (North Slope) and Aklavik HTC 2009; ACCWM 2014a). They likewise migrate during the winter to the treeline in order to escape the windswept hard snows of the barrens and improve access to forage (Legat *et al.* 2001; ICC *et al.* 2006).

"In the spring or summer we try to get all our caribou from along the shore. When it's a lot of mosquitoes they always go, you know, towards the wind, from the ocean. That's where they always go. When it's hot too they can't stay up on the mountains, they always go towards the sea." (Barbara Allen [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 29)

Smaller-scale dispersal is also common, with barren-ground caribou moving long distances in search of food (Legat *et al.* 2001; ICC *et al*. 2006) and seeking relief from heat and insects at

summer ice and snow patches (Thorpe *et al*. 2001). Some Gwich'in harvesters have actually indicated that Bluenose caribou are able to locate food under the snow by touch and smell (Benson 2015).

> *"If there is nothing one place, they go look for it and they find it easy too. By winter time…the way they walk they could feel it…by their hooves. They know where is good grass on the lake too, they dig that out." (Gabe Andre [Tsiigehtchic], GEKP in Benson 2015: 26)*

Periodically, calving grounds will also undergo small-scale shifts in location as the caribou attempt to avoid unfavourable conditions relating to weather, snow depth, insects, predation, forage availability, and human activity (Thorpe *et al.* 2001).

Inuvialuit sources indicate that barren-ground caribou typically prefer colder temperatures (although Benson (2015) includes an interview with one Gwich'in Elder who has observed that they are actually more productive in warmer weather). Colder temperatures in winter prevent icing conditions, which impede travel and can render forage unavailable. Colder conditions during summer result in reduced insect activity and lower corresponding stress levels for the caribou (ICC *et al.* 2006; Jacobsen 2013). There has been some speculation in traditional knowledge sources that barren-ground caribou may begin to range further north in an effort to avoid stresses related to this kind of heat (Katz 2010).

> *"Hard winter, tough winter, like [cold and windy] this kind of weather is not good for the land because the snow is getting hard on top. If it rains it's going to freeze and the caribou can't break through that ice barrier to get down to where they want, you know, under the snow where the lichens and grass they eat are." (Anonymous [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 44)*

> *"It's all important, wherever they can find food. They gotta follow the food. If it rains in the fall time it's real bad—freeze-up. Under that snow it turns to ice. That's when the caribou starve. If it's good fall, not much rain or not too warm weather, they'll stay healthy." (Anonymous [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 29)*

> *"When there's big storms, they probably have to reserve their energy to wait for warmer weather. I know they don't travel a lot in cold weather. They stay put. But in warmer weather, they'd start traveling." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 28)*

Interactions

Mixing with other caribou

As discussed in *Range* (p. 10), it is very clear from traditional and community knowledge that

there is mixing and movement among neighbouring herds of barren-ground caribou (Thorpe *et al.* 2001; WRRB 2010g; Inuvialuit Game Council [IGC] 2012; Kavik-Stantec 2012b; ACCWM 2014b; Benson 2015). Beyond interactions among herds, barren-ground caribou may also interact with different kinds of caribou, including Dolphin and Union caribou (Kiilliniq or Victoria Island caribou) and boreal woodland caribou.

Dolphin and Union caribou migrate seasonally between Victoria Island (summer) and the mainland NWT/Nunavut (winter). Since the 1970s, overlap in the ranges of Dolphin and Union caribou and other barren-ground caribou herds has increased in Nunavut. The summer range of barren-ground caribou has extended north and the winter range of Dolphin and Union caribou has extended south. Interactions between Dolphin and Union and other barren-ground caribou in the Dolphin and Union wintering area are seen to be increasing. Mixed groups of caribou from the Dolphin and Union population and other barren-ground caribou are a common sight on hunting trips (Thorpe *et al*. 2001)

A variety of views exist in the traditional and community knowledge literature regarding the nature of the interaction between boreal woodland caribou and barren-ground caribou. In the Tłı̨chǫ, it has been observed that while the two species are known to 'share space' (Legat and Chocolate 2012: 9) in the winter, they tend to use the habitat differently; a boreal caribou's character is secretive and they therefore seek out thick, concealing bush. Despite this, boreal caribou are known to sometimes follow barren-ground caribou back to the tundra. The opposite (barren-ground caribou sometimes remaining with boreal caribou) is also true (Legat and Chocolate 2012).

> *"We all know where tǫdzı [boreal caribou] lives around this whole area. When hozuʔekwǫ̀ [barren-ground caribou] migrate back to us, then the two kinds of caribou live near each other in the winter, but sometimes during spring migration maybe one or two tǫdzı will follow them back to the tundra. A few years ago we went for a trip to hozuʔekwǫ̀ birthing ground. We saw a whole herd of hozuʔekwǫ̀. There were so many hozuʔekwǫ̀. We were using a helicopter. We landed on top of an esker where we could see. I saw a caribou that was bigger than the others in the herd. I suggested we take a closer look at the one bigger caribou, so when we got closer I looked at its head and the legs, it was a tǫdzı. That is how the animals roam on this land not lots but maybe one or two will follow hozuʔekwǫ̀." (Jimmy Rabesca [Whatì] in Legat and Chocolate 2012: 9)*

In other regions – the Gwich'in Settlement Area (GSA), northern Yukon, the Sahtú, the Dehcho, and northern Saskatchewan—the two species of caribou have been observed intermingling and foraging together (Johnson and Ruttan 1993; Nagy *et al.* 2002; Gwich'in Social and Cultural Institute [GSCI] 2005; Cluff *et al.* 2006; Legat *et al.* 2012; Gwich'in Renewable Resources Board [GRRB] 2009; Carriere 2010; Environment Canada 2010; Katz 2010; Benson 2011; Dehcho First Nations 2001; Bayha pers. comm. 2012; ACCWM 2014b; Benson 2015; Polfus *et*

al. 2016). Information was not available describing the influence the interaction between barren-ground caribou and boreal woodland caribou has on survival or mortality.

> *"There's a lot of Bluenose caribou all through here – Sitidgi Lake, back – and woodland caribou meet them in this area. There's not a big population of woodland; never has been. But they are in here and they mingle…On the surveys, we've seen woodland caribou and Bluenose caribou in the same herd, just feeding at that particular time, and then of course when they migrate to their calving grounds [the Bluenose caribou] go this way; the woodland mostly calve in this area." (Willard Hagen [Gwich'in community unidentified], Gwich'in Traditional Knowledge of Mackenzie Gas Project in Benson 2015: 42)*

> *"There used to talk of barren ground caribou (60 years ago) reaching La Ronge, woodland caribou follow the small ones back up north, that is what the old people thought from this area; It is believed that the woodland caribou left with the barren land 50 years ago." (Carriere 2010: 108)*

> *"[There] was the general agreement between communities of the relationship of boreal caribou with barren ground caribou. Several comments indicated that the two subspecies are seen traveling together and mixing together in the winter." (Cluff et al. 2006: 7)*

Interactions with competitors

Muskoxen

Muskoxen have recently undergone an expansion of their range on two fronts, from the Yukon into the NWT and southwards in the NWT from existing populations (WMAC pers. comm. 2015). Increasingly, this growth has brought muskoxen in contact with barren-ground caribou. This may influence the mortality and survival of barren-ground caribou as a result of direct competition for food; destruction of lichen by pawing it to the ground; avoidance behaviour (when they come near, barren-ground caribou tend to move away, either because they are afraid of them or don't like how they smell); and lastly, attracting or supporting wolf predation (WMAC (North Slope) and Aklavik HTC 2009; ACCWM 2014b; Benson 2015).

> *"Right across from Bella Arey's camp is that big hill. Caribous used to be right on top there, but after the muskox start hanging around there, they go further and further back. You don't see them along there." (Annie B. Gordon [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 35)*

Barren-ground caribou become stressed by muskoxen, as from a distance they look very similar to grizzly bears, one of their principal predators (ICC *et al.* 2006). Barren-ground caribou are also known to have a strong sense of smell, and it has been suggested that they tend to avoid the

powerful smell of muskoxen (ACCWM 2014b; Benson 2015).

> *"…But I know when the muskox went up to around Paulatuk, they used to always have caribou there. And the caribou just disappeared when the muskox arrived. I'm not sure what it is with muskox. It's – I don't know if it's their smell, or they just eat too much." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 42)*

Muskoxen may also be influencing the normal predator-prey relationship between barren-ground caribou and wolves. An influx of muskoxen into an area allows for the wolf population to survive and possibly grow, whereas in the past low caribou numbers would lead to a decrease in the number of wolves (ACCWM 2014b).

Reindeer

In the northern portion of the NWT, there are areas where barren-ground caribou and domesticated (or formerly domesticated) reindeer may come into contact with one another. It has been noted that reindeer and caribou compete directly for the same range and forage (ACCWM 2014b). Traditional knowledge holders have also pointed out that caribou and reindeer hybridization does occur (WMAC (North Slope) and Aklavik HTC 2009; Benson 2015). WMAC (NWT) (pers. comm. 2015) reports that these hybrids rut and give birth earlier than barren-ground caribou, which could favour hybrids in competition for range and forage.

> *"[The rut is] usually the same time of year, but there was one summer, one August that I got a caribou, couple of caribou. [I] skinned it out and put it away, but when I started cooking it, it was stink. It really stunk up the kitchen and it was too strong to eat. So I give it to the ENR [Environment and Natural Resources] guy and they sent it out and told me it was, with the DNA work that they done, they said it was half reindeer. And reindeer rut in August. So that's what they were telling me." (Jack Goose [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 49)*

> *"Another time, there was some [Bluenose caribou on a small lake near] Campbell Creek…on that lake there, was just full of caribou. Yeah, we shot 32 caribou. In the fall…That'd be in the late '80s…But probably some of [them were] reindeer, because there was one there who was kind of spotted, kind of grayish. And we were trying to get him, me and Buster [McLeod], and we couldn't get him…But that was Bluenose and probably reindeer mixed, I guess, because they used to do [the reindeer] slaughtering around there, very close to the airport…[reindeer have shorter noses and] shorter legs, I think. Yeah, a little shorter, not too much…But we couldn't get them, though, that one [obvious reindeer] there. Probably other ones were part reindeer, too. But supposed to be mixed, mixed in with Bluenose." (Richard Ross [Gwich'in community unidentified] in Benson 2015: 43)*

Wood bison

The ranges of wood bison and barren-ground caribou overlap, or have the potential to overlap in the portion of their ranges near the community of Behchokǫ̀ at this time. The Mackenzie population of wood bison has been expanding northwards in recent years as well, being observed as far north as Whatì (Richardson pers. comm. 2015). With respect to this expansion, wood bison are seen as bringing predators and disease (e.g., anthrax) into barren-ground caribou range as well as competing for forage that has already been impacted by forest fires (Tłı̨chǫ Government and WRRB 2017).

Interactions with predators

Traditional and community knowledge sources indicate that barren-ground caribou are subject to predation pressure from a number of animals in the NWT. Wolves and grizzly bears are most commonly noted, but wolverines, lynx, and eagles may also hunt barren-ground caribou. There is some concern that populations of a number of these predator species are increasing in some regions; in particular, wolves, grizzly bears, wolverines, and eagles (ACCWM 2014b).

> *"Long ago there were a lot of trappers out on the land. They could make a good living trapping. Today there is nobody out there, so all those predators are growing, especially the wolves. They are really migrating. I don't like saying that but it is true. And the wolves, they are bad for caribou and moose too." (Anonymous [Tsiigehtchic] in ACCWM 2014b: 36)*

> *"Wolf numbers are very high, individuals are healthy, and the packs are large – there are more than 30 in some packs. The elders have reported that when this happens they will kill indiscriminately, taking more than they will use. This is of concern especially when the caribou numbers are low." (Anonymous [Kugluktuk] in ACCWM 2014b: 40)*

> *"We are seeing more predators in August and September. I saw 12 grizzly bears in a three kilometer radius, all following the caribou." (Anonymous [Paulatuk] in ACCWM 2014b: 35)*

> *"There were not too many grizzly bears in the past, but nowadays whenever you go out, you are seeing bears and they are everywhere." (Anonymous [Kugluktuk] in ACCWM 2014b: 40)*

Wolves

Found above and below the treeline, wolves are the primary predator of barren-ground caribou (Benson 2015; Denesuline Né Né Land Corp. 2015). Community members have made particular note that wolves are very capable of killing healthy caribou and that the notion that wolves only prey on the weak and injured is false (Thorpe *et al.* 2001; Katz 2010; ACCWM 2014b). This notion is derived from the older wolves who are kicked out of their packs and prey on the weak and injured caribou (Katz 2010).

"They say wolves only go after the lame and the sick…They more or less will go after that cow caribou and they'll look for good caribou too, you know... They're smart animals. They're not going to look at that old caribou, they want good meat too." (Freddy Frost [Old Crow] in Katz 2010: 33)

"And according to people long ago they, they [wolves] get best caribou they could. And it's a female caribou." (Joel Peter [Old Crow] in Katz 2010: 33)

Wolves are very effective predators due to their speed and their ability to work in groups. They are also strategic, chasing caribou until they become tired or injuring caribou (Benson 2015).

"Wolves are very smart. They strategize. They know how to hunt. Just a little nip, a little blood, and they follow and follow and follow until they get them. I've seen so many trails and so many wolf kills, mile at a time, that you could tell that all they do is just run. And if they know it's like a good bite, then eventually, the caribou is going to lay down and stiffen up, and they can't get up. So they just follow and take their time and they're there. Yeah, they're a smart animal, that, very smart. There's the place up…Caribou Creek, on the Dempster. Traditionally, that's where the wolves would chase the caribou into these little narrows, and there's like an ambush there. They plan it. And then they don't try to kill them right away. Well, of course, if you get the change, you do. But all they do is just bite them, bite their tendons…and there's so many of them sometimes." (James Firth [Inuvik] in Benson 2015: 39)

"Wolf, he grab them by the legs, and, once the caribou is played out, he fall down and they grab them by the throat…kill them right there…They run fast, [and they can] leave the wolf behind just like nothing, if it's good going, but lot of time if it's lots of snow, the wolf he – when it's lots of them, they [take] shifts running…One plays out, well, I jump in the side, the other one go [they break trail for one another]." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 40)

There are two types of wolves described by community members based on their strategy for killing caribou: migratory wolves, which follow the caribou along their migrations, and stationary wolves, which have a defined home range through which the caribou pass during their annual migrations (Katz 2010). Wolf numbers and barren-ground caribou numbers are linked; when wolf numbers are high, barren-ground caribou populations will decrease (Dumond 2007).

"Caribou go down where there are many wolves. When the wolf population is going up, the caribou population is doing down." (Anonymous [community unidentified] in Dumond 2007: 17)

The presence of smaller groups of barren-ground caribou (30-50 individuals as opposed to hundreds) has been attributed to wolf predation. It has been suggested that wolves are responsible for breaking up the caribou into these smaller groups (it is unclear if this is in

reference to caribou on the winter range only or more broadly across the year) (Gordon *et al.* 2008).

Barren-ground caribou have developed strategies for dealing with wolf predation. During the winter months, caribou are able to avoid wolves by travelling through deep snow (Katz 2010; Benson 2015), as well as by spending time on frozen lakes where they are able to spot and smell wolves from a greater distance and therefore move to avoid them. Calving ground selection strategies such as choosing large flat areas where wolves may be spotted and smelled for long distances and calving in a large group for herd protection are also employed as a protection against wolves and other predators (Thorpe *et al.* 2001).

> *"[They calve] probably at a place that is relatively flat you know, not too many hills around, so that they can see whatever is coming for miles … Somewhere that they could see a long ways so that they can see … any danger that is coming towards them." (Naikak Hakongak [Kitikmeot community unidentified] in Thorpe et al. 2001: 111)*

It has been noted that barren-ground caribou can, to some degree, protect themselves from wolves by kicking them (Benson 2015). At certain times of the year, barren-ground caribou males protect females and calves by travelling on either side of the herd. In travelling together, the younger animals learn from the older adults (Legat *et al.* 2008; WRRB 2010a).

> *"My father used to tell me that when the herd migrates the bulls kept the females in the inner circle to protect them from being attacked by the wolves. The caribou are part of the food chain and if the wolves didn't take down a caribou, they didn't eat. So wherever you see a caribou, you will see a pack of wolves, my dad use to tell me that and so did Chief Jimmy Bruneau... The bulls were usually killed by the wolves because they are on the outside circle of the herd so when the statistics came out and the report said the bull population is declining, I believe it." (Jimmy Martin [Behchokǫ̀] in WRRB 2010a: 12)*

There are documented terms in Aboriginal languages identifying different age groups and the relationships among the family members.

Grizzly bears

Grizzly bears are found primarily in the tundra, alpine, subalpine, and treeline regions of the NWT. This brings them into frequent contact with barren-ground caribou when they are in their late spring, summer, and early fall ranges. Although not as effective as wolves, grizzly bears are nonetheless able to kill barren-ground caribou. Grizzly bear predation has been described by traditional knowledge holders during the post-calving season, and during the calving period when calves are the most vulnerable (Thorpe *et al.* 2001; BQCMB 2011b; ACCWM 2014b; Benson 2015; Denesuline Né Né Land Corp. 2015).

> *"I have seen a grizzly chasing a calf once. I caught sight of it as they were disappearing*

behind a hill. The grizzly probably ate it…." (Paul Omilgoitok [Ikaluktuuttiak] in Thorpe et al. 2001: 108)

Wolverines and lynx

Wolverines are frequently mentioned when barren-ground caribou predators are being discussed (Dumond 2007; WRRB 2010c; BQCMB 2011b) and lynx less so (Benson 2015). Wolverines frequently scavenge caribou that have been killed by either wolves or grizzly bears (Benson 2011). Although not main predators of barren-ground caribou, there is mention that wolverines and lynx have been witnessed killing caribou on their own (Benson 2014, 2015; Denesuline Né Né Land Corp. 2015).

"I tracked a wolverine when I was trapping, I saw where it staked a caribou. It jumped from a tree on a 2 year old bull caribou's back and worked to pull it down for about a half a mile until the caribou gave up." (Charles Pokiak [Tuktoyaktuk] in WMAC (NWT) pers. comm. 2015)

"Even [though] the wolverine is small, it can still get a caribou." (Charlie Keyok [Kitikmeot community unidentified] in Thorpe et al. 2001: 109)

"Wolverine is another predator but it mainly feed on wolves and bear kills. Wolverine can also kill caribou. They chase them for a long time." (Anonymous [Kitikmeot community unidentified] in Dumond 2007: 17)

"Lynx, he jump on top the caribou, and he chew behind the head…the big sinew here, he chew that one…caribou will get paralyzed…fall down. [Lynx will kill] anything they get, whatever they can grab first." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 41)

Eagles

Eagles have been suggested as a possible predator of barren-ground caribou, particularly calves. The nature and intensity of this predation was unfortunately not described (ACCWM 2014b; Benson 2015).

"I think they [the calves] were left, there was so much snow that…they [eagles] got some of that caribou, not all of them, some of that caribou got, ah, left behind a bit because the snow condition that they had their calves on [the], other side Caribou Lookout. And, you could see six or seven eagles flying around there all the time. So I think they pick them, pick them off whenever they get a chance and all the little animals there too." (Stanley Njootli [Old Crow] in Katz 2010: 39)

Caribou harvesting

As described in the *Preamble* (p. 5), the people of the NWT are intrinsically linked to barren-ground caribou. The importance of caribou cannot be understated in this report. At present, individuals from nearly every community in the NWT are involved in the harvest of barren-ground caribou.

Both men and women are involved in the harvesting of caribou; generally with the man harvesting and the women preparing the caribou after the harvest.

> *"[Women] have lots of knowledge. They work on the hide make dry meat and take care of the family. We have to take this into consideration. The woman works harder than the man." (Archie Wetrade [Gamèti] in Barnaby and Simmons 2013: 19)*

> *"The men were the hunters, trappers and fishermen. They had a big role, but the women too had a role in the communities and villages. The men and women worked together to move on the land and survive." (Fred Sangris [Ndılo] in Environmental Monitoring Advisory Board [EMAB] 2012: 11)*

> *"When people are getting ready to hunt…the women are really excited. They are making moccasins because they can just taste the dry meat and the caribou tongue when their husband comes back with the caribou meat." (Lisi Lafferty [Behchokǫ̀] in EMAB 2012: 17)*

> *"[There are] sacred rules that we follow. …as Dene women, we follow many, many strict rules, like all Dene do, but especially women. It's also for our own safety. It's …to respect the animal." (Bella Ts'eleie [Fort Good Hope] in SRRB 2016b: 104)*

Using traditional and community knowledge, it is possible to see that harvesting patterns tend to shift over the long term in association with changes in regional barren-ground caribou abundance and as habitat changes as the result of disturbances such as forest fire (Legat *et al.* 2001). Overall however, the harvest of barren-ground caribou and use of the land by harvesters is very widespread and occurs across much of the range of barren-ground caribou. The presence of a trail network across the landscape is evidence of this use and is supplemented by use of modern access corridors such as seismic lines, winter roads, and all-season roads (Benn 2001; Kendrick *et al.* 2005; Tłı̨chǫ Government 2007a; Croft and Rabesca 2009; Katz 2010; Kavik-Stantec 2012b; Wray and Parlee 2013; ACCWM 2014a).

Quantifying the subsistence harvest in the NWT is quite difficult, given that the GNWT does not track aboriginal subsistence harvest, and that what is tracked by aboriginal governments and organizations is done sometimes by herd and sometimes by region, which complicates interpretation. Information is also not always consistently collected or shared.

Some information on subsistence harvest levels in the NWT is available through the formal harvest studies conducted in some regions (Inuvialuit Harvest Study 1988-1997 [Joint Secretariat

2003], Sahtú Settlement Harvest Study 1999-2003 [SRRB 2007], Gwich'in Harvest Study 1995-2001 [GRRB 2009]), but this information is limited to the periods when these studies were in progress and is now largely out of date. In the Inuvialuit Settlement Region (ISR), harvest data for species under quota is regularly reported (Environment and Natural Resources [ENR] 2015) and in the Wek'èezhìı area, information can be obtained from harvest and monitoring summary reports developed jointly by the WRRB, Tłı̨chǫ Government, and the GNWT. In the GSA, harvest data is continuing to be collected regularly by the GRRB.

Harvest[4] in the GSA between 1995-2001 consisted of an annual average of 104 Bluenose caribou (range = 22-153) and 1,558 Porcupine caribou (range = 452-2,206) (GRRB 2009). In the ISR, an annual average of 3,113 caribou was harvested between 1988-1997, although these were not separated by population (barren-ground caribou, Peary caribou, or Dolphin and Union caribou) (Joint Secretariat 2003). Between 2009-2014, Inuvialuit harvested an annual average of approximately 274 Bluenose-West caribou, below the quota set for this herd (ENR 2015). In 2012-13, Gwich'in and Inuvialuit harvest of the Porcupine herd was approximately 615 and 176, respectively (Boxwell 2013, 2014; Cooley and Branigan 2014), possibly due to decreased availability. Sahtú harvest data from 1998-2003 indicates an average annual harvest of 702 Bluenose-West caribou with substantial variation among years (range 81 [2003] – 1,015 [1999]) (SRRB 2007). As of 2016-17, Belarewíle Gots'ę̀ Ɂekwę́: Délı̨nę Caribou Conservation, a Délı̨nę Got'ı̨nę Plan of Action has set a harvest threshold of 150 for the Bluenose-East herd (Délı̨nę Ɂekwę́ Working Group 2016). Délı̨nę is the main Sahtú community harvesting this herd. In the Wek'èezhìı area, the 2013-14 subsistence harvest was reported as 167 Bathurst caribou and 1,474 Bluenose-East caribou (Barren-ground Technical Working Group 2015). As of 2016-17, harvest levels have been set at zero for the Bathurst herd (Tłı̨chǫ Government and GNWT 2016a; WRRB 2016a) and 750 for the Bluenose-East herd (Tłı̨chǫ Government and GNWT 2016b; WRRB 2016b) within Wek'èezhìı.

Broadly speaking, relative to harvests 30 or 40 years ago, the total number of barren-ground caribou harvested by subsistence hunters has decreased across the NWT (Joint Secretariat 2003; Gordon *et al.* 2008; GRRB 2009; WMAC (North Slope) and Aklavik HTC 2009; Boxwell 2013, 2014; Cooley and Branigan 2013; Jacobsen 2013; ACCWM 2014b). Much of this is simply due to changing needs (A.W. Banfield *in* Sandlos 2004), although increased costs associated with harvesting and current harvest restrictions[5] also factor heavily into this.

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[4] "It is not known if all hunters that reported their harvests knew the difference between woodland and barren-ground caribou or the difference between each herd [Bluenose or Porcupine]." (GRRB 2009: 5).

[5] Inuvialuit harvest on Tuktoyaktuk Peninsula herd restricted between April 1 – June 15 to permit the migration of the Cape Bathurst herd (Davison *et al.* 2014; ENR 2016a). All Cape Bathurst harvest suspended as of 2007 (ENR 2016)a. Aboriginal harvest of Bluenose-West caribou limited by quota (345 animals for the Inuvialuit, 345 for the Sahtú, and 22 for the Gwich'in) (ENR 2016a). Voluntary restriction of aboriginal harvest on Bluenose-East caribou (4 percent (%) of the 2006 herd size) recommended by the WRRB and SRRB (ENR 2016a). Annual harvest of Bathurst caribou limited to 300 throughout the Wek'èezhìı area and Yellowknives Dene First Nation territory

Additional detail on harvest reporting, estimates, and restrictions is included in *Population dynamics - Scientific Knowledge Component* (p. 139).

For many of the communities at or below the treeline, barren-ground caribou harvesting takes place from late summer/early fall until late spring, as this is when barren-ground caribou are accessible (Legat *et al*. 2001; Kendrick *et al*. 2005; Barnaby and Simmons 2013). Further north, in communities such as Paulatuk, Tuktoyaktuk, and Aklavik, barren-ground caribou are accessible throughout the year (Community of Aklavik *et al.* 2008; Community of Paulatuk *et al*. 2008; Community of Tuktoyaktuk *et al*. 2008), although in both situations, the timing and location of harvest is also guided by a focus on the best quality meat, hides, and parts (e.g., guts, eyes, head, brain, hooves, etc.) (Gwich'in Elders 1997; Thorpe *et al.* 2001; Lyver and LKDFN 2005; Planning Group 2006; WMAC (North Slope) and Aklavik HTC 2009; ACCWM 2014b; Benson 2015).

> *"Every fall and winter we go hunting on the land after freeze-up. This is the way my parents taught me, so I am teaching my boy the way I was taught." (Terri Enzoe [Łutsel K'e] in Barnaby and Simmons 2013: 10)*

> *"We just look for fat ones. When [you] go out to get the caribou, you watch and get just fat ones, dry cows, and that kind." (Jacob Archie [Aklavik] in WMAC (North Slope and Aklavik HTC 2009: 65)*

> *"We never bother caribou 'til fall. My dad wouldn't let us shoot caribou until August. We could see them in the hills but we didn't shoot them, can't. Not allowed, because our parents said, 'Wait 'til he gets fat and good shape before we kill him.' ... They don't want him to get bothered like that. Summer time there's lots of mosquitoes and he suffer ... never have fat in July. They always told us to wait 'til August." (Alice Husky [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 65)*

Selection for meat and hide quality involves considerations such as the timing of rut (which renders the meat of mature males inedible as a result of the hormones released in their bodies during this time) (Padilla 2010; Wray and Parlee 2013) and the impact of environmental factors on the hide (i.e., warble flies, which can bore holes in caribou hides) (Gwich'in Elders 1997; Thorpe *et al.* 2001; ACCWM 2014b).

> *"…[T]hat's when they start, October, they start getting stink and October 10th, after that nobody can shoot [bull] caribou. Our elders used to tell our young people, 'Don't bother to shoot [bull] caribou after the 10th of October, because then they get really stink, you can't eat it." (Annie B. Gordon [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 48)*

(Tłı̨chǫ Government and GNWT 2011; Adamczewski pers. comm. 2015). Aboriginal harvest within a mobile core conservation zone around Bathurst collared females suspended entirely as of 2015 (GNWT 2015).

Parasites and disease

Insects such as nose bot flies, warble flies, and mosquitos can significantly influence barren-ground caribou behaviour, body condition, and ultimately productivity and survival.

Harassment from mosquitos can be quite severe in the summer range of barren-ground caribou, particularly when the temperatures are hot and humid. Extreme harassment from mosquitos can cause a loss of body fat as caribou try to outrun them (WMAC (North Slope and Aklavik HTC 2009).

As part of their reproductive cycle, nose bot fly larvae use the sinus cavity of caribou to survive the winter months. Nose bot larvae are commonly found in harvested caribou but are not considered overly harmful (WMAC (North Slope) and Aklavik HTC 2009).

The warble fly uses the caribou as a host throughout the spring and summer months. Warbles bite caribou and lay their eggs under the skin. The eggs then hatch into larvae, which bore holes into the hide. The caribou are particularly bothered by the biting warble flies and may lose body fat or die from exhaustion in an attempt to run away from the irritation caused by the warbles (ICC *et al.* 2006; WMAC (North Slope) and Aklavik HTC 2009).

The stress caused by these insects can result in less time spent resting and foraging. Warm, wet summers that promote high insect development and activity are particularly stressful, and caribou will be leaner than during cold, dry summers. Newborn calves can also be killed as a result of intense mosquito outbreaks (WMAC (North Slope and Aklavik HTC 2009). Although it is very unusual for caribou to be killed by insects outright, the impacts they have on behaviour, body condition, and productivity can be significant (Dumond 2007).

Other diseases and abnormalities mentioned by land users include cysts or white spots in the meat, swollen joints, lame animals, sores and puss, watery joints, *Besnoitia*, *Brucella*, and bad livers (Kutz 2007; Russell *et al*. 2008; WMAC (North Slope) and Aklavik HTC 2009; ACCWM 2014b; TRTI 2016). Parasite and disease trends are discussed in more detail in *Population dynamics* (p. 45).

STATE AND TRENDS

Population

Abundance

Among traditional and community knowledge holders, it is thought that barren-ground caribou have always been relatively abundant compared to other large land mammals such as moose or bears. The abundance of barren-ground caribou is one of the characteristics that makes them so

iconic.

Harvesters speak of abundance in terms of large family camps, large or small herd sizes, or transporting bales, and bales, and bales of dry meat (Berkes 1999; WMAC (North Slope) and Aklavik HTC 2009). Changes in abundance are discussed in more detail in *Changes in herd size* (below).

Changes in herd size

Population trends vary among herds. The Porcupine herd is clearly increasing and there is some indication that the Tuktoyaktuk Peninsula herd may also be increasing. The Bathurst and Bluenose-East herds are likely decreasing and there is some evidence of recent declines in the Beverly and Qamanirjuaq herds. Trends for the Cape Bathurst and Bluenose-West herds are not clear based on available resources and there is no available trend information for the Ahiak herd.

It is important to note that many traditional and community knowledge sources don't attribute trend information to any particular herd, instead observing general trends in their region or around their community. Because of this, and the difficulty inherent in assigning observations from a given community to a single herd, trend information is presented below both by herd and by region/community, as appropriate.

Porcupine herd

Historic highs were documented for the Porcupine herd between the 1940s and 1980s (WMAC (North Slope) and Aklavik HTC 2009). Community monitoring results then indicated a decline from 1980-2001 (Svoboda *et al*. 2013). After 2002 however, the availability[6] of Porcupine caribou in the winter and spring improved steadily, while availability in the fall improved from 2002-03 to 2004-05 and then dropped from 2005-06 to 2006-07 (Russell *et al.* 2008; Svoboda *et al.* 2013).

> *"Never in my time did I ever go out to hunt caribou that I seen, just like they say long ago, the ground used to move when the caribou is passing by. Just like a wave – the hills, the caribou going." (Jerry Arey [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 25)*

Tuktoyaktuk Peninsula herd

Trends in the Tuktoyaktuk Peninsula herd are only directly mentioned once in available traditional and community knowledge literature. This information suggests a possible increase since the 2001 removal of reindeer from the peninsula (ACCWM 2014b; Davison *et al.* 2014; ENR 2016a).

[6] Availability defined as proximity of caribou to interviewees' communities (Russell *et al.* 2008).

"There is less activity now [out on the land] and the caribou have spread out. The Tuk Peninsula caribou herd returned after the reindeer was removed from the Peninsula. Now that the caribou have come back to the peninsula, the other caribou have spread out." (Anonymous [Tuktoyaktuk] in ACCWM 2014b: 23)

Cape Bathurst and Bluenose-West herds

'Declines' are more commonly felt to be the result of shifts in migration routes (ACCWM 2014b). This perspective is perhaps supported by reports of increases in availability in the Paulatuk area, even though other communities may be observing decreases in availability (ACCWM 2014b).

"I don't believe that the caribou is declining; it's just that they're getting harder to find…." (Wilbert Kochon [Colville Lake] in SRRB 2007: 62)

"[I am] commenting on the numbers [in the presentation dropping] from 1992 – high numbers to really low numbers now. I hear people saying they don't notice a decline in the herd. Hunters for sure would have seen this. I haven't heard any evidence of their being less caribou. If there was that big a decline, for sure hunters would see carcasses. To lose 10,000 in ten years? I'm sure the users of the herd would say that something was going on." (Anonymous [Aklavik] in ACCWM 2014b: 26)

"Caribou are staying in our area all year-round now. There have been changes in distribution, as they used to be out past Anderson River. This year, the herd was having calves in different areas." (Anonymous [Paulatuk] in ACCWM 2014b: 22)

"There are more caribou nowadays, still they come and go – one year nothing, next [year] they come back. Cycles or something, so many years at a time and [then they] come back again." (T001 [Tuktuuyaqtuuq] in ICC et al. 2006: 11-47)

There is historic evidence of a decline in Bluenose caribou in the GSA in the 1940s, followed by an increase in the mid-1980s, and perhaps another sharp decline in 2004-05 (the result of icing conditions in the winter that resulted in starvation and a subsequent hot summer that saw an increase in predator populations) (Benson 2015). Around Tuktoyaktuk, caribou were last abundant in the 1970s, when they returned after a period of scarcity in the 1920s (ICC *et al.* 2006; ACCWM 2014b).

"Because in the 1940s no, more than that…in those days you don't see meat like this around here, you don't see no caribou meat but you see very few moose meat. Lots of times I said, if it wasn't for rabbit and fish, if it wasn't for rabbit and fish people will be starving. We'll be hungry those days in 1940s…this meat start not long ago about 10 years ago [in the mid-1980s], I guess. Start to be lots of caribou…When you travel hundreds of miles you never see a

track of caribou or moose tracks, nothing." (Joan Nazon [Gwich'in community unidentified], GEKP in Benson 2015: 47)

"About 50 years ago now, all of a sudden, it just – there was just nothing, no caribou. Just over one year, just nothing. So since then, we've been hunting the woodland caribou." (James Firth [Inuvik] in Benson 2015: 46)

More locally, a sharp decline in Bluenose caribou was observed in the Inuvik area in the 1960s, something that the population has not entirely recovered from (Benson 2015). Declines were similarly reported in Fort Good Hope (ACCWM 2014b). In the ISR as a whole, caribou are being seen in smaller groups than in the past (ACCWM 2014b).

"…biggest bunch you see of caribou is about 50 to 60, not like the huge herd that came first." (T056 [Tuktuuyaqtuuq] in ICC et al. 2006: 11-47)

Bluenose-East and Bathurst herds

Information from traditional and community knowledge holders indicates likely declines in Bluenose-East and Bathurst caribou since the 1990s (Tłı̨chǫ Government 2007a, b, c; Nesbitt and Adamczewski 2009; WRRB 2010b, c; ACCWM 2014a; Judas 2012; Barnaby and Simmons 2013; ACCWM 2014b; TRTI 2016).

"I can go back to 1962, and I've observed that since 1990, the population has really been going down." (Joseph Judas [Wekweètì] in Judas 2012: 49)

"So regarding the reduction of the – I don't want to blame anybody. So I've been thinking about it for ten (10) years, the reduction of the caribou. For me, it seems like it's the truth…." (Charlie Simpson [Whatì] in WRRB 2010d: 238)

"The herd migration is changing very fast. Even on the barren lands the migration is changing. A while ago in the fall people seen caribou tracks and looked around and saw nothing. Before when people saw caribou tracks, they would see one or two caribou and then a couple of days later the whole herd arrives. It would just feel like the ground was moving. Nowadays it is not like that. It is very hard to keep track of the herd. My late grandfather once said, in the near future the animals are going to change. I think this change has already started." (Henry Catholique [Łutsel K'e] in Parlee et al. 2001: 11)

"It seems that the numbers in the Bathurst herd are declining. I do not know why. But here in Kingauk (Bathurst Inlet), there are always a lot of caribou in the springtime…lots in number. A couple of years ago there seemed to be lots in number as they were passing through." (Jessie Hagialok [Bathurst Inlet] in Thorpe et al. 2001: 86)

"This year there were hardly any [caribou]. This year, this spring, [there have been] hardly

any caribou since April…Less caribou compared to last year. Like the caribou never came from south…There were always caribou around in the springtime [in other years]…coming from south." (Doris Kingnektak [Cambridge Bay] in Thorpe et al. 2001: 89)

This recent decline was the subject of a 2010 survey by the LKDFN (Parlee *et al.* 2014), which indicated that about 70% of harvesters had observed a decline in caribou numbers compared to previous years (with about 29% observing a serious decline), despite about a 50% decrease in harvest since 2000.

Locally, declines in caribou have been reported in Kugluktuk and Behchokǫ̀ (ACCWM 2014b). Harvesters in Wekweètì last had good success harvesting caribou in 1996-97. After that however, the caribou population changed, decreasing consistently each year (TRTI 2016). In contrast, Gamètì has reported a stabilized or increasing caribou population in their area (ACCWM 2014b).

Historic trends were noted by Danny Beaulieu (2012), with periods of abundance in the 1890s, 1924, 1954, and 1984, and corresponding periods of low numbers during each World War (1915 and 1945), as well as 1975 and 2005. These trends roughly correspond to those observed by Barry Taylor (*in* WRRB 2010c), who observed a peak in the 1980s that was preceded by a period of lower numbers in the 1960s and 1970s.

"The most recent memory of a time of scarcity was in the 1960s. At this time, the community of Wekweètì had to be evacuated to Behchokǫ̀ (Rae-Edzo) and Gamètì (Rae Lakes)." (John B. Zoe [Behchokǫ̀] in Zoe 2012: 71)

"Our legends talk about ekwǫ̀ disappearing long ago. There have been times of scarcity and times of abundance. The elders have always believed that when ekwǫ̀ became scarce they would go away to be left alone – to recover and replenish themselves." (John B. Zoe [Behchokǫ̀] in Zoe 2012: 71)

"Over my life in the north, I've watched the caribou numbers cycle up and down. …The '60s and '70s had lower numbers available to hunters. They were definitely in a down cycle. Then came the '80s and vast numbers were everywhere. They came south in the winter. They went further around the lake and into the provinces. Everybody was happy and content: we had caribou, and nobody cared what they were called [Ahiak, Beverly or Bathurst]." (Barry Taylor [Yellowknife] in WRRB 2010c: 186)

Beverly, Ahiak, and Qamanirjuaq herds

Available traditional and community knowledge suggests recent declines in both the Beverly and Qamanirjuaq herds, although not as substantial a decline in the Qamanirjuaq herd based on knowledge available up to 2013 (BQCMB 2011b; BQCMB 2014a, b).

"…Caribou populations are getting smaller these days, and the Beverly herd has decreased the most, to very low levels…." (Albert Thorassie [northern Manitoba community unidentified] in BQCMB 2011b: 12)

Prior to this however, few knowledge holders indicated that there were changes in caribou abundance. Where changes in abundance have been noted, it was often understood to be changes in migration patterns, rather than changes in absolute numbers (Cizek 1990; Kendrick 2003; Spak 2005).

"The caribou don't migrate through this area [Lutsel K'e] any more. Some people say the caribou don't migrate towards us now. Some also say the caribou have decreased in numbers but I still think there is plenty of caribou. If people don't see caribou for a while, the caribou will come looking for the people. To this day the caribou are still like this. The problem is now the mines interfere with their migration and stop the caribou coming to the people. Another problem is all the land that has been burnt around Lutsel K'e and this also keeps the caribou away. In the past when there were forest fires the land would burn just to a certain point, but now the fires burn out of control. …Now there are many large burn areas that the caribou stay away. They do not migrate through those areas because there is nothing to feed on." (Madeleine Drybones [Łutsel K'e] in Kendrick 2003: 192)

"During the early 1980s, when the caribou herds, were still perceived to be in a precarious state… The biologists claimed that the population of the herds had seriously declined whereas the native users claimed that parts of the herd had simply 'gone elsewhere'. … In the course of time, improved census-taking techniques revealed more caribou than the earlier surveys had shown… ." (Cizek 1990: 20)

In northern Manitoba, in the area of the Manitoba Chipewyan, previous periods of scarcity have been observed (early- to mid-1950s, early- to mid-1970s), but these episodes were associated with environmental events (e.g., destruction of migration route by fire, unusually warm winter) or episodes of mistreatment of the caribou (Smith 1978).

"The decline in caribou numbers in the 1950s and 1960s coincided with the onset of serious caribou studies by the Canadian Wildlife Service. The Chipewyan attributed the decrease in caribou in this area to the capture and tagging, which caused the caribou to avoid the area, rather than to any real decline in numbers." (Smith 1978: 72).

In the area of the Athabasca Denesuline (northern Saskatchewan), knowledge holders suggest a recent decline in caribou in their region. From Denesuline Né Né Land Corp. (2015), the last period of abundance may have been 1975-1980s. Noted periods of scarcity included the 1950s, 1965, and before 2009 (Denesuline Né Né Land Corp. 2015).

There is no information regarding the population trends of the Ahiak herd in the available

traditional and community knowledge literature. This is not to say that there is no information; however, it may not yet have been gathered or transcribed.

Caribou population cycles

Barren-ground caribou population increases and decreases are naturally cyclical in nature. These cyclical changes have not been quantified, but available traditional and community knowledge seems to suggest that they can be quite large (Katz 2010; WMAC (North Slope) and Aklavik HTC 2009; Beaulieu 2012; ACCWM 2014b) and that the rate of change may depend on whether the population is increasing or decreasing.

> *"Traditional knowledge tells us that caribou herds increase quickly and decline more slowly." (Danny Beaulieu [Yellowknife] in Beaulieu 2012: 66)*

> *"So the de -- the decrease of caribou has been said, but we're not -- how can caribou disappear? The pop -- the population decrease in the past. We know about the decrease of population of animals in the past through our Elders. And -- and when the population goes down it -- it -- population grows back up. Once the – the animals population grows out -- and population goes down…." (Harry Apples [Behchokǫ̀] in WRRB 2010b: 186)*

Across the NWT, there are a variety of views regarding the length of these cycles, ranging from as short as 10 years (WRRB 2010b), to a mid-range of 30-60 years (Community of Inuvik *et al.* 2008; Katz 2010; ACCWM 2014a; Beaulieu 2012; Denesuline Né Né Land Corp.; ACCWM 2014b), to as long as 80-100 years (Berkes *et al*. 2000).

> *"Probably a 20, 25-year cycle, I think. So we're probably at the bottom end now." (James Firth [Inuvik] in Benson 2015: 47)*

> *"Caribou populations go up and down. Scientists have spent thirty years trying to figure out why caribou go up and down. They can pound their head on the cement block as they'll never figure it out. It's a thirty-year cycle, up and down." (Danny Beaulieu [Yellowknife] in Beaulieu 2012: 60)*

> *"If the animals -- all animals, sometimes they disappear for ten (10) years, and then there's thousands again. We are not the boss of these animals, it -- it is the Creator." (Leon Modest [Délı̨nę] in WRRB 2010b: 213)*

It has also been observed that peaks in the cycle (the population highs) are not as high as they used to be (Nesbitt and Adamczewski 2009; WMAC (North Slope) and Aklavik HTC 2009). However, owing to the limited period over which population studies have been undertaken, and the fact that harvesting regulations may prevent hunters from harvesting except in specific areas, it is often difficult to understand these cycles (Benson 2015).

Cycles and changes in abundance may be related to changes in herd movements or migrations

(Thorpe *et al*. 2001; NSMA 2012; ACCWM 2014b), but are perhaps also being influenced by other factors (both natural and human-caused). These factors could include: habitat loss, forest fires, reduced forage, climate change, unfavourable weather conditions (icing, extremely hot summers), industrial development, increased access, increased predation, increased disturbances, hydroelectric regulation of reservoir levels, harvest of the leaders, wastage, land use in calving and rutting grounds, increased insect activity, overharvest, removal of prime breeding males, overharvest of females, irritation from collars, habitat fragmentation, and competition from other animals such as muskoxen (Thomas and BQCMB 1994; Thorpe *et al.* 2001; Legat *et al*. 2001; ACFN Elders *et al.* 2003b; Kendrick 2003; Kendrick *et al.* 2005; ICC *et al.* 2006; Tłı̨chǫ Government 2007a; WMAC (North Slope) and Aklavik HTC 2009; Katz 2010; WRRB 2010b, c, d, e; BQCMB 2011b; Kavik-Stantec 2012b; Sangris 2012; Barnaby and Simmons 2013; WRRB 2013; ACCWM 2014b; BQCMB 2014a, b; Benson 2015). Further discussion on the causes of population change is included in *Threats and limiting factors* (p. 59).

When herds are at the bottom of their cycles (small populations), the herds may be influenced by people through activities like harvesting and development, and it is likely that the downward population trend will continue if these impacts are allowed to continue (Tłı̨chǫ Government 2007a, b, c; WRRB 2010b; BQCMB 2011b).

> *"We know that scarcity is a reality that repeats itself over time. The big difference today is that there are a lot more pressures on ekwǫ̀ than existed in the era before industrial development, before the fur trade … . Now we have a lot of development, we have a lot more people, we have new methods of harvesting. These modern pressures caused by humans are something that must be dealt with." (John B. Zoe [Behchokǫ̀] in Zoe 2012: 71)*

> *"If we continue our current behaviour, there may be no caribou left to exercise our Aboriginal rights to harvest. Many will argue that the numbers are wrong, that a climate change is the culprit, that development is the main cause of the decline, that wolves are a major factor, or that it is the outfitters taking precious, precious bulls out of the population. There is no one (1) reason that this is happening. The decline in caribou is an important indicator that we are feeling the effects as the cumulative effects from all the above." (Alphonz Nitsiza [Whatì] in WRRB 2010b: 43)*

> *"There was a Denesųłiné prophet from Łutselk'e who said, 'One day we're going to walk on the caribou trails with tears in our eyes.' Sometimes you hope he's wrong, but the way that development is happening and the way our hunting practices are going, I just don't think he's wrong. When I use traditional knowledge to predict the future of caribou, it doesn't look good for our grandchildren, our children. The future for the caribou is not good. Only we can help them. I think the big thing is to control development across our land, across Canada and the Northwest Territories. I hope that my son's children and his children's children will see*

caribou herds migrating through our land." (Danny Beaulieu [Yellowknife] in Beaulieu 2012: 65)

Population dynamics

Garner (2014), in a community-based caribou monitoring report for the Tłı̨chǫ region, provides pregnancy rates during the winter months from January 2010 until April 2014 for the Bluenose-East herd. During this time, rates were at their lowest in the winter of 2010 (65%), increased to nearly 100% in February 2011, and were punctuated by a sharp drop in 2012 (75%). There were gradual increases the following years (80% in 2013 and 88% in the winter of 2014). Garner (2014) cautioned against the overuse of this data, however, as the sample sizes are too low to be statistically valid. In contrast, Joseph Judas has observed a decline in pregnancy rates of females migrating northwards in the spring:

"All the females are supposed to be having a baby but some of them are not like that, they have no babies! They are supposed to have it but it didn't happen. But before those [mines] being established, almost all the females used to have babies to go back to the barrenlands. So in that case it's a really big change from those times till today." (Joseph Judas [Wekweètì] in TRTI 2016: 33)

A brief reference to pregnancy rates exists for the Cape Bathurst and Bluenose-West herds in the Tuktoyaktuk and Inuvik regions, suggesting a high rate of pregnancy—nearly 100% (Kavik-Stantec 2012b). In Paulatuk, an increase in the number of calves was reported between 2002 and 2008 (ACCWM 2014b). In 2010, community members in Kugluktuk noted a decrease in the number of calves (ACCWM 2014b).

Sex ratio is not mentioned explicitly in the available literature; however, it has been reported by harvesters in certain regions that the number of males in some populations of barren-ground caribou has decreased relative to the past (Tłı̨chǫ Government 2007a; Kavik-Stantec 2012b).

"… I haven't spotted a bull among the herd in the last two years when I go hunting with other people. I see cows and calves but never a bull. The population of the cows and calves are at a healthy level because I have seen lots of them when they were heading over the hills at one of the lakes. I spotted a few bulls in the herd but less than what I used to see years ago." (Joe Black [Behchokǫ̀] in Tłı̨chǫ Government 2007a: 31)

Movement between herds is well documented and is frequently mentioned by community members when discussing barren-ground caribou herds and movements (WRRB 2010c, e, g; Beaulieu 2012; IGC 2012; Kavik-Stantec 2012b; Sangris 2012; ACCWM 2014b).

"Nobody knew where they went or what they did, but they were gone for years. The elder that I talked to thinks that they might have gone to migrate with the other herds. I asked him, "Why

do you think they would have migrated together with the other herds?" He said, the way nature works is that ekwǫ̀ could be in big numbers, but in some years the breeding bulls are not there. When the breeding bulls are not there, immature bulls will take over. There is more inbreeding, and the herds become weak. The calves are not strong; many don't survive. He said the cows sense that something is wrong, so they leave, and migrate with other herds. Then years later they come back, when they're strong again." (Fred Sangris [Ndılo] in Sangris 2012: 78)

"Caribou that migrate between the barrens and the boreal forest are referred to as hozıʔekwǫ̀, as opposed to tǫdzı—woodland caribou. Hozıʔekwǫ̀ return to the barrens to give birth to calves. They usually return to the same place each year. Periodically, hozıʔekwǫ̀ shift migration patterns and may follow other caribou to their calving grounds." (WRRB 2010g: 24)

Traditional knowledge holders have also documented movement between barren-ground caribou and Dolphin and Union caribou. Since the 1970s, overlap in the ranges of Dolphin and Union caribou and other barren-ground caribou herds has increased; the summer range of barren-ground caribou has extended north and the winter range of Dolphin and Union caribou has extended south. Barren-ground caribou may even be moving onto Victoria Island in the spring or summer (Thorpe *et al.* 2001).

"During the spring, I have noticed some barrenland caribou up in Victoria Island, and heading to Victoria Island from the mainland. I guess maybe a mixed breed, I do not know." (George Kavanna [Kitikmeot community unidentified] in Thorpe et al. 2001: 80)

Physical condition

The physical condition of caribou tends to be assessed by traditional and community harvesters using a number of common indicators: condition of the fur (shiny or worn), speed (fast or slow movements), condition of internal organs, body condition (fat and muscle tone), quality of the meat, herd size, whether the head is held erect, and presence of a strong leader (WMAC (North Slope) and Aklavik HTC 2009; Benson 2015; Moller *et al.* 2004). Monitoring of fat content is of particular importance as it provides an indicator not just of individual health, but of habitat condition and forage adequacy as well (Berkes 1999).

"Good-looking caribou – their horns look nice and their fur is pretty white. By that you know the caribou is fat…during the [late] fall you don't shoot the male caribou because they are skinny. They don't eat at that time because [of the rut] – they are chasing the female caribou…When you shoot a caribou, the first thing you do is check if the caribou is fat by cutting in the middle of the stomach. If the caribou is fat, the hunter is happy." (J.B. Rabesca [Łutsel K'e] in Parlee et al. 2005: 32)

Harvesters and community members have reported numerous instances of poor body condition

(ICC *et al.* 2006; Legat *et al*. 2008; WMAC (North Slope) and Aklavik HTC 2009; WRRB 2010b, 2013; ACCWM 2014b; TRTI 2016). Examples of this include low levels of fat; changes in bone marrow colour and consistency; changes in hides (e.g., thin hides that are easily torn, hides that stick to the flesh of the animal, infections/parasites); changes in the flavour, colour, and smell of the meat (e.g., yellow/white pus on the meat, white spots, cysts, blister-like spots, very little fluid in the meat); abnormalities in the meat and internal organs (e.g., blister-like appearances in the stomach and lungs, yellow-green mucous in the lungs, lungs sticking to rib cage, white spots on liver); late shedding of velvet by males; swollen or watery joints; and bruises. Declines in fat content are particularly concerning, potentially resulting in starvation if their access to forage is prevented for a period of time (e.g., icing events) (TRTI 2016).

"When you cut the caribou, it smells. Some of them smell; as soon as you open it, you smell it. But some of these you cut it open it smells really good, just like before, but some of them is not like that. Just smells; it hits you really strong." (William Quitte [Wekweètì] in TRTI 2016)

"Before, I see some of them when you cut the bone, it used to be really thick, bone marrow, and it was really thick. Now when you shoot a caribou, when you look, it's like water inside. It's not like before. Some of them when you try to eat it with dry meat it's like water. It wasn't thick; it's all changing." (William Quitte [Wekweètì] in TRTI 2016)

"When I shoot caribou sometimes, one out of five, I'll see caribou with the lungs sticking to the ribs…Sometimes you have to cut it off. It's stuck to the lungs, and not only that sometimes you see green stuff on the lungs too." (Bruce Football [Wekweètì] in TRTI 2016)

"There used to be lots of fat in the intestines, but not these days. The caribou are also not as fat and they are not soft fat in the stomach. There used to be thick fat in the large intestine but that too is not there." (Johnny Boline [Wekweètì] in TRTI 2016)

"Elders reported that caribou have always traveled great distances. In the past, most caribou were healthy; however, due to increased mineral exploration and use of faster machines (trucks, skidoos, planes), caribou are not able to rest and eat. Caribou fat and meat used to be oily and good to eat; today, the fat and meat are dry and taste differently. Healthy bone marrow was whitish pink; however, more and more, hunters are finding the marrow to be reddish in colour, lighter and watery. There are fewer warble flies seen today which is an indication of fewer caribou." (WRRB 2013: 4)

"Women provided descriptions of different abnormalities they have witnessed, such as sores on kidneys, sandpaper-like kidneys, and bluish or yellowish meat. They noted that the caribou tail tells if the caribou is fat or skinny and that bone density changes from summer to winter." (WRRB 2013: 5)

"... I was 15 to 16 years old when I first used to start going out with my father. Back then, them

caribou used to be in a way lot better shape than what they are nowadays, eh? ... when I first used to start going out with my father it used to be a lot more approachable and a lot healthier shape I'd say, but nowadays they sure change. They're wilder and the majority of them caribou are not as fat or healthier... [as] back then." (Anonymous [Inuvialuit community unidentified] in ICC et al. 2006: 11-48)

"When I shoot -- I -- I shot five (5) caribou at one -- when I cut up the caribou, it's like it's all gutted out. It's like -- it's like salty in -- on the fla -- in -- what -- how did that happen? ... In the past -- in the past when I shoot caribou, caribou was very healthy, but today when we touch caribou, when we shoot caribou, we touch the hide, it just rips. In the past it never used to happen." (Harry Apples [Behchokǫ̀] in WRRB 2010b: 188)

"Their liver, they get short but [with] white spots, they say you're not supposed to have liver with white spots on them." (T045 [Tuktuuyaqtuuq] in ICC et al. 2006: 11-48)

"There are hardly any fat caribou around now. Even their bone marrow has no more taste to it. A lot has changed. Could it be because of the wildlife management? It is because nobody does anything or says anything to those Wildlife Economic development and Renewable Resource people. That's the reason why they still put radio collars on the caribou and other animals. And they use a tranquilliser [sic] to put animals to sleep that spreads throughout the animal's body, which does not make the meat tasty." (Moise Martin [Behchokǫ̀] in Legat et al. 2008: 42)

"The number of diseased caribou is increasing and there are different types of diseases being reported now – lungs stuck to rib cages, pus in joints, tape worm cysts, and sandpaper skin." (Anonymous [Kugluktuk] in ACCWM 2014b: 58)

In addition to these reported declines in caribou body condition, there have also been reports of deceased animals (TRTI 2016).

"I guided with Boyd Warner at Tsǫ̀tì (Little Martin Lake)… . In 1997, 98, 96. These were good years, like heaven, successful. 1999 was my last year and we hardly had any caribou. It dropped and that's when we saw a lot of dead caribou on that lake in that area. Not only that, caribou are just dying by itself. We saw one caribou right in front of us in that area. There is a little island right in front of us. We saw one caribou slowly make it to the island, bedded down and it just died." (Bruce Football [Wekweètì] in TRTI 2016)

In contrast, there are also numerous references to caribou being generally healthy and to improvements in body condition throughout the NWT (WMAC (North Slope) and Aklavik HTC 2009; Kavik-Stantec 2012b; Svoboda *et al.* 2013; ACCWM 2014a, b; Denesuline Né Né Land Corp. 2015).

The Tłı̨chǫ Government (Garner 2014), the Arctic Borderlands Ecological Knowledge Co-op (Russell *et al.* 2008), and the Łutsel K'e Dene First Nation's Wildlife, Lands and Environment Department (LKDFN 2005) have been involved in community-based monitoring programs of caribou health and body condition. Similar work has also been taking place in the Sahtú region, as a partnership between the SRRB, Sahtú Renewable Resource Councils (RRCs), ENR, the University of Saskatchewan, and the University of Calgary (Carlsson *et al.* 2015a, b). These four projects provide insight into year-to-year changes in the health and body condition of caribou harvested from the Porcupine, Bluenose-West, Bluenose-East, Bathurst, Ahiak, and Beverly herds in each region/community. These particular community-based studies are important, as they are reasonably current and give us a somewhat up-to-date indication of body condition.

The Tłı̨chǫ Government's Caribou Health and Monitoring Program recorded the depth of back fat, kidney fat, and bone marrow fat stores in both adult females and males from the Bluenose-East herd during the late winter from 2010 to 2014 (Garner 2014). Generally, hunter observations of caribou health corresponded well with fat measurements. The herd was felt to be in generally good health. Females were in better health than males, but that is typical given the time of year during which the study was conducted. Back fat, kidney fat, and bone marrow fat stores were higher in 2014 that in both 2012 and 2013, indicating improved health.

In the work presented by the Arctic Borderlands Ecological Knowledge Co-op from the years 2000-2007, no trend was evident in changes to body condition in the Porcupine herd (Russell *et al.* 2008).

Utilizing the work resulting from the Ni hat'ni program (LKDFN 2005), as well as the information documented by Lyver and LKDFN (2005), it is possible to examine the trend in body condition of caribou from the Bathurst, Beverly, and Ahiak herds surrounding the community of Łutsel K'e from 2000-2005 (note that data from 2002 is absent). During this period, the body condition appears to fluctuate year-to-year, with no evident trend. However, Łutsel K'e harvesters interviewed in Kendrick *et al.* (2005) indicated that the foetuses of harvested females are smaller and less developed (relatively hairless) than earlier times. More recent information was not available for this region.

The Sahtú Wildlife Health Monitoring Program produced back fat data for the Bluenose-West and Bluenose-East herds in the Sahtú region between 2005-2008 (Bluenose-West) and 2004-2014 (Bluenose-East) (Carlsson *et al*. 2015a, b). Consisting primarily of quantitative measurements, this study is discussed in more detail in *Population dynamics – Scientific Knowledge Component* (p. 139).

Predicting the future of caribou

Benson (2015) suggests that were Bluenose caribou to become extinct, other caribou would move into and occupy their range. In fact, because caribou could be absent for a time from that range, the habitat would become more suitable for immigrants (it would "become even better

because over time, things grow back again") (James Firth [Inuvik] *in* Benson 2015: 45).

> *"I think as the land…grows up again, then I think you'll see more of…that Bluenose East? You'll see them moving this way. In this area too, because of the reindeer, there's a lot of mixtures. And the old-timers say they even breed together now." (James Firth [Inuvik] in Benson 2015: 45)*

It may be possible that individuals from the Lorillard River herd north of Chesterfield Inlet may move into the Qamanirjuaq herd (AREVA Resources Canada Inc. 2012). Dolphin and Union caribou, which range between the mainland and Victoria Island, are close enough to exchange individuals with herds of barren-ground caribou (Thorpe *et al.* 2001; SARC 2013). Although scientific sources (SARC 2013) consider Dolphin and Union caribou to be behaviourally and morphologically distinct from barren-ground caribou, traditional and community knowledge sources clearly suggest that these two groups do exchange individuals (Thorpe *et al.* 2001). Immigration from the other barren-ground caribou herds found in northeastern Nunavut is unlikely due to the numerous straits separating the different herds. Two other barren-ground caribou herds—the Forty Mile and Central Arctic herds—are found to the west of the NWT overlapping the Porcupine herd range and may be a source of immigrants.

In addition to range overlap between different herds of barren-ground caribou, it should be noted that boreal woodland caribou and mountain caribou have been observed interacting with barren-ground caribou in many regions. This behaviour has been documented in the ISR, GSA, Sahtú Settlement Area (SSA), the North Slave region, the Tłı̨chǫ, and the Dehcho (Johnson and Ruttan 1993; Nagy *et al*. 2002; GSCI 2005; Cluff *et al*. 2006; GRRB 2009; Carriere 2010; Environment Canada 2010; Katz 2010; Benson 2011; Dehcho First Nations 2001; Bayha pers. comm. 2012; Legat and Chocolate 2012; ACCWM 2014b; Benson 2015; Polfus *et al*. 2016) (see *Interactions*, p. 26 for further detail). Despite clear documentation that the three kinds of caribou interact and sometimes even travel with one another, whether this suggests the possibility of rescue is unclear.

> *"In the summer woodland caribou come up as far north as Husky Lakes. I've seen them with barren-ground [caribou] running around in the barrens. A population shift is happening. What about a 'crossover' of herds?" (Anonymous [Inuvik] in ACCWM 2014b: 104)*

However, it is important to note that if the declines seen in the NWT's barren-ground caribou herds (see *Changes in herd size*, p. 38) are the result of adverse habitat conditions, then the habitat currently available in the NWT may not be adequate to support immigrants.

Habitat

Habitat availability

In general, traditional knowledge sources emphasize the importance of habitat for barren-ground caribou ecology. Key habitat for barren-ground caribou includes calving grounds, rutting areas, and winter forage habitat (discussed in more detail in *Caribou habitat*, p. 14 and *Migration routes and movement*, p. 17). Habitat quality throughout their range is mixed, "All over, there's good and there's bad [habitat], and in-between" (Tom Wright [Inuvik] *in* Benson 2014: 30) and movement to take advantage of quality habitat is well-known, "Their feed will affect them. All the lichens…those take a long time to grow, so if they overuse certain areas, then the caribou move" (Bluenose Caribou Management Working Group [Tsiigehtchic] *in* Benson 2015: 30).

Prior to the 1950s, the winter migration of barren-ground caribou extended south of Lake Athabasca. Elders in the community of Fort Chipewyan have stated that the migrations stopped after forest fires burnt large areas of caribou habitat, wiping out forage to the north of the community in the South Slave region of the NWT. Although this habitat appears to have recovered from this damage, the caribou migration has not returned and it is not presently occupied by caribou (ACFN Elders *et al.* 2003a, b). As described in *Search effort* (p. 13), it is unlikely that there is potential, undiscovered, habitat in the NWT.

Habitat fragmentation and trends

Barren-ground caribou tend to inhabit areas that are fairly rugged in nature, most notably the Porcupine herd, whose range frequently traverses mountainous areas. Rugged terrain is not just restricted to the mountainous regions of the extreme northwest corner of the NWT; difficult terrain and a number of large lakes also persist as barriers to movement in the central barrens of the NWT. While it is known that barren-ground caribou are able to move over difficult terrain (Benson 2015), it is well known among traditional and community knowledge holders that barren-ground caribou frequently reuse corridors to traverse these areas of rugged terrain (Kendrick *et al.* 2005; WMAC (North Slope) and Aklavik HTC 2009).

> *"It depends on the snow and if there's lots of snow. There's just certain places that they would travel by, and that's what I learned from elders. They try to find ridges, because ridges, if you get lots of snow, ridges are always blown off so you get good travelling." (Billy Archie [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009)*

Whereas mountains and deep snow generally characterize impediments to movement in the range of the Porcupine herd, the countless lakes that dominate the landscape in the central NWT are the most significant natural barrier to dispersal for the other herds in the territory. As many lakes in the NWT are too large to swim across, narrow portions – or caribou crossings – on these

large water bodies are extremely important and play a large role in dictating the direction caribou travel across the landscape. Water crossings are particularly sensitive to human disturbances such as the construction of camps, cabins, mines, roads, or other infrastructure in their vicinity, and if crossings become blocked, it can shift migration routes (Kendrick 2003).

Increasing levels of habitat fragmentation and change are frequently reported in the NWT. Community members have consistently highlighted the destruction to habitat caused by forest fires, climate change, industrial development, and roads (Benn 2001; Legat *et al*. 2001; Kendrick 2003; Kendrick *et al*. 2005; ICC *et al.* 2006; Katz 2010; BQCMB 2011b; AREVA Resources Canada Inc. 2012; Kavik-Stantec 2012b; Northwest Territory Métis Nation 2012; Environmental Impact Review Board [EIRB] 2013; WRRB 2013).

Natural habitat changes are largely influenced by climatic conditions. In many regions, knowledge holders have observed that weather has become more unpredictable (ACCWM 2014b) and that timing of seasonal events (i.e., onset of autumn, freeze-up and break-up dates) has changed over time (ACCWM 2014b). These kinds of changes can have both direct and indirect impacts on caribou, including drowning (breaking through ice during migrations) (ACCWM 2014b), alterations to the types of forage, and intensity of insect activity on the summer range (Dumond 2007; WMAC (North Slope) and Aklavik HTC 2009). There are also concerns about thinner ice, less snowpack, less precipitation, increasing frequency of icing events (ACCWM 2014b), and increasing intensity and frequency of forest fires (Thomas and BQCMB 1994; Legat *et al*. 2001; ACFN Elders *et al.* 2003a, b; Kendrick 2003; Kendrick *et al*. 2005; Lyver and LKDFN 2005; ICC *et al.* 2006; Tłı̨chǫ Government 2007a; Nesbitt and Adamczewski 2009; Katz 2010; WRRB 2010b, c; BQCMB 2011b; BQCMB 2014a, b; Benson 2015; Denesuline Né Né Land Corp. 2015). Warming temperatures and the melting of permafrost have also created more waterlogged ground on the summer range. It has been suggested that caribou tend to avoid these areas of soft ground (ACCWM 2014b).

> *"Caribou start eating greening willow and then grass in the summer and then lichens in the fall and winter. They need the good food to grow. The taste of the meat is different according to the season because they eat different things. We need the rain, the sun and the cool. If it's too hot the plants dry up, caribou have to feed something of low value. If the weather goes up and down, the animals suffer too. The weather has become more unpredictable." (Allen Niptanatiak [Kugluktuk] in Dumond 2007: 20)*

> *"In the past, it will freeze up fast in October. Now doesn't freeze up fast. Last year November already set traps, this year had to use a boat. No ice forming along the shore or no snow. … Ice forms slowly, and ice melts rapidly now." (Denesuline Né Né Land Corp. 2015: 6)*

> *"Maybe sometimes it snows too much and then it rains. This makes it hard for the caribou. Today with the warm weather…it's all changing. An elder said that all the wind now comes*

from directions other than the north. When it's from the north it is cold. Now it comes from the south and east." (Anonymous [Colville Lake] in ACCWM 2014b: 45)

"During the fall season and after the snow has fallen, there are times when it rains and the snow becomes crusty and the caribou cannot get to the vegetation. Because of this, the herds tend to head south towards the tree line. This is a change we notice more and more – it rains after it snows, the snow becomes frozen, making it harder for the caribou to get their food." (Anonymous [Kugluktuk] in ACCWM 2014b: 47)

"When we go to Shingle, a few years ago, we see cut banks. I think it's going to affect a lot of caribou. Even when they're crossing that river, mostly through Blow River, you know. The land is just cutting right through and they'll have hard time getting into that other side. Their migration would be all different, 'cause all that thing is just falling down. They can't climb up, even how smart hooves they have. They have hard time to go up on top. Start going to other places where their old route is." (Barbara Allen [Aklavik] in WMAC (North Slope and Aklavik HTC 2009: 24)

"I know an elder told us, Gwich'in elder, said that's [permafrost melt] just like quicksand, so caribou are not going to come through there, so it could be changing their migration patterns, right? So, I know you're starting to see more water." (Billy Archie [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 24)

Forest fires are one of the most frequently cited causes of habitat fragmentation and change. After a forest fire, it may take years for lichen to begin to regrow in an area that has been burned. As such, large forest fires have the ability to strip the land of suitable forage for barren-ground caribou in their winter habitat. Traditional and community knowledge holders have suggested that these burnt areas, especially those from large and intense fires, may function as barriers to the migration and movement of caribou, as they will not pass through areas that lack feeding opportunities (Thomas and BQCMB 1994; Legat *et al.* 2001; Kendrick 2003; Kendrick *et al.* 2005; Lyver and LKDFN 2005; ICC *et al.* 2006; Wilson 2006; Tłı̨chǫ Government 2007b; Nesbitt and Adamczewski 2009; Katz 2010; WRRB 2010a, b, c; BQCMB 2011b; Jacobsen 2013; WRRB 2013; Denesuline Né Né Land Corp. 2015). The barrier created by forest fires becomes particularly strong when viewed over the long term, as much of the winter habitat in certain regions of the NWT has been burned since the 1960s (Fig. 3, p. 54).

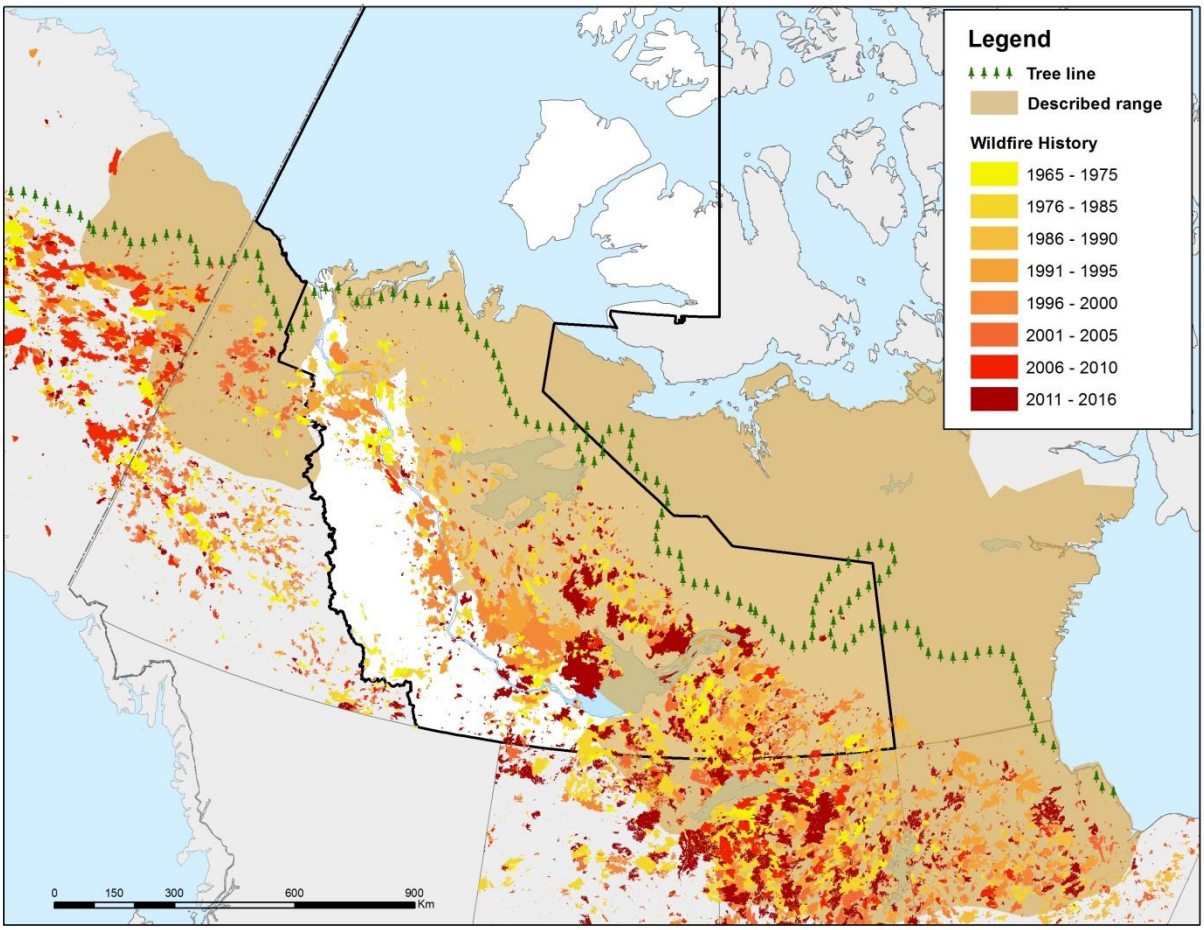

Figure 3. Fire history and barren-ground caribou (Thorpe *et al*. 2001; Parlee *et al.* 2005; ICC *et al.* 2006; Dumond 2007; Community of Aklavik *et al*. 2008; Community of Paulatuk *et al.* 2008; Benson 2011; Beaulieu 2012; Kavik-Stantec 2012b; ACCWM 2014b; Alaska Interagency Coordination Center 2016; Canadian Forest Service 2016).

"When you take – when you take a look at this, this is Behchokǫ area. This is the Behchokǫ. You see all the area that burned out with – from forest fire? You see, when the caribou start roaming, migrate to our area, so they can't bypass this – this burned area, so they find different routes. So most caribou we don't see, it goes to the south. Some are coming to us. A portion have come to us. In November, this is the area where the caribou, they migrate to, this area. It was getting – it was a bit warm at that time. For the past fifty years, how many forest fires have destroyed our land? When you take a look at this, in the past, the area – if you – if you pull – pull this all together for the past fifty years, it will determine how the – the animal migrates, if we took all the data for fifty years past." (Leon Lafferty [Behchokǫ̀] in WRRB 2010c: 354)

"...It's just that sometimes caribou... don't have much food in the summer when they're migrating, you know. Back and forth. It's because we have a lot of forest fires over here in the

last few years and lot of the country is burned over, so they won't go to that part of the area when they migrate. It will go around it or sometimes... not even come....” (Freddy Frost [Old Crow] in Katz 2010: 40)

The forested areas of the NWT recover at different rates; forests near the treeline take much longer to regenerate caribou forage than boreal forests further south (Kendrick 2003; Kendrick *et al*. 2005). This difference in regeneration rates may also influence habitat fragmentation since areas burned near the treeline may be avoided for longer periods of time by caribou than similar sized burns further south (ACFN Elders *et al*. 2003a, b).

It has been suggested by community members that the government should adopt a new approach to fighting more forest fires in key barren-ground caribou habitat (Jacobsen 2013; BQCMB 2014b). Others have suggested that the government should create designated barren-ground caribou winter habitat sanctuaries where all forest fire is suppressed (Tłı̨chǫ Government 2007a).

The threat of forest fires is discussed in further detail in *Threats and limiting factors* (p. 59).

Habitat fragmentation and change associated with industrial development and associated infrastructure and activities is documented throughout the NWT, and is considered to be one of the most significant factors affecting barren-ground caribou (Fig. 4, p. 56) (Mannik 1998; Thorpe *et al.* 2001; Kendrick 2003; Kendrick *et al.* 2005; Community of Aklavik *et al.* 2008; BQCMB 2011b; AREVA Resources Canada Inc. 2012; LKDFN 2012; Northwest Territory Métis Nation 2012; Olsen *et al*. 2012; Tłı̨chǫ Government 2012; BQCMB 2014a, b). As discussed further in *Threats and limiting factors* (p. 59), impacts associated with industrial development include altering migration patterns, changing caribou behaviour, and decreasing quantity and quality of habitat and forage (Parlee *et al*. 2001; Golder Associates 2003; Kendrick 2003; Cumberland Resources Ltd. 2005; AREVA Resources Canada Inc. 2012; Olsen *et al*. 2012; Thorpe *et al.* 2001; Dumond 2007; Benson 2015).

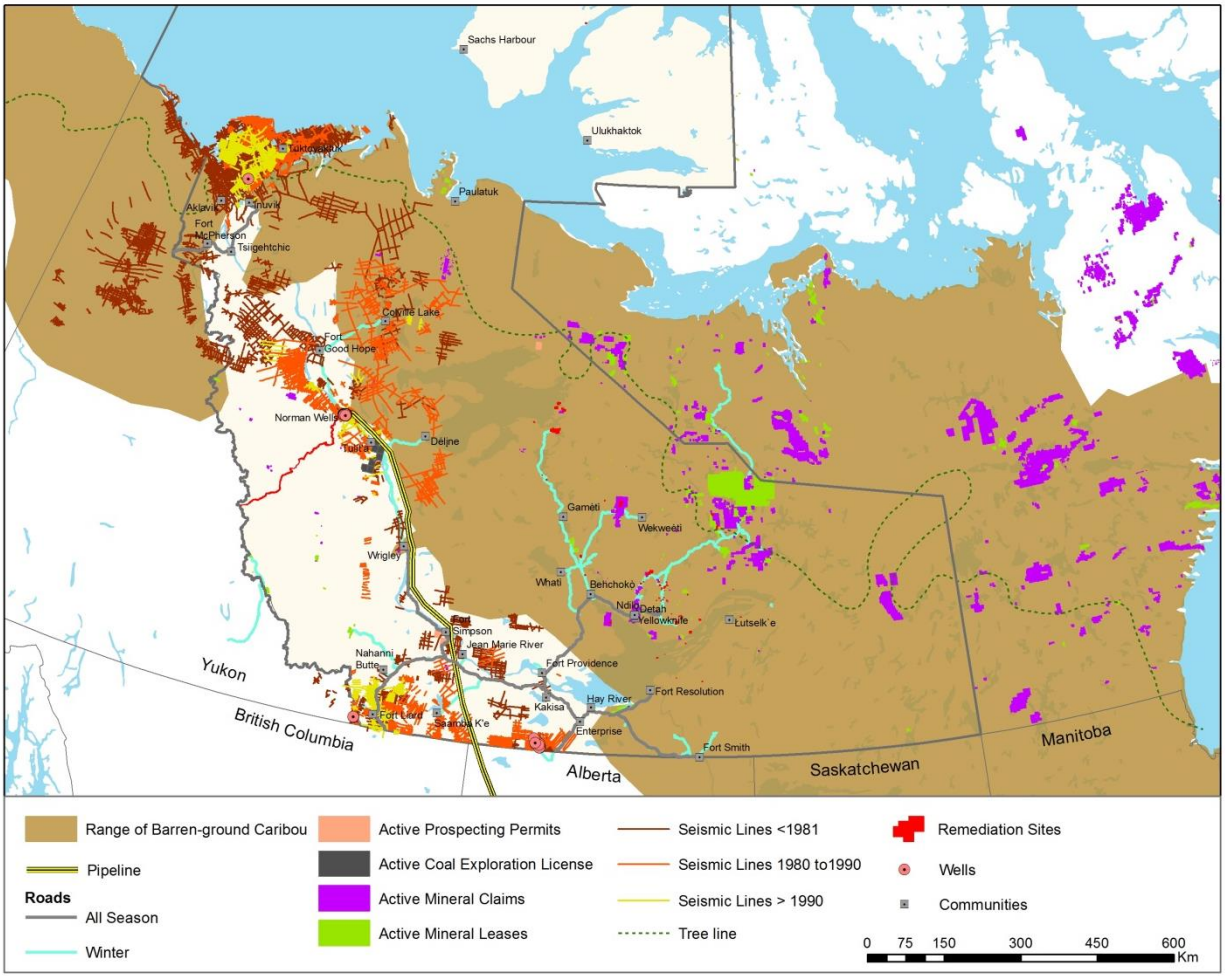

Figure 4. Disturbance related to development activities and barren-ground caribou range. Disturbance data from Centre for Geomatics (SDE Geodatabase), CIMP Inventory of Landscape Change Map Viewer, and Williams pers. comm. 2017. Range from Thorpe *et al.* (2001); Parlee *et al.* (2005); ICC *et al.* (2006); Dumond (2007); Community of Aklavik *et al.* (2008); Community of Paulatuk *et al.* (2008); Benson (2011); Beaulieu (2012); Kavik-Stantec (2012b); and ACCWM (2014b). Treeline displayed as green perforated line. Please note that disturbance footprints are not to scale; they have been expanded to improve visibility and readability. Map by B. Fournier, ENR, GNWT.

The effects on caribou habitat resulting from land use activities are influenced by the bodies responsible for governing, approving, permitting, and developing the projects. Community members have highlighted the need for the government to better regulate land use activities as a means of improving barren-ground caribou habitat (WRRB 2010f; ACCWM 2014b).

> *"…In their intervention, the YKDFN have reiterated the priority issues, recommending actions which could be taken… For example, as has been previously brought up, the development of calving ground protections are essential and simply cannot be shuffled off to a long-term issue. There are already mine proposals in the environmental assessment process in Nunavut, along with many exploration programs. Every other NWT caribou herd has protection for their*

calving grounds, and the Bathurst should be no different, else the Dene hunters who are sacrificing to help the herd recover may, in the end, be suffering for nothing. These are the types of issues that will require the Federal Government to be involved. Remember, until last year the GNWT had not undertaken meaningful management actions, which is one (1) of the reasons that we are all here today… It is not clear how the Minister … have determined that caribou are not affected by how land or water is used. Unless they get over this and begin to fulfill their duties, caribou and their habitat will continue to be divorced… YKDFN have provided evidence in their written intervention, and as well as submitted affidavits to the Federal Court, on how Elders, leadership and experts believe that there is a definite link between development and caribou behaviour…." (Todd Slack [on behalf of Yellowknives Dene First Nation] in WRRB 2010f: 14-17)

"There's no point having a plan in place if the government isn't motivated to do anything because of other interests, for example, economic development. If they won't abide by the rules, it's no good. If an animal is in decline it is up to the minister to decide what to do. He could throw it back to COSEWIC or say it is not in decline for economic reasons." (Anonymous [Inuvik] in ACCWM 2014b: 130)

"You see all these plans and all you see is targeting harvest. It never considers industry impacts. Why is that? It is obviously impacting movements of caribou and other species...." (Anonymous [Inuvik] in ACCWM 2014b: 162)

Changes to the range of caribou

Changes to the range of barren-ground caribou are presented below by region.

In the past, barren-ground caribou were known to occur further to the south and southeast, much closer to the communities of Fort Smith, Fort Resolution, and the Rocher River in the NWT, Fort Fitzgerald and Fort Chipewyan in Alberta (ACFN Elders *et al.* 2003a, b; Beaulieu 2012; BQCMB 2014b) and into Saskatchewan and Manitoba (BQCMB 2014b, 2015; Denesuline Né Né Land Corp. 2015). Near Fort Chipewyan, Fort Resolution, and Rocher River this extended range occurred prior to the 1950s (ACFN Elders *et al.* 2003a, b; Beaulieu 2012). The contraction in their range in this region appears to be substantial—several hundred kilometers—with a large movement away, towards the east and northeast, from the communities of Fort Resolution and Fort Smith (ADFN Elders *et al.* 2003a, b; Beaulieu 2012).

Historic barren-ground caribou winter range in the central portion of the territory was also known to be located further to the south, with caribou coming in close proximity to the communities of Behchokǫ̀, Yellowknife, Dettah, and Ndılo (Legat *et al*. 2001; Beaulieu 2012). Current winter ranges of the barren-ground caribou herds of the eastern and central NWT have contracted somewhat and have shown a general shift northwards (Legat *et al.* 2001; NSMA

2012).

In the Gwich'in region, the migration route, and as a result, the range of Bluenose caribou has changed significantly since the 1970s-1980s, shifting away from Gwich'in communities and closer to Tuktoyaktuk, around Husky Lakes, and possibly Noell Lake (Benson 2015). James Firth [Inuvik] (*in* Benson 2015: 44) notes that this may be due to population decreases: "…I just think there's not enough of them anymore to make it this far, you know…It just seems like they're just trying to survive now, and not having to expend too much energy or something." Changes in range have also been noted near the community of Paulatuk where barren-ground caribou herds (Cape Bathurst or Bluenose-West) have been reported to be staying near the community for much of the year. Likewise, hunters in Délı̨ne noted that caribou in their region (Bluenose-East and/or Bluenose-West herds) were further north and east (from Caribou Point) than they are normally found (ACCWM 2014b). The Bluenose herds were also historically used by Tsiigehtchic and Inuvik residents but current use is restricted as a result of changes in migration patterns towards Fort Good Hope and Colville Lake (compared to the 1970s and 1980s), as well as the implementation of a tag system (Benson 2015).

Traditional knowledge holders often mention the disappearance of barren-ground caribou populations. In some instances, it is thought that the caribou have gone underground and that when they become lonely for people, they will return (Kendrick *et al.* 2005). In other cases, caribou are thought to have disappeared as the result of disrespectful treatment by humans by not following the traditional laws and harvesting protocols that demand respect be given to caribou for giving their lives to help humans survive in the harsh northern environment. This is the lesson at the heart of the frequently told story of the man hitting a caribou with a stick, and the caribou's subsequent shunning of that region for an extended period of time (Legat *et al*. 2001; Kendrick *et al*. 2005; Jacobson 2013; ACCWM 2014b). When caribou disappear, it is frequently framed in the context of their movement patterns having changed rather than there being a decline in the absolute number of caribou (Thorpe *et al.* 2001; NSMA 2012; ACCWM 2014b). However, local cases of extirpation have also been noted: it has been suggested that the Porcupine herd disappeared for many years in either the 1920s or 1940s (Katz 2010) and a herd disappearing in Nunavut on Southampton Island in 1955 has also recorded (WRRB 2010d; Nunavut Department of Environment 2011).

The major changes to range of barren-ground caribou identified by traditional and community knowledge holders are primarily felt to be the result of forest fires (see *Habitat fragmentation and trends,* p. 51), food availability and hunting pressure (Benson 2015; Denesuline Né Né Land Corp. 2015). Localized contractions in range resulting from human encroachment in the form of roads, mines, mineral exploration camps, towns, oil and gas, hydro projects, and utility corridors have also been documented and are discussed in *Threats and limiting factors* (p. 59).

As discussed in *Migration routes and movement* (p. 17), the range of barren-ground caribou calving grounds or summer range may undergo periodic changes or slight shifts over time. Shifts

may also occur in the location of herd wintering grounds, as for the Bluenose herd, which may have shifted its wintering grounds in the late 1980s (Benson 2015).

One of the more controversial discussions revolves around what has happened with the Beverly herd. As Kendrick *et al*. (2005) note, caribou are often hard to locate and as such, a narrative may be used to discuss their absence. Observations that herds occasionally "disappear underground or underwater" are frameworks for understanding the varied and inconsistent nature of the migration of these wide-ranging herds. Traditional knowledge holders have experienced disappearances but "they are not gone in an absolute sense; rather, they may be temporarily using another area of their range" (Kendrick *et al.* 2005: 181). As such, many believe that the Beverly herd has simply moved away from their traditional range, rather than having drastically declined in the manner described by ENR (2011).

THREATS AND LIMITING FACTORS

Traditional and community harvesters know a great deal about threats because they observe how the caribou interact with their environment. Many of these threats are interrelated and cumulative. Loss of habitat due to forest fires and effects related to climate change are probably the two most common factors cited in the traditional and community knowledge literature. There are also an abundance of references to resource development, as traditional knowledge is frequently collected for use in the environmental assessment process. Other factors that are occasionally referenced include invasive species, disease, contaminants, predation, harvesting, and management practices. For the most part, future and potential threats and limiting factors are expressed as a worsening of current effects. These are covered in more detail below.

Forest fires

As noted in *Habitat fragmentation and trends* (p. 51), concern about the frequency, intensity, and impact of forest fires in the NWT is both common and well-documented. Forest fires are considered one of the dominant threats to barren-ground caribou habitat in the NWT, and although it is a natural limiting factor that the species has experienced for millennia, concerns persist.

Traditional knowledge holders generally agree that fires can have a significant adverse impact on habitat. Large fires remove forage, often leaving it unsuitable for barren-ground caribou for decades, if not centuries (Parlee *et al.* 2005; ACCWM 2014b). This can result in altered migration routes, reduced survival of calves, and reduced body condition in adults (Thomas and BQCMB 1994; Legat *et al*. 2001; ACFN Elders *et al.* 2003b; Kendrick 2003; Lyver and LKDFN 2005; Wilson 2006; Katz 2010; BQCMB 2011b; Jacobsen 2013; WRRB 2013; ACCWM 2014b; BQCMB 2014b). Although forest fire is a dominant concern in the winter range, which tends to

be below the treeline, there are concerns about fires in the summer ranges of some of the herds as well, particularly their calving grounds, suggesting that fire is an issue throughout the range of the species (Golder Associates 2003).

> *"When we have forest fires, it's pretty evident that when timber gets too dry we have forest fires. As we see today, the tundra is becoming too dry from the lack of rain, and because of that we seem to get more forest fires. The dry tundra creates a lot of dust." (John Akana [Umingmaktok] in Golder Associates 2003: 27)*

The length of time that passes before fire-affected habitat recovers to a point where it is once again suitable for barren-ground caribou appears to be between 10-60 years (Katz 2010; WRRB 2010b; ACCWM 2014a; Benson 2011; Beaulieu 2012; Benson 2015), with the range possibly related to variations in regional ecosystem productivity. Some knowledge holders have observed that barren-ground caribou return to burned areas soon after there is new growth, while others believe that caribou will never again returned to a burned site, or that it may take upwards of 100 years for habitat to become suitable again (Kendrick *et al*. 2005; Parlee *et al*. 2005; Parlee *et al*. 2005).

> *"Another problem is all the land that has been burnt around Łútsël K'é and this also keeps the caribou away. In the past when there were forest fires the land would burn just to a certain point, but now the fires burn out of control. In the past there were not that many areas that were burnt so the caribou were everywhere. Now there are many large burn areas and the caribou stay away. They do not migrate through those areas because there is nothing to feed on." (Madeline Drybones [Łutsel K'e] in Kendrick 2003: 173)*

> *"Lichens growing back, 10 to 20 years after a fire, it can take to come back." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 54)*

> *"It takes quite a while. I think about ten years, anyway, before grass and the moss start to grow back." (Gabe Andre [Tsiigehtchic] GEKP in Benson 2015: 54)*

> *"Well, it burns up everything. So you've got to wait a few years to revitalize, but they say when it comes back it's always better. [For the first plants to grow back] it's two or three years, but very long. But maybe lichen might grow slower. Like there's different sedges they call it, but they grow slower too. Maybe the stuff for the moose come back sooner. But, even…marten and all that, they come back real fast. Caribou too because they like those new places." (Tom Wright [Inuvik] in Benson 2015: 54)*

> *"From the marten side, [they'll come back in] one year. From caribou, probably, looking at areas that burned out there, probably five, six years." (James Firth [Inuvik] in Benson 2015: 55)*

> *"Regarding the forest fires, some scientists say it's good for new growth. But do you know*

what the caribou eat? If the lichen burns, it will take over 100 years for the plants to grow back. Some scientists say these forest fires are good, but it's not like that for us. There never used to be so many forest fires. I have never before seen a forest fire started by lightning." (Pierre Marlowe [Łutsel K'e] in Parlee et al. 2005: 34)

"All the herds used to go in a circle through the year. One year the Bluenose-West came right to Norman Wells and to the Enbridge road [west side of the community]. They are not doing those circles anymore. That's why you can't get a good count because the caribou are spread all over. Blame it on industry, mines, muskoxen, and fires – the fires burn caribou feed and it takes 100 years to grow." (Anonymous [Norman Wells] in ACCWM 2014b: 29)

Prior to the 1950s, the winter migration of barren-ground caribou extended south of Lake Athabasca. Elders in the community of Fort Chipewyan have stated that the migrations stopped after forest fires burnt large areas of caribou habitat, wiping out forage to the north of the community in the South Slave region of the NWT. The elders noted that while the habitat destroyed during these fires appears to have recovered, the caribou still have not returned (ACFN Elders *et al.* 2003a, b). The same is true of the Bluenose herd's migration route, which has moved away from Travaillant Lake as a result of fires (Benson 2015).

"The caribou probably don't come south anymore because they let the North Country burn. In Saskatchewan they don't fight fires enough. Otherwise, it would have been good caribou habitat. Earlier the caribou came down every year. In 1947 they come to Fort Chipewyan." (Rene Bruno [Fort Chipewyan] in ACFN Elders et al. 2003a: 100)

"The caribou used to be really plentiful around Travaillant Lake when I was growing up as a kid, but since then, there was a fire that burnt just north of Rat Lake and east to Big Lake and all through this whole section…And since that time, the caribou, because all their food supply had burned in this area, they move…they travel just a little bit north of the lake. But…I've noticed since 1986, as the vegetation is growing back, the caribou are starting to come back down through here, because we see their trails and their tracks and so on. But they don't stay for as long as they used to. They usually just make their way through, and then they travel further north, and then they're going across east – or west, to Inuvik." (Dan Andre [Gwich'in community unidentified], Gwich'in Traditional Knowledge of the Mackenzie Gas Project in Benson 2015: 44)

According to the BQCMB (2014b), forest fires have damaged much of the Beverly herd's winter range. This loss of high-quality habitat means that vulnerable calves have less access to high value forage and are, therefore, at a higher risk of mortality during their first winter (BQCMB 2011b).

The scale of the 2014 fire season and the suggestion that climate change may bring even hotter

and drier summers to a number of regions in the NWT (Tymstra *et al.* 2007) indicates the importance that a change in current fire management practices could have on the future stability of barren-ground caribou as a species, and mitigate the degree and/or immediacy of forest fire as a threat (Cizek 1990; Jacobsen 2013; Benson 2015).

> *"…back in the days, soon as they spot fires, we would fight fires. We worked all day. We didn't want to let our land burn down, because we wanted to protect it. Now they just let area burn, but they should take it out." (Francis Simpson [Whatì] in Jacobsen 2013: 17)*

> *"Long ago if a fire started somewhere they'd attack it right away. Now they don't do that; they let it burn and it burns a lot of caribou feed and young birds." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 55)*

Industrial development

Industrial development (mining, oil and gas, hydroelectric development, etc.) is considered to be one of the most significant factors affecting barren-ground caribou (Mannik 1998; Thorpe *et al.* 2001; Kendrick 2003; Kendrick *et al.* 2005; Community of Aklavik *et al.* 2008; BQCMB 2011b; AREVA Resources Canada Inc. 2012; BQCMB 2014a, b; Denensuline Né Né Land Corp. 2015). As noted in *Habitat fragmentation and trends* (p. 51), activities associated with industrial development can disturb caribou and affect their behaviour, the quality of habitat and forage, and ultimately, the survivability of the species (Parlee *et al.* 2001; Kendrick 2003; Olsen *et al.* 2012). The impacts from development are thought to be worse in the winter, potentially resulting in loss of habitat, increased predation, and added hunting pressure (Benn 2001; Joint Review Panel 2009; Katz 2010; Kavik-Stantec 2012b), while development on or near calving grounds and migration corridors is also considered to have negative impacts on caribou (Thorpe *et al.* 2001; Canadian Arctic Resources Committee [CARC] 2007; Boulanger *et al.* 2012).

Partially due to the incorporation of traditional and community knowledge in environmental assessment processes, there exists a large amount of available information on the observed and potential impacts of industrial development on barren-ground caribou and their habitat (Cumberland Resources Ltd. 2005; ICC *et al*. 2006; Dumond 2007; De Beers Canada Inc. 2010; AREVA Resources Canada Inc. 2012; Kavik-Stantec 2012a; Jacobsen 2013).

Caribou are said to avoid large development activities, potentially resulting in altered migration routes, with knowledge holders observing that the caribou sometimes will not return to affected areas for many years.

> *"The caribou used to migrate to our land. But now there are mines in the way of their major migration route. That's the reason why caribou mind-spirit is weak – it is too weak to come toward our land now. The caribou feel like there is something in their path, so they turn the other way. The smell of fumes and smoke can blow far on the barren ground, and the caribou*

can sense that." (Caroline Beaulieu [Behchokǫ̀] in Legat et al. 2008: 42)

"People have asked that no mining take place near calving grounds because they are afraid it would diminish the number of caribou." (Paul Omilgoitok [Ikaluktuuttiak] in Thorpe et al. 2001: 84)

"By observing the mines I've seen that they are not good for the caribou. In the past, the caribou used to migrate and stop in the Dathi Hue (Walmsley Lake) area. Very few caribou move through that area now. People also do not go up into that area now. You go to the mines to observe the caribou. I've been up to the mines three times and have observed the caribou there. You just see a few caribou here and there. For me the mines have changed the way caribou behave, although I am not all that sure how much they have changed. I know the main caribou migration trails are still there. In the past you could see caribou trails all along the landscape, even in the summer. You could see their tracks everywhere. Now you do not see them that much. Just some of the main migration routes remain. These are the only tracks you see. In the past you could see where the caribou have played when they've stopped, but now you do not see these signs of caribou playing. You only see the migration trails. After they put the mines up in the barrens the caribou have changed for me. The meat, however, still tastes the same. The way I hunt, I know how far the caribou are from my house. These days the caribou are much farther away than they used to be. In the past it was not like that." (Noel Drybones [Łutsel K'e] in Kendrick et al. 2005: 185)

"Caribou have very good smell and sight so any industrial development scares them away." (Bluenose Caribou Management Working Group [Inuvik/shared] in Benson 2015: 49)

Mineral exploration and mining have increased in areas such as the Kitikmeot and Kivalliq regions of Nunavut, and there is a lot of concern about the ability of certain herds to withstand the increased pressure (BQCMB 2011a). Exploration and development of mineral resources in the Beverly and Qamanirjuaq herds' ranges have been raised as topics of great concern by the BQCMB and its constituent communities, who have spoken out against development in important caribou habitat. Despite this, interest in mineral development in the region has continued to grow, especially in the Beverly calving ground south of Garry Lake, where the number of tenures issued for mineral exploration peaked at more than 700 in 2008, and in the Qamanirjuaq calving ground, where exploration was approved in 2012 and 2013 (BQCMB 2014b). Similarly, the impact of mining on the Bathurst herd's calving grounds is a key concern for many people (Thorpe *et al.* 2001; Golder Associates 2003; Tłı̨chǫ Government 2012).

Oil and gas exploration and development is, for the most part, occurring in the winter ranges of barren-ground caribou only. According to Industry, Tourism and Investment (ITI), the NWT has large undeveloped oil and gas reserves that could represent a significant portion of Canada's marketable petroleum resources (ITI 2014). If this industry were to expand, the potential future

threats associated with oil and gas could increase significantly. Community members in the Mackenzie Delta, where the construction of above-ground pipelines is possible, have suggested that these pipelines, if constructed, may inhibit the migration of caribou, as they will not pass under them, particularly during winter when deep snow will effectively shorten the gap between the ground and the pipeline (ICC *et al.* 2006; ACCWM 2014b).

The potential for oil and gas development on the calving grounds of the Porcupine herd (within the Arctic National Wildlife Refuge in Alaska) has increased substantially following the 2016 presidential election in the United States. The president has indicated support for opening onshore and offshore leasing for energy projects. A decision to open up energy leases in the Arctic National Wildlife Refuge could potentially allow exploration and development in critical calving habitat used by the herd.

Impacts related specifically to hydroelectric development are limited to the influence these projects can have on ice conditions on large waterways and, by extension, the ability of barren-ground caribou to safely cross this ice (Kendrick 2003; Kendrick *et al.* 2005; Barnaby and Simmons 2013). This impact is noted specifically for the Beverly herd, where flooding of Nonacho Lake from the Taltson hydroelectric project has influenced ice conditions on the lake. This project has also affected the availability of winter forage, with sporadic flooding events damaging lakeside vegetation (Kendrick 2003; Kendrick *et al.* 2005; Barnaby and Simmons 2013). If the projects listed in the draft NWT Hydro Strategy (ITI 2008) come to fruition, then the possible future impacts of this industry may be substantially larger than they are at present.

> *"My son went hunting at Nonacho Lake, past Grey Lake. We go pretty close to where they have the hydro, and there is a lot of overflow on Nonacho Lake due to the hydro." (Terri Enzoe [Łutsel K'e] in Barnaby and Simmons 2013: 10)*

Pollution

The effect of pollution, including airborne particulates from mines and downstream effects on flora and fauna is an important concern for traditional knowledge holders (Legat *et al*. 2008; Kendrick *et al.* 2005; Diavik Diamond Mines 2011; BQCMB 2011b; Jacobsen 2013). Tailings ponds and hazardous wastes have not been adequately managed in the past, so there is understandably concern about the reliability and effectiveness of management on current and future projects (Golder Associates 2003; Kendrick 2003; AREVA Resources Canada Inc. 2012).

> *"During the last 4 years, been seeing different results in the caribou when using the skins, the meat and other parts that she uses. When you take apart the caribou you can see white spots and bristles, especially inside the knee parts and on the skin. Also, there are rough parts on the caribou bones, especially on the ankles. The caribou are changing. Sometimes there is less hair on the ankles. They get this from when they walk near the mine sites. Before the caribou meat was nice and tender. But the last 4-5 years, the caribou are changing." (Anonymous*

[Whatì] in Jacobsen 2013: 29)

"Tailing ponds from mining camps near Contwoyto use to be very bad and are bad for caribou. There is either no vegetation around or it is possibly contaminated. There is no vegetation 5 miles around the tailing ponds." (John Ivarluk [Kugluktuk] in Dumond 2007: 20)

A wide range of contaminants have been found in wildlife in northern Canada (Braune *et al.* 1999). The accumulation of toxic substances represents a potentially serious threat to barren-ground caribou. Contaminant levels were monitored in most major barren-ground caribou herds across the north during the 1990s under the Northern Contaminants Program to provide a baseline of what types and levels of contaminants are present, to help understand their source, and to consider their significance to caribou (Croft *et al.* 2009).

There are a few notable examples of contamination sources that are being observed by traditional knowledge holders. These include radioactive fallout from nuclear weapons testing (WMAC (North Slope) and Aklavik HTC 2009), contaminated sites such as the Distant Early Warning (DEW) Line, and abandoned and/or orphaned industrial sites. For the most part, the contaminated sites documented in the Canadian Federal Contaminated Sites Inventory (Treasury Board of Canada Secretariat 2014) are in the winter range of barren-ground caribou. There is limited information regarding the degree and scale of this threat in the available traditional knowledge literature.

Though the number of contaminated sites is relatively small in the NWT range of barren-ground caribou, traditional knowledge holders have observed impacts on the health of caribou:

"[About 3 years ago] me and George were hunting down the hill towards King Point. We shot two big bulls, boy they looked good. When we got there, there was just this light turquoise colour [stuff] coming out of his nose. Cancer ... One time, I don't know how many caribou we shot, just turquoise coming out ... I know there was a lot of sick caribou, not only me who shot them. There's quite a few [in that area] ...I never see sick caribou for six or seven years ... [three years ago] was bad ... Well last few years the caribou we shoot they're healthy since they had that DEW Line clean-up." (George Selamio [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 93)

"Sometimes some caribou are not healthy anymore. We never used to see caribou just go swimming in the ocean. A few times we see caribou just jumping in the ocean, and it's not common to see caribou like that ... They belong up on the land ... They get big lumps around [their joints] when they're swimming in the ocean like that... I mean their behaviour is not like before. Everything is changing. Mostly after that DEW Line ... Sometimes they got big sores on their body too, and you can't eat them. You just have to burn them." (Barbara Allen [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 93)

Further information on body condition trends is included in *Physical condition* (p. 46).

Seismic lines, pipelines, and roads

Despite a fairly small physical footprint, linear features like seismic cutlines, pipelines, and roads can impact barren-ground caribou in a variety of ways, including destroying habitat, creating barriers to movement, and increasing predation as the long open right-of-ways allow predators to spot caribou from great distances in areas where they would normally have tree cover (Kendrick 2003; Kendrick *et al*. 2005; Joint Review Panel 2009; BQCMB 2011b; BQCMB 2014b; Benson 2015).

> *"They'll slaughter them. Well, somebody'll shoot them every time they see them regardless. They'll clean them right out." (Morris Blake [Gwich'in community unidentified] in Benson 2015: 50)*

> *"What it does is opens up the country to everybody. You just go down the highway until you see the tracks…people don't realize it. It's going to change the way we do things so much, right, from cutting wood to…your peace and quiet on the land is not going to be there anymore…10 years ago, when they put the coal plant between here and Good Hope, they made that winter road all the way down to Thunder River. Everybody was on there that had a 4x4, hauling wood. And many caribou were shot, many, but woodlands. Unfortunately, that's what's going to happen." (James Firth [Inuvik] in Benson 2015: 50)*

> *"When they had that road out to Good Hope that one year from Inuvik, there was caribou right between Inuvik and Travaillant. And some people found out, and they went up and just slaughtered them. It was about six, eight years ago. They had a winter road out there. They were exploring route possibilities for the pipeline, I think. And we heard that they ran into some caribou. And then a couple of days later, we got a report saying that there was just caribou legs and heads all over out there. [So,] I'm pretty sure that would happen [with the Mackenzie Highway]. Nobody goes out there and hunts, and then suddenly, there's a road, and everybody is out there hunting." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 55)*

Likewise, the presence of roads, road construction, traffic, and pipeline right-of-ways are examples of habitat disturbances that may be impacting some barren-ground caribou herds year round (Thorpe *et al*. 2001; Legat *et al.* 2001; ICC *et al*. 2006; Kavik-Stantec 2012b).

Traditional knowledge holders often note that barren-ground caribou are stressed by dust associated with road traffic, as well as noise (discussed in more detail in *Threats and limiting factors - Noise*, p. 68). Barren-ground caribou observed near roads can appear nervous and may run into the bush at the slightest noise or human scent (Legat *et al.* 2001). Traffic on the road and the physical presence of the road itself may change barren-ground caribou behaviour (Thorpe *et*

al. 2001; Dumond 2007). Even if they don't modify their migration routes around infrastructure, barren-ground caribou quickly learn to avoid the areas with the greatest level of disturbance; for example, sections of highway where hunting has occurred (Benn 2001).

Some elders think there are ways of technically mitigating the impact of roads. Others feel that negative effects will be inevitable:

> *"Regarding the winter road, if you make a road, you cannot make it too high. It's too hard for the caribou to get over it. It should be lower. The caribou won't just pass through a little pathway you make, they go all over. The road needs to be fixed." (JB Rabesca [Łutsel K'e] in Parlee et al. 2005: 35)*

> *"No matter what you do, caribou will be affected by these mines and roads. The only way to not affect the caribou is to have no mines and roads. If there is a mine, there will be roads. And if you have a road, there will be trucks on it. If they put it through, you can't stop everything for the caribou. But maybe that is what the caribou need." (Pierre Catholique [Łutsel K'e] in Parlee et al. 2005: 35)*

> *"[I] went to the mines this summer to check out the caribou. They don't like those mine roads. They're too high for them to get across, and they have sharp boulders on the sides where caribou can get hurt from falling or getting stuck. We even drove in a truck on the road, and saw the caribou having trouble going up and down the sides of the road. It's no good, and it's no good for us Dene people. Those mines should do something about this, or maybe soon our caribou will be all gone." (Anonymous [Łutsel K'e] in De Beers Canada Inc. 2010: 70)*

Traditional knowledge holders involved in the Inuvik to Tuktoyaktuk Highway traditional knowledge workshops suggest roads may have an initial negative effect on barren-ground caribou, but over time the caribou may eventually habituate to it, as they have with the Dempster Highway (Kavik-Stantec 2012b). Participants suggested that to mitigate over-harvesting of the caribou, if a road is constructed, there ought to be more or improved regulations around barren-ground caribou harvesting in the region, and these regulations will need to be properly enforced (Kavik-Stantec 2012b).

With the exception of the NWT's ice road system, a few all-season roads in the Mackenzie Delta, and the proposed all-weather road from the Lupin mine site to Bathurst Inlet (79 km) (Kendrick *et al.* 2005), threats related to roads are generally highest in the winter range of barren-ground caribou. For instance, the construction of the Mackenzie Valley Highway (over 800 km) and fibre-optic link (1,154 km) will be through the historic winter range of Bluenose caribou and will be close by their current winter range. There is also the possibility of construction of an all-weather road connecting Yellowknife to Whatì (94 km) (Department of Transportation [DOT] 2016). Partial funding for this project was recently approved (CBC News 2017).

As of 2007, the total length of linear features in the NWT (including main roads, winter roads, transmission lines, service roads, and pipelines) was 5,658 km (equivalent to a density of 0.40 km/km^2; substantially less than that seen in other jurisdictions). This is highest in the Taiga Plains (3,645 km; 0.75 km/km^2) and Taiga Shield (1,122 km; 0.34 km/km^2) ecoregions (ENR 2016b). With the proposed projects noted above, this is expected to increase to some degree.

Noise

Traditional knowledge studies indicate that barren-ground caribou do not tolerate noise or human disturbance well, and that minimizing noise disturbance is important for barren-ground caribou (Golder Associates 2003; Cumberland Resources Ltd. 2005; AREVA Resources Canada Inc. 2012; Benson 2015). Noise is associated with changing barren-ground caribou behaviour and stress:

"Across from Délı̨nę we had a lot of caribou. PetroCanada came in and did drilling and the caribou left. Now they are over at Hottah Lake area. Caribou avoid noise – they hear noise and they go away. Before the oil company the caribou were even on this side of the lake." (Anonymous [Délı̨ne] in ACCWM 2014b: 50)

"Low-level flying bothers caribou, as does the activity of active development." (Tom Wright [Inuvik] in Benson 2015: 49)

"Elders went to Diavik to look at the mine site and there were not many caribou there. We used to see a lot of caribou migrate through that area. We suspect the noise from the mine has made the caribou move away. A lot of the old caribou trails are now covered with moss. There is so much noise from the mine site; the caribou are migrating away from the site instead of going along the shores." (Joseph Nitanatuaq [Kugluktuk] in Terra Firma Consultants 2004: 34)

"I know with disturbances, they tend not to return after they found out it's disturbed. Like, if somebody made a big cut road, well, the next year when they came, they would detour that area." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 50)

"Regarding petroleum development - in the 1970s and 1980s people had to go 60 to 80 miles to hunt caribou east of Tuktoyaktuk because of all the noise from industry." (Charles Pokiak [Tuktoyaktuk] in WMAC (NWT) pers. comm. 2015)

Generally, traditional knowledge holders have observed that after the disturbance subsides, barren-ground caribou will return to the area, although this can take as long as 10 years (Kavik-Stantec 2012b).

In some cases, it was noted that barren-ground caribou can become habituated to sensory

disturbances:

"We know caribou and muskoxen are less sensitive to noise. They've gotten used to it. …Caribou and muskox have gotten used to airplanes, skidoos. They're probably more tolerant. Many years ago, when the wildlife had contact with machinery, they were easily spooked. That's not the case today. They have adapted to trucks, skidoos and air planes. They've adapted. And all terrain vehicles too. They have adapted to almost every day noise levels. That wasn't the case years ago." (Moses Koihok [Iqaluktuuttiaq] in Golder Associates 2003: 29)

"I've been with the Bluenose caribou and I worked around the Tuk area lots when all the exploration was going on up there and you would see caribou on those roads and close to the drill sites and whatnot." (Harry Carmichael [Gwich'in community unidentified] in Benson 2015: 49)

"Caribou don't seem to be bothered by that stuff. On the Dew Line they used to have to chase the caribou off the airstrip when the planes come at Blow River." (Tom Wright [Inuvik] in Benson 2015: 50)

Climate change

Climate change-related effects on barren-ground caribou are described throughout the available traditional knowledge literature, representing observations made in every region where barren-ground caribou are found and at every stage of their life cycle. The number of community observations, as well as discussions about climate change is increasing.

Increased variability in weather patterns is resulting in hotter, drier summers that increase the chances of large forest fires, while more frequent freezing rain events make it very difficult for caribou to access winter forage (BQCMB 2011b). Additionally, changing climatic conditions are causing changes in range and abundance of predators, as well as habitat alterations resulting from melting permafrost and erosion (WMAC (North Slope) and Aklavik HTC 2009; Boxwell 2013). Changes in climate that result in caribou gaining earlier access to vegetation could be beneficial (Benson 2015), but the many impacts of climate change discussed here are thought to have adverse effects on barren-ground caribou. While healthy caribou herds can adapt to some degree to these kinds of habitat changes, caribou herds in decline have more difficulty adapting (Benson 2015).

The effects of climate change can be both direct (e.g., icing events) (Thorpe *et al.* 2001; WMAC (North Slope) and Aklavik HTC 2009; Benson 2015; Denesuline Né Né Land Corp. 2015) and indirect (e.g., increasing number or intensity of forest fires) in nature (Thorpe 2000; Gordon *et al*. 2008; Katz 2010; Boxwell 2013; Jacobsen 2013; ACCWM 2014a; BQCMB 2014b; Benson 2015).

"It depends on the food that's growing up and the freezing rain, freezing snow and everything

like that, it's not good for the caribou." (Donald Avuigana [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 48)

"Climate change has taken a toll on caribou, predators and habitat, participants said. It is warmer now than in the past across the Beverly and Qamanirjuaq caribou ranges, with more flooding and freezing rain. This unusual weather may be altering caribou movements, encouraging disease and resulting in more drownings at river crossings." (BQCMB 2011b: 30)

"Oh, [icing events are] hard on them. They can't run. They just walk. They can't run away, and [they] have a heck of a time to find food." (Morris Blake [Gwich'in community unidentified] in Benson 2015: 52)

"I'm sure it happens when it happens, but I think it's more in the last 10 years, because I never used to remember it raining in the fall time when we were kids. It's mainly in the fall time with the rain, and probably the heavy snow that covers the lakes before they freeze, because it you have too much snow on the lake before it gets cold enough to freeze, the lake stays open. And then there too if they're crossing, they'd run into slush and they would cut their hooves. Even…with that crust, it would cut their hooves up." (Julie-Ann Andre [Gwich'in community unidentified] in Benson 2015: 52)

"Deep snow doesn't necessarily mean the caribou will be skinny, but out on the barrens when the snow is really hard packed and in the forest when the snow is crusted; it is harder for the caribou to break through that for their food." (Jim Fatte [Łutsel K'e] in Lyver and LKDFN 2005: 48)

Changing weather conditions may also influence caribou mortality, as extreme weather events, especially cold conditions during the calving season, may increase the mortality rate of calves.

"Due to climate change they changed [calving locations] quite a lot. Sometimes the spring come too early and then [they] have a heck of a time to cross rivers in order to get to the calving grounds ... I remember [10] years ago that happened ... Some years when it's warm in the spring time they have a difficult time to get through here 'cause there's lots of snow. Some years that snow is hard enough to go on top ... You know, they're migrating a little too late, starting late from way up [Fort McPherson] way. They should be down there by April, April and May where they have their young. Sometimes they're up here 'til end of May and then it's too late. Then when they're heading down they drop their young on their way down. So they start having their young ones about the end of April. Some years May is so cold those youngsters don't survive. It's too cold." (Donald Avuigana [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 54)

As mentioned in *Caribou habitat* (p. 14), snow conditions can have a large impact on caribou. Deep or wind-packed snow and ice crusts make it hard or even impossible to access forage. Deep snow may also influence the ability of caribou to move across the landscape. These deep snows are particularly hard on small caribou calves.

During the summer, extreme heat events lead to heat exhaustion and exacerbate stress from biting insects (Dumond 2007).

> *"With the hotter summers that we're having now, that must be hard for them. Because of that, there's a lot more mosquitoes. So I think that really affects them…I think we used to get more rain. It seems like we don't get as much as we used to, the last few years, anyway. You talk about climate change…It never used to be that way. But in the last few years, I really noticed that all the falls have been like stretched right out longer, like this year and the year before, the rabbits were white, and we never even had snow. So it's late." (James Firth [Inuvik] in Benson 2015: 52)*

> *"During hot days, caribou have to try to keep cool otherwise they can overheat. It is likely that as climate generally warms and days of extreme heat and forest fires become more frequent, ways to prevent dehydration and overheating become more important for caribou. Caribou adapt to the heat by staying near the shorelines, lying on patches of snow, drinking water, wading and swimming in the water, eating moist plants, and sucking on mushrooms." (Thorpe et al. 2001: 150)*

Adherence to traditional laws and harvesting protocols

Non-traditional harvest practices are considered a threat to barren-ground caribou; this includes activities like reckless shooting, overuse of motorized vehicles, wastage of meat and leaving carcasses on the ground, not sharing meat, and not using the entire carcass. Traditional knowledge holders state that barren-ground caribou may move out of an area if traditional laws and harvesting protocols that respect the caribou are not followed (Beaulieu 2012; Sangris 2012; Benson 2015; Denesuline Né Né Land Corp. 2015).

> *"They used to respect caribou long ago. When we hear the caribous are coming, we just leave them for a while 'til the leader pass, 'til the lead bunch pass. After they pass, they always start hunting. Like today, soon as they hear there's caribou down here they take off with speed boats and put their skidoos in the boat and just drive up—hit the leader. I guess since that time our caribou don't like to go through that route anymore. I guess that's why we don't have too much caribou." (Anonymous [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 23)*

> *"There's too many people around that don't have respect. And that's why you have so many wounded caribou. They don't take the time to set up the gun, and they just shoot into the herd.*

[Everyone should] just take what you need. A toboggan can only handle so much, you know. So just take what you need." (James Firth [Inuvik] in Benson 2015: 55)

It is commonly remarked that disturbing the leaders of the migration can have detrimental effects. The leaders are seen as the knowledgeable individuals that lead the way for the rest of the herd (Legat *et al.* 2001).

One of the main concerns that arises from non-traditional harvesting is the loss of quality breeding males associated with sport hunting or male-only harvest practices (ACCWM 2014b; Benson 2015):

"Shooting only bulls is very dangerous. Sport hunters shoot the good breeding bulls and it can affect the population… Sports hunters don't understand that the bulls are important to the herd. They tend to go for the largest, strongest bulls, but they should be left in the herd to pass on their genes. The practices involved in sports hunts contradict the law of 'survival of the fittest' and removing the best bulls will weaken the herd." (Anonymous [Kugluktuk] in ACCWM 2014b: 170)

"Killing all the bulls, when it's time to breed, there won't be any prime caribou for breeding. They are needed in the rut." (Bluenose Caribou Management Working Group [Inuvik] in Benson 2015: 38)

At the same time, management boards like the Porcupine Caribou Management Board (PCMB) and the BQCMB are supporting male dominated hunting practices (BQCMB 2011b). Fred Sangris (Ndılo) (*in* Sangris 2012: 78) documents the concern that elders have with respect to the loss of mature males:

"He said, the way nature works is that ekwǫ̀ could be in big numbers, but in some years the breeding bulls are not there. When the breeding bulls are not there, immature bulls will take over. There is more inbreeding, and the herds become weak. The calves are not strong; many don't survive. He said the cows sense that something is wrong, so they leave, and migrate with other herds."

Overharvesting

Traditional knowledge holders recognise that the harvest of barren-ground caribou is seen by biologists as an important threat, but the topic of overharvesting is highly controversial. At the very most, hunting pressure was identified as a moderate current threat to some barren-ground caribou herds in the NWT (Legat *et al.* 2008; ACCWM 2014b). Traditional knowledge holders also know that compared to historical times, the subsistence harvest brings in only a fraction of the caribou it used to, since people are no longer entirely reliant on the environment, including caribou, for subsistence (A.W. Banfield *in* Sandlos 2004).

Over-harvesting is mentioned in a variety of reports from across barren-ground caribou range (WMAC (North Slope) and Aklavik HTC 2009; WRRB 2013; ACCWM 2014b; BQCMB 2014a) and especially if the informal wild meat economy (such as when caribou meat is sold via social media groups) represents a wide-ranging impact on barren-ground caribou, harvest may represent an important threat:

> *"This is more of a concern or advice. I think it is about time that the WMAC and the boards start trying to decide what they consider is commercial. People are harvesting and selling their caribou. [I] know of someone shooting 15 caribou on the highway and getting paid $4,000. No good will come of this. This is a touchy issue but we need [to consider it]. People are sadly mistaken if they think it is not happening. I know of someone who came up from Fort Smith and shot and sold so many caribou that he paid off his VISA. The only way it is going to work is if we all work together." (Anonymous [Inuvik] in ACCWM 2014b: 130)*

> *"[I] met a chief from down there and he said the same thing – people are doing it. He bought caribou from someone; [it's] too easy. I am concerned about how many people are doing that – a guy comes to the door and asks how many do you want, going door to door. Hopefully that don't happen here." (Anonymous [Fort McPherson] in ACCWM 2014b: 168)*

> *"I have a problem with commercial harvesting, not with outfitting. I don't like to see a price put on the caribou. It creates a financial incentive for hunting caribou for selling. There are more rules with outfitters. Because they are limited to one or a few tags, they aren't just going to blast away. This would more than likely be the biggest impact on the caribou, if allowing commercial harvesting. Subsistence and resident harvesters are not out to make profit. They harvest for the needs of their community. There is always the temptation to make more money if there is commercial harvesting." (Anonymous [Aklavik] in ACCWM 2014b: 168)*

It has also been noted that when barren-ground caribou population numbers are lower than typical in a natural cycle, any threats are exacerbated and recovery is slower (Beaulieu 2012).

> *"You can't expect the caribou to go up when we are killing, killing, killing." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 55)*

Many traditional knowledge holders agree that proper hunter education and enforcement of regulations can limit the adverse impacts of harvesting:

> *"[Young hunters leave parts behind] 'cause they don't know, nobody tell them. They don't know how to eat the head or cook the head. Arms, they throw them away, they don't pack them out." (Anonymous [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 84)*

> *"[Caribou is] not as much as before .... I think people bother them too fast. Don't let the first bunch pass. When I was growing up the elders used to let the first bunch pass. They follow*

their trail. It's like if you want out, you make trail, somebody will follow you. If that trail is not there the caribou is going to go some other place. That's what is happening now." (George Selamio [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 45)

At the same time, it is generally acknowledged that active management and enforcement of harvest numbers and harvesting practices needs to occur (ACCWM 2014b):

"Active management really needs to happen with the human activities and especially those associated with harvesting because action can be taken there that is proactive. We know that not all communities harvesting caribou have or account for wounding loss. Some communities are very good and responsible with community hunts, taking only what is required and making sure wounded animals are found and harvested. Other communities take more than is needed, have high wounding losses which are not accounted for and have admitted such." (Anonymous [Fort Simpson] in ACCWM 2014b: 116)

Predation

Wolves, wolverines and grizzly bears are known predators of barren-ground caribou (discussed earlier in *Interactions,* p. 26). Wolf numbers are reported to have increased (Benson 2015), possibly in response to increases in moose and muskoxen abundance. The impact of this increased wolf abundance on barren-ground caribou is a concern to traditional knowledge holders (Tłı̨chǫ Government 2007a; WRRB 2010c, d, 2013; Benson 2015). Alongside a reported increase in the number predators, there has also been a corresponding decrease in the number of people who are hunting wolves (Dumond 2007; WRRB 2013) and desire to better understand predation rates in relation to harvesting rates (Benson 2015).

"With the numbers that are given to us, it's not affec -- the proper numbers, as we are told that estimate numbers are given to us. The tradition knowledge for our Inuit know for many years. They've heard many times that caribous are declining and we're the ones that get pointed for that declining. The -- the wolfs has to be looked at. Grizzly bears coming around further north has looked at." (Attima Hadlari [Kitikmeot community unidentified] in WRRB 2010c: 205)

"Long ago there were a lot of trappers out on the land. They could make a good living trapping. Today there is nobody out there, so all those predators are growing, especially the wolves. They are really migrating. I don't like saying that but it is true. And the wolves, they are bad for caribou and moose too." (Bluenose Caribou Management Working Group [Tsiigehtchic] in Benson 2015: 51)

"We need to know predation over harvest rate. I think the predation rate on the herds is more than harvest. We need to know this to manage better." (Bluenose Caribou Management Working Group [Inuvik/shared] in Benson 2015: 51)

Concerns about predation are described throughout the available traditional knowledge literature, and are of high importance to knowledge holders throughout the barren-ground caribou's NWT range.

> *"Regarding the predations of the caribou, I guess, you know, like predators like such as wolves, so the wolf population seems to be increasing somewhat -- the treeline wolf, that is. So this -- the -- if you look at the caribou about, mean that there's about two hundred (200) wolves, I guess, yonder. They consume something like four thousand (4,000) caribou a year. So I've seen -- I've seen on a trip down to Wekweètì one time, and there we ran into a wolf pack about -- in amount of a hundred and fifty (150). But according to the ENR report, I guess, out in the -- through the dens, you know, they identified there were --it sounds like it's a low number. But if you were out on the land, you find more wolves. Yes, to date, the -- they carry -- the wolves, I guess, you know, they – they come into, I don't know, hundreds in a pack. We just came out from the hunt from -- out on the Granite Lake area. There's a lot of wolves out there. I guess they're feeding on some caribou out there as we speak." (Joe Rabesca [Behchokǫ̀] in WRRB 2010d: 164)*

> *"Sometimes wolves are good, but some of them are bad. They're hungry all the time. They just go, and they leave all the good parts too sometime. They just eat a little bit." (John Jerome [Inuvik] in Benson 2015: 51)*

Traditional knowledge holders often suggest that hunters and trappers should be encouraged to harvest more wolves, with the intent being to limit the impact of predation on barren-ground caribou.

> *"Elders also talked about wolves in our country; they have said one wolf kills around fifty caribou a year. Our group said they know there is a large wolf population in the country. So some of the elders suggested that maybe it's time to give wolf and bear tags to outfitters when they take groups out on the land. The outfitters could start hunting wolves and bears to reduce their population, the elders would like to see that done as well." (Jackson Lafferty [Behchokǫ̀/Yellowknife] in Tłı̨chǫ Government 2007a: 21)*

> *"…[A]lso there's lots of, like, wolf. Probably the wolf takes many of the caribou, even in Wekweètì, because a -- a wolf eats all the time, and also the bear. It'd be good to have that in our monitoring to see maybe we should be harvesting more wolf." (Charlie Simpson [Whatì] in WRRB 2010d: 239)*

However, Benson (2015) also notes that wolves and caribou are linked, with the wolf population limited by the caribou population, and further suggests that culling wolves could lead to an increase in the wolf population. Likewise, Denesuline Né Né Land Corp. (2015) knowledge holders state clearly that wolves should not be killed; they are felt to be integral to the health of

the ecosystem, providing food for scavenging animals like foxes.

> *"I think there is less because the Bluenose does not come in there anymore, I think maybe last year we might have got four wolves. Where usually we get 10 or 12. I think the wolves are more after moose in that area. There is quite a bit of moose in there. But before when the Bluenose were all in there, there was bears and lots of wolves and lots of wolverines." (James Firth [Inuvik] in Benson 2015)*

> *"And there's so much wolves. [Because they are] breeding, apparently…Some of us used to kill them, and then, a couple people told us, 'you shoot one wolf, suddenly next year it'll be four more', for example. They breed because they die. That's what I've been hearing, and that's pretty close to what I've been seeing." (Morris Blake [Gwich'in community unidentified] in Benson 2015: 41)*

It has also been noted that the populations of grizzly bears and eagles, known and possible predators of barren-ground caribou calves respectively, may be increasing (Benson 2015).

Disease and parasites

There is relatively little information on the magnitude of the impact parasites and disease have on barren-ground caribou in the available traditional and community knowledge sources. Most of the information that is available is related to nose bots and warble flies and trends in the latter (see *Interactions*, p. 26, and *Physical condition*, p. 46).

Parasites such as nose bots and warble flies are generally considered normal in barren-ground caribou, but their impact on caribou health can be exacerbated if other factors are also affecting the health of the caribou.

> *"When summers are warm and wet there are more insects. Insects, in particular warble flies and nose bots flies can affect the behaviour of caribou. Caribou spend less time feeding or resting when flies are abundant. By fall time caribou are not as fat compare to years with a cooler summer." (Anonymous [Kugluktuk] in Dumond 2007: 15)*

> *"In the recent years, we observe more sickness in caribou. During the rut, the animals are weak and it is easier for predators to get them. Predators have increased. In the past caribou seemed healthier." (Anonymous [Kugluktuk] in Dumond 2007: 15)*

The potential for disease transmission between white-tailed deer, which are extending their range in the NWT (e.g., as far north as Fort Good Hope), and barren-ground caribou, is a potential threat. BQCMB (2011b), the only source that mentioned this interaction, indicated that white-tailed deer may negatively influence the survival of barren-ground caribou and that hunters should make an effort to harvest as many deer as possible in an effort to stop their advance northwards into caribou winter habitat.

In general, the number of diseased barren-ground caribou is seen to be increasing, and there are different types of diseases and conditions being reported now, including, for example, lungs stuck to rib cages, pus in joints, tape worm cysts, and sandpaper skin.

Collars

Traditional knowledge holders in every region of the NWT have noted that some research methods, especially collaring, are impacting barren-ground caribou. These practices remain controversial in many communities. The main concerns are that these research methods cause physical injury, stress, and weakening of the animals, and that these practices are culturally inappropriate and disrespectful (Kendrick *et al.* 2005; Tłı̨chǫ Government 2007c; Katz 2010; WRRB 2010b). Concerns with collars are associated with the large size and weight of the collars, the loss of hair that the collars may cause by rubbing, interference with feeding, irritation and the possibility of strangulation, and icing of collars (Kendrick *et al*. 2005; Denesuline Né Né Land Corp. 2015):

While the majority of the comments related to collaring in the available traditional knowledge literature see the practice as negative, some individuals may be comfortable with the research method and have even suggested methods of improvement:

> *"Not allowing more collars to be deployed on caribou for monitoring winter distribution is not responsible. More collars are needed." (Anonymous [NWT Métis Nation community unidentified] in ACCWM 2014b: 109)*

> *"If [the collars] were different colours for each herd, then people would know which herd they were looking at and they could tell if they were mixing." (Anonymous [Aklavik] in ACCWM 2014b: 107).*

> *"Well, if you lose 10 caribou [through being collared], you might gain 10,000. So, there's always a sacrifice. If you want something there's going to be a sacrifice." (Tom Wright [Inuvik] in Benson 2015: 58)*

This threat can be reversed or mitigated through the use of culturally acceptable research methods (ACCWM 2014b). As noted by Ryder *et al*. (2010), there is good agreement between traditional knowledge and collar data in areas where local resource users currently harvest. Traditional knowledge information became less robust and agreed less with collar data in areas that are not visited often, a fact that has been observed by traditional knowledge holders themselves:

> *"Another thing that bothers me is we used to go up to the headwaters [Arctic Red River] to get caribou – [we] don't know what the herd is doing because no one goes up there anymore – [this] should be looked at. Everyone needs to be involved to manage caribou." (Anonymous*

[Tsiigehtchic] in ACCWM 2014b: 131)

POSITIVE INFLUENCES

A number of positive influences, both current and potential, exist for barren-ground caribou and their habitat in the NWT. These are outlined below.

Protection measures

The calving grounds of three herds are partially protected from development through their inclusion in various protected areas: portions of the Porcupine herd's range are found in Ivvavik National Park and Vuntut National Park (Yukon) (Community of Aklavik *et al*. 2008; Community of Inuvik *et al*. 2008; Parks Canada 2016); the Bluenose-West herd's calving grounds are found in Tuktut Nogait National Park (NWT); part of the traditional inland calving grounds of the Beverly herd are found within the Thelon Game Sanctuary (NWT and Nunavut) (BQCMB 2011b), and the Queen Maud Gulf Bird Sanctuary encompasses most of the Ahiak and Beverly herds' calving grounds (coastal Beverly calving ground only) (ACCWM 2014a). Some habitat protection may also be provided through a proposed NWT national park, Thaidene Nene, in the ranges of the Bathurst, Beverly, and Ahiak herds (*Wildlife Act* 2013).

Land use plan zoning provides some protection to barren-ground caribou herds throughout the NWT. Under the Gwich'in and Sahtú land use plans, barren-ground caribou are offered protection through special management zones and conservation/heritage conservation. While development is permitted in special management zones, it is limited by specific conditions in each zone designed to protect identified values. Many of the special management and conservation zones include barren-ground caribou as a value to be respected (Gwich'in Land Use Planning Board 2003; Sahtú Land Use Planning Board 2013).

The Tłı̨chǫ Land Use Plan, released in 2012 by the Tłı̨chǫ Government, establishes five land use planning zones: wehexlaxodıale (land exclusion zone), dèk'èasıì?edaà (habitat management zone), gowhadǫ̀ yek'e t'u k'e (traditional use zone), Tłı̨chǫ̀ nawoo kè dèt'ahot'ıı (cultural heritage zone), and asu haxowu gha enehatǫ (enhanced management zone). Each zone offers varying levels of protection depending upon the values that they are designed to preserve (Tłı̨chǫ̀ Government 2013).

In the Inuvialuit Settlement Region, six community conservation plans set out guidelines for land and resource use in their respective regions. Special Designated Lands of importance to barren-ground caribou include: Bluenose-West caribou herd winter range; eastern North Slope, east of Babbage River (Community of Aklavik *et al*. 2008; Community of Inuvik *et al*. 2008; Community of Tuktoyaktuk *et al.* 2008); Fish Hole/Cache Creek and Big Fish River (Community of Inuvik *et al*. 2008); Bluenose-West caribou core calving and post-calving

grounds (Community of Paulatuk *et al.* 2008); and Cape Bathurst caribou core calving and post-calving grounds (Community of Paulatuk *et al*. 2008; Community of Tuktoyaktuk *et al.* 2008). In addition to these land protection categories, conservation measures aimed specifically at barren-ground caribou are beneficial. These include supporting certain management planning initiatives, protecting important habitat from disturbance, ensuring harvest is sustainable, and discouraging meat wastage (Community of Aklavik *et al.* 2008; Community of Inuvik *et al.* 2008; Community of Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008).

The draft Nunavut Land Use Plan includes provisions for the protection of core calving areas, post-calving areas, migration corridors, water crossings, and rutting areas. Once approved, the land use plan could act as a positive influence on Nunavut caribou herds, including the four herds shared with the NWT (Qamanirjuaq, Bathurst, Bluenose-East, and Beverly). Development applications that are submitted prior to land use plan approval, however, will be grandfathered and not subject to the protection provisions included in the land use plan (Nunavut Planning Commission 2016).

Caribou of the Tuktoyaktuk Peninsula herd are offered seasonal protection through application of a closed harvesting season in regulations (Davison *et al.* 2014; ENR 2016a). All harvest is currently closed on the calving grounds of the Cape Bathurst herd near Cape Bathurst, Husky Lakes, and Liverpool Bay. A summary of current harvesting restrictions is included in *Interactions* (p. 26).

Traditional laws and harvesting protocols also provide for the protection of calving grounds; harvesting in calving grounds is discouraged because calving grounds represent important areas for caribou reproduction. It is essential to avoid disturbing caribou during this critical time of life; this is seen as a lack of respect and is a violation of traditional laws and harvesting protocols. Conversely, the absence of human presence in calving grounds could facilitate access by predators. This is commonly discussed in communities (Firth pers. comm. 2017) and shows a strong awareness of these issues and represents a positive influence. In this context, predator control programs could be beneficial for the protection of calving grounds.

Harvest reduction and decline

Relative to harvests 30 or 40 years ago, the total number of barren-ground caribou harvested by both subsistence hunters and resident hunters has decreased across the NWT (Joint Secretariat 2003; Gordon *et al.* 2008; GRRB 2009; WMAC (North Slope) and Aklavik HTC 2009; Boxwell 2013; Cooley and Branigan 2013; Jacobsen 2013; ACCWM 2014b; Boxwell 2014). The onset of this reduction in harvest coincided with the adoption of the skidoo, as hunters no longer needed to provide meat for their dog teams (WRRB 2010b; ACCWM 2014b). Declines in harvest also stem from various socioeconomic barriers such as the increased costs associated with utilizing motorized transport in accessing the caribou herds and the introduction of harvest restrictions (ACCWM 2014b). Details on harvest management are provided in *Interactions* (p. 26).

"In the days when I was driving sled dogs in the barren-lands, caribou -- quite a bit of caribou were taken for food source because in the olden days, almost every household, or tipi -- or tipi or tents had to go out hunting to feed their families, and they had to stock up on the fat and on the meat that they needed." (Fred Sangris [Ndılo] in WRRB 2010c: 238)

"Long ago people harvested a lot – they had to harvest for their dogs..." (Anonymous [Aklavik] in ACCWM 2014b: 67)

"…Today, in the Dene communities across the north, not every household goes out and hunt caribou. Not every household. So we can't blame the Aboriginal." (Fred Sangris [Ndılo] in WRRB 2010c: 238)

"Today it is not like years ago where you had to feed yourself and your dogs. Today you don't need that. One or two caribou – I go through three and from spring to now and I still have caribou left – three in the spring and that is all a guy needs." (Anonymous [Tsiigehtchic] in ACCWM 2014b: 68)

"We see a lot of caribou around our camp and … I guess when my family was home we probably went through 15–20 caribou a year. Now the two of us, we go through three, four maybe at the most, that's about it. So we don't need to harvest as much." (Anonymous [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 73)

"Participants in the young adult focus group said that they generally do not hunt much because they do not have snowmobiles." (Anonymous [Rankin Inlet] in AREVA Resources Canada Inc. 2012: 4-7)

"In the ISR and GSA hunting zones had an effect on the average distance harvesters had to travel to hunt caribou." (ACCWM 2014b: 74)

The reduction in harvest reduces overhunting and increases the sustainability of the caribou populations (WMAC (North Slope) and Aklavik HTC 2009).

"Don't overhunt. If you follow that, don't overhunt, you'll always have caribou… If you overhunt you're killing [caribou] for nothing. Why hunt more than what you need? If you go to the store you buy what you need, you don't overbuy. Same thing, hunting." (George Selamio [Aklavik] in WMAC (North Slope) and Aklavik HTC 2009: 73)

Positive aspects of harvesting and indigenous caribou management

The continued harvest of caribou also has the ability to help prevent dramatic fluctuations in caribou populations, and can help limit the spread of diseases.

"… [T]hey sent over a few caribou and then now there's overpopulated...Back in '67 the -- the

Government sent some caribou over to the island. And about twenty (20) years later we finally can harvest a few and then after that we're telling the Government that we need to harvest more before the disease that's coming around. And then, of course, the Government didn't listen to us at the time and -- and then finding out later on that disease has started coming around. And from there the GN was willing to work with us. So when they're over populated in the species, over populated, they get disease." (Lucassle Nakoolak [Coral Harbour] in WRRB 2010c: 207)

Active participation in co-management can be seen as a positive influence, supporting collaboration and culturally appropriate caribou conservation planning, as well as stewardship. However, it's also acknowledged that herd protection cannot be achieved by one group or one community alone; it must involve the territory as a whole (Benson 2015).

"We're the ones that said, 'Because there's no caribou, then here's a quota.' And everybody bought into it. Of course, there's people that are going to break the law. But that's far and [few] in between there. Yes, definitely, we are part of it. And we support it." (James Firth [Inuvik] in Benson 2015: 57)

"I'm thinking about the future of our caribou. I've not hunted caribou for the last six years. I'm trying to abide by this. I think there should be a temporary ban on hunting all caribou until a management plan is in place. Don't wait for the Minister to act. We are at a critical stage and if we want to keep our caribou we are going to have to move all at once." (Bluenose Caribou Management Working Group [Inuvik/shared] in Benson 2015: 58)

There is increasing emphasis on the important of engaging and training youth in the areas of traditional laws and harvesting protocols.

"When on a hunting trip or just going out on the land, you should involve youth. Describe the land, the names and the important of the area. Please describe it in both Dene language and English so the youth can better understand and gain knowledge and wisdom. The youth don't mind if they don't get paid. They just want to be given chances to go out on the land. Most youth don't own any survival gear. So please help our youth by providing rides, a place to sleep, and meals for the trip. Taking our youth on the land to hunt, trap, fish and monitor will support the ʔekwę́ conservation plan because it will teach the youth how we take care of our land, ensuring our culture and traditions are preserved. That's how we can make sure the caribou will come back." (Ted Mackeinzo[Délı̨nę] in Délı̨nę ʔekwę́ Working Group 2016: 18)

"Our youth must know about how the grandfathers hunted and what the big issue is today about caribou. Many of them are probably wondering why we're talking so much about it. I think all we want is for children to hunt like their grandfathers." (Walter Bayha [Délı̨nę] in SRRB 2016a: 36)

"All our youth get to go out on the land. They all hunt for themselves. They all hunt for their families, but they're taught at a young age to live out there. I have two nephews that are at the age of ten they were already going hunting. Nowadays, they're fifteen and sixteen. They go out there. They talk about what they hunted and how they hunted. I'm proud to say that I could hear that they have respect for what they're doing because, as hunters, you want to respect." (David Codzi [Colville Lake] in SRRB 2016a: 37)

Acknowledgements

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Contributors of traditional and community knowledge to this report:

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- Danny Beck [Northwest Territory Métis Nation] pers. comm. 2017
- Leon Andrew [Norman Wells] pers. comm. 2017

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- Morris Blake [Gwich'in community unidentified]
- Richard Ross [Gwich'in community unidentified]
- Tom Wright [Inuvik]
- Willard Hagen [Gwich'in community unidentified]

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- Dean Cluff [Yellowknife]

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- Various anonymous interviewees

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- Allen Niptanatiak [Kugluktuk]
- Three anonymous Kugkluktuk and Kitikmeot interviewees
- John Ivarluk [Kugluktuk]

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- Fred Sangris [Ndılo]
- Lisi Lafferty [Behchokǫ̀]

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- John Akana [Umingmaktok]
- Moses Koihok [Iqaluktuuttiaq]

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- Four anonymous interviewees

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- Francis Simpson [Whatì]
- One anonymous interview from Whatì

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- Joel Peter [Old Crow]
- Stanley Njootli [Old Crow]

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- May Algona [Kugluktuk]
- Mary Kaniak [Bay Chimo]

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- Charlie Simpson [Whatì]
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- Fred Sangris [Ndılo]

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- Jimmy Martin [Behchokǫ̀]
- Joe Rabesca [Behchokǫ̀]
- Leon Lafferty [Behchokǫ̀]
- Leon Modest [Délı̨nę]
- Lucassle Nakoolak [Coral Harbour]
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From Zoe 2012:

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Scientific Knowledge Component

PREAMBLE

This status report benefitted from the simultaneous drafting of a status report for the assessment of barren-ground caribou under the federal *Species at Risk Act* (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2016). Many of the sections in the scientific knowledge component of this report and the COSEWIC (2016) report were drafted simultaneously and therefore contain the same content. The Species at Risk Committee (SARC) acknowledges the Terrestrial Mammal Sub-committee of COSEWIC for its work.

SPECIES OVERVIEW

Names and classification

Scientific name	Rangifer tarandus groenlandicus Linnaeus 1767
Common Name (English)	Barren-ground caribou
Common Name (French)	Caribou de la toundra (Canada), renne (France)
Name of subpopulation(s)/herd(s)	Porcupine, Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq
Family	Cervidae Deer Family
Life Form	Vertebrate, terrestrial mammal, deer, caribou

Systematic/taxonomic/naming clarifications

Caribou from the Mackenzie Delta east to Hudson Bay including Baffin Island are classified as the sub-species *groenlandicus (*Banfield 1961). Within the Northwest Territories (NWT), *R. t. groenlandicus* presents as nine identifiable subpopulations/herds: Porcupine, Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq. These nine herds fall within COSEWIC's Designatable Unit (DU) 3 (barren-ground caribou of northern and northwestern Canada) (COSEWIC 2011). For the purposes of this report, the term 'herd' will be used to describe these groups.

The Porcupine caribou herd, which seasonally crosses into the western NWT from the Yukon

and Alaska, was classified as an *R. t. granti* "intergrade" between *R. t. groenlandicus* and the Alaskan sub-species *granti* (Banfield 1961). However, this taxonomy is out-dated as techniques and analyses have changed since Banfield's (1961) classification, which was mostly based on skull characteristics, pelage colour, and antler shape. Based on genetic analyses of nuclear and mitochondrial DNA (see *Population*, p. 122), although the Porcupine herd was genetically more distinct than the other NWT and Nunavut (NU) barren-ground caribou herds, the differences were not supportive of a sub-species level of distinction (Zittlau 2004). However, owing to the degree of geographic separation of the Porcupine herd from the other eight herds, it has been assessed separately here.

Naming clarifications

Refined definitions of herds since the 1960s and increased knowledge of caribou movements led to changes in the number of herds identified within the NWT. Until Thomas (1969) recognized herds based on their return to an annual calving ground, the herds were based on winter distribution across the NWT (including the area that became NU). This meant that Banfield (1954) recognized 16 herds, which Thomas (1969) reduced to four herds (Bluenose, Bathurst, Beverly and Qamanirjuaq). Then, Nagy (2009b) summarised how three calving areas had been recognized for the Bluenose herd (Kelsall 1968; Hawley *et al.* 1979; Brackett *et al.* 1982; Latour and Heard 1985; Latour *et al.* 1986) in the Cape Bathurst, Melville Hills and Bluenose Lake areas. Nagy (2009a and b) used a cluster analysis of the locations of satellite-collared females in 1996-2006 to support the designation of the Cape Bathurst, Bluenose-West and Bluenose-East herds. Further examination of the basis for the number of herds (Nagy *et al.* 2011) used NWT and NU data for all satellite-collared caribou (1993-2008) to examine the annual spatial clustering between females. The designation of six herds in the NWT was considered robust and supported the use of definitions based on fidelity to calving grounds (Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly (as defined by Nagy *et al.* 2011) and Qamanirjuaq) (Nagy *et al.* 2011).

The most recent herd to be identified was the Tuktoyaktuk Peninsula herd, which was recognized in 2005 after domesticated reindeer had been removed from the Tuktoyaktuk Peninsula. People had reported seeing caribou there and a survey in September 2005 revealed 3,800 caribou, of which less than a third were reindeer (Branigan 2005; Nagy and Johnson 2006; Davison and Branigan 2011).

There is currently uncertainty about whether there are four or five herds (Beverly, Ahiak (sometimes referred to as the Queen Maud Gulf herd), Qamanirjuaq (NWT and NU), Wager Bay and Lorillard (NU only)) in the eastern barren lands. This reflects changing knowledge, differences in how herds are defined either by calving ground affiliation among females or overall (all seasons) affiliation (Nagy *et al.* 2011), analytical techniques, as well as changes in caribou abundance and movement. Up until the late-2000s there was general agreement that the

Beverly herd calved on an inland calving ground south of Garry Lake, while the Ahiak herd calved along the Queen Maud Gulf coast (Gunn *et al.* 2000; Adamczewski *et al.* 2009; Adamczewski *et al.* 2015).

Surveys conducted in 1994 on the Beverly herd's traditional inland calving ground revealed an estimated 120,000 breeding females (43,100 SE) on the calving ground and an estimated 276,000 adults and yearlings in the herd as a whole (106,000 SE) (Campbell *et al.* 2012a). The herd was not surveyed again until 2002 (Johnson and Mulders 2009); the results from this survey suggested that the herd had declined. Further surveys took place in 2007, 2008, 2009, and 2010 and suggested an even more rapid decline of breeding females on the traditional inland calving ground (90-100 caribou in June 2010), to the point where densities of breeding females were too low to survey further (Campbell *et al*. 2012a). In 2007-2010, a high (43 percent (%)) degree of switching (females that move from one herd's annual calving ground to another's) was observed in collared Beverly females that switched from calving on the traditional inland calving ground to the coastal Queen Maud Gulf (Gunn *et al.* 2012). Females in most herds have a low (<5%) annual rate of switching between neighbouring calving grounds (Gunn *et al*. 2012) (see *Movements* for additional information on switching, p. 106).

One interpretation of the available data (e.g., Gunn *et al*. 2012; Adamczewski *et al*. 2015) suggests that following the collapse in densities on the traditional inland calving ground, the remnant Beverly herd joined the larger Ahiak herd. This accounts for the calving ground switch shown by the collared females in 2007-2010 (as a behavioural response to maintain the advantages of gregarious calving). By this interpretation, the Beverly herd is considered to be no longer identifiable.

A second interpretation (e.g., Nagy *et al.* 2011; Nagy and Campbell 2012) suggests that the Beverly herd is still extant, but occupies the western of two contiguous calving grounds along the coastal Queen Maud Gulf, somewhat overlapping with the calving grounds of the Ahiak herd (Fig. 6, p. 99). In this interpretation, some of the Beverly females started calving along the coast prior to the 2002 survey and the herd used both the traditional inland calving ground and the coastal calving ground from the mid-1990s to the late-2000s (Nagy and Campbell 2012). The switch shown by the collared caribou in 2007-2010 is seen as the last of a continued movement that started much earlier. Campbell *et al*. (2012a) stress that other mechanisms (e.g., predation, human disturbance, disease, low productivity, insects, weather, etc.) were probably also at play and the herd did suffer a decline as a result of these factors and moved to the coastal calving ground in order to avoid these influences. However, they contend that this shift in calving distribution likely took place over many years (Nagy *et al.* 2011).

With both interpretations, it is important to note that irregular studies and low collar numbers (a satellite collaring program on the Beverly herd wasn't started until 2006) across both the Beverly and Ahiak herds' ranges hampered detailed understanding of the factors that may have influenced the decline and/or calving distribution shift (Campbell *et al*. 2012a; Beverly and

Qamanirjuaq Caribou Management Board [BQCMB] 2014).

For the purposes of this report, the Beverly herd's annual range is considered to encompass both the traditional inland calving ground and the coastal calving ground (Fig. 6, p. 99). Where studies have considered the two calving grounds separately, the terms Beverly North and Beverly South are used to describe those caribou associated with the coastal calving ground and the traditional inland calving ground, respectively.

Description

Barren-ground caribou are a medium-sized cervid (member of the deer family) characterized by migratory and gregarious (social) behaviour. Mature males have a striking white neck and mane, a brown back, and a distinct white and dark band along the flank separating the brown back from the white belly (Fig. 4, p. 97). The legs are dark brown with a white line around the top of the hooves. The head is dark brown and often has a light 'skull cap' and a light coloured muzzle. The pelage of females and juveniles is a more muted version of the males' colours. Newborn calves are typically ruddy in colour. Wide variation in pelage from light to dark can often be seen in caribou groups. Both sexes are antlered and the antlers of mature males can be massive and are shed after the rut. The velvet is dark brown and shed in the fall (Miller 2003). Pregnant females usually keep their antlers until a few days after their calves are born while non-pregnant females shed their antlers in late winter (Whitten 1995; Bergerud *et al.* 2008).

A conspicuous characteristic of their appearance compared to other deer is their large hooves with dew claws long enough to be weight-bearing. The hooves are flexible and can spread wide enough to lessen sinking into snow or soft ground. The hoof edges are sharp in winter to give a stronger grip on snow and ice.

Figure 4. Barren-ground caribou females in winter (left) and male caribou in velvet in late summer (photo credits: GNWT/J. Nagy, ENR).

Mature female caribou are about 10-15 % smaller and weigh 10-50% less than adult males and both sexes vary seasonally in body weight; for example, females can weigh 90-135 kilograms (kg) in the fall and lose about 10% of their weight during the winter, although this varies greatly depending on the winter foraging conditions (Boertje 1996; Miller 2003). Over decades, body size varies with density and migration distance (Bergerud *et al.* 2008; Couturier *et al.* 2009a, b), which in turn reflects whether the herd is in an increasing or decreasing phase (Couturier *et al.* 2010).

Barren-ground caribou in the NWT (including the Porcupine herd) are considered to be genetically, behaviourally and morphologically distinct from Dolphin and Union caribou (*R. t. groenlandicus x pearyi*) (McFarlane *et al.* 2016) as well as genetically distinct from Peary caribou (*R. t. pearyi*) and boreal woodland caribou (*R. t. caribou*) (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2011).

Distribution

Canadian distribution

Barren-ground caribou (defined as COSEWIC Designatable Unit 3) in Canada (Fig. 5, p. 98) are restricted to the NWT, NU and Yukon with winter use of northern regions of Manitoba,

Saskatchewan, and (historically) Alberta.

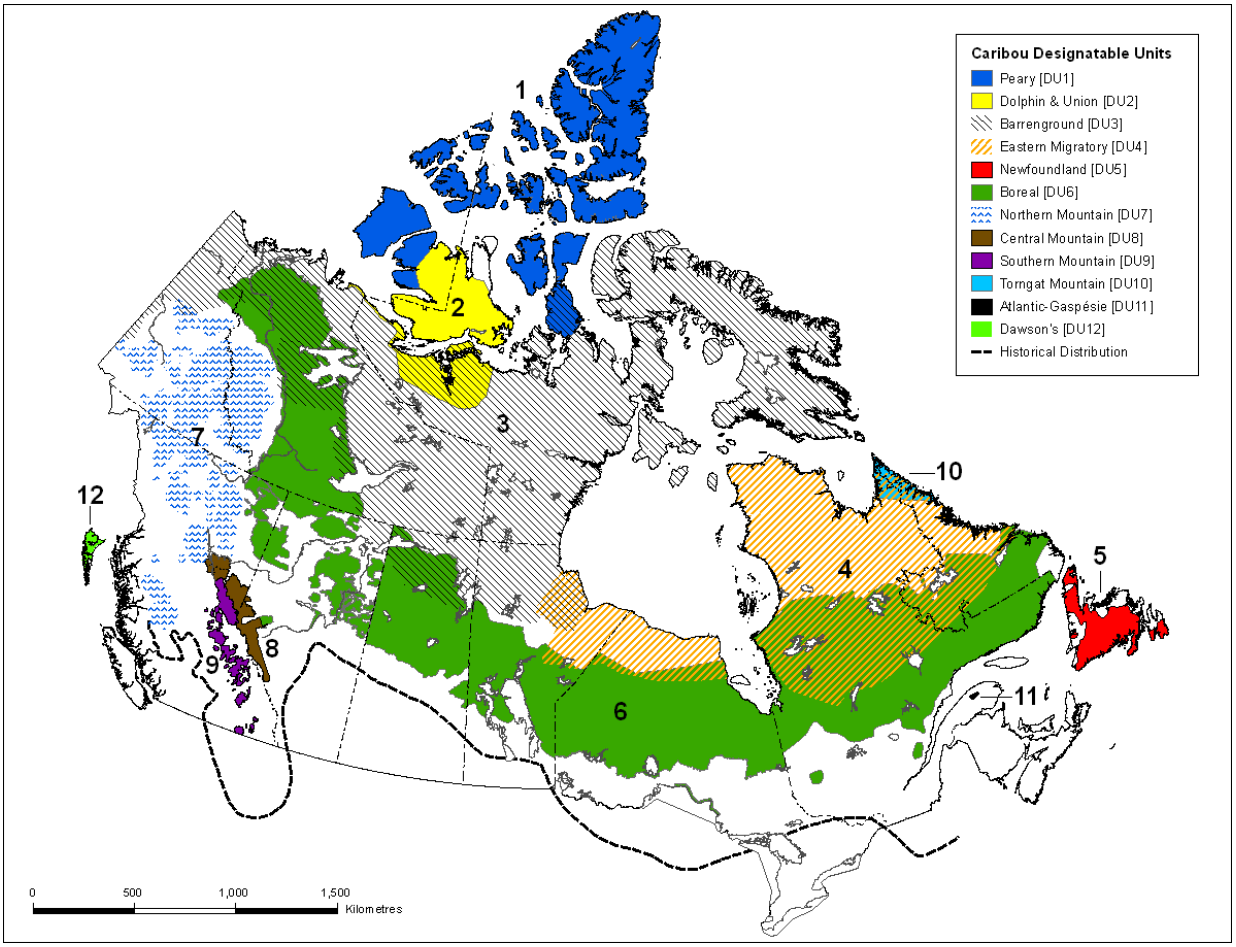


Figure 5. Designatable Units for caribou (*Rangifer tarandus*) in Canada (COSEWIC 2011). Map courtesy of COSEWIC (used with permission).

NWT Distribution

The distribution of barren-ground caribou within the NWT is from the Mackenzie River east to the NWT-NU boundary and southeast to the Saskatchewan border except the southwest corner of the NWT (approximately west of the Slave River to the Mackenzie Mountains) (Fig. 6, p. 99). Barren-ground caribou herds in adjacent jurisdictions (i.e., Wager Bay and Lorillard herds from the northern Kivalliq and eastern Kitikmeot areas of NU) occasionally spend time in the NWT, particularly in winter when herds show the greatest degree of overlap (Nagy and Campbell 2012; Campbell *et al.* 2012b).

The annual distribution of the Tuktoyaktuk Peninsula, Cape Bathurst and Bluenose-West herds is almost entirely within the NWT whereas the Porcupine herd's range includes Alaska, Yukon, and the NWT. For the Bluenose-East, Bathurst, Ahiak, Beverly, and Qamanirjuaq herds, calving and summer distribution is mostly within NU.

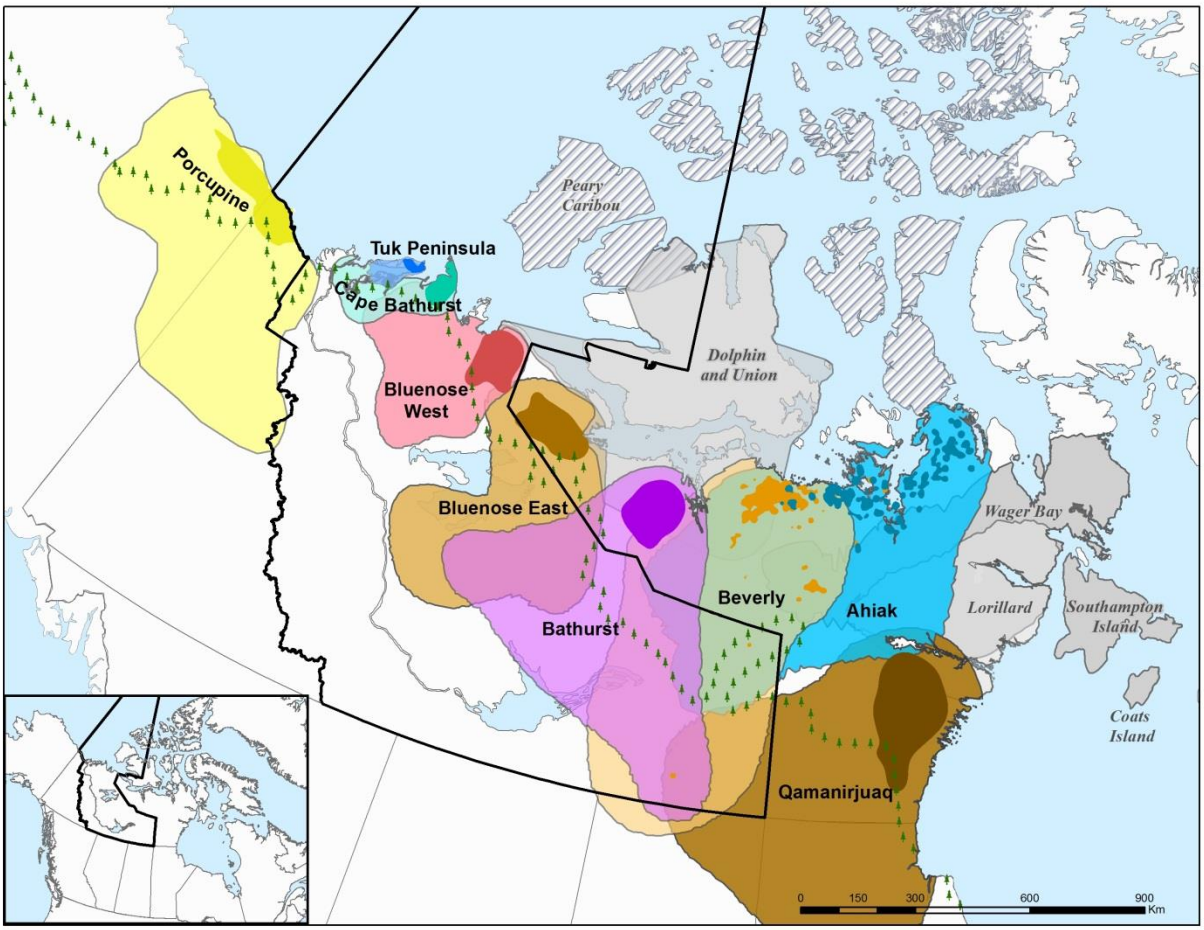


Figure 6. Distribution of barren-ground caribou range (pale colours) and calving grounds (dark colours) in the NWT (black border) from 1996-2009. Treeline displayed in green tree symbols. The NU barren-ground caribou herds that are referenced in this report (Wager Bay, Lorillard, Southampton Island, Coats Island), as well as Peary caribou and Dolphin and Union caribou, are displayed in grey scale for completeness only but are not a part of this assessment. More barren-ground caribou not shown in the figure are also present on Baffin Island and Prince Charles Island (NU). Calving ground data layers courtesy CASLYS with data from the Government of Nunavut and Government of the Northwest Territories (GNWT) . Range shape files from Nagy *et al*. (2011) with data from Government of Nunavut and GNWT. For the Tuktoyaktuk Peninsula herd, all data from GNWT. For the Porcupine herd, all data courtesy of United States Fish and Wildlife. Map by B. Fournier, ENR, GNWT.

The longer-term annual distribution of barren-ground caribou is relatively continuous across the NWT although the calving, post-calving, and early-summer distribution tends to be more discontinuous. Calving grounds are the smallest seasonal ranges, although post-calving and early summer ranges are also relatively small; <5% of the annual range for the Bathurst herd compared to 77% of the annual range for the rut to spring migration (Gunn *et al.* 2013a).

Locations

The NWT Species at Risk Committee's (SARC) (2015) criteria for considering extant locations in the assessment of status define 'location' as a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the species present. Female caribou from a single herd aggregate together on their calving ground, which means that large proportions of any one herd could be exposed to a single threatening event.

Central and eastern barren-ground caribou have eight extant locations in the NWT, based on herd-specific threats and concentration of individuals at calving grounds (described in *Threats and limiting factors*, p. 168). The Porcupine caribou herd is considered one location.

Extent of occurrence

The 'extent of occurrence' encompasses the geographic distribution of all barren-ground caribou within the NWT (SARC 2015). The 'extent of occurrence' is the area contained within the shortest continuous boundary that encompasses all known, inferred, or projected sites of present occurrence, excluding cases of vagrancy. Simply put, it is a measure of the widest possible current range of the species. The extent of occurrence for the eight central/eastern herds of the NWT (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq), calculated using a single minimum convex polygon encompassing the annual range of all herds and excluding the portions of their annual range not within the NWT, was approximately 787,473 km^2 (Fig. 36, p. 251). The extent of occurrence for the Porcupine herd, calculated in the same manner was 21,337 km^2.

Area of occupancy

'Area of occupancy' (AO) is the area within the extent of occurrence that is occupied by a species, excluding cases of vagrancy. This measure reflects the fact that the extent of occurrence may contain unsuitable or unoccupied habitats. In the case of dispersed species, AO should be calculated based on the smallest area essential for the survival of existing populations. Calculated as such, AO does not need to occur within the NWT. For the purposes of this report, calving grounds have been identified as the smallest area essential for survival. The summed AO (area of the calving grounds) for the eight central/eastern herds of the NWT (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq), minus overlap in the Beverly and Ahiak calving grounds, is 161,852 km^2. The AO for the Porcupine herd is 23,952 km^2. Note that because AO includes essential habitat not within the NWT, AO for the Porcupine herd (which calves in Alaska and the Yukon) is larger than its corresponding NWT-only extent of occurrence.

The index of area of occupancy (IAO) is a measure that aims to provide an estimate of area of occupancy that is not dependent on scale (SARC 2015). Due to the large extent of the calving

grounds of barren-ground caribou, AO and IAO are the same.

Search effort

The quantitative effort to determine barren-ground caribou range in the NWT is drawn from systematic aerial caribou surveys that have taken place since the early 1980s, satellite collar information[7], as well as from large winter range surveys and ear tags prior to the 1980s.

Aerial surveys are usually flown for a particular seasonal range, such as calving grounds or winter ranges, for the individual herds. Over time, the most consistent search effort is for calving grounds. Less frequently, larger areas are surveyed; for example, in 2007 and 2008 the calving grounds of seven herds were covered during systematic aerial surveys to map all the calving distributions at one time (Environment and Natural Resources [ENR] 2013a; Poole *et al.* 2013).

Between 2000 and 2006, the tundra regions had a substantial amount of survey effort for some calving grounds (e.g., Nagy and Johnson 2006; Nagy *et al.* 2008), but in 2007 and 2008 survey methodologies were improved, and calving distribution was more systematically surveyed over larger areas, and densities were measured for calving grounds (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq) across the NWT and NU. The 2007 and 2008 surveys are summarized (Poole *et al.* 2013) with assessment of the sampling and data recording. Some of these calving grounds were also surveyed in subsequent years but not all survey reports were available for this report.

The comparability of annual and seasonal distribution data collected during aerial surveys has improved as surveys have become more standardized, including use of Geographic Positioning Systems (GPS) to record locations (Adamczewski *et al.* 2014; Poole *et al.* 2013).

Between 1959 and 1979, Beverly, Bathurst and Qamanirjuaq caribou caught during summer river crossings were individually marked with ear tags. Between 5-7% of the ear tags from 7,463 Beverly caribou, 678 Bathurst caribou, and 2,552 Qamanirjuaq caribou were returned by hunters, along with the location in which the caribou was harvested, providing some indication of distribution and movements (Heard 1984).

In the NWT between 1986 and 1988, females from the Bluenose-East and Bluenose-West herds were fitted with radio-collars and radio-tracked to map calving locations (McLean and Fraser 1992). The use of radio-tracking continued after 1988, mainly to locate caribou aggregations for photographic counts for the Cape Bathurst, Bluenose-West, Bluenose-East, and Tuktoyaktuk Peninsula herds (Nagy 2009a). After 1996, the use of satellite telemetry became more widespread and was used to track the movements of individual caribou (mostly females). Until

[7] 'Collars' refer collectively to very high frequency (VHF) collars, GPS collars, and/or satellite collars, which have all been used to track caribou movement (Fisher *et al.* 2009).

the use of satellite collars, descriptions of caribou winter distribution from aerial surveys could not always be attributed to a specific herd unless the surveys were continued into May to track the direction of pre-calving migration. Use of GPS collars with satellite uplink, which allows for higher accuracy and more locations per day, started in 2006 (Beverly, Ahiak) and 2008 (Bathurst).

Sample size and representation of the collared animals for a herd limit the ability to describe distribution. Prior to the mid-2000s, annual satellite collar sample sizes were mostly low (under 20 collars per herd and more often under 10 collars per herd). In addition, it is mostly mature females that are fitted with satellite collars so distribution mapped from satellite locations may under-represent herd distribution (especially during calving as early post-calving and winter, male and female caribou differ in range use). For example, caribou males are frequently further south during the winter (e.g., Thomas *et al.* 1998) and most males are well south of the calving grounds in June. VHF collars were placed on males from the Cape Bathurst and Bluenose-West herds sporadically during the mid-1980s to mid-2000s in preparation for post-calving surveys (Nagy and Johnson 2006; Nagy 2009a), and by the mid-2000s male collars comprised roughly 20-30% of the collars on the Cape Bathurst, Bluenose-West and Bluenose-East herds (Nagy and Tracz 2006; Nagy *et al.* 2008; Nagy 2009a). Satellite collars have been placed on males from the Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West and Bluenose-East herds since 2007-09 (ENR 2013a). Satellite collars were first placed on Bathurst herd males (20) in 2015, along with increased collars (30) on females (Adamczewski pers. comm. 2015). Overall, collar numbers on NWT herds varied in 2015 but after a large deployment there have been 50-60 collars on each of the Bluenose-West, Bluenose-East and Bathurst herds and at least 30 each on the small Tuktoyaktuk Peninsula and Cape Bathurst herds, including 20-40% on males in each herd.

Analyses to examine the representation of collars relative to overall distribution require aerial surveys to compare the distribution of collared caribou to the overall caribou herd, and these surveys are relatively infrequent. However, D'Hont *et al.* (2009) mapped barren-ground caribou distribution in late winter 2004 in the western NWT (Great Slave Lake to the Mackenzie delta and east to the Coronation Gulf area of NU), and found that while non-collared caribou are associated with collared females, there are also areas with caribou but no collared caribou, indicating that collared caribou may not be entirely representative of the distribution of the whole herd. The concentration of females on their calving grounds means that the satellite-collared females are more representative of calving distribution (Nagy and Johnson 2007a and b; Gunn *et al.* 2008).

Typically, the locations of satellite-collared caribou are analyzed using statistical techniques such as minimum convex polygons or kernel density estimation techniques, which require a minimum sample size of 30-50 individually marked animals (Seaman *et al.* 1999). Otto *et al.* (2003) observed that the number of satellite collars needed to represent a herd's distribution during different seasons ranged from 23-68 collars at the 75% probability level, to 36-181 collars at the 95% probability level, with calving having the lowest estimated required collar sample sizes and

late summer-early fall and winter seasons having generally the highest estimated required sample sizes. Mapping cumulative distribution over a number of years reduces the effect of reduced sample sizes but loses information on the scale of annual variation.

In the NWT, the systematic effort and extent of coverage make it unlikely that there are unexplored areas (at the scale of 100 km^2) that could harbour substantial numbers of barren-ground caribou. The negative data (areas searched and barren-ground caribou not found) are available in the individual survey reports.

The information is sufficient across the NWT to describe the overall and seasonal distribution of individual herds (BQCMB 2000; Nagy *et al.* 2005, 2011; Nagy 2009b; Nagy and Campbell 2012; Gunn *et al.* 2013a); however, it is uneven among herds and over time, especially to describe seasonal distribution for some herds or trends in cumulative annual and seasonal distribution. The uncertainties partly arise from the limitations of satellite-collar locations (representativeness and sample size) as well as gaps and time lags in the analysis and reporting of surveys and telemetry data, which reduces the probability of detecting changes, especially trends in distribution. Seasonal and annual ranges for the Cape Bathurst, Bluenose-West, and Bluenose-East herds from 1996-2004 have been reported (Nagy *et al.* 2005), but changes in seasonal or annual distribution among years have not been examined formally. Information on annual distribution by season has been reported for the Bathurst herd based on satellite-collared females (1996-2005; Gunn *et al.* 2013a).

BIOLOGY AND BEHAVIOUR

Habitat requirements

A conspicuous habitat requirement for barren-ground caribou is the use of large annual ranges. The large ranges are a consequence of migrations between seasonal ranges and large population sizes. Migration and gregarious behaviour is likely linked to the trade-off between the need to minimize the risk of predation and the need for forage (McCullough 1985; Fryxell and Sinclair 1988; Bergerud *et al.* 2008).

Nutritional requirements for caribou are high during spring and early summer when body reserves are depleted from the long winter and females have the additional energetic costs of pregnancy, pre-calving migration and lactation (Russell *et al.* 1993). Most information about barren-ground caribou nutrition is related to the requirement for protein and carbohydrates (energy) rather than micro-nutrients such as minerals like sodium and potassium (White and Trudell 1980; White 1983; Russell *et al.* 1993). However, barren-ground caribou are known to use mineral-rich overflow on lakes during spring migration and females use sodium-rich mineral licks on at least the Bathurst calving ground and the Beverly inland calving ground (Fleck and

Gunn 1982; Heard and Williams 1990a).

Caribou are generalist foragers (Kelleyhouse 2001) and select for nutrient content according to the stage of plant growth rather than plant species (Kuropat and Bryant 1980). Plant nutritional value peaks as leaf and flower buds start to open; barren-ground caribou time their migrations to the tundra to take advantage of the peak nutritional value of the plants relative to the timing of their peak needs, which differ between males and females (White and Trudell 1980; Russell *et al.* 1993; Heard *et al.* 1996). Further discussion on nutritional adaptations and interactions with plants, in particular lichens, can be found in *Physiology and adaptability* (p. 113) and *Interactions* (p. 114).

During calving, females will sacrifice the higher plant quality and biomass available to males that are further south to reduce predation risk (Fancy and Whitten 1991; Russell *et al.* 1993; Heard *et al.* 1996; Bergerud *et al.* 2008). When females reach their calving grounds, typically the snow-cover is melting, leaving patchy mottled ground that is various shades of tan and brown, which means newborn brown-coloured calves are less conspicuous (Bergerud *et al.* 2008). As snowmelt accelerates and plant green-up rapidly advances, a female's nutritional needs increase to support her growing calf until about three weeks after birth. By then, calves are foraging as well as suckling (White and Trudell 1980). On the calving ground, the timing of snow-melt and the amount of greening vegetation available to lactating females (as measured through satellite imagery) is related to early calf survival (Griffith *et al.* 2002).

On summer ranges, features that allow caribou to reduce exposure to insect harassment represent key habitat requirements based on studies in Alaska (White and Trudell 1980; Russell *et al.* 1993) and Scandinavia (Skarin *et al.* 2004, 2008). Mosquito species and warble fly (*Hypoderma tarandi*) harassment can be reduced by caribou selecting remnant snow patches, eskers or coastal flats and shallow water to gain relief through increased exposure to winds and cool temperatures. However, summer habitat use patterns at broad or fine scales are unreported for NWT herds, except for the Bathurst herd, where the same pattern of insect avoidance was observed (Witter 2010; Witter *et al.* 2012a). Summer range indicators of forage availability explained 59% of the variation in late-winter calf-female ratio one and half years later on Bathurst herd range (Chen *et al*. 2014). Good summer range appears to contribute to high pregnancy rates the following winter, then to high calving rates in spring, and higher calf survival the following late winter.

By late August and September, plants are starting to senesce (die back) and the insect harassment season is finished. Caribou rebuild their body reserves of protein and fat through feeding on shrub leaves, grasses and sedges and especially mushrooms (Skoog 1968; Russell *et al.* 1993). Habitat requirements have not been detailed in the NWT during and after the October rut except that most barren-ground caribou herds return to the taiga in early winter in search of forage and shelter (Bergerud *et al.* 2008). The ability to digest lichens is a key adaptation as lichens are high in digestible carbohydrates and are readily available in the winter taiga. However, since lichens are low in protein, caribou must also seek out evergreen leaves and sedges as well as dried leaves

and twigs of shrubs (Russell *et al.* 1993).

The winter range of the Porcupine herd is in the Taiga Cordillera. The Tuktoyaktuk Peninsula, Cape Bathurst, and Bluenose-West herds' winter ranges are largely within the Taiga Plains ecozone. The winter range of the Bluenose-East herd is partly in the Taiga Plains and partly in the Taiga Shield. All the other herds' (Bathurst, Beverly, Ahiak, Qamanirjuaq) typical winter ranges are largely in the Taiga Shield ecozone. These zones are differentiated by climate and under-lying geology (e.g., Precambrian Shield). While generalized descriptions of vegetation, climate and terrain at the ecozone scale for the tundra and forested regions are available (Ecosystem Classification Group 2007 (rev. 2009), 2008, 2010, 2012), there have been few analyses specific to the NWT on identifying attributes that are critical for barren-ground caribou winter habitat. The winter habitat attributes for the Bathurst calving and winter ranges and for the Beverly winter ranges are the best known (Thomas and Kiliaan 1998a, b; Thomas *et al.* 1998; Griffith *et al.* 2001; Barrier 2011; Barrier and Johnson 2012).

The taiga in the NWT is mostly black spruce (*Picea mariana*), white spruce (*P. glauca*), and jack pine (*Pinus banksiana*) trees (Ecological Stratification Working Group 1996). The understory includes shrubs such as Labrador tea (*Ledum* spp.), willow (*Salix* spp.), dwarf birch (*Betula glandulosa*) and blueberry/cranberry (*Vaccinium* spp.). The lowest level vegetation consists of extensive mats of lichens and mosses. Caribou use of those forests is strongly influenced by forest fires and snowfall at the landscape scale. On the eastern winter ranges of the Taiga Shield in the NWT, the caribou of the Beverly herd selected stands of black spruce mostly 150-250 years old and with high amounts of foliose lichens (leaf-like lichens) (Thomas and Kiliaan 1998a, b). As snow depth and hardness changed during the winter, the caribou changed their movement patterns to areas with less snow (Thomas *et al.* 1998). For the Bathurst herd, also wintering within the Taiga Shield, Barrier and Johnson (2012) reported how caribou avoided areas of the winter range with a high density of forest fire burns and selected the older patches of forest (>40 years old), which have more favourable snow conditions, higher cover of lichens and herbaceous forage as well as lakes nearby, which caribou use to reduce the risk of predation (Barrier and Johnson 2012). Barrier and Johnson (2012) relied on the movements of satellite-collared females to describe their selection of winter habitats and commented on the extent of individual variation among collared females in their trade-offs between foraging and predation risk. The winter habitat selection for the Cape Bathurst, Bluenose-West, and Bluenose-East herds varies among years. In recent years, the Cape Bathurst herd appears to be wintering around the Tuktoyaktuk Peninsula and Husky Lakes. Bluenose-West caribou are wintering from the southern Tuktoyaktuk Peninsula and Husky Lakes to Paulatuk and south to Great Bear Lake, and the Bluenose-East herd is largely wintering south, east, and northeast of Great Bear Lake (D'Hont *et al.* 2009). Wintering habitat for the Tuktoyaktuk Peninsula and Qamanirjuaq herds has not yet been described.

Whether caribou winter on the tundra, in the tree-line transition zone or in the taiga, the wintering range is not a fixed characteristic of a herd and can vary from year to year (Gunn *et al.*

2013b).

At the macro-climate scale, the climate within overall barren-ground caribou range is characterized by a short plant growth season whose onset is annually variable (Arctic Climate Impact Assessment [ACIA] 2005; Federal, Provincial and Territorial Governments of Canada 2010). Winters are long and cold. The climate is dry and the snow pack accumulates mostly in the fall, typically followed by light snow falling from December to March. Regionally, the climate has west-east and north-south gradients and as well, the climate is influenced by the corridor formed by the Mackenzie River, linking the Beaufort Sea to the continental interior, and the shadowing effect of the Mackenzie Mountains. Great Slave and Great Bear lakes impose further regional variation as these large lakes melt and freeze up weeks later than surrounding smaller lakes.

Imposed on this general climate pattern is the effect of global weather circulation patterns, which are recurring and persistent large-scale pressure and circulation anomalies on a sub-continental scale (Bonsal and Shabbar 2011). These patterns, which include the Arctic Oscillation, are characterized by episodic (recurring trends) patterns roughly at the decadal scale in winter temperatures and snowfall that subsequently impose patterns on river flow. Biological signals of climatic oscillations are extensive and include changes in plant growth, tree-growth, and the timing of freeze-up and break-up. Krezek-Hanes *et al.* (2011) described how the global circulation patterns modify the prevalence of large forest fires with runs of years with large fires and runs of years with smaller areas burnt. The Arctic Oscillation's phases coincide with changes in caribou abundance, suggesting that climate has a role in caribou cycles through cumulative effects on habitat (Zalatan *et al.* 2006; Joly *et al.* 2011). However, effects of the Arctic Oscillation and Pacific Decadal Oscillation varied among individual Alaskan herds (Joly *et al.* 2011).

Movements

Migration

The annual migrations are one of the most conspicuous characteristics of barren-ground caribou. Reasons for migration are complex and likely involve access to higher abundance or quality of forage (McCullough 1985) and/or reduction of the risk of predation (Fryxell and Sinclair 1988; Bergerud *et al.* 2008) or parasitism (Folstad *et al.* 1991; Hughes *et al.* 2009). The annual reproductive cycle is marked by the female's annual and often extensive pre-calving migration to the calving ground where almost all pregnant females in a herd congregate at relatively high densities (depending on herd size). The timing of arrival on the calving ground varies annually and appears to reflect the condition of the females and travelling conditions such as snow depth and hardness (Bergerud *et al.* 2008). In the Bathurst herd, the annual dates of the arrival of females on the calving ground varied from 20 May to 5 June (Gunn and Poole 2010). In each

herd, most calves are born during the peak of calving, which is only a few days, although it may extend over a period of 10-14 days (Bergerud 1975; Bergerud *et al.* 2008). Evidence of late-born calves was found by Nagy and Johnson (2007a and b) in the Cape Bathurst and Bluenose-West herds in the early 2000s. The dates for the peak of calving are annually variable and differ among herds. The males and juveniles that do not migrate to the calving grounds overlap in distribution with the females and calves during the summer. In late October fall migration is underway and the rut (mating season) begins.

Using the rates of individual movements of satellite-collared females from all herds (1993-2009), Nagy (2011) identified 12 activity periods for migratory barren-ground caribou, the timing of which was largely synchronized among the NWT and NU herds. There were three peaks when daily mean rates of movements were highest: pre-calving, early summer (insect harassment season) and the rut. The mean daily rates of movements differed among the herds (Nagy 2011).

Spatial fidelity

In general, barren-ground caribou show long term fidelity to calving grounds, pre-calving migratory routes, post-calving areas and water-crossings despite large changes in the abundance of caribou (e.g., Gordon 2005; Zalatan *et al.* 2006). The basis for determining geographic fidelity at the herd scale is through mapping annual range use during aerial surveys and from satellite-collared caribou. Fidelity is described from the amount of overlapping distribution between consecutive surveys and individually from the movements of collared females, although how the boundaries and overlap are determined potentially influences how fidelity will be measured (Nagy and Johnson 2007a, b; Poole *et al.* 2013). Considerable interest has centered on describing herd spatial fidelity based on year-round affiliation of females (Nagy *et al*. 2011) or only fidelity to calving grounds (Thomas 1969; Gunn and Miller 1986; Roffler *et al.* 2012).

At the herd scale, annually, calving grounds do not usually completely overlap. If the unoccupied area each year is in a consistent direction, it is deemed a directional shift, but if there is no consistency in direction, it is deemed a non-directional shift. Caution should be used in comparing calving ground locations determined only by aircraft surveys with locations determined by use of satellite telemetry as criteria for determining boundaries differ. For example, for the Cape Bathurst, Bluenose-West, and Bluenose-East herds, Nagy (2009a and b) showed cumulative overlap in calving grounds based on satellite-collared females (1996-2006) relative to areas mapped during aerial surveys in the mid-1970s (Hawley *et al*. 1979; Fig. 7, p. 108). Overlap had persisted for the Cape Bathurst and Bluenose-West herds while the calving grounds of the Bluenose-East herd appear to have shifted east.

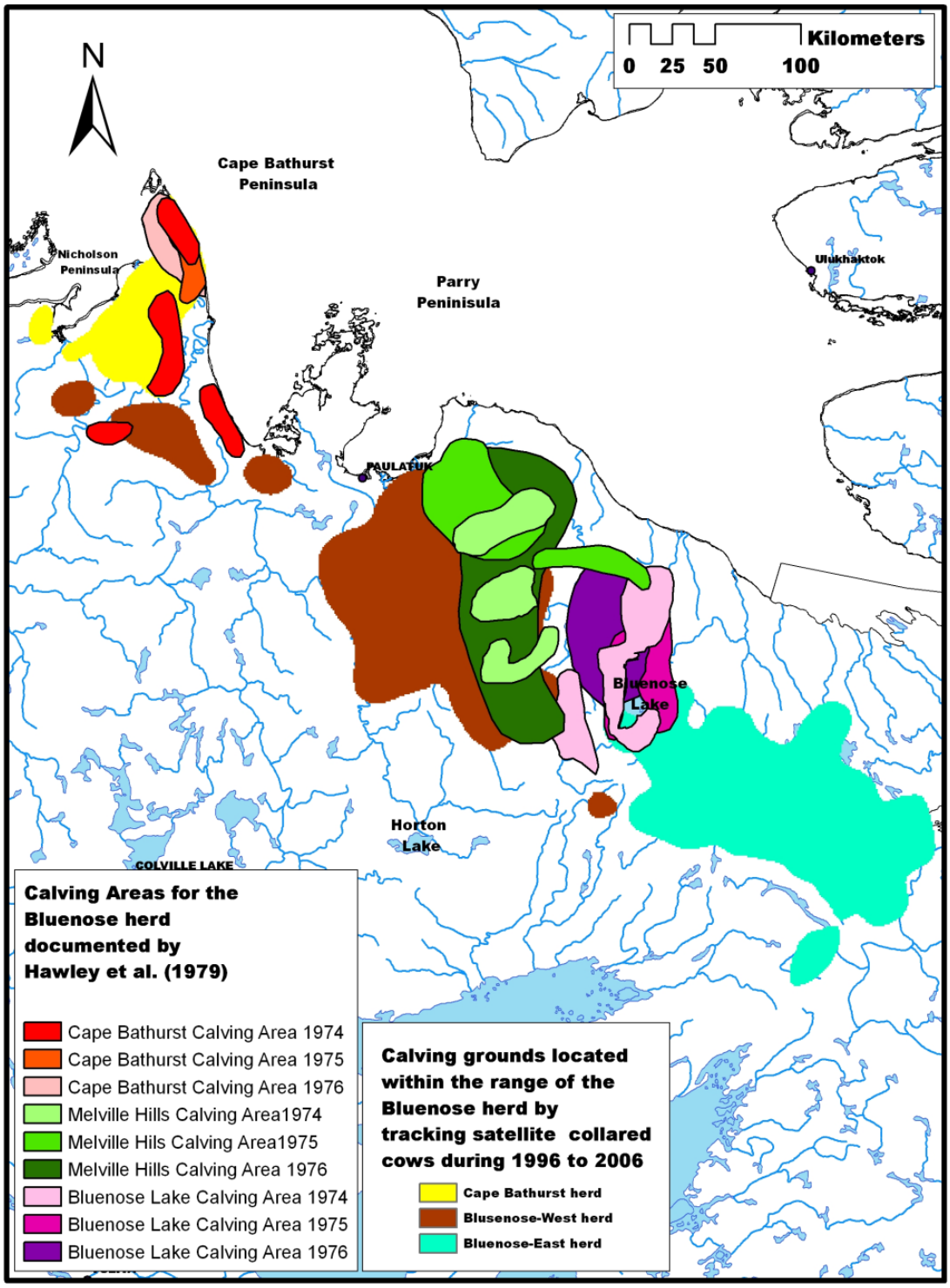


Figure 7. Comparison of "Bluenose" calving grounds 1974-76 (Hawley *et al*. 1979) and 1996-2006 (Nagy 2009a, b) (reproduced from Nagy 2009b) (see *Systematic/taxonomic/naming clarifications*, p. 93, for information on how naming practices for these herds have changed over time).

The length of the period for which there is information may partially influence the likelihood of detecting whether there are periods of directional as well as non-directional shifts in calving

ground locations. There was no evidence for a directional shift in the Cape Bathurst, Bluenose-West, Beverly (1957-94), and Qamanirjuaq (1974-2008) calving grounds. The Bathurst herd had two periods (1966-84 and 1996-2012) when the annual shifts in overlap were non-directional (Gunn *et al.* 2007; Fleck and Gunn 1982). Then, between 1984 and 1996, the consecutive overlap was consistently westward and the calving ground shifted approximately 250 km from east to west of Bathurst Inlet to an area where calving had been recorded in the 1950s (Gunn *et al.* 2008).

The satellite-collared females also reveal fidelity at the individual scale. Based on satellite-collars, the annual fidelity of individual females to a single calving ground is usually high (93-99%) although sample size is limited both for the number of females and the number of years for which data are available (Lieb *et al.* 1994; Boulet *et al.* 2007; Bergerud *et al.* 2008). For example, between 1996 and 2004, in the Bathurst herd, most collared females (78%) had two or three years of monitoring during calving and 22% had four to six years of calving monitoring (Gunn *et al.* 2013a). Natal calving grounds for collared females (the calving ground on which that female was born) are unknown, although it seems likely that behavioural traditions are passed from older to younger females in the natal year.

Females in most herds reveal a low (<5%) annual rate of switching[8] between neighbouring calving grounds; however, there are exceptions. For the Beverly herd, nine of 21 collared females (43%) that calved on the traditional inland calving ground (Beverly South) switched to the coastal Queen Maud Gulf between 2007 and 2010 at a time when the densities on the traditional inland Beverly calving ground had sharply declined (Gunn *et al.* 2012; Adamczewski *et al.* 2015).

There is no evidence for geographic fidelity to specific rutting areas, in part because rut generally coincides with fall migration when the caribou are in relatively large aggregations and movements are rapid. However, the pattern of annual use of rut areas has had limited analysis, although Nagy (2009b) mapped the cumulative rut areas for the Cape Bathurst, Bluenose-West, and Bluenose-East herds.

Satellite-collaring can also reveal quite large movements by some individual females. Nagy (2009b) described how a Cape Bathurst female, one of 82 satellite-collared females, moved south to the Colville Lake area following a coastal icing event in fall 2003. The female remained in the central portion of the Bluenose-West range for the following two years before it returned to calve on the Cape Bathurst Peninsula in 2005, which suggests the movement was a temporary dispersal. An environmentally-forced movement that followed freezing rain and heavy snowfall occurred along the coast of Hudson Bay in November 2004 (Campbell pers. comm. 2005 *in*

[8] 'Switching', for the purposes of this report, refers to individual females that change calving ground location (Gunn *et al.* 2012).

Gunn 2013). Collared females that had calved northwest of Wager Bay (NU) and on the Qamanirjuaq herd's calving grounds moved more than 1,000 km to winter east of Great Slave Lake during the 2004-05 winter. Limited collar data also suggests that at least some Qamanirjuaq caribou females have wintered east and southeast of Reliance during winters 2011-12 to 2013-14 (ENR 2013a).

Further discussion of trends in annual herd distribution are included in *Distribution trends* (p. 158).

Dispersal

Most of the NWT tundra and taiga do not appear to have significant barriers limiting movements or dispersal. The large lakes likely cause detours when they are not frozen. The Mackenzie River is likely a barrier limiting the movements of the Porcupine, Tuktoyaktuk Peninsula, Cape Bathurst, and Bluenose-West herds. There are traditional water crossings across some of the large rivers that caribou encounter annually (e.g., Beverly caribou crossing the Thelon River (Gordon 2005)) that have been used for thousands of years.

Life cycle and reproduction

The reproductive lifespan of caribou is likely about 12 years, with females living as long as 12-16 years, and males for a few years less (Thomas and Kiliaan 1998b). Generation time, used in species assessment, is estimated at 8-9 years based on adult survival and fecundity (Boulanger pers. comm. 2011).

Monitoring the sex ratio is based on assigning caribou into sex and age classes either from the ground or from the air during fall surveys when the caribou are assumed to have the least segregation of age and sex classes (e.g., Campbell *et al.* 2010; Nishi *et al.* 2010). Caribou are classified as females, males or calves based on their appearance and external sex characteristics. Describing the sex ratio provides information on relative mortality of the two sexes and, if the trend of the subpopulation is known, the ratios can be corrected to estimate actual mortality for either sex from ratio data (Bender 2006).

Until recently, there was relatively little information on the sex ratio for the different herds. Monitoring the sex ratio for the Bathurst herd started in 2004 (Gunn *et al.* 2013a) after two unsuccessful attempts in fall 2000 and 2001 when it was believed that the samples were not representative of the herd as the caribou were rapidly migrating. The overall sex ratio in 2004 was 37 males to 100 females (0.37 ± 0.03 (SE)) although it strongly varied among locations (Gunn *et al.* 2005a). Davison (2015) reports values for the Bluenose-West herd in 2009 as 70 males:100 females and Boulanger *et al.* (2014) report values for Bluenose-East herd in 2009 as 43:100.

The female's body condition determines the age of first pregnancy and the annual likelihood that

a female will conceive. Barren-ground caribou usually calve at three years of age, although under high forage availability and a corresponding high rate of body growth, females can calve at two years of age (Thomas and Kiliaan 1998b; Bergerud *et al.* 2008).

Breeding takes place in October (rut) and calving follows in June after a gestation averaging 225-235 days (Skoog 1968; Bergerud 1975). Females typically give birth to a single calf; twins are very rare (Thomas and Kiliaan 1998b). The calf is able to stand within a few minutes of birth and in 2-3 days can keep pace with the maternal female. Lactation depends on the female's protein reserves (Gerhart *et al.* 1996). The calf's growth rate depends on the female's milk production; under-weight calves have a low chance of survival. Calves are typically weaned in the fall but stay with the female during the first winter. Yearlings, especially females, follow the females to the calving ground (Bergerud *et al.* 2008).

Caribou are sexually dimorphic, meaning the sexes differ in body size and display ornamentation (pelage and antlers). The breeding system is polygynous (a male mates with more than one female) and it has been assumed that body and antler size largely affect the male's competitive ability to control access to females (Miller 2003). However, at least in reindeer, the paternity of calves revealed that the conventional view of exclusive breeding by a few successful large breeding males was incomplete as smaller (younger males) were also active breeders (Røed *et al.* 2005).

Although observations of rutting behaviour in the NWT are limited, the rut is known to occur in the fall over two-three weeks, within a longer period when the females can have several oestrus cycles of 10-12 days (McEwan and Whitehead 1972; Bergerud 1975; Ropstad 2000). Nonetheless, during the rut, conceptions are highly synchronous. For example, in the Qamanirjuaq herd in 1966 and 1967, 80% of the conceptions were during the first 11 days (19-29 October) of a four- to five-week mating season (Dauphiné and McClure 1974). Little attention has been focused on breeding synchrony during the rut and whether it is behavioural or environmental. In other gregarious large mammals such as bison (*Bison bison*), females use scent to monitor oestrus status in other females (Berger 1992). Synchrony during the rut likely leads to birth synchrony, although females can change the timing of birth by a few days (Berger 1992; Bergerud *et al.* 2008).

Calving is highly synchronized with most calves born within a few days of each other. For example, between 1957 and 1994, the peak of calving for the Beverly herd was determined as a 4-5 day period between 1 and 17 June (Gunn and Sutherland 1997). For the Bathurst herd from 1966 to 1996, the annual peak was five days between 3 and 15 June (Sutherland and Gunn 1996). This information is based on aerial surveys. The technique for determining the peak of calving since 1996 is based largely on the movements of satellite-collared caribou, as females giving birth show a distinctive drop in movement rates (Kelleyhouse 2001). Post-1996 data should therefore be used with a degree of caution, understanding that the technique cannot always identify such precise peak calving dates as aerial surveys and recognizing the limitations

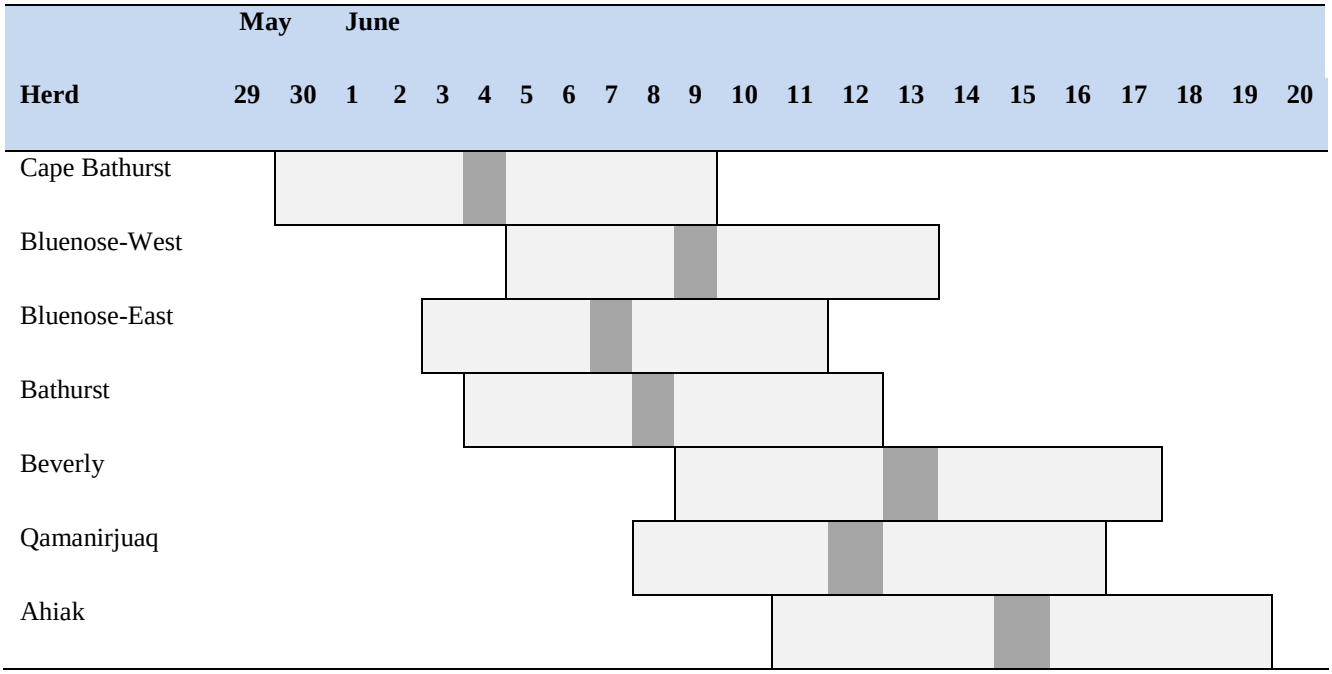
associated with using a few collared females as a representation of the entire herd's behaviour.

Since the mid-1990s, there have been large changes in herd population numbers, which may in part be from trends in physical condition (see *Abundance*, p. 122) (Chen *et al*. 2014). During this period, changes in fall condition of females, reflecting habitat conditions on the summer range and possibly driven in part by climate change (see *Threats and limiting factors - Climate change*, p. 173), may have influenced the timing of oestrus (and therefore the timing and degree of synchrony of the rut). For example, the Bathurst herd, between 1999 and 2009, saw a shift in the peak of calving to four days later (to 8-14 June) (Gunn and Poole 2010), with the exception of 2005 when the peak of calving averaged about six days later than normal. A shift to earlier calving (5-6/7 June) was recorded in 2010-2012 (Croft pers. comm. 2016).

For the other herds, the information reported on the annual variation and trends in the timing of peak of calving is similar. For instance, between 2001 and 2005, the peak of calving based on aerial surveys was 15-26 June for the Bluenose-West herd, and at this time, calves were either a few days or a week old based on their appearance (Theberge and Nagy 2001; Nagy and Johnson 2007b), which indicated late calving compared to Nagy's (2011) summary of average dates.

At the broad scale of the NWT and NU, the peak of calving is generally earlier for the western herds than for the herds to the east and north-east (Table 1, below), based on data from satellite-collared females between 1993-2009 (Nagy 2011).

Table 1. Mean calving date (dark grey) and ±1 Standard Error (light grey) estimated from satellite-collared female daily movement rates between 1993-2009 (based on Nagy 2011; the study did not consider the Tuktoyaktuk Peninsula or Porcupine herds). Median calving data was reported as June 1 (1983-1996) in the Porcupine herd (Griffith *et al*. 2002).



Physiology and adaptability

The physiology and adaptability of barren-ground caribou in the NWT has not been specifically studied. However, Alaskan and Norwegian reindeer have been well-studied for their ability to conserve heat and moisture while being active during long and cold winters (Blix *et al.* 2011) and for their nutritional ecology (White 1983; Gerhart *et al.* 1996; Chan-McLeod *et al.* 1999; Russell and White 2000).

Adaptations by caribou to long cold winters include their dense pelage. The pelage consists of hollow guard hairs and an under-fur of thin and woollen hairs with an average of 2,000 hairs/centimetre $(cm)^2$ (12 millimetres (mm) long) on the legs and 1,700 hairs/cm^2 (30 mm long) on the back (Timisjarvi *et al.* 1984). Caribou also have intricately developed scrolled nasal bones, which provide a large surface area over which the animal breathes and which then provides a large surface to warm and moisten incoming air (Dieterich and Morton 1990). Conversely, caribou also need to be able to avoid over-heating during exercise. When they run or move through deep snow and build up body heat, they can resort to open mouth panting, which forces air flow over their thick tongue with its plentiful blood supply (Miller 2003). If body heat continues to build up, the animal has a complicated arrangement of veins and arteries in the head, which selectively keeps the brain cool (Blix *et al.* 2011). Caribou muscles are well-adapted to both speed and endurance as the muscles have microscopic fibre types that have a high proportion of fast-contracting fibres as well as a high oxidative and high glycolytic capacity (Essén-Gustavsson and Rehbinder 1985). Caribou also have relatively large hearts for their body size (Dauphiné 1976), which contributes to speed and endurance.

These physiological adaptations are supported by behavioural traits that save energy and minimize the gain of metabolic heat by, for example, following in each other's tracks in the snow. Walking through deep snow is energetically costly (Fancy and White 1985). Less is known about how caribou cope with heat during summer although caribou may be vulnerable to extreme heat (Soppela *et al.* 1986). Caribou will seek remnant snow beds or stand in water, which likely is an attempt to keep cool and avoid insects (Bergerud *et al.* 2008); panting and sparsely haired extremities may also effect heat loss (Miller 2003).

Caribou are adapted to a long season when plant growth has stopped and forage quality has declined. Cold temperatures, wind chill and snow impose high energetic costs, which are met by mobilizing body reserves of fat and protein. They can seasonally metabolize 26-42% of their body protein, mostly from muscles (Gerhart *et al.* 1996; Chan-McLeod *et al.* 1999) in addition to 90% or more of their fat reserves (Adamczewski *et al.* 1993). As well as breaking down protein for energy, females are allocating protein reserves to fetal growth, lactation and their own survival needs (Barboza and Parker 2008). While caribou adapt to these conditions by reducing their maintenance energy requirements, they also select a diet to minimize loss of body mass.

Caribou, unlike most wildlife, have the unique ability to use lichens as an important food

resource because they have rumen microflora that can ferment them (Aagnes *et al*. 1995). Lichens are a characteristic feature of the taiga, forming extensive and abundant mats, which enable caribou to forage efficiently on them. They are high in digestible carbohydrates (Svihus and Holand 2000), but are very low in protein and minerals. Late winter, especially for pregnant females, is a demanding time for protein and minerals (Parker *et al.* 2005). Caribou can offset the low protein content by recycling nitrogen and selecting vascular plants higher in protein (Parker *et al.* 2005). A mixed diet of lichens and vascular plants with higher protein levels also stimulates digestion of the lichens (Aagnes *et al.* 1995).

The digestive physiology of caribou reveals other adaptations. During the brief annual pulse of plant growth in spring and summer, by selectively foraging on the high protein flower buds of cotton-grass, caribou can selectively digest the protein to "multiply" its effect on growth and reproduction (White 1983; Cebrian *et al.* 2008).

As is typical of long-lived species, caribou adaptability depends on trade-offs between reproduction and survival (Gaillard *et al.* 1998, 2000). Females can safeguard their own survival in years of restricted forage access either by not becoming pregnant or weaning their calf prematurely (Russell and White 2000).

Caribou behaviour is relatively plastic. Their ability to make long distance movements are the core of their adaptive abilities relative to environmental variations (Bergerud *et al.* 2008) (see *Movements*, p. 106). A consequence of this adaptive behaviour is that barren-ground caribou need extensive annual ranges for survival (Bergerud *et al.* 2008).

Caribou can learn to adapt to human activities (Haskell and Ballard 2008) although little is known about how to facilitate that adaption. More typically, caribou responses to humans are similar to their responses to predators (ranging from being alert to displacement and avoidance) (Stankowich 2008).

Interactions

Most of the winter diet of barren-ground caribou, and even some of the summer and fall diet, consists of lichens, but caribou are not dependent on lichens (Russell *et al.* 1993; Thomas 1998; Bergerud *et al.* 2008). Barren-ground caribou feed on a variety of plants (shrubs, forbs, grasses and sedges, and mushrooms) (Russell *et al.* 1993; Bergerud *et al.* 2008). While not an obligate relationship, the large amounts of lichen forage on the winter range likely contributes to the periodic high numbers of barren-ground caribou and their widespread distribution (Kelsall 1968). High densities of caribou can also affect the vegetation (Manseau *et al.* 1996; Bergerud *et al.* 2008; Zamin and Grogan 2013) through trampling, the removal of plant material and fertilizing effects of caribou fecal pellets.

Many interactions are intraspecific, owing to the gregarious behaviour exhibited by barren-ground caribou that contributes to their survival. However, there are costs from gregariousness,

including competition for forage, increased risk of parasites and disease, and increased vulnerability to threats (described in the following sections).

Interactions between neighbouring barren-ground caribou herds in the NWT are most likely to occur when the herds are at high abundance and during widespread distribution (Gunn and D'Hont 2002; Nagy 2009a) such as seen on the winter ranges (e.g., Gunn and D'Hont 2002).

Interactions with other herbivores

Barren-ground caribou share their ranges with other mammalian and avian herbivores, but assessment of these interactions in the NWT has to be largely drawn from experience elsewhere as they have not been studied in detail. The interactions can include overlapping diet and habitat, shared predators and possible interactions through parasites and diseases.

The approximately four year (lemmings and voles) and 10 year (snowshoe hares) cycles of small-bodied herbivores and their predators mean that over time, pulses of biomass and energy pass through the tundra and taiga. Sometimes these different length cycles will be synchronized by climate (Sinclair *et al.* 1993). In the NWT, the cyclic abundance of the small mammal species is tracked (ENR 2015). When lemmings and voles peak they can reach 200-300 individuals/hectare (ha), and remove 50-70% of the annual growth of tundra plants (Kryazhimskii and Danilov 2000), although how that relates to caribou forage is unknown.

Geese (*Chen* spp.) colonies and flocks of ptarmigan (*Lagopus* spp.) may contribute to pulses of forage removal as they periodically reach high numbers on barren-ground caribou summer and winter ranges, respectively. Concentrations of geese resulted in decreased vegetation cover, species richness, and diversity of vegetation inland from the Queen Maud Gulf coast (Alisauskas *et al.* 2006). Ptarmigan follow caribou to feed on plants exposed when caribou dig craters through the snow (Pedersen *et al.* 2006) and their numbers periodically peak, but the effect of their foraging, especially on dwarf birch and willow is uncertain (Syroechkovskii 1995).

Barren-ground caribou have overlapping distribution with three large-bodied herbivores: moose (*Alces americanus*), muskoxen (*Ovibos moschatus*), and boreal woodland caribou (*R. t. caribou*).

Muskoxen distribution has increased in the NWT, with muskoxen re-occupying large parts of their historic ranges. Most overlap is of relatively low densities of muskoxen on the tundra. Muskoxen distribution has recently expanded along the tree-line and spread south of the tree-line in the south-eastern NWT (Gunn *et al.* 2009; Adamczewski pers. comm. 2011), east towards Hudson Bay, and south past the tree-line within the Kivalliq region of NU (Campbell *et al.* 2012b). Muskoxen have been reported as far south as the Alberta and Saskatchewan borders (Adamczewski pers. comm. 2013b). Studies describing the relationship between caribou and muskoxen have focused on habitat use and diet on the Arctic islands (e.g., Thomas *et al.* 1999; Larter *et al.* 2002). Within the taiga, habitat relationships are unknown and other effects such as overlap in diet (especially grasses and sedges), displacement, supporting predation, or shared

parasites and diseases have not been studied. Caribou and muskoxen harbour similar parasites, such as tapeworms and muscle worms, but interspecific parasite relationships are uncertain (Kutz *et al.* 2012; Elkin pers. comm. 2012).

A large part of the distribution of boreal woodland caribou overlaps the winter ranges of barren-ground caribou, especially the Bluenose-West and Bluenose-East herds (Gunn *et al.* 2004). The 2012 SARC assessment of boreal woodland caribou reports that about 40% of the range of boreal caribou overlaps the cumulative winter range of barren-ground caribou (SARC 2012).

Moose distribution overlaps barren-ground caribou distribution mostly in the taiga but also on the tundra since the 1900s (ENR 2016b), especially west of Bathurst Inlet and along river corridors (Banfield 1974). Moose tend to use early successional habitat in the taiga, such as after forest fires, as well as along streams and rivers – feeding on shrubs, sedges and grasses. Moose and caribou also share some of the same species of parasites, which have wolves as the final host (*Taenia hydatigena*, *T. krabbei*, *Echinococcus granulosus*) (Rausch 2003; Elkin pers. comm. 2012).

On frozen lakes, caribou are attracted to muskrat (*Ondatra zibethicus*) pushups (Kelsall 1970). Although the significance for the muskrats is unknown, the caribou likely benefit from the frozen green roots and stems of cattails, sedges, and grasses, which have high levels of protein (Klein 1990).

Predation

Predators figure prominently in caribou ecology, affecting survival and reproduction, which in turn contribute to changes in abundance. Caribou can be thought of as living in a 'landscape of fear' (Laundré *et al.* 2010), which is to say that many of their movements and habitat selection choices are a consequence of minimizing their risk of exposure to wolves and grizzly bears (*Ursus arctos*), and less often wolverine (*Gulo gulo*) and lynx (*Lynx canadensis*) (Bergerud *et al.* 2008). An array of predators and scavengers depend on barren-ground caribou. The role of predation in caribou population dynamics probably differs among herds, and likely has a greater impact during declines and the phase of low numbers (constant mortality would have a greater effect at lower populations). Grizzly bears may have a greater impact on newborn caribou on calving grounds (Reynolds and Garner 1987; Adams *et al.* 1995), but wolves are effective predators of all sex and age classes of caribou throughout the year (Miller 2003; Bergerud *et al.* 2008).

The vulnerability of barren-ground caribou to predation varies with environmental conditions and seasonal distribution. When caribou congregate, especially on the calving grounds, newborn calves are particularly vulnerable, although there are few recent estimates of the rate of predation. On the Qamanirjuaq and Beverly herd calving grounds, examination of calf carcasses was used to describe predation rates (Miller and Broughton 1974; Miller *et al.* 1985, 1988). On the Beverly herd's calving ground, 154 of 287 carcasses of caribou calves were killed by wolves

in June 1981-83 and most (72.1%) were less than four days old at death (Miller *et al.* 1985, 1988). Calves located within large groups of females and calves were less vulnerable to predation than those on the periphery on the Porcupine herd's calving grounds (Griffith *et al.* 2002).

There is little recent information on predation rates on barren-ground caribou in the NWT and NU. During the late 1980s, radio-collared wolves were tracked in the Bluenose-West range to measure caribou kill rates in late winter and summer. The kill rate for two packs of six and seven wolves in April 1992 was almost a caribou killed every two days (Clarkson and Liepins 1992). Earlier studies in the Yukon suggested that wolves will kill caribou at the rate of just under a caribou every 10 days per wolf (Hayes and Russell 2000).

Information on wolf predation, based on indices of predator abundance and diet, is available; however, there is relatively little information on grizzly bear predation. Grizzly bear diets can consist of 10-93% caribou, depending on the season (Gau *et al.* 2002). With the exception of populations that eat salmon, grizzly bear populations in areas of the Arctic with access to barren-ground caribou consistently showed the highest terrestrial meat consumption of any North American population (Mowat and Heard 2006). Grizzly bear sightings have increased at least on the range of the Bluenose-East herd over the past two decades (Dumond 2007). Higher densities of grizzly bears, possibly sustained by muskoxen as alternative prey, may influence neonatal caribou calf survival, which could affect herd recovery from low population levels.

Wolverine and lynx occasionally take adult caribou (Bergerud 1971; Dumond 2007). Wolverines are effective scavengers of wolf-killed caribou (Lee 1995; van Dijk *et al.* 2008) as well as sometimes being able to kill caribou through persistent long chases (Dumond 2007). Ravens (*Corvus corax*) scavenge wolf kills, removing enough meat that the scavenging affects wolf kill rates (Kaczensky *et al.* 2005); ravens can take 75% of the edible carcass from a pair of wolves. In Alaska, immature golden eagles (*Aquila chrysaetos*) take calves on calving and summer ranges (Whitten *et al.* 1992). Golden eagle predation on caribou is unreported for the NWT and NU, although golden eagles have been sighted during calving ground surveys of the Cape Bathurst, Bluenose-West (Nagy and Johnson 2007a and b), Bluenose-East and Bathurst herds (Tracz pers. comm. 2015).

Information to index wolf predation is primarily through wolf sightings during aerial surveys and the number of wolves harvested (Heard *et al.* 1996). In 2007 and 2008, the major calving grounds in the NWT and NU were flown at about the same time. Poole *et al.* (2013) summarized sightings of bears and wolves on eight calving grounds from 2007 and 2008. In general, proportionately higher densities of wolves were observed in more eastern herds, with higher densities of grizzly bears in more western herds. This is supported by the numbers of grizzly bears mapped on the Cape Bathurst and Bluenose-West calving grounds during 2000-04 (Theberge and Nagy 2001; Nagy and Johnson 2007a and b).

Heard (1992) observed an average of eight wolves/100 hours flying in the Queen Maud Gulf

area during the 1980s, which is lower than the 24-33 wolves/100 hours observed during surveys of the Ahiak herd in 2007 and 2008 (Poole *et al.* 2013). Williams (1995) observed 25 wolves and eight bears/100 hours flying the Beverly calving ground in 1993 and 54 wolves and 12 bears/100 hours in 1994. This is higher than observed in 1987 and 1988, which saw 13 wolves and 1.7 bears/100 hours and no wolves and 1.9 bears/100 hours flying, respectively (Heard and Jackson 1990). Incidental observations may only provide a very rough index of predator numbers, however, as accurate counts of wolves, in particular, would require intensive survey flying (Serrouya *et al.* 2015) and much higher coverage than caribou surveys generally provide.

Between 1987 and 2012, wolf sightings recorded during late winter aerial surveys for the Bathurst herd suggest no trend in wolf sightings or mean pack size (Williams and Fournier 1996; Croft pers. comm. 2012; Gunn 2013). The number of adult wolves sighted at dens on the tundra summer range of the Bathurst herd from 1996-2012 has fluctuated widely (Fig. 8a, p. 119) but suggest a declining trend (Cluff pers. comm. 2015).

The number of active den sites observed during pup counts on the Bathurst summer range decreased between May/June (during birthing of pups) and mid- to late-August (Fig. 8b, p. 119). Since 2007, the number of den sites active in June and remaining active in August became so low (n = 1-4) that there was increased uncertainty as to whether pups were relocated elsewhere or total litter loss had occurred (Fig. 8b, p. 119). A recent study examining the behavioural response of wolves to declining population in the Bathurst herd has shown that, contrary to what would be expected, wolves do not show a behavioural or adaptive response to contractions in Bathurst summer range, continuing to select den sites in esker-rich areas, despite the large distance between the dens and prey base. Reduced access to prey during this key pup growth period can adversely impact pup survival and population growth among wolves (Klaczek *et al.* 2015).

Aerial surveys have been conducted since 2006, on a 70,000 km^2 portion of the Bathurst caribou summer range, to estimate occupancy of wolf dens. The technique samples 10 km x 10 km grid cells with the flight path visiting previously known den sites and searching eskers and esker-like habitat for new dens. Surveys are conducted when visibility is good, daytime temperatures are cool, and at a time of day when wolves are likely resting outside the den, most notably before biting insects arrive. Repeated surveys are critical to model detection probability, but unfortunately have been lacking. Limited repeated visits to some den sites have permitted a crude assessment of detection probability. There is no trend in wolf den occupancy from 2006-12. Future surveys are planned to better quantify detection probability (Cluff pers. comm. 2015).

There have been changes in the number of wolf dens observed/1,000 km flown during surveys since 1996. When surveys began, flight paths typically went from one active den site to another, with little search for new dens. Although skewed because of reduced search time, during the late 1990s, 11 wolf dens/1,000 km flown were observed. From 2006-12, annual estimates have observed a range of 3.55-5.78 wolf dens/1,000 km flown (mean = 4.63). Caribou abundance has

declined from 1996-2012. Virtually all adjacent active wolf dens observed since 1996 have been at least 15 km apart (Cluff pers. comm. 2015), with this distance between dens possibly increasing as the barren-ground caribou population has decreased (Klaczek *et al.* 2015).

Very little information is available for wolf abundance on barren-ground caribou winter range. Mattson *et al*. (2009) commented that wolf abundance on the Bathurst caribou winter range is poorly understood. Wolves collared in 2012 and 2013 have improved understanding somewhat, but the analysis of those data have only been rudimentary. Population estimates of wolves are notoriously difficult and expensive to obtain. Subsequent data analyses and an upcoming program review will help direct how wolves should be monitored in the territory and reconcile what information is needed with what can be reasonably obtained (Cluff pers. comm. 2015).

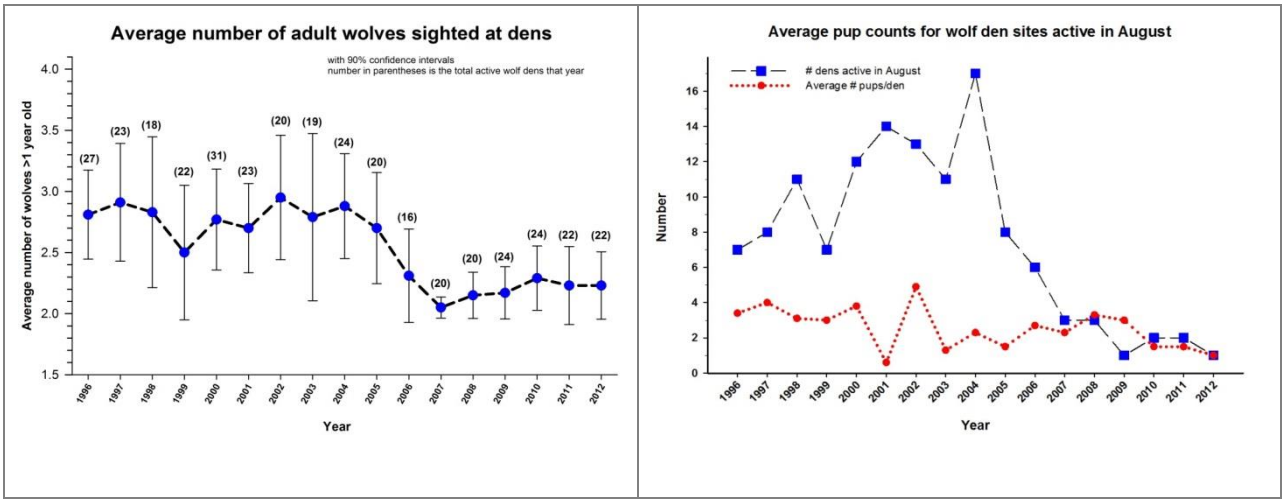


Figure 8a-b. Bathurst caribou summer range wolf den trends: a) wolves sighted per den (1996-2012); b) wolf pup count (1996-2012) (Cluff pers. comm. 2015).

From 1987-2012, Bathurst caribou numbers peaked and declined. There was no clear trend of predator sightings on late winter and calving ranges during this period, but since the mid-1990s, there is some evidence that wolf productivity has declined based on den use and pup survival rates (Adamczewski *et al.* 2009; Cluff pers. comm. 2013). Although changes in the abundance of a predator relative to its prey will have time lags, there is uncertainty as to exactly how and when predator abundance responds to changes in caribou abundance since alternative prey availability will have an influence.

Parasites and disease

The role of parasites and diseases in barren-ground caribou at the population level has been little studied (Gunn and Irvine 2003).

Studies of the effect of warble flies and gastro-intestinal nematodes on caribou and reindeer

reveal that those parasites can influence host body reserves and pregnancy rates (Albon *et al.* 2002; Hughes *et al.* 2009). Warble fly parasites reduce foraging time when caribou try to avoid the adult insects. Female flies lay their eggs on the caribou (Witter 2010; Witter *et al.* 2012a). Once the bot and warble fly (oestrid flies) eggs hatch, the caribou host then incurs the protein costs of the immune responses and the growth and maintenance costs of the larvae (Thomas and Kiliaan 1990; Cuyler *et al.* 2012).

Some parasites, such as tapeworms and muscle worms, intimately link barren-ground caribou to their predators and may even modify caribou behaviour by increasing susceptibility to the predator, which increases the chances of the parasite completing its life cycle (Kutz *et al.* 2012). Wolves are the final host for some parasites, which they acquire by feeding on the intermediate host (e.g., caribou) (Rausch 2003). Wolves also hunt moose, which harbour a similar array of tapeworms in the NWT as barren-ground caribou (*Taenia hydatigena, T. krabbei, Echinococcus granulosus*) (Elkin pers. comm. 2012).

Although disease outbreaks rarely cause many deaths in barren-ground caribou, large mortality events have been reported. The blood parasite *Microfilaria setaria* was associated with the 1973-74 deaths of thousands of domestic reindeer in northern Finland as well as subsequent outbreaks in the region (Laaksonen *et al.* 2010).

Barren-ground caribou harbour a diverse array of gastro-intestinal nematodes and tapeworms, muscle and lung worms as well as blood parasites (Kutz *et al.* 2012), but their interrelationships are not well described or understood. Wild Svalbard reindeer reduce the risk of parasite transmission by foraging away from the vicinity of fecal pellets containing parasite eggs and larvae (Van de Waal *et al*. 2000). This behaviour may come at a cost of lost foraging time or additional energy expenditure. Folstad *et al.* (1991) suggests this as one reason why barren-ground caribou leave their calving grounds.

While individual herds have been sampled for some parasites, especially the more conspicuous ones (warbles (Witter 2010) and *Besnoitia* (Larter 1999) for example), detailed and systematic sampling is mostly lacking. Recently, the CircumArctic Rangifer Monitoring and Assessment Network (CARMA), in association with the University of Calgary's Faculty of Veterinary Medicine, tested field protocols for standardized monitoring of caribou and reindeer health. Between 2007 and 2010, a total of 544 caribou were sampled using standardized protocols from eight herds (Brook *et al.* 2009; Ducrocq *et al.* 2012; Kutz *et al.* 2012), to establish a baseline for parasite monitoring. Preliminary results suggest differences among herds and that current (2007-09) levels of diseases and parasites are relatively low (Kutz *et al.* 2012). Caribou collected in 2007-09 were part of the first systematic survey for Johne's disease (*Mycobacterium avium paratuberculosis* (MAP)) in caribou across a wide geographic range. NWT barren-ground caribou levels were less than 4% prevalence (Forde *et al.* 2012). MAP is economically important among domestic sheep and cattle because this bacterial disease can result in death (Forde *et al.* 2012).

Other bacterial diseases like brucellosis can cause lameness and affect reproductive rates. Brucellosis rates are generally low in barren-ground caribou across the NWT and NU (Elkin pers. comm. 2012). Larter and Nagy (1996) showed a 5% prevalence from blood samples of 42 Cape Bathurst caribou collected in 1995. Brucellosis is one of the diseases that is routinely tested for in blood samples. Contrastingly, foot rot (another bacterial disease) also causes lameness (Handeland *et al.* 2010), but is diagnosed based on sighting lame caribou and testing hoof samples. The disease is characterized by swollen feet and lameness and is seen in late summer. Warm temperatures and muddy ground constitute favourable conditions for this soil-borne bacterium, which enters the foot through minor abrasions. This may be why sharp gravel on roads is considered to be a pre-disposing factor (Radostits *et al.* 2007 *in* Handeland *et al.* 2010). The percent of lame Bathurst caribou seen during fall sex and age composition counts was higher in 2001 (0.03%; n = 6,122) than in 2000 (0%; n = 4,695) and 2004 (<0.01%; n = 12,444). In 2001, foot rot was diagnosed on the Bathurst late summer range (Gunn *et al.* 2005a).

Trends in most parasites are unknown in the NWT. An exception is warble flies, since the larvae are obvious as they grow under the skin along the caribou's back in late winter. The level of infestation is partly determined by weather and varies among herds and among years; males and calves tend to have proportionally more larvae (Thomas and Kiliaan 1990; Cuyler *et al.* 2012). Not only are the larvae easy to count, but the adult flies are active only when the temperatures and wind speed are suitable. This means that an index can be calculated to determine likely conditions for warble fly harassment. In summer 2004, the severity of warble fly harassment was relatively high on the Bathurst herd's range; in the subsequent winter 163 caribou harvested from this herd all had warbles (Gunn 2013). Of the relatively few males harvested, 46% were classified as having high infestations of warbles while only 5% of the females had warble numbers in the high category. The warble fly activity index for the summer range of the Bathurst herd shows a significant increase as the summers became warmer, especially after the early 1980s (Fig. 9, p. 122; Gunn 2013).

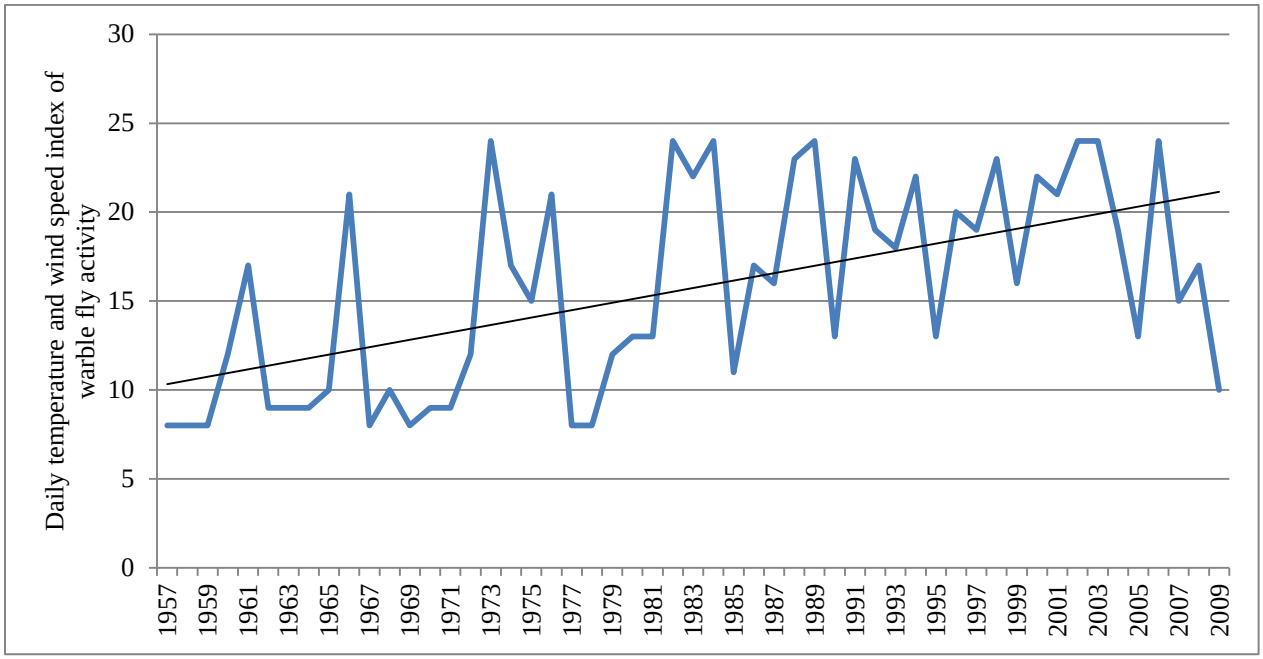


Figure 9. Trend in warble fly activity index and mosquito intensity index based on 1957-2009 daily temperature and wind speed from Lupin weather station on the range of the Bathurst herd (reproduced from Gunn 2013).

The increase in community-based sampling, such as the Sahtú region's caribou health program, has increased both interest and opportunities for the collection of baseline information (Brook *et al.* 2009) and is leading to innovative and low cost approaches to measuring trends in diseases (Curry *et al.* 2011) and health (Wu *et al.* 2012). Wu *et al.* (2012) found that lesions on caribou teeth are a permanent record of physiological stress for which the timing (year) can be determined (from aging the tooth). This is important because it also relates to monitoring age structure.

STATE AND TRENDS

Population

Abundance

The size of barren-ground caribou herds changes over periods that span decades (Morneau and Payette 2000; Zalatan *et al.* 2006). The most recent estimate of population size for the Porcupine herd is 197,228 (2013) (Table 2, p. 123). The remaining herds considered in this report are estimated et roughly 530,000 barren-ground caribou in, or adjacent to, the NWT (Table 2, p. 123). Removing the estimates for the Qamanirjuaq herds, which does not often occur in the NWT, leaves approximately 270,000 barren-ground caribou occurring in the NWT as of 2015.

Table 2. Most recent estimates of size of barren-ground caribou herds that regularly spend at least a portion of their time in the NWT. Numbers provided are for non-calf animals except the Porcupine herd, which includes calves.

Herd	Year	Estimate	95% CI or SE	Survey type	Reference
Porcupine	2013	197,228	28,561 CI	Post-calving photo census	Caikoski 2015
Tuktoyaktuk Pen.	2015	1,701	n/a	Post-calving photo census	Davison pers. comm. 2017
Cape Bathurst	2015	2,259	84 CI	Post-calving photo census	Davison pers. comm. 2017
Bluenose-West	2015	15,274	1,370 CI	Post-calving photo census	Davison pers. comm. 2017
Bluenose-East	2015	38,592	4,733 CI	Calving ground photo census	Boulanger *et al.* 2016b
Bathurst	2015	19,769	7,420 CI	Calving ground photo census	Boulanger *et al.* 2016a
Ahiak	2011	71,340	3,882 SE	Strip transect visual census	Campbell *et al*. 2012a
Beverly South[9]	2011	Densities of breeding females too low to survey further	n/a	Calving ground visual census	Campbell *et al*. 2012a
Beverly North	2011	124,189	13,996 SE	Calving ground visual census	Campbell *et al.* 2012a
Qamanirjuaq	2014	264,718	44,084 CI	Calving ground photo census	Campbell et al. 2015

The two main methods used to estimate the number of caribou in NWT barren-ground caribou herds are either a sample count on the calving grounds or an estimate based on photographed counts of post-calving aggregations (Heard 1985; Heard and Williams 1990b; Adamczewski *et al.* 2014). NWT surveys are used to estimate trend and relative herd size.

Herd size for the Bathurst, Beverly, Ahiak, and Qamanirjuaq herds is estimated from stratified calving ground strip transect surveys. Visual counting was used up to the early 1980s, after which continuous strip transect photography replaced visual counting to increase accuracy, except when the females are relatively dispersed or at low densities. The surveys are timed for close to the peak of calving when female movement rates are minimized. Reconnaissance surveys are flown to map the distribution of breeding females (females with calves or females with hard antlers that are not shed until a few days after birth). The flight lines extend well beyond the distribution of breeding females to ensure that no areas of calving are missed. The location and movements of collared individuals support mapping the caribou distribution. Based on the pattern of density and composition, the distribution of breeding females is then stratified into high, medium and low density strata. All high density strata and most or all medium density strata are surveyed by a specialised photo plane flying at a relatively high altitude and 20-40% coverage, although there are some exceptions (there was over 70% coverage for the Bathurst herd in 2012 and over 50% covered for both the Bathurst and Bluenose-East herds in 2015; Croft

[9] See *Systematic/taxonomic/naming clarifications* (p. 93) for more information on Beverly herd naming clarifications.

pers. comm. 2015). Low density strata are surveyed using visual surveys and the same methodology as the reconnaissance surveys, but at roughly 20% coverage.

The proportion of 1+ year old caribou that are breeding females is determined from surveys conducted immediately after the photographic survey to estimate the proportions of breeding and non-breeding caribou based on antlers, calves and distended udders. The number of 1+ year old caribou is counted on the photos and combined with the visual counts and the proportion of breeding females from the composition surveys to estimate the number of breeding females on the calving ground. Herd size is then estimated by extrapolating from the estimate of breeding females by adjusting for non-pregnant females (using an estimate of herd pregnancy rate) and by adjusting for males based on one or more estimates of sex ratio obtained from fall composition counts.

Post-calving aggregation photo surveys were developed in Alaska during the 1960s and were first applied to the Bluenose herd in 1986 and 1987 (McLean and Russell 1992). The post-calving aggregation surveys are possible because all sex and age classes of a herd form large aggregations in late June through July in response to insect harassment (Valkenburg *et al.* 1985). This technique requires relatively large numbers of satellite or VHF collars to locate the aggregations. Caribou movements and group size are monitored using collars and reconnaissance flights, and when the caribou are aggregating, the groups are located from the collared caribou and photographed using hand-held or mounted cameras from fixed-wing aircraft. A 20% overlap between successive frames provides full coverage of the aggregation. The search effort is to ensure that a high proportion of caribou (>90%) are found in groups with at least one satellite collar, and large groups usually have several collars. The number of caribou on either printed or digital photographs is counted, although methods for this have varied.

As the calving ground strip transect survey methodology only samples a portion of the herd, the precision of the estimate is measured by its variance or uncertainty around the mean (often provided as 95% confidence intervals or standard errors). The precision can be increased by reducing variations in density within a stratum (Mowat and Boulanger 2000). Considerable effort has been applied to increasing precision and how the estimates can be used to statistically determine trends in the number of breeding females and herd size (Nishi *et al.* 2007, 2010).

Post-calving photo surveys were initially designed as total counts and as such, did not have estimated confidence intervals; caribou observed outside of photographed groups, often through visual counts, were simply added to the total. Counts from post-calving photo surveys done on the winter ranges of the Cape Bathurst, Bluenose-West, Bluenose-East and Tuktoyaktuk Peninsula herds may include confidence intervals, which are calculated from the total number of radio-collared caribou available, and the number of caribou and number of radio-collared caribou in all aggregations observed during the survey (Nagy and Johnson 2006). A Lincoln-Petersen based estimator has been used in the NWT to estimate caribou groups missed, based on the number of collars found in photographed groups as a proportion of the collars available (e.g.,

Nagy and Johnson 2006). The method depends first on when the caribou aggregate (which is weather dependent and by no means predictable), on the collared caribou being representative of the entire herd, locating a high proportion of the collared caribou and of caribou aggregations, and accuracy in counting the caribou. These uncertainties have at times caused difficulties in estimating the trend in abundance. Nagy (2009a) provided a detailed appraisal of post-calving aggregation surveys for Cape Bathurst, Bluenose-West and Bluenose-East herds.

More recently, estimation of herd size from post-calving surveys has been carried out using calculations described by Rivest *et al.* (1998), initially in Quebec for the George and Leaf River herds and more recently for the migratory tundra herds in Alaska (Porcupine, Teshekpuk, Central Arctic and Western Arctic; Alaska Department of Fish and Game 2011). This method provides a more robust way of calculating likely herd size and variance around the estimate. The estimation uses photographed groups with at least one collar as samples of the herd (see Adamczewski *et al*. 2014 for a synopsis). Rivest *et al*. (1998) estimates back-calculated for the Western Arctic herd suggested that where collar numbers are sufficient (usually 100+ in the Western Arctic herd) and survey coverage is high, total counts and Rivest *et al.* (1998) estimates are very similar because the likelihood of substantial portions of the herd being missed is very low (Alaska Department of Fish and Game 2011). Rivest-based estimates were first calculated for an NWT post-calving survey in 2010 for the Bluenose-East herd (Adamczewski *et al*. 2014) and the GNWT is assessing a transition to Rivest-based population estimates from post-calving surveys.

Direct comparisons of calving photo and post-calving surveys have only been carried out twice, with paired surveys of the George River herd of woodland caribou in Quebec/Labrador in 1993 (Couturier *et al.* 1996) and the Bluenose-East herd in 2010 (Adamczewski *et al.* 2014). The 1993 George River surveys indicated similar results between the June calving ground census (583,800 ± 33.8% caribou at least one year old) and July post-calving survey (608,400 ± 14.4%). The June 2010 calving ground survey for the Bluenose-East herd led to an estimate of 114,472 ± 6,908 (SE) caribou at least one year old, which was similar to an estimate of 122,697 ± 16,202 (SE) based on the post-calving survey in July of that year (Adamczewski *et al.* 2014).

Globally, barren-ground caribou extend from Alaska to western Greenland. This includes the nine NWT herds considered in this report, as well as herds in Alaska, Nunavut, and western Greenland. Caribou in Russia are considered to be a different subspecies (*Rangifer tarandus sibiricus*) and caribou in Quebec and Labrador, although displaying similar migratory behaviour, are considered to be phylogenetically distinct from barren-ground caribou (COSEWIC 2016). Including the Porcupine herd, there are roughly 750,000 barren-ground caribou in Alaska (Alaska Department of Fish and Game 2016). Across Canada, barren-ground caribou numbered approximately 800,000 in 2015 (COSEWIC 2016), while in Greenland, barren-ground caribou total approximately 73,430 (Gunn 2016).Given approximately 730,000 barren-ground caribou within herds that touch upon the NWT, the NWT could be considered home to approximately 45% of the global population.

Trends and fluctuations

The NWT Species at Risk Committee's criteria for considering population declines in the assessment of status follow the recommendation of the International Union for the Conservation of Nature (IUCN) to consider declines over three generations or 10 years, whichever is longer (IUCN 2001; SARC 2015). This equates to roughly 25 years given the estimation of an 8-9 year generation time (based on adult survival and fecundity; Boulanger pers. comm. 2011). Although standardization of monitoring methods started in the mid-1980s (Heard and Williams 1990b, 1991), the length of comprehensive demographic monitoring (population and other surveys) has varied among herds and monitoring of vital rates (such as adult and calf survival) has been limited.

There is evidence for some barren-ground caribou herds that abundance fluctuates at relatively regular intervals but over varying timescales, suggesting a cyclic dynamic (Morneau and Payette 2000; Gunn 2003; Zalatan *et al.* 2006). Advantages of 'safety in numbers' for animals that frequently occur in densely packed aggregations include predator-swamping (high population densities reduce the probability of an individual animal being eaten) and increased foraging (likely through reduced need to remain vigilant because of vigilance by conspecifics) (Skoog 1968; Bergerud *et al.* 2008; Gunn *et al.* 2012).

Barren-ground caribou numbers were generally low from the 1950s to the 1970s, when numbers began to increase (Kelsall 1968; Bergerud *et al.* 2008). By the mid-1980s to mid-1990s (timing varied among herds), the population was peaking in abundance and then declines were underway during the late 1990s into the 2000s. Numbers stabilized for some herds between 2009-2012 but the declines of the 1990s-2000s (70-90%) have continued through 2012-2015 and most NWT herds are either declining further or stable at low numbers. As the exact extent of the low numbers in the 1950s to 1970s was unmeasured at the time, comparisons with the current phase of low numbers are not possible. It is also unknown whether the current low numbers are less than historic minima. The frequency of hoof scars on spruce roots adjusted for the loss of older trees can provide a measure of past population abundance (Zalatan *et al.* 2006). Spruce roots collected on the Beverly range in 2002 suggested the frequency of hoof scars was below the historic minimum in the 1920s (Zalatan *et al.* 2006). Roots collected in 2002 on the Bathurst herd's range was prior to the accelerated decline in the herd, precluding comparison with the historic low in the 1920s. A reconstruction of the George River herd's abundance from 1800 to the early 2000s suggested that maximum and minimum numbers varied over time and that length of time between peaks also varied (Bergerud *et al.* 2008).

The causes of cyclic changes in abundance are complex and driven by climate interacting with forage availability, predation, harvest and pathogens (Zalatan *et al.* 2006; Bergerud *et al.* 2008). Harvest and predation likely play a stronger role in the later decline phase of the cycle (Bergerud *et al.* 2008; Boulanger *et al.* 2011). The likely causes of declines can only be determined through monitoring of vital rates and environmental conditions during the peak population size as well as

during the declines.

The frequency of sampling and certainty of information is sufficient to measure trends over the previous 25 years for the western NWT herds and the Bathurst herd. Post-calving aggregation photography for the Cape Bathurst, Bluenose-West and Bluenose-East herds are reported in considerable detail to allow assessment of the data (Nagy 2009a, b; Nagy and Johnson 2006; Nagy and Tracz 2006; Nagy *et al.* 2008; Nagy *et al.* 2009). Calving ground photographic censuses for the Bathurst herd between 1986-2009 included assessments of uncertainties in the data and estimates of the trends in the number of breeding females (Gunn *et al.* 1997, 2005b; Nishi *et al.* 2007, 2010). Trends for the more eastern herds shared with NU and Saskatchewan are uncertain. Sampling frequency for the Beverly and Ahiak herds has been low since the mid-1990s. Photographic and visual surveys of the Beverly calving grounds have permitted estimates of herd size and calving ground density from 1987-2002 (Williams 1995; Johnson and Mulders 2009). Between 2007 and 2011, aerial surveys of the traditional Beverly calving grounds were undertaken but extremely low numbers precluded estimating numbers (Johnson and Williams 2008; Johnson *et al.* 2009, Campbell *et al.* 2012a).

For the Ahiak herd (which calves along the Queen Maud Gulf coast), Gunn *et al.* (2000) described visual systematic survey estimates of caribou on the calving grounds in 1986 and 1996. In 2006, the survey emphasis switched to measuring the distribution and density on the calving grounds. Johnson *et al.* (2008) reported on the sampling effort and observations for surveys of the Ahiak calving ground in 2006, 2007 and 2008; the surveys reported densities but did not derive herd estimates. Campbell *et al.* (2012a) estimated herd size for caribou calving along the length of the Queen Maud Gulf coast in 2011.

Sampling for vital rates including calf survival, pregnancy rates, adult survival and harvest has been inconsistent among herds and there is limited current information (since 2005). Most is reported as summaries, limiting any assessment of trends. Adult sex ratio and calf survival (reported as a ratio), can be influenced by changes in either the numerator or denominator of the ratio (Caughley 1974). The assumptions associated with these ratios is often overlooked. Boulanger *et al.* (2011) indicated that changes in adult female survival of the Bathurst herd likely inflated the estimate of calf survival during a few years of low female survival.

Nagy and Johnson (2007a and b) detailed the mapping and sampling effort for measuring calf production on the calving grounds of the Cape Bathurst and Bluenose-West herds, which were used to develop a population model to examine the demographic mechanisms underlying the decline of the Bathurst herd (Boulanger *et al.* 2011). The sampling efforts and representation of the sampling for those vital rates are reported up until 2005 (Gunn *et al.* 2005a, 2013a).

Table 3. Simulated population change for seven subpopulations of barren-ground caribou and the summed change for all subpopulations (total population). The Monte Carlo analysis applied the exponential model and a generation time of nine years. Percentage population change was calculated using the mean simulated estimates for 1989 and 2016 and the 95th (5th percentile population estimate in 1989 versus 95th percentile 2016) and 5th percentile (95th percentile population estimate in 1989 versus 5th percentile 2016) of the project population estimates. Table reproduced from COSEWIC (2016).

Subpopulation	Mean % population change	95% Upper Confidence Interval	95% Lower Confidence Interval
Porcupine	31%	132%	-31%
Cape Bathurst	-85%	-78%	-90%
Bluenose-West	-87%	-81%	-92%
Bluenose-East	-89%	-66%	-96%
Bathurst	-96%	-93%	-97%
Southampton[10]	113%	232%	31%
Qamanirjuaq	-4%	48%	-39%
Total population	**-54%**	**-17%**	**-76%**

Porcupine herd

Calf productivity and survival in the Porcupine herd is monitored annually, and abundance estimates date back to the early 1970s. Herd numbers were estimated using post-calving photographic census methods. Numbers increased through the 1980s to peak at 178,000 in 1989, followed by a slow decline (3.5% annually) to 2001 (Fig. 10, p. 129). Post-calving surveys were attempted annually from 2003 to 2009 but failed due to unsuitable conditions for aggregations and photography. The 2010 survey was successful, estimating 169,000 (153,493-184,403; 95% CI) caribou (Caikoski 2011). A subsequent survey in 2013 estimated 197,200 (168,667–225,789; 95% CI) (Caikoski 2015), the highest estimate since standardized population estimates began in the early 1970s. The Porcupine herd has shown an increase of 31% over three caribou generations (1989-2016) (Table 3, above) (COSEWIC 2016).

[10] Not being considered in this assessment of barren-ground caribou.

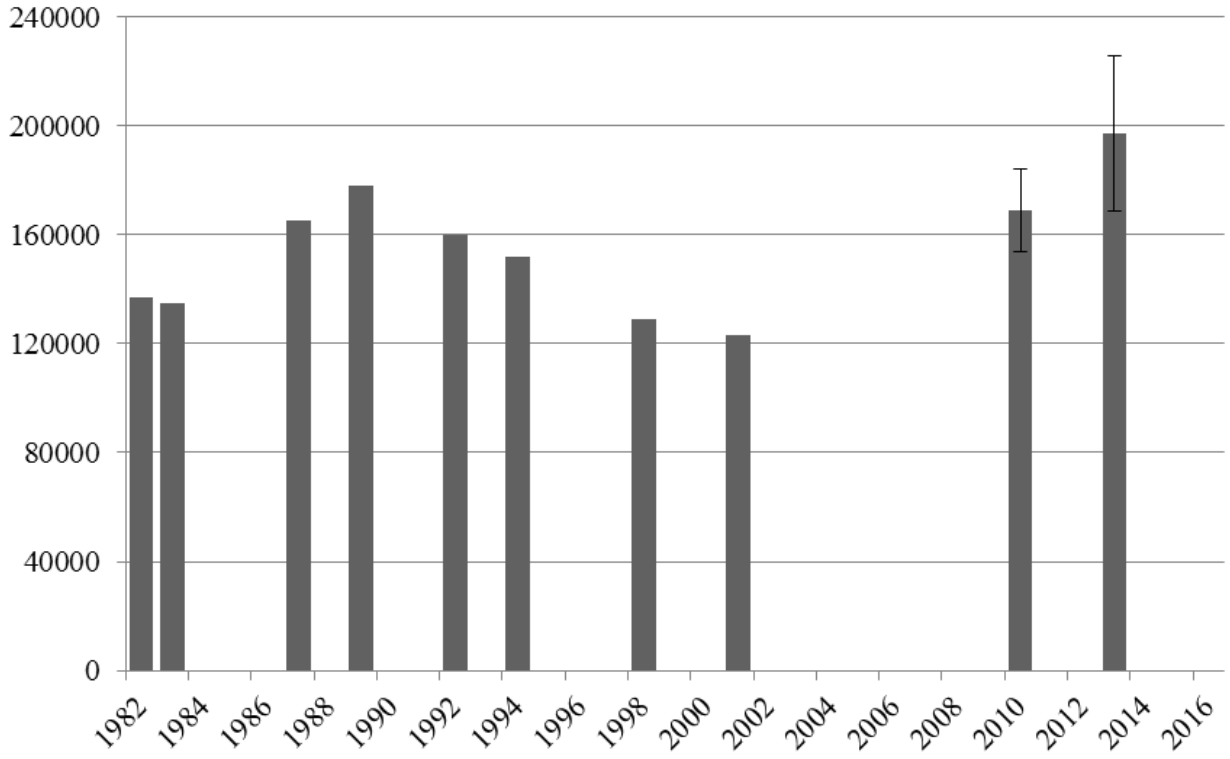


Figure 10. Porcupine herd estimates based on post-calving photo census (Caikoski 2011, 2015). Estimates include calves. Error bars where available are 95% CI.

Since 2001, Porcupine herd birth rates ($\bar{x}$ = 0.81; range 0.64-0.88), June calf survival ($\bar{x}$ = 0.73; range 0.57-0.83) and post-calving survival ($\bar{x}$ = 0.86; range 0.75-0.92) have remained relatively strong in most years (Caikoski 2011; based on total counts). Fewer data were available for March calf:female ratios ($\bar{x}$ = 31:100; range 20-39:100). Annual Alaskan harvest estimates in the past decade have ranged from 200-700 caribou (Caikoski 2011); Canadian harvest of Porcupine caribou was 2,920 in 2013-14 (Porcupine Caribou Management Board [PCMB] 2016), with an average annual Canadian harvest estimated at approximately 4,000/year (PCMB 2010a).

Tuktoyaktuk Peninsula herd

The Tuktoyaktuk Peninsula herd was only recognized in 2005, therefore long-term trends are unavailable. Domestic reindeer inhabited the Tuktoyaktuk Peninsula for most of the 21st century, but the private herd was moved away in about 2001 (Branigan 2005). A systematic aerial count in September 2005 estimated 2,700 reindeer/caribou (including calves), of which about 20% were domesticated reindeer (Branigan 2005). A post-calving photographic survey in July 2006 estimated 2,866 non-calf reindeer/caribou (Nagy and Johnson 2006). Subsequent surveys in July 2009 and July 2012 estimated 2,753 ± 276 (95% CI) (Davison *et al.* 2014), and 2,192 ± 178 (95% CI) reindeer/caribou (Davison pers. comm. 2012), respectively. The most recent survey, done in 2015, showed an estimate of 1,701, with no variance as all 26 collars were found

(Davison pers. comm. 2017) (Fig. 11, below). Thus, numbers were relatively stable between 2005 and 2009, declining to 2012 and declining further to 2015. Late winter calf survival from 2008 to 2011 was high; mortality, including harvest, is unknown (Davison and Branigan 2011).

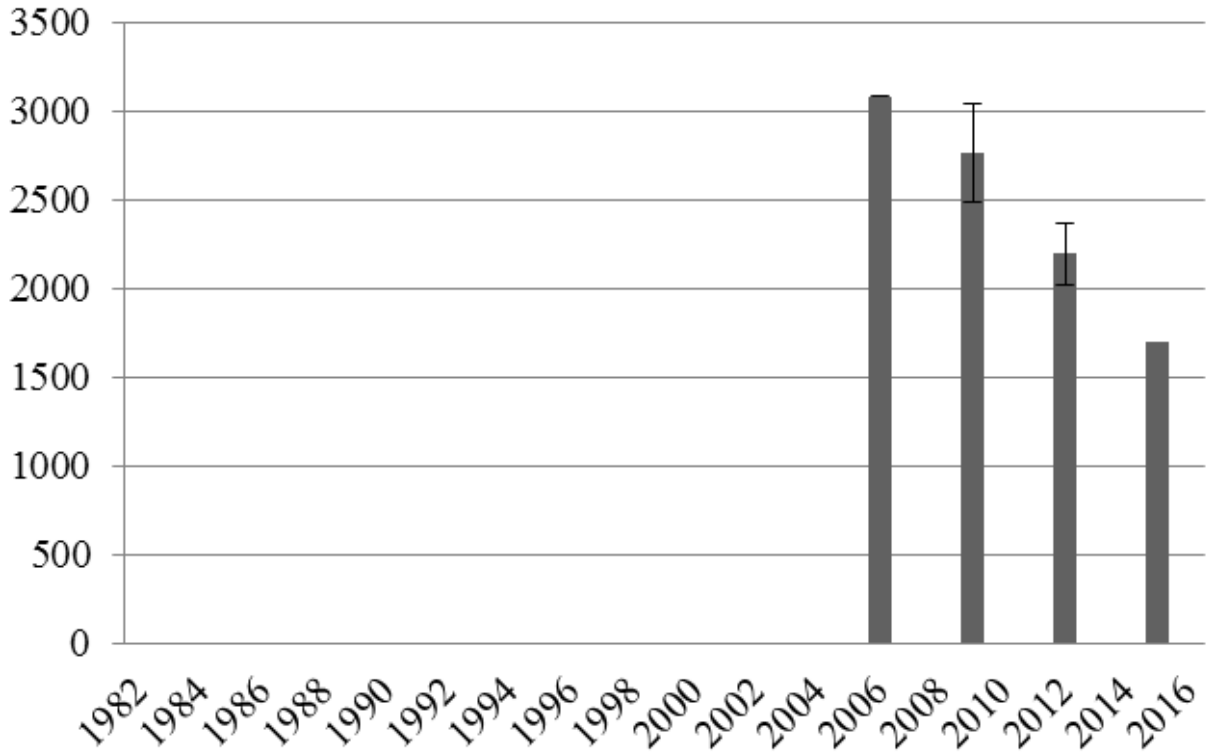


Figure 11. Tuktoyaktuk Peninsula herd population estimates, all from post-calving photographic surveys (Nagy and Johnson 2006; Davison pers. comm. 2012; Davison *et al.* 2014; Davison pers. comm. 2017). Error bars where available are 95% CI.

Cape Bathurst herd

The Cape Bathurst herd population was high in at least 1992 followed by a significant decline through 2006, and was then roughly stable between 2006-2015 (Fig. 12, p. 131). Early population estimates were based on calving ground surveys, which combined the Cape Bathurst, Bluenose-West and Bluenose-East herds (Hawley *et al.* 1979). The method changed to post-calving aggregation counts in 1987 and 1992. Nagy (2009a) re-analyzed the surveys to produce herd-specific counts using a Lincoln-Petersen estimator. The 1992 estimate was 19,300 ± 5,400 (95% CI) and declined to about 11,100 ± 1,800 in 2000, 2,430 ± 260 in 2005, reaching a low of 1,820 ± 150 in 2006 (mean annual 17% exponential rate of decline; Nagy and Johnson 2006). In 2009, the estimate was 1,934 ± 350 caribou (Davison *et al.* 2014), in 2012 it was 2,427 ± 0 caribou (all collars accounted for in aggregations observed; Davison 2015), and in 2015, the estimate was 2,259 ± 84 caribou (Davison pers. comm. 2017). The Cape Bathurst herd has shown a decrease of 85% over three caribou generations (1989-2016) (Table 3, p. 128)

(COSEWIC 2016).

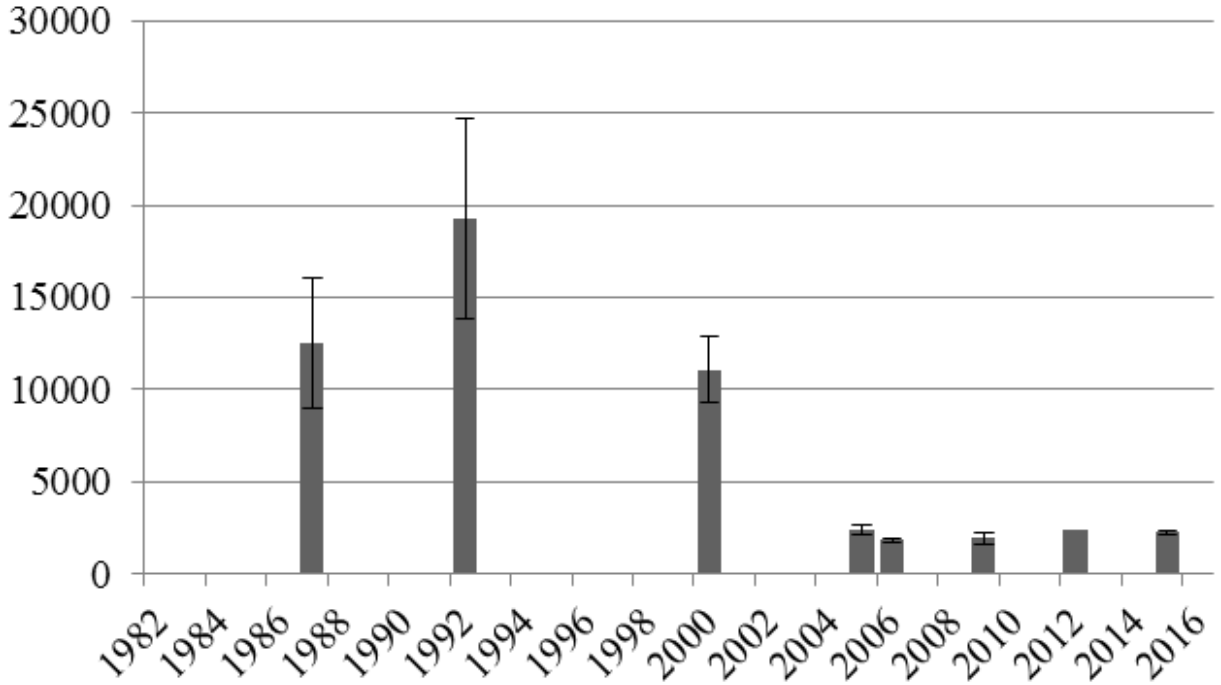


Figure 12. Cape Bathurst herd population estimates, all from post-calving aggregation counts adjusted for collars observed compared to number known to be active during the survey (Nagy and Johnson 2006; Nagy 2009a; Davison *et al.* 2014; Davison 2015; Davison pers. comm. 2017). Estimates from 1986 and 1992 based on reanalysis of "Bluenose" photo survey data. Error bars where available are 95% CI.

Pregnancy rates of Cape Bathurst caribou sampled in 1995 were high (96%; n = 47 adult females; Larter and Nagy 1996). Late winter calf survival based on calf:female ratios was low in 2007 (22 calves:100 females), higher for 2008-11 (42-49:100 females), and low again in 2013 (26 calves:100 females) (Davison 2015). Adult survival is unrecorded, although harvest rates were relatively high during the decline (estimated at approximately 500 caribou, mostly females, in 2005; Nagy 2005). In 2007, the harvest was closed based on recommendations from the Wildlife Management Advisory Council (NWT) (WMAC (NWT)) and Gwich'in Renewable Resources Board (GRRB) (Davison 2015).

Bluenose-West herd

Similar to Cape Bathurst, Bluenose-West numbers likely peaked in 1992 based on a count of 112,400 ± 25,600 (95% CI) caribou (Lincoln-Petersen estimator) and then declined through 2006. As with the Cape Bathurst herd, these early population estimates were derived from surveys that combined the Cape Bathurst, Bluenose-West, and Bluenose-East herds (Hawley *et al*. 1979). Nagy (2009a) re-analyzed the surveys to provide herd-specific counts. Estimates were 76,400 ± 14,300 in 2000, and 20,800 ± 2,040 in 2005 (Nagy and Johnson 2006; Nagy 2009a) and 18,050 ± 527 in 2006 (Nagy and Johnson 2006) (Fig. 13, below). Surveys were also conducted in 2009 (17,900 ± 1,300 caribou; Davison *et al.* 2014), 2012 (20,465 ± 3,489 caribou; Davison 2015), and 2015 (15,274 ± 1,370; Davison pers. comm. 2017). The Bluenose-West herd has shown a decrease of 87% over three caribou generations (1989-2016) (Table 3, p. 128) (COSEWIC 2016).

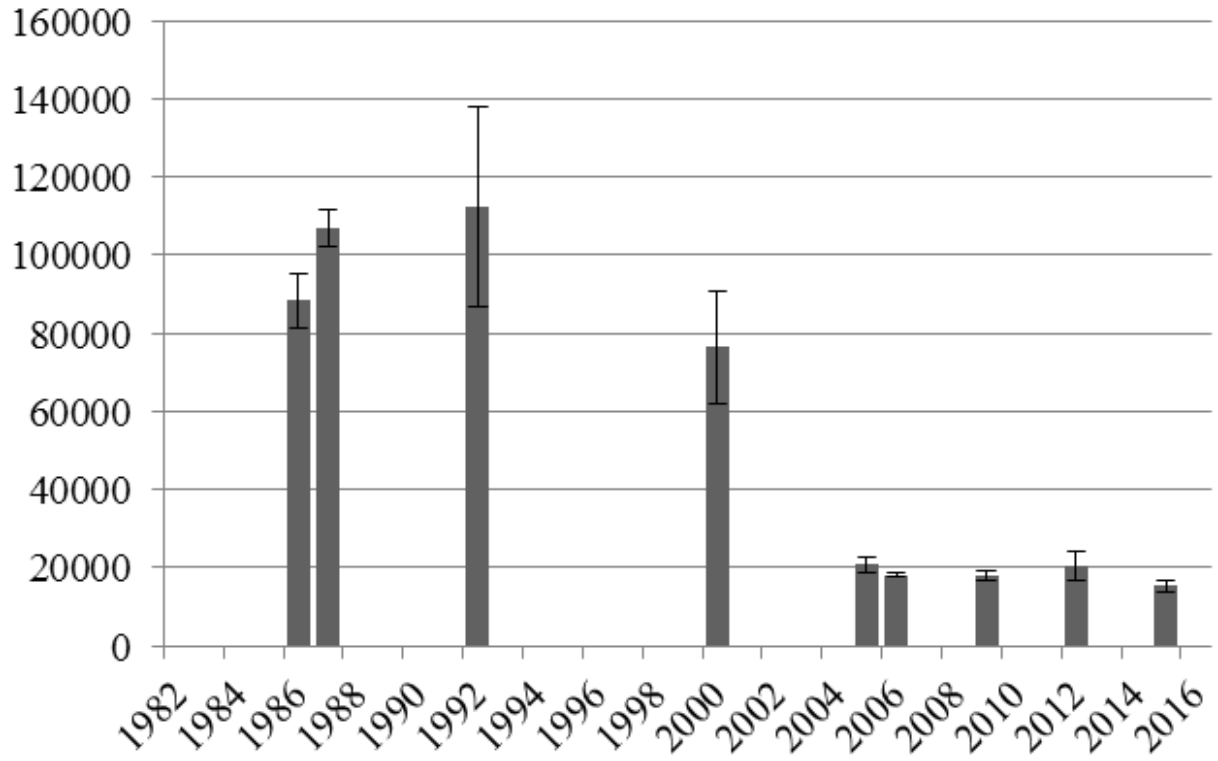


Figure 13. Bluenose-West herd population estimates, all from post-calving aggregation counts (Nagy and Johnson 2006; Nagy 2009a; Davison *et al*. 2014; Davison 2015; Davison pers. comm. 2017). Estimates from 1986, 1987 and 1992 based on reanalysis of "Bluenose" photo survey data. Error bars where available are 95% CI.

Late winter calf survival was low in 2007 (26 calves:100 females), higher in 2008 and 2009 (42-44 calves:100 females) and lower in 2011 (32 calves:100 females) (Davison 2015). A fall composition survey in 2009 estimated 70 males:100 females (Davison 2015). The Bluenose-West herd currently has a total allowable harvest of approximately 720 caribou with an 80% male ratio, based on the recommendations of WMAC (NWT), the GRRB, and the Sahtú

Renewable Resources Board (SRRB).

Bluenose-East herd

As with the Cape Bathurst and Bluenose-West herds, early population estimates were based on calving ground surveys, which combined the Cape Bathurst, Bluenose-West and Bluenose-East herds (Hawley *et al.* 1979). Although pre-2000 survey data was re-analyzed to provide herd-specific population estimates, there were ultimately too few collars within the range of the Bluenose-East herd to produce credible population estimates from this time (Advisory Committee for Cooperation on Wildlife Management [ACCWM] 2014). Based upon post-calving photo surveys, herd estimates were 104,000 ± 22,100 (95% CI; Patterson *et al*. 2004) in 2000, 70,100 ± 8,100 in 2005 (Nagy *et al*. 2008), and 66,800 ± 5,200 in 2006 (Nagy and Tracz 2006). The herd exhibited an annual rate of decline of 10% between 2000 and 2006 (Fig. 14, p. 134). A 2010 post-calving survey estimated 122,697 ± 16,202 (SE) (Adamczewski *et al.* 2014). Adamczewski (pers. comm. 2012) suggested the 2005 and 2006 estimates may have underestimated herd size because of poor aggregation of individuals during the surveys, making both the decline to 2006 and the subsequent increase to 2010 less steep than documented. A calving ground survey in 2013 estimated 68,300 ± 7,610 (SE), a substantial drop from the 2010 estimate (Adamczewski pers. comm. 2014). The estimated number of breeding females on the calving grounds also decreased from 51,757 ± 4,836 (SE) in 2010 to 34,470 ± 1,634 in 2013. The 2015 results of a calving ground photo survey show that the herd declined further, to 38,592 ± 4,733 (CI), along with a continued decline in the number of breeding females to 17,135 ± 4,363 (Boulanger *et al.* 2016b). The Bluenose-East herd has shown a decrease of 89% over three caribou generations (1989-2016) (Table 3, p. 128) (COSEWIC 2016).

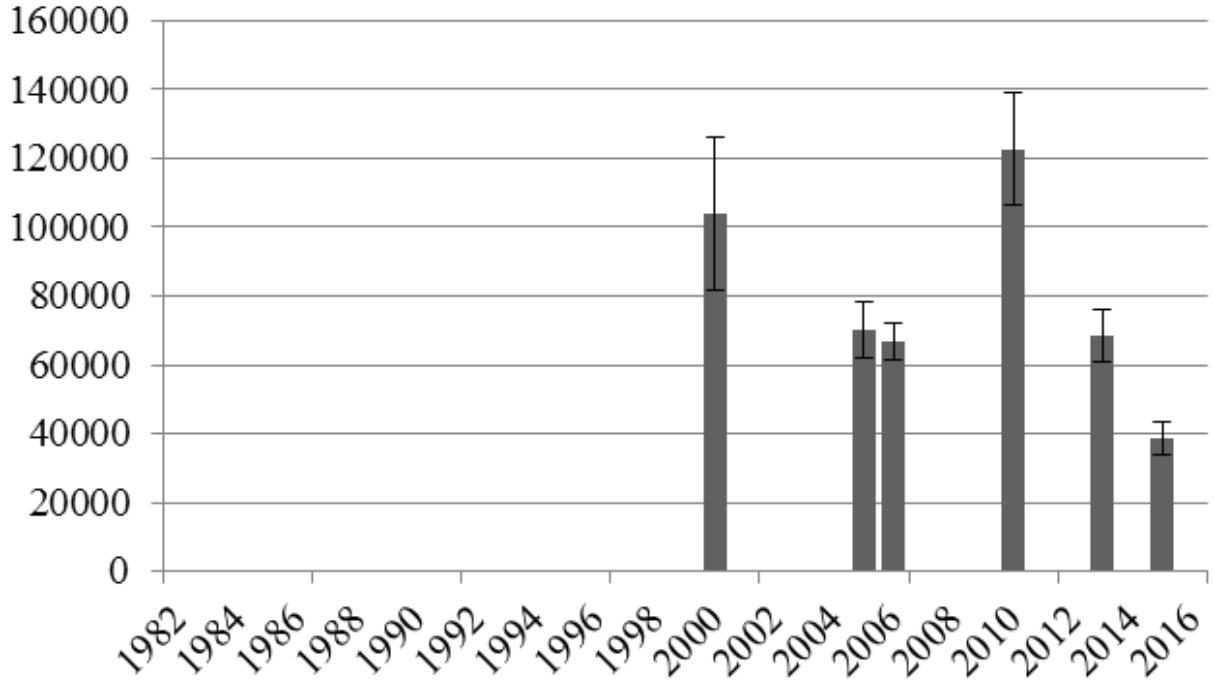


Figure 14. Bluenose-East herd population estimates from post-calving surveys 2000-2010 and from calving photo surveys in 2013 and 2015 (Patterson *et al*. 2004; Nagy and Tracz 2006; Nagy *et al.* 2008; Adamczewski pers. comm. 2013a; Adamczewski *et al*. 2014; Boulanger *et al.* 2016b). Error bars where available are 95% CI.

Davison (2015) suggested the increase between 2006 and 2010 was due to relatively high calf survival and a change in the herd's winter distribution, which reduced hunter harvest. Late winter calf:female ratios were low at 25 calves:100 females in 2001, high at 38 and 52 calves:100 females in 2004 and 2011, and low at 27 calves:100 females in 2012 (Davison 2015). The sex ratio in fall 2009 was 43 males:100 females (summarised *in* Davison 2015).

Adult survival of Bluenose-East caribou is unknown and although harvest information was collected between 1996 and 2001 in NU (Priest and Usher 2004), the annual totals also include harvest from the Dolphin and Union herd (Davison 2015). Harvest of the Bluenose-East herd increased after 2010 harvest restrictions were placed on the Bathurst herd (Adamczewski pers. comm. 2013a).

Bathurst herd

Bathurst numbers increased during the late-1970s and early-1980s, peaking during the mid-1980s to mid-1990s (Case *et al.* 1996; Gunn *et al.* 1997), and then declined through 2009 with a more rapid rate of decline (70%) between 2006 and 2009 (Nishi *et al.* 2007, 2010). The decline was supported by trends in calf survival (1985-2010). The decline appeared to cease between 2009 and 2012. The most recent (2015) population estimate is 19,769 ± 7,420 (CI; Boulanger *et al*. 2014) (Fig. 15, p. 135). The Bathurst herd has shown a decrease of 96% over three caribou

generations (1989-2016) (Table 3, p. 128) (COSEWIC 2016).

An indirect index, the frequency of hoof scars on spruce roots, suggested low caribou abundance during the 1920s, a high peak during the mid-1940s, and low abundance between the mid-1950s to 1970 (Zalatan *et al.* 2006). Visual surveys prior to 1982 are indicative of trend but likely under-estimated true herd size based on side-by-side comparisons of visual and photographic surveys (Heard and Jackson 1990).

The number of breeding females declined from 203,800 ± 25,600 (95% CI) caribou in 1986 to 55,593 ± 18,446 (95% CI) in 2006, 16,604 ± 4,451 (95% CI) in 2009, and 15,935 ± 2,926 (95% CI; Boulanger *et al.* 2014) in 2012. Results of the 2015 calving ground photo survey show that the number of breeding females in the herd dropped by nearly half between 2012 and 2015 to 8,075 ± 3,467 (95% CI) (Boulanger *et al.* 2016a).

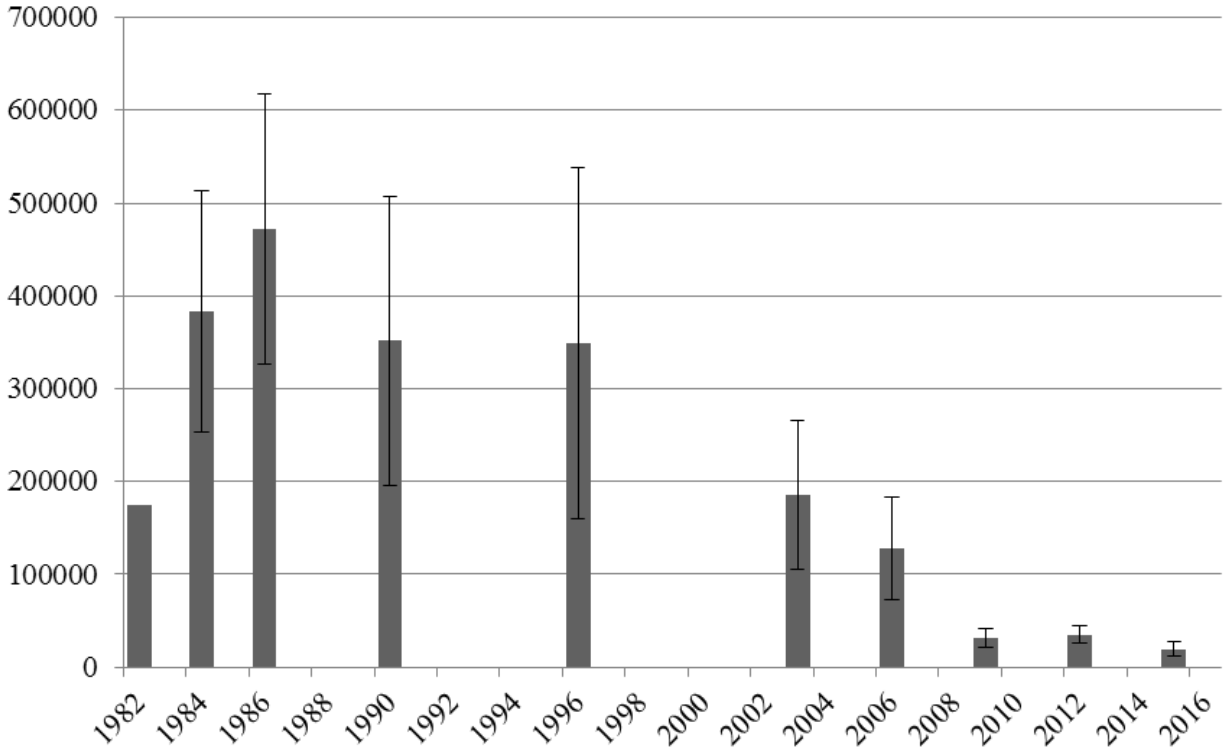


Figure 15. Bathurst herd population estimates (Case *et al*. 1996; Gunn *et al*. 1997; Nishi *et al*. 2007, 2010; Boulanger *et al*. 2014 ; Boulanger *et al*. 2016a). Estimates prior to 1982 were based on visual calving ground surveys, and after 1981 were based on calving ground photo surveys. Error bars where available are SE, escept for the 1995 survey result where error bar is 95% CI.

The trends in vital rates were toward reduced calf survival (1995-2005) and relatively low survival of adult females (2005-10). Because the sample size of the satellite-collared females was low, demographic modelling was used to estimate adult survival (see *Population dynamics*, p. 139; Boulanger *et al.* 2011). Low female survival rates very likely contributed to the herd's further decline 2012-2015. Calf:female ratios between 2012-2015 have been below 30 calves:

100 females in late winter, consistent with a declining trend. There is limited evidence of a low pregnancy rate, particularly in 2014-15 (the proportion of breeding females on the calving ground was 59% where about 80% would normally be expected) (Boulanger *et al*. 2016a).

Ahiak herd

The first systematic (stratified visual) calving survey for the Ahiak herd was in 1986 and covered a small area west of Adelaide Peninsula (Gunn *et al.* 2000). It estimated 11,265 ± 1,615 (SE) breeding female caribou on the calving ground. The next calving ground survey in 1996 was more extensive covering from Adelaide Peninsula to the region south of Kent Peninsula. The estimate was 83,134 ± 5,298 (SE) breeding female caribou on the calving ground (Gunn *et al.* 2000). Results from the 1996 survey were used to extrapolate the entire Ahiak herd estimate to approximately 200,000 caribou (Gunn *et al*. 2000). However, while the spacing of transects in 1986 was adequate, this was not the case in 1996, when the number of transects was very low and the southern boundary of the calving distribution was not well-defined.

No surveys were conducted from 1996 to 2005. Between 2006 and 2010, annual reconnaissance surveys were conducted along the coastal Queen Maud Gulf, including the Adelaide Peninsula, to map calving distribution and estimate densities. Calving densities were relatively stable between 1996 and 2007. Densities of 1+ year old caribou were 3.9 caribou/km^2 in 1996 (Gunn *et al.* 2000), 3.1 caribou/km^2 in 2006 and 3.0 caribou/km^2 in 2007 (Johnson *et al.* 2009). Density was lower in 2008 (1.1 caribou/km^2), which may have been a consequence of low pregnancy rates and/or non-breeding females being late to reach the calving grounds. An extensive survey of the central Queen Maud Gulf area to the northeast mainland was conducted in June 2011 (Campbell *et al.* 2012a) (Fig. 16, p. 137). The survey was used to estimate the number of adult caribou and yearlings in the Ahiak herd (as defined by Campbell *et al.* 2012a) at 71,340 ± 3,882 (SE). However, given the infrequent survey history, different interpretations of herd structure (see *Systematic/taxonomic/naming clarifications*, p. 93), and differences in location of the surveyed areas, the population trend for the Ahiak herd is uncertain.

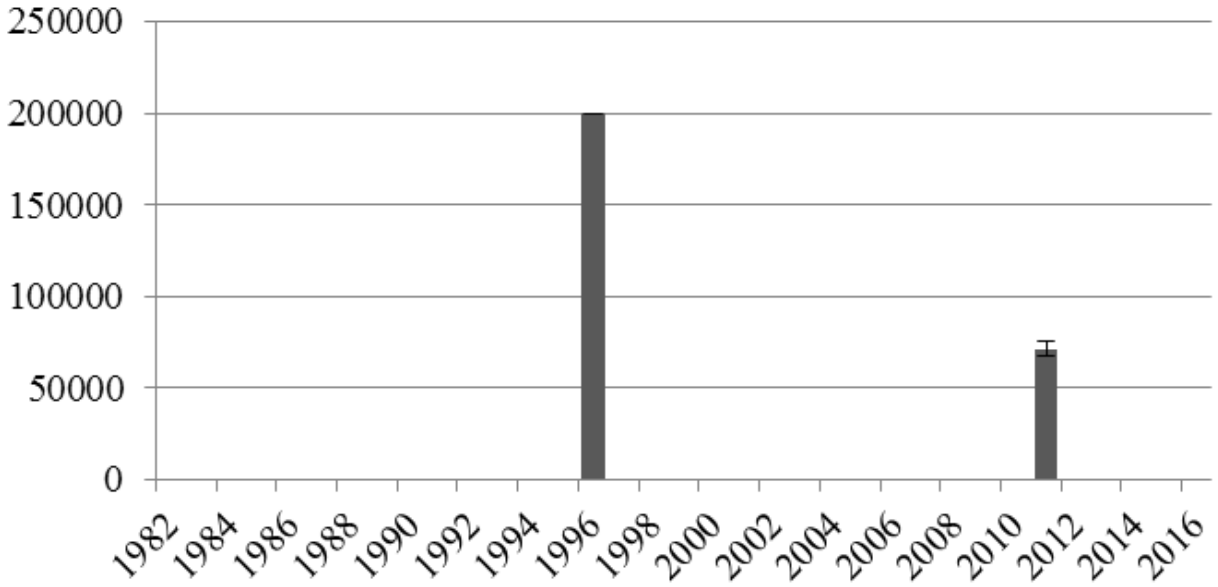


Figure 16. Ahiak herd population estimates (Gunn *et al.* 2000; Campbell *et al.* 2012a). Given infrequent survey history, different interpretations of herd structure, and differences in location of surveyed areas, population trends for the Ahiak herd are uncertain. Error bars where available are SE.

Beverly herd

The Beverly herd (as defined as calving in the traditional inland calving ground [Beverly South], see *Systematic/taxonomic/naming clarifications*, p. 93), was surveyed frequently between the early 1970s and mid-1990s. Population estimates, calf survival, adult survival and distribution suggest the herd was likely at a stable peak of about 264,000 and 276,000 between 1984 and 1994, respectively (Thomas and Barry 1990a and b; Heard and Williams 1990b, 1991; Williams 1995; Thomas 1998). Estimates of late winter calf survival halted in 1995. No information was collected until a systematic reconnaissance survey in June 2002 mapped calving distribution and densities (Johnson and Mulders 2009). The survey was not designed to estimate population size, but it revealed a small calving ground with low densities compared to 1994. Subsequently, four calving ground delineation surveys were conducted from 2006 to 2009 (Johnson and Williams 2008; Johnson *et al.* 2009; Adamczewski *et al.* 2015), which in 2009 reported few females, low calf:female ratios, and an extrapolation of numbers to likely less than 500 caribou on the traditional inland calving grounds. More recently, reconnaissance surveys conducted by Campbell *et al*. (2012a) showed densities of breeding females on the traditional inland calving ground to be too low to warrant further survey. This represents a decline of over 99% over three generations on the traditional inland calving ground. Adult female survival rates were very low for satellite-collared females with at least one year's history of calving on the traditional Beverly calving ground (Adamczewski *et al*. 2015). Based on aerial survey data, adult survival and calf production as well as analysis of telemetry data at the annual scale, the Beverly herd declined through the last half of the 1990s and the 2000s (Gunn *et al.* 2012 and 2013b; Adamczewski *et*

al. 2015).

Campbell *et al.* (2012a) estimated 124,189 (SE = 13,996; CV = 0.11) 1+ year old caribou for this population based on a calving ground survey along the central and western Queen Maud Gulf coast (Beverly North) in June 2011. Given the 1994 estimate of about 276,000 adults, the Beverly [North] herd is considered to have declined by 45% between 1994 and 2011 (Fig. 17, below).

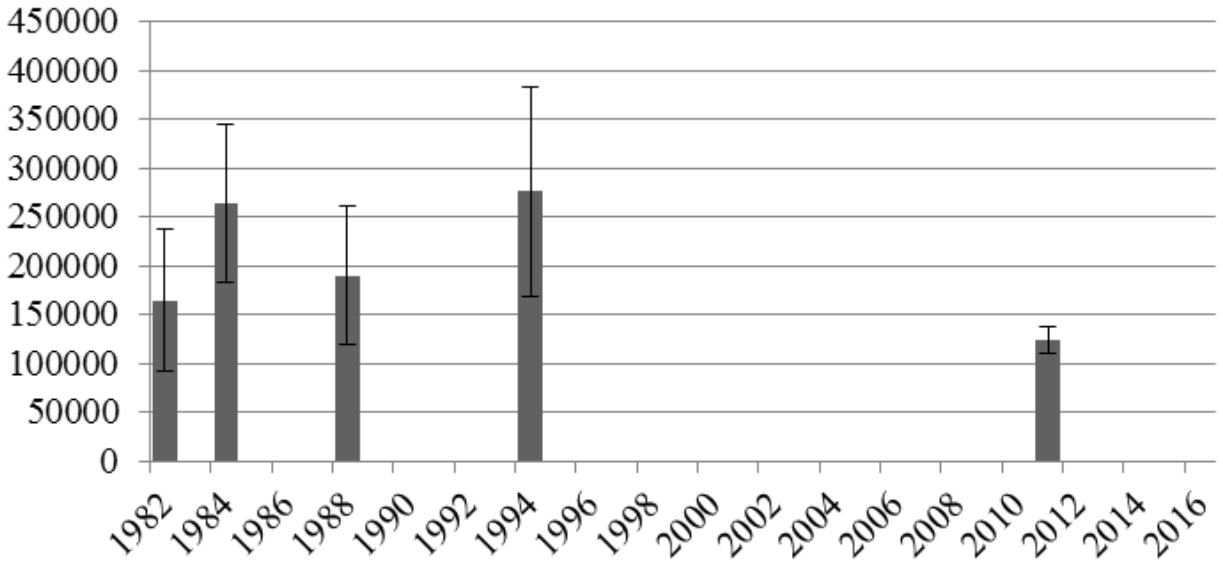


Figure 17. Beverly herd numbers as estimated from surveys (Thomas and Barry 1990a and b; Heard and Williams 1990b, 1991; Williams 1995; Thomas 1998). A survey conducted in 1993 is not shown in the figure due to low survey coverage (Williams 1995). The 2009 survey of the traditional inland calving ground (i.e., Beverly South) herd resulted in an extrapolation of likely less than 500 caribou and does not appear in the above histogram. 2011 shows herd numbers as estimated from surveys along the coastal Queen Maud Gulf (i.e., Beverly North) (Campbell *et al.* 2012a). Calving ground photo surveys were conducted after 1981. Error bars where available are SE.

Qamanirjuaq herd

Surveys of the Qamanirjuaq herd date back to 1950 (Banfield 1954 *in* Heard and Calef 1986), with estimates of 120,000 in 1950 (Banfield 1954 *in* Heard and Calef 1986), 149,000 in 1955 (Loughrey unpubl. data *in* Heard and Calef 1986), and 63,000 in 1968 (Parker 1972 *in* Heard and Calef 1986). Between 1980-1982, a large, unexpected increase in herd size was observed. This increase was attributed to immigration (from northeastern mainland NWT), increased birth rates, and increased survival rates (Heard and Calef 1986; Heard and Jackson 1990). Between 1983 and 1985, Heard and Calef (1986) reported population estimates between 126,000-320,000. Post-calving photo surveys in July 1987 resulted in an estimate of between 230,000-260,000 Qamanirjuaq caribou; however, given the absence of males in this sample, it was thought to be biased low. A more realistic estimate is 270,000-300,000 (Russell 1990). Calving ground photo surveys in June 1988 resulted in a population estimate of approximately 220,000 ± 72,000 SE, which, together with estimates since the early 1980s, suggested that the population of the herd

was stable (Heard and Jackson 1990). The herd reached a high in 1994 of 496,000 (BQCMB 2014). Only two population surveys have been successfully completed since that time (344,078 in 2008 and 264,718 in 2014), and these suggest a decline (BQCMB 2014; Campbell *et al.* 2015). Although there is uncertainty associated with this trend (length of time between surveys and uncertainty in estimates, especially in 1994), the possibility of a decline is supported by the results of calving ground reconnaissance surveys in 2008 and 2012 that indicated a 10-20% decrease in relative density of caribou on the calving grounds during that period (BQCMB 2014; Campbell *et al.* 2015) (Fig. 18, below). Based on Monte Carlo analysis, the Qamanirjuaq herd has shown a decrease of 4% over three caribou generations (1989-2016) (Table 3, p. 128) (COSEWIC 2016).

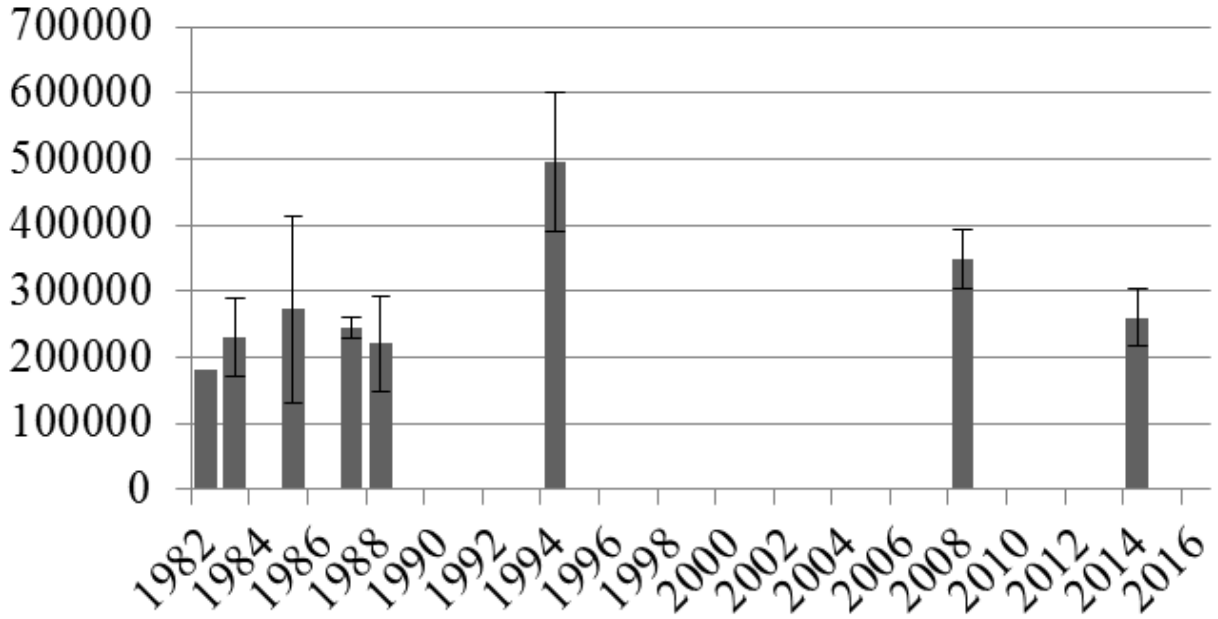


Figure 18. Qamanirjuaq herd numbers as estimated from surveys (Heard and Calef 1986; Heard and Jackson 1990; Russell 1990; BQCMB 2014; Campbell *et al.* 2015). Prior to the use of aerial photography, herd population estimates were based on visual sample counts of strip transects on the calving grounds (Heard 1985 *in* Heard and Jackson 1990). Error bars where available are SE.

Population dynamics

Most of the information used to describe herd structure and vital rates is collected during aerial and ground surveys whose frequency is quite variable among herds and over time. The variability impedes describing trends in abundance and the underlying rates of births and death.

Understanding birth and death rates (which depend on life history traits such as age of maturity, longevity and fecundity) is necessary not only to determine why herds decline but also to estimate the probability of recovery. In the NWT, the amount of information is inconsistent across the herds, with only the Bathurst herd having sufficient information to measure trends in

calf survival and herd size to support demographic modeling (Boulanger *et al.* 2011). Although demographic modeling was considered using a spreadsheet 'Caribou Calculator', for the Bluenose-West, there was insufficient herd-specific information on vital rates (Adamczewski pers. comm. 2012).

Information on pregnancy rates, body condition and health (contaminants, diseases and parasites) has been collected from almost all herds at intervals. However, much of the information has been only partially reported. While the parasite and disease aspects of some more recent data collections (post-2000) (Kutz *et al.* 2013) are leading to a series of papers and theses (Kutz pers. comm. 2012), no summaries or reports of the physical condition data could be found except for the Bathurst herd (Adamczewski *et al.* 2009).

The Sahtú Wildlife Health Monitoring Program produced back fat data for the Bluenose-West and Bluenose-East herds in the Sahtú region between 2005-2008 (Bluenose-West) and 2004-2014 (Bluenose-East) (Carlsson *et al*. 2015a, b). For the Bluenose-West herd, back fat depths for both sexes averaged 3.3 mm in 2005 (range = 0-12.7; n = 14), 37.8 mm in 2007 (range = 5-70; n = 19), and 35.8 mm in 2008 (range = 20-70; n = 12). Samples were weighted in favour of males, both as a function of hunter preference at the time of year harvest took place and also because of programs promoting majority male harvest (Carlsson *et al.* 2015b). The large majority of back fat samples taken for the Bluenose-East herd were from males (75 out of a total of 87 samples). Between 2004-2013, average back fat depth in males varied between around 3 mm and 6 mm. In 2007, the only year for which there were female samples (n = 10), average back fat depth measured less than 1 mm. In 2014, average back fat depth increased to approximately 19 mm for males and 14 mm for females, although samples sizes this year were quite small (n = 4 males and 2 females) (Carlsson *et al.* 2015a).

Age structure

In other long-lived mammals, the importance of age structure is well recognized (Coulson *et al.* 2005). In caribou, shifts in age structure can accelerate rates of decline and influence recovery (Eberhardt and Pitcher 1992). The extent of variability within age classes (cohorts – animals born in a given year; Caughley 1977) for barren-ground caribou is likely high given the annual variations in productivity (Boulanger *et al.* 2011). Age structure influences rate of change in caribou herds and the probability of persistence, but there are few data or population models to assess the age structure for caribou as these models depend on age-specific rates of survival and productivity. To estimate age-specific rates requires relatively large numbers of harvested animals that can be aged from their teeth. An exception is for the caribou sampled in the late 1980s for the Beverly herd (Thomas and Barry 1990b). This analysis showed the importance of middle-aged females as the age-specific fecundity rates indicated that 54% of all calves born were from females aged three-six years.

Bergerud *et al.* (2008) reported that in the George River woodland caribou herd, the mean age of

females increased by 13 months from the increasing phase to the decline phase of population cycles (1974-93). A shift to more older females likely would lead to a greater frequency of breeding pauses if the older females were more nutritionally stressed. For the Bathurst herd, information on age structure was collected in 1992 and again in 2008 (Elkin pers. comm. 2012; data from CARMA 2014). These data could suggest an older age structure in 2008 but sample sizes are small (Fig. 19, below).

Figure 19. Comparison of percent females by age class for the Bathurst herd in 1992 (*n* = 97) and 2008 (*n* = 37). Data from CARMA (2014) and B. Elkin (pers. comm. 2012).

A shift in age structure (Fig. 19, above) towards an older mean age was considered to be a factor in the later (2006-09) stages of the decline of the Bathurst herd (Boulanger *et al.* 2011). This suggestion was based on demographic modeling and acknowledges the problem caused by the low sample sizes for age-class rates of pregnancy and survival. Despite the importance of age structure, especially in diagnosing causes of declines and the probability of recovery, there is relatively little current information on age structure for NWT barren-ground caribou herds.

Birth rate

Pregnancy rate is used as an approximation of birth rate (natality). If intra-uterine mortality (foetus aborted or absorbed) is rare, pregnancy rates are a suitable index of calves born in June. Pregnancy rates can vary annually in barren-ground caribou as females may undergo reproductive pauses if they have insufficient body reserves to conceive (Cameron 1994). This proportion of females may be enough to change the population's pregnancy rate (Cameron

1994). Pregnancy rates of barren-ground caribou are monitored either from harvested caribou or by observations during the calving period.

Working with harvesters to determine pregnancy (presence of a foetus) has been used in the NWT for some herds. Hunter-harvested caribou on the late winter range of the Beverly herd in the late 1980s were examined for age specific pregnancy rates (Thomas and Barry 1990a). The overall pregnancy rate was 87% (Thomas and Barry 1990a). Annual pregnancy rates in females at least four years old varied from low averages of 76% and 78% to high averages of 98% and 100% during these years (Thomas and Barry 1990a).

Based on small samples of the Bathurst herd between 1990 and 2000, pregnancy rates of >2 year-old females varied between 20% and 93% (Table 4, below) during years when the warble fly activity index (Russell *et al.* 1993) was relatively high and the females were consistently lean in late winter (factors that may increase stress and adversely impact birth rates).

Table 4. Number of adult females, pregnancy rate, back fat (mm) and number of warbles for Bathurst herd 1990-2000 (data from CARMA 2014).

Year	Adult females	Pregnant	% preg	Back fat		Warbles				Warble Index[1]
				Mean (mm)	SE	Mean	SE	Min.	Max.	
1990	10	2	20	19	3.47	16.8	3.57	11	27	24
1991	18	11	61	1.7	1.08	61.0	24.8	10	320	13
1992	28	22	79	5.0	1.49	61.3	16.5	2	226	23
1995	13	10	77	3.6	1.15	70.0	18.3	0	192	22
2000	14	13	93	21.4	13.2	29.9	8.5	4	126	16

[1]The warble fly activity index (Russell *et al.* 1993) is based on daily wind speed and temperature 1957-2009 averages 15.7 ± 0.80 SE (range 8-24) as reported in Gunn *et al.* (2013a).

A sample of 150 females from the Bathurst herd collected by hunters in winter 2005 showed that pregnancy rates differed across the winter range and averaged an unusually low level of 63% (Gunn 2013). In March 2008 and April 2009, Bathurst females averaged 12.5 mm of back fat (range 1.5-26.0 mm) and 6.6 mm (range trace – 23 mm), respectively. In March 2008 and April 2009, 26 of 26 adult females (100%) and 25 of 28 adult females (89%), respectively, were pregnant during collection (Adamczewski *et al.* 2009). The warble fly activity index scores were 15 and 17 for 2008 and 2009, respectively. All studies on warble fly activity index involved very small sample sizes and the results should be viewed with this in mind.

On the calving grounds, post-partum and pregnant females are identifiable by the presence of their calf, or at least one hard antler and/or a distended udder (Bergerud 1964; Whitten 1995). Most parturient females (females either pregnant or recently calved) retain their hard antlers until two to three days after the birth of their calf, although Whitten (1995) cautions that on exceptionally good ranges, females may drop their antlers before birth. For the Bathurst herd, the calf:female ratio is measured during the years when the number of breeding females is estimated

on the calving ground. The ratios for the Bathurst herd (Table 5, below) cover the period from a peak in high numbers to a decline (1986-2009). The ratios varied annually and averaged 67 calves:100 females (±4.4 SE). Results from the June 2015 survey showed that the overall proportion of breeding females was 59% in the survey area, which suggests a low pregnancy rate in the Bathurst herd in 2015 (Boulanger *et al*. 2016a).

Table 5. Numbers of calves, breeding and non-breeding females, and calf:100 females ratio at the peak of calving for the Bathurst herd, 1986-2009 (compiled from Gunn *et al.* 1997; Gunn *et al.* 2005b; Nishi *et al.* 2007, 2010).

Year	Breeding females	Non-breeding	Total females	Calves	Calf:100 females
1986	670	157	827	604	73
1990	847	158	1,005	634	63
1996	3,273	467	3,740	2,954	79
2003	4,016	600	4,616	3,412	74
2006	4,373	1,348	5,721	2,878	50
2009	2,033	417	2,450	1,528	62

For the Bluenose-West herd (Table 6, below) during calving, Nagy and Johnson (2007b) reported that average calf:female ratios had declined from 1981 and 1983 (78 calves: 100 females) to 2000-05 (57 calves: 100 females). Similarly, for the Cape Bathurst herd, calf:female ratios have declined since the early 1980s (83.9 and 71.7: 100 females in 1981 and 1983 versus 42 calves: 100 females in 2000-05; Nagy and Johnson 2007a).

Table 6. Survey dates and calf:female ratios for Cape Bathurst and Bluenose-West (from Nagy and Johnson 2007a, b)

	Bluenose-West			Cape Bathurst		
Year	Survey date	Calves per 100 females	SE	Survey date	Calves per 100 females	SE
2000	9-11 June	38.7	missing	11-June	64.4	missing
2001	12-15 June	14.0	1.76	15-June	19.2	3.38
2001	23-26 June	54.1	2.30	22-23 June	32.4	2.53
2002	19-22 June	53.7	1.56	25-26 June	47.0	1.92
2003	21-25 June	53.2	1.83	25-June	46.5	8.85
2004	18-23 June	60.9	1.43	16-June	52.6	2.72
2005	19-21 June	59.4	3.69	18-June	32.9	3.50

Calf:female ratios at the peak of calving on the Beverly herd's traditional calving ground showed a declining trend over time based on aerial surveys in 1988-2009 (Table 7, p. 144; summarized *in* Adamczewski *et al.* 2015).

Table 7. Calf:female ratios on the Beverly traditional calving grounds.

Year	Calves: 100 females	Source
1988	65-81	Gunn and Sutherland 1997
1994	65-82	Williams 1995
2002	53-75	Johnson and Mulders 2009
2007	32	Johnson *et al.* 2009
2008	15	Johnson and Williams 2008
2009	2	Williams pers. comm. *in* Adamczewski *et al.* 2015

Recruitment and calf survival

Recruitment to the population is measured by calf survival to one year, after which survival rates are assumed to be similar to those of adults (Boulanger *et al.* 2011). Typically, recruitment is either expressed as the percentage of calves to the total population or as calf to female ratio at one year of age. In the NWT, calf: female ratios have been most commonly assessed at about 10 months of age (late March or early April), following Heard and Williams (1991). While populations can withstand annual variation in calf survival, persistent low calf survival may influence population trends negatively (Gaillard *et al.* 1998, 2000; Coulson *et al*. 2005; Chen *et al*. 2014). Calf survival is likely less resistant to environmental variation than adult survival (e.g., Russell and White 2000). Calf survival may vary substantially from year to year, which necessitates long term data sets to detect temporal trends (Chen *et al.* 2014).

Calf survival rates are measured through changes in successive calf: female ratios, which reflect the proportion of calves that have died per 100 females and requires an estimate of the birth calf: female ratio with a correction for adult female mortality for the interval between birth and the timing of the composition survey (fall or late winter). Calf: female ratios appear correlated with finite rates of increase in herd numbers (r = 0.84), with approximately 25 calves: 100 females during spring required to maintain numbers (Fig. 10.2 *in* Bergerud *et al.* 2008). Currently, calf survival rates (as estimated through changes in successive calf: female ratios and corrected for adult female mortality) have only been reported for the Bathurst herd, possibly because adult female survival rates are not available for the other NWT herds.

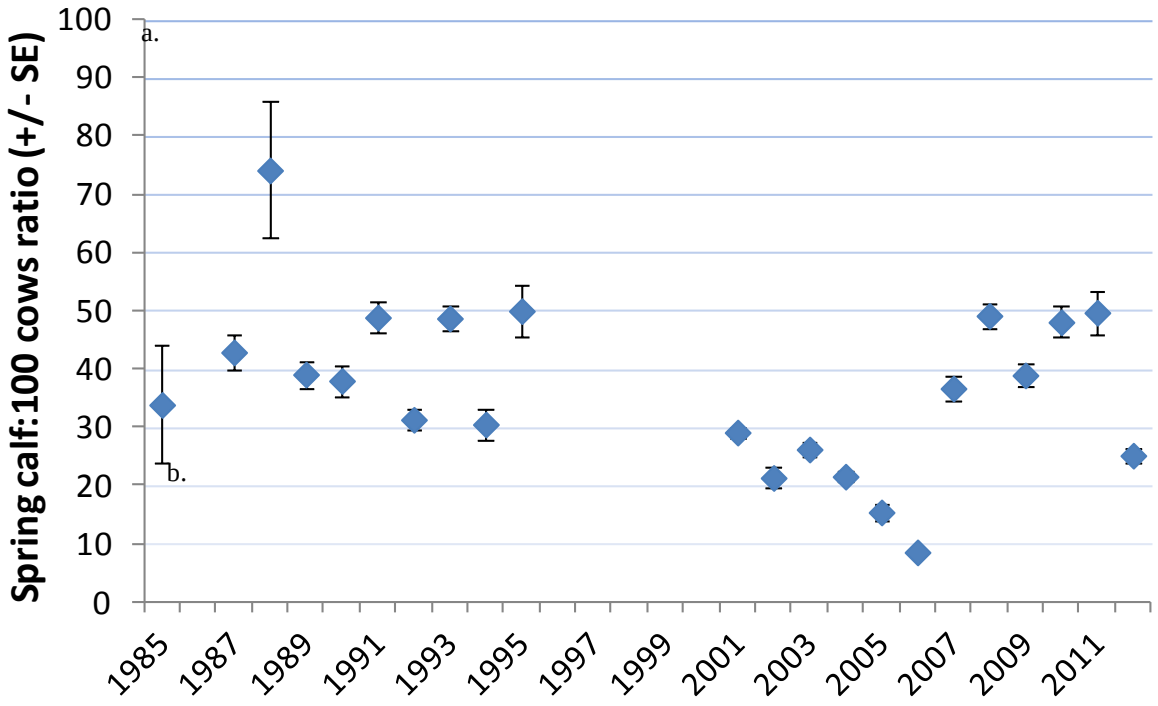
Because of the variability in body condition and sex/age class structure prior to the pre-calving migration, sampling across the distribution of caribou is necessary to determine female: calf ratio (Thomas and Kiliaan 1998b). Gunn *et al*. (2013a) reported a range of 9-24 calves: 100 females for four areas of the Bathurst herd winter range.

Mean late winter calf survival declined in the Bathurst herd from a rate of 40% (SE 4.8) in 1985-96 to 20% in 2001-04 (SE 1.1) (Gunn *et al.* 2005a, Chen *et al*. 2014). Based on fall composition surveys in late October 2000, 2001, and 2004, calf survival rates were lower during the summer than winter (Gunn *et al.* 2005a). Subsequent changes in calf survival from 2006 to 2009 (a

rebound followed by a decline) may have been affected by the declining adult female survival, which affects the denominator, thus inflating the calf-female ratio (Boulanger *et al.* 2011). A consideration for monitoring caribou herds is that while fecundity, adult female survival and calf survival are all inter-related parameters (through nutritional ecology, Chen *et al.* 2014), measuring only one of those parameters limits interpretation for describing trends in herd abundance.

The Bathurst, Cape Bathurst, and Bluenose-East herds have more than 10 years with information to measure trends in late winter calf: female ratios. Spring ratios for the Bathurst herd dropped throughout the early 2000s, rebounded from 2007 to 2011 (Fig. 20a, below), and have returned to low levels since 2011 (Croft pers. comm. 2015), keeping in mind the possible effect of low female survival on these ratios. Ratios were low in the early 1990s for the Cape Bathurst herd compared to the 1980s and 2000s (Fig. 20b, p. 146), which could suggest low recruitment. For the Bluenose-East herd, surveys started in 2001 when the calf: female ratio was relatively low (25 calves:100 females) but between 2002 and 2010 the ratio average was 47 ± 2.2 calves: 100 females, although the calf survival was not estimated (Davison 2015).

a.



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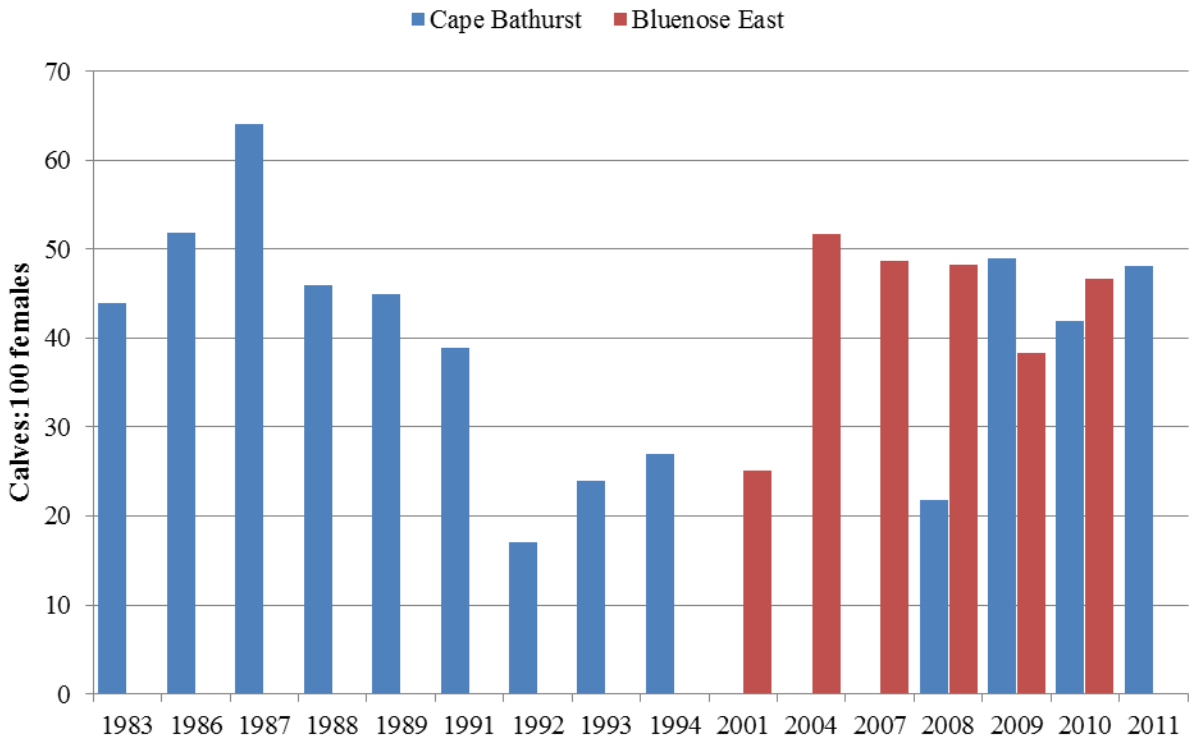


Figures 20a and b. Calves: 100 female ratios for (a) for the Bathurst herd for 1985-2012 (data from Boulanger *et al.* 2016a) and (b) the Cape Bathurst and Bluenose-East herds (1983-94 sampling may have included caribou from Bluenose-West herd) for 1983-2011 (data from Davison 2015).

Heard and Williams (1991) reviewed calf: female ratios for the Bathurst, Beverly, Bluenose (the Cape Bathurst, Bluenose-West and Bluenose-East herds were still considered a single herd at this time) and Qamanirjuaq herds from 1986-89 when these herds were increasing in number; ratios were consistently above 30 calves: 100 females.

Boulanger *et al.* (2011) and Crête *et al.* (1996) noted that the level of calf recruitment, indexed as the calf: female ratio, needed for a stable herd depends on the female survival rate. "There must be 52 calves per 100 females in autumn in a caribou population for balancing mortality when annual survival of yearlings and adults reaches 0.80; the autumn ratio must be 39 when annual survival is 0.85" (Crête *et al.* 1996). These results suggest caution in interpreting 10-month calf: female ratios; consistently low values (below 30:100) are indicative of a declining natural trend, but higher ratios may be less clearly indicative of herd trend as adult survival may vary. Ratios of 30:100 may not be clearly linked to a stable herd.

Adult female mortality

Herd trends are the most sensitive to adult female survival as adult females are usually the largest proportion of the herd (Crête *et al.* 1996; Boulanger *et al.* 2011). The most sensitive vital rates

are those under the greatest selective pressure so those rates are expected to have the lowest variability (Gaillard and Yoccoz 2003). Despite the importance of describing adult mortality, time series data on adult female survival are only available for the Bathurst and Porcupine herds; data are limited for other herds.

Relatively small changes in adult survival rates can change the population trajectory of a herd, but detecting such changes is difficult. Detecting changes in survival rate requires a large sample of marked individuals whose fate is known. Currently for the Bathurst herd, satellite-collared individuals (typically ≤20/year) are used to measure adult female mortality. Consequently, estimated survival is imprecise. Therefore, demographic modeling using calf survival and herd size was used and suggested that adult female annual survival declined between 1985 and 2009 to well below 80% (Fig. 21, below; Boulanger *et al.* 2011). The effect of hunter harvest is something that must be considered. The model used by Boulanger *et al.* (2011) detected declines in adult female survival that were not seen in analyses of collar-based data alone.

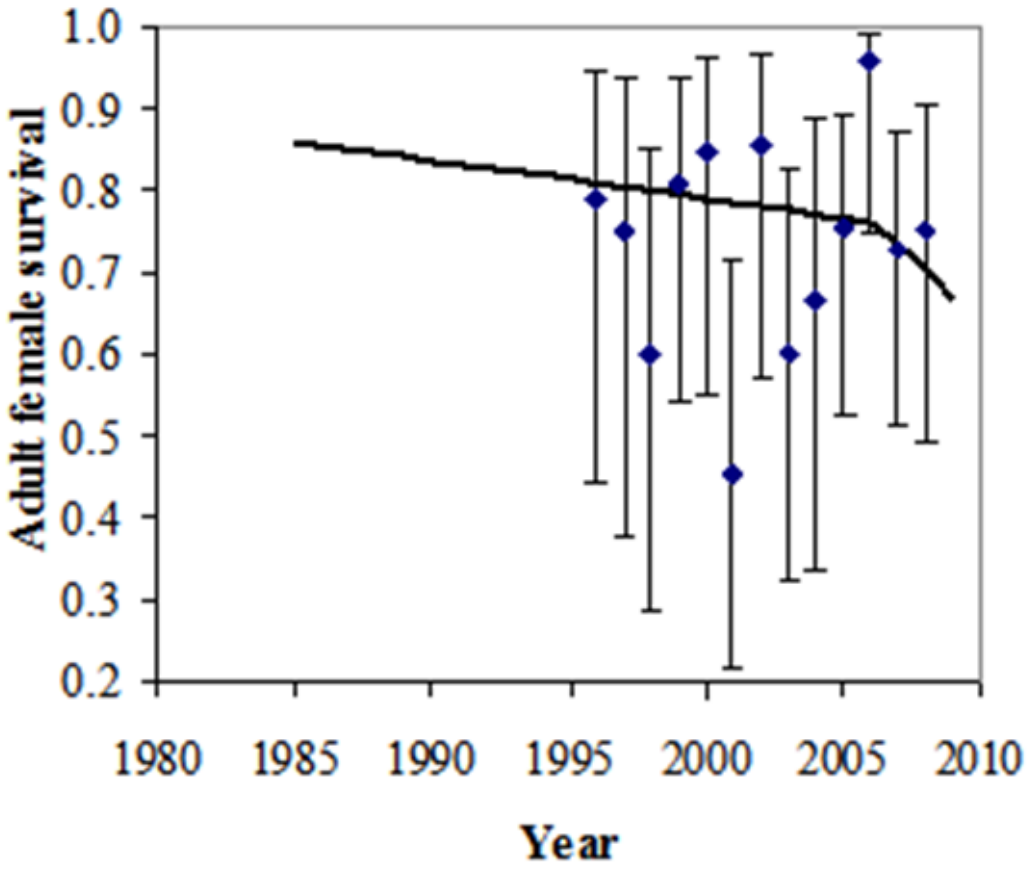


Figure 21. Trend in adult female mortality based on satellite-collared caribou in the Bathurst herd 1996-2009 (95% CI) (from Boulanger *et al.* 2011).

Average annual survival for the Porcupine herd between 2003 and 2012 was 0.852 (within year variability 0.065-0.097 of point estimate). Survival was lowest in 2004-05 (0.739) and highest in 2010-11 (0.905) (Porcupine Caribou Technical Committee 2013).

For the Beverly herd from 1980-87, age-specific death rates were estimated by constructing a life-table from a large sample of harvested caribou (Thomas and Barry 1990b). During this period the herd numbers were considered to be stable. Mortality was 10.6% between age two and three years, 11.3% from three to four years, and 22.4% between 10 and 11 years. From 2007-09, survival of Beverly females was estimated at 58% (CI 42-72%; Adamczewski *et al*. 2015), based on a small number of satellite collared females that had spent ≥1 year of calving on the traditional Beverly calving grounds. Survival of Ahiak females was estimated at 79% (CI = 67-88%) for the same period.

When herds are declining or at low numbers, harvest is additive to natural mortality and can accelerate a decline and limit recovery from low numbers, as found in the Bathurst herd (Boulanger *et al.* 2011) and the Cape Bathurst and Bluenose-West herds (Adamczewski *et al.* 2009) in the 2000s. The three general categories of hunting licence holders in the NWT (aboriginal hunters, resident hunters, and commercial hunters) target different sex/age categories, which collectively could affect survival rates.

Aboriginal harvest data are not always available for continuous periods of time, but the harvest can be substantial. The Dogrib Harvest Study collected information on the Bathurst herd from 1986-1993; it reported annual harvests of about 7,000-23,000 caribou (Boulanger *et al.* 2011). No data were available after the end of the study. Harvest data from check stations and community hunts during the 2005-06 season indicated a decline to about 4,500 caribou (Boulanger and Gunn 2007). Harvest estimated for winter 2008-09, including harvest by outfitters, resident hunters, and as calculated from check-station data and model analysis, was a similar 4,000-7,000, predominantly females (Adamczewski *et al.* 2009). In these years, the herd was declining but remained readily accessible on winter roads, progressively amplifying the effect of a fairly constant harvest from a declining herd (Boulanger *et al.* 2011).

Annual use of winter ranges by caribou can be variable and overlap between neighbouring herds may be substantial; most of the harvest occurs in the winter. Formal subsistence harvest studies have been conducted for the Inuvialuit Settlement Region and Sahtú and Gwich'in settlement areas of the NWT, and in Kugluktuk through the Nunavut Harvest Study (summarized *in* Davison 2015). Information is available through regional land claims, but is limited to the periods when these studies were in progress. The BQCMB also compiled and reported estimates of annual harvests from the Beverly and Qamanirjuaq herds until 2007-08. Total estimated annual harvest from both herds was about 13,000-14,000 in 2005-06 to 2007-08, with most of the harvest from the Qamanirjuaq herd (listed in Gunn *et al.* 2011b).

Deriving harvest numbers for individual herds can be challenging. Harvesters of Cape Bathurst, Bluenose-West, and Bluenose-East caribou come from 14 communities in six land

claim/regional areas in two Territories.

Recent harvest levels for Bluenose-East, Bathurst, Beverly and Ahiak herds are summarised as a 2011 annual report to the Barren-ground Caribou Technical Working Group established through the Revised Joint Proposal on Caribou Management Actions in Wek'èezhìı (Tłı̨chǫ Government and GNWT 2011). The total reported harvest for the Bluenose-East herd was 3,466 for 2009-10, 2,918 for 2010-11, and 1,885 for 2011-12, and for the Beverly and Ahiak herds together was 1,046 for 2009-10 and 240 in 2010-11 (additional harvest by Łutsel K'e (NWT), NU, Saskatchewan and Alberta are unknown). The harvest for the Bathurst herd has been restricted to 300 caribou since 2010, and during 2010-11 was estimated at 213 caribou. However, in some winters Bathurst collared caribou wintered east and west of the protected zones; notably in 2013 when several Bathurst collared females wintered in the Hottah Lake area where larger harvests of Bluenose-East caribou occurred. In such winters the Bathurst harvest may have been greater than 300. In January 2015, a no harvesting mobile conservation zone was set up around collared Bathurst females. Harvest on the Bluenose-East herd has been restricted to 1,800 animals in the NWT with an 80% male harvest (GNWT 2015) (additional harvest by NU is unknown). Overlap on the winter range, particularly for the Bluenose-East and Bathurst herds, and limited numbers of collared caribou have complicated estimation of winter harvest levels (Adamczewski pers. comm. 2013a).

Reported harvest of barren-ground caribou by resident hunters in the NWT peaked in the early 1990s, and has declined steadily since then (Fig. 22, p. 150). Resident harvesting was restricted in 2007 when the number of tags per resident hunter was reduced from five to two and the harvest was restricted to males only (Carrière 2012; ENR 2013b). Annual resident hunter reported harvest has been 14 during 2010-11 and 2012-13 (ENR 2013b). Before harvest restrictions were put in place, resident hunters from the Inuvialuit, Gwich'in and Sahtú Settlement areas hunted primarily Cape Bathurst, Bluenose-West and Bluenose-East caribou. Resident hunters from Yellowknife and the North/South Slave regions hunted primarily Bathurst caribou and possibly some Bluenose-East caribou (Adamczewski *et al.* 2009).

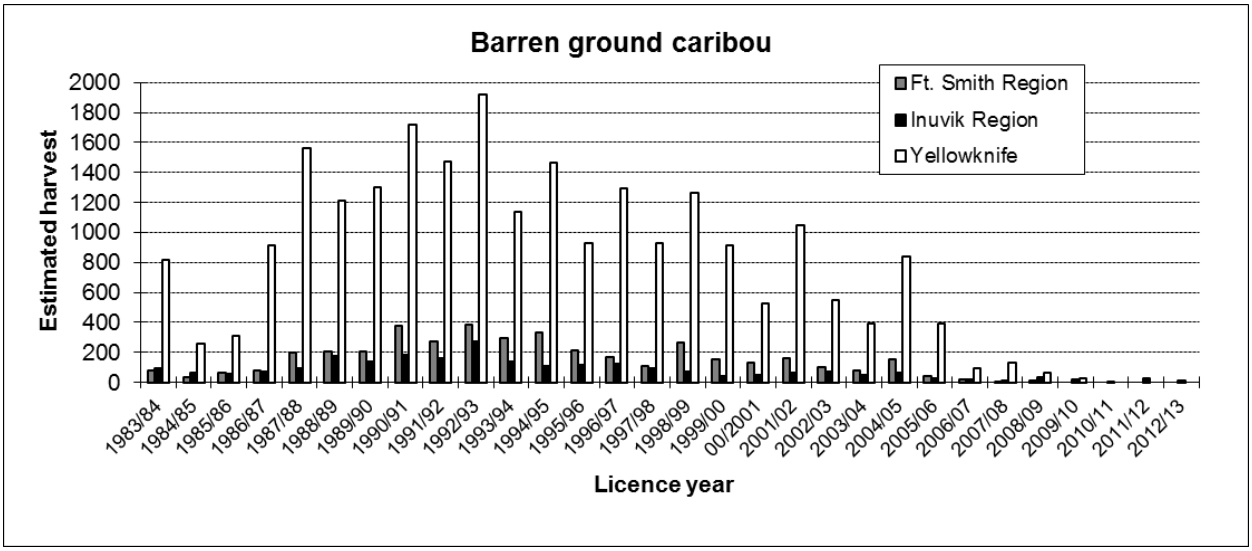


Figure 22. Estimated numbers of barren-ground caribou harvested by resident hunters in the NWT from 1983/84 to 2012/13. Regions (Fort Smith, Inuvik and Yellowknife) are where hunters reside, not where they hunted. The Inuvik Region consists of hunters from the Inuvialuit, Gwich'in and Sahtú Settlement areas, and the Fort Smith Region consists of hunters from the North Slave (except Yellowknife), South Slave and Dehcho regions (ENR 2013b).

Outfitter harvesting is mostly quota-based, guided, non-resident hunting focused on prime males. The average annual harvest of caribou males by outfitters on the Bathurst herd was 828 between 1997-2009, peaking in 2001 at 1,166 males. Quota changes between 2005 and 2009[11] reduced the commercial harvest (Adamczewski *et al.* 2009). Outfitter harvest was terminated in 2010 over concerns about declining herd numbers and due to land claim requirements when aboriginal harvest is restricted. Outfitter camps accessed mostly Bathurst caribou, with some access to Bluenose-East caribou. Currently, there is no commercial harvesting of any NWT barren-ground caribou herd.

Immigration and emigration rates

Conventionally, since 1967 (Thomas 1969), barren-ground caribou herds are defined based on the fidelity of females to specific calving grounds, although this approach has long been considered a working model that may require modification (Gunn and Miller 1986). Nagy *et al.* (2011), using satellite tracking locations throughout all seasons, conducted hierarchical and fuzzy clustering analyses to assess the robustness of herds within the NWT and NU. They found that for the Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Qamanirjuaq, and Lorillard herds, herd designation was robust and herd structure and spatial fidelity were

[11] Commercial harvest eliminated in the Inuvialuit Settlement Region and Gwich'in and Sahtú Settlement areas; Zone 1/BC/06 in the ISR closed to resident, non-resident and non-resident alien hunters; and resident tags in the rest of the NWT were reduced from five to two (Carrière 2012).

maintained over time. However, the Ahiak (called Queen Maud Gulf in Nagy *et al*. 2011) and Wager Bay herds were distinct but behaved as individuals.

Satellite-collared female caribou that switch calving grounds have been used to assess immigration/emigration over relatively short time frames (decades). The rate of switches among calving grounds for the Bluenose-West, Bluenose-East and Cape Bathurst herds is generally low; Nagy (2009b) recorded switching between calving grounds for three of 151 caribou-years. Similarly, Gunn and Poole (pers. comm. 2014) noted two of 63 pairs (3.2%) of consecutive calving locations were switches between Bathurst and Bluenose-East herds, while Adamczewski *et al.* (2009) calculated Bathurst rates of switching at 3-4%. Contrastingly, the Beverly herd has shown a high rate of individual females switching from their traditional inland calving ground to a calving ground on the coastal Queen Maud Gulf (Nagy *et al.* 2011; Gunn *et al.* 2012) (see *Systematic/taxonomic/naming clarifications*, p. 93, for more details on herd naming and *Distribution trends*, p. 158, for more information on Bathurst calving ground movements). Based on females collared between 2006 and 2008 on the traditional Beverly winter and summer ranges, females for which the first recorded calving was on the Beverly traditional inland calving ground had a high rate of switching to the coastal Queen Maud Gulf calving ground (30 and 40%), where the Ahiak herd also calves. In comparison, switching of females that had calved on the coastal Queen Maud Gulf calving ground to the Beverly traditional inland calving ground was low (2%) (Adamczewski *et al*. 2015). Adamczewski *et al*. (2015) also estimated the probability of Beverly females returning to their traditional inland calving ground was 28% (CI 13-47%) and the probability of Ahiak females returning to their coastal Queen Maud Gulf calving ground was 78% (CI 65-87%).

Genetic variability, based on analyses of nuclear and mitochondrial DNA can measure emigration/immigration between herds over longer durations. However, caution is needed as there is a quite different perception of immigration rates in the context of genetics. Genetic migration refers to at least one individual per generation emigrating to another subpopulation and being a successful breeder. In large subpopulations, even a few migrants will counter a low rate of genetic drift, resulting in subpopulations that are not genetically different (Mager 2012; Mager *et al.* submitted). Current DNA analyses suggest that the current herd structure is a re-sorting, either through migration routes and/or immigration/emigration from pre-glaciation herd structure (McFarlane *et al.* submitted).

Assessment of the genetic variability for the Porcupine, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Ahiak and Beverly herds using microsatellite DNA analysis indicated some subpopulation structure, but the isolation-by-distance pattern was unclear as neighbouring herds were not necessarily more closely related (Zittlau 2004; McFarlane *et al.* submitted). However, the apparent lack of subpopulation structure may also reflect the methods used (Kennedy *et al.* 2010; Roffler *et al.* 2012). Assessment of the genetic variability among the herds of barren-ground caribou relied on neutral genes that do not code for functional proteins (Zittlau 2004). While nuclear DNA did not show differentiation between the Western Arctic, Central

Arctic (in Alaska) and Porcupine herds, using the functional gene complex associated with immune function (MHC), the Porcupine and Western Arctic herds both shared and had distinct MHC alleles (Kennedy *et al.* 2010). Also, mtDNA and nuclear DNA analyses may show different patterns since mtDNA is inherited by females and nuclear DNA by both parents.

In summary, the level of emigration and immigration is not normally a significant factor in demography as the rate of switches by females between calving grounds is typically low. Over longer time scales, erratic movements, shifts from traditional ranges, and changes in migratory behaviour can occur (Skoog 1968; Hinkes *et al.* 2005). Largely missing are analyses examining what happens to females that associate together during calving and associate together during the rut and the dispersion of males during the rut. There is no evidence that over the long term NWT barren-ground caribou herds depend on immigration for survival. Demographic analyses indicate rates of fecundity and mortality explain changes in abundance. Whether herds are genetically distinct or not does not affect whether the herds may be demographically independent. For Alaskan herds, Mager *et al.* (submitted) concluded that "population dynamics within each herd may be independent over the time scales relevant to management, even if they experience substantial gene flow from other herds."

Rates of switching between herds by collared males have had little assessment in the NWT; Roffler *et al.* (2012) described male movement among rutting areas of Alaskan herds with high female philopatry.

Possibility of rescue

The possibility of a rescue is influenced by the contiguous distribution of barren-ground caribou in neighbouring jurisdictions. Barren-ground caribou are mostly not genetically distinct at the current level of analyses and techniques, which suggests that natural dispersion and colonization or translocation could result in a rescue.

Habitat

Habitat availability

At the scale of seasonal ranges, as population abundance increases and decreases, there are changes in range use (Skoog 1968; Hinkes *et al.* 2005), especially in the winter range (e.g., the George River herd in Quebec; Bergerud *et al.* 2008; see *Distribution trends*, p. 158). During the 2000s, the Bathurst herd reduced its use of ranges southeast of Great Slave Lake (Gunn *et al.* 2013a). A reduction in range use as population declines suggests there are currently unoccupied or less heavily used habitats because winter range boundaries have contracted. There have not been analyses at different spatial and temporal scales for the other seasons or herds in the NWT to determine if there is unoccupied habitat and how that relates to habitat availability or changes

in the numbers of caribou.

It is not a simple matter to categorize what is 'available' habitat; habitat is not just vegetation types (see *Habitat requirements*, p. 103). Habitat availability varies annually due to effects of weather (timing of plant green up, snow or ice) and risks of predation and parasitism (summarized in *Habitat requirements*, p. 103). Forest fires affect forage availability, especially slow-growing plants like lichen (Thomas 1998), as do the caribou themselves (Manseau *et al.* 1996); these effects are over decadal timescales. The effects of caribou on forage availability in the tundra are poorly known (Zamin and Grogan 2013). During high population levels, impacts by the George River herd (Quebec) on lichen flora were ubiquitous and extensive in some areas (Bergerud *et al.* 2008). Caribou, while cratering through snow, fragment and disturb lichen and thus create a mosaic of lichens at different stages of succession (Boudreau and Payette 2004a, b; Gaio-Oliveira *et al.* 2006; Joly *et al.* 2009). Even at relatively low population size browsing pressure on shrubs can be sufficiently strong to cause substantial biomass and nitrogen losses from the dominant shrub species (Zamin and Grogan 2013). Habitat availability is likely also influenced through caribou interactions with forage plants, which would include fertilization, compensatory growth and change in vegetation community structure. However, the extent and frequency of these effects is unmonitored.

Information on seasonal habitat availability is limited, except for the Beverly herd during the late 1980s (BQCMB 1994; Thomas *et al.* 1998; Thomas and Kiliaan 1998b) and the Bathurst herd in the late 2000s (Barrier and Johnson 2012). In both cases, winter habitat availability was assessed as adequate, although monitoring for the size and frequency of forest fires was considered necessary to ensure that habitat availability was maintained.

Habitat fragmentation

The most conspicuous natural fragmentation of caribou habitat, other than the large lakes and major rivers, is through forest fires. On forested winter ranges, forest fires promote a mosaic of differently aged patches. Lichens take decades to recover after fire and caribou tend to avoid recently burned areas (Thomas and Kiliaan 1998b). However, caribou may still move through recent burns early in the winter (Thomas *et al.* 1998; Barrier and Johnson 2012) and may also select habitats adjacent to the burn boundary (Barrier 2011). Large contiguous fires could possibly fragment winter ranges, but currently there are no analyses measuring the level of habitat fragmentation. Shifts in winter range, including unusual movements, suggest caribou are not currently limited in dispersing within or through fragmented habitat at the scale of the overall winter range. Shifts of individually marked females between calving grounds indicates that suitable habitat for dispersal exists between herds (see *Population*, p. 122).

The annual burn rate and the severity of fires are higher in the western Taiga Shield and Taiga Plains than in other areas of the NWT (Krezek-Hanes *et al.* 2011). Most of the area that has burned is south and west of the Bluenose-West and Cape Bathurst ranges; for the Bluenose-East

and Bathurst herds, fires have been prevalent within the south and west of their range (Fig. 23, below). Whether those large burns restrict the extent of the winter ranges is unknown. Burned areas are mapped as contiguous polygons, but burn severity varies widely and unburned areas within burns can be extensive; thus, maps of burns can be somewhat misleading to simple interpretation.

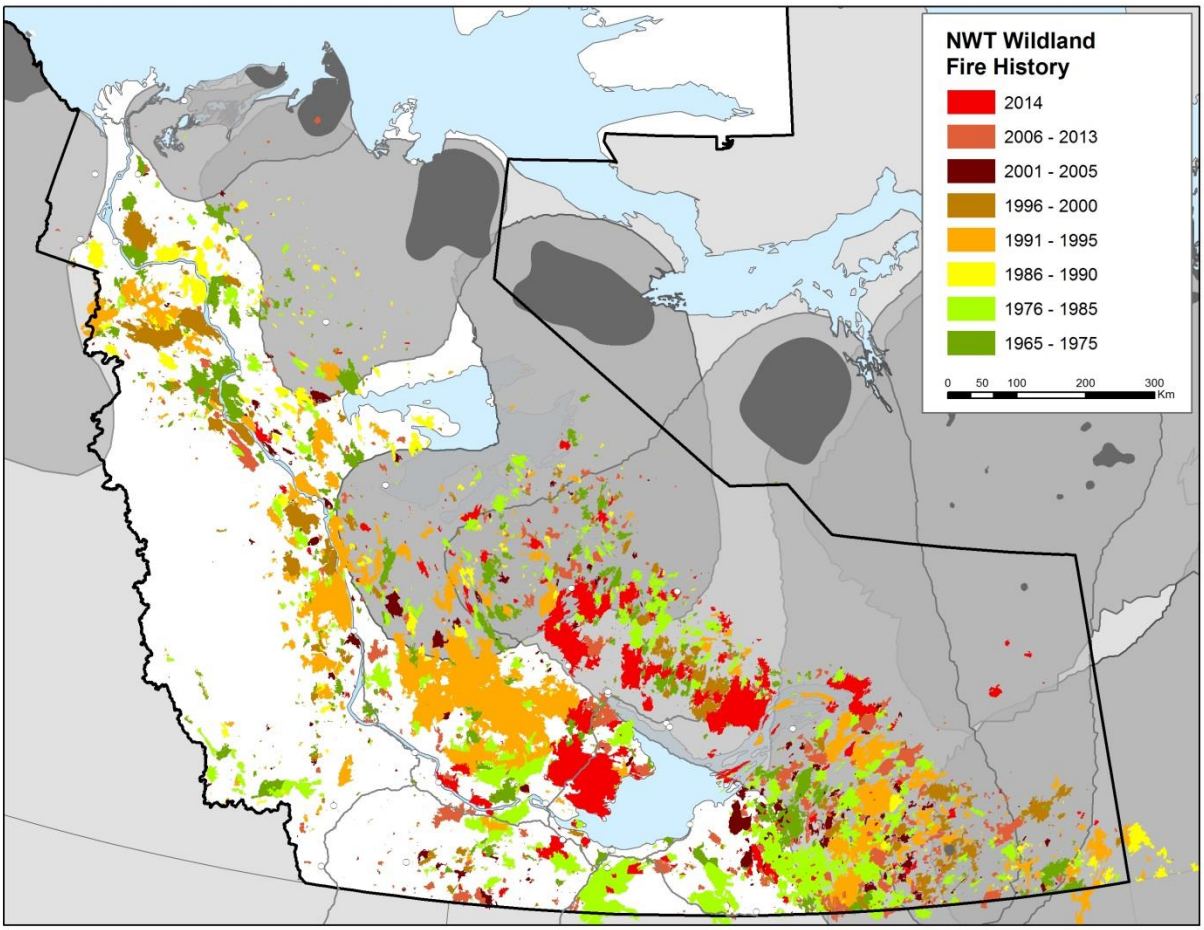


Figure 23. Fire history from 1965 to 2014 within the NWT (from K. Groenewegen, ENR, used with permission; barren-ground caribou herd layers added by B. Fournier, ENR based on Fig. 6. p. 99)

Experience elsewhere in the world regarding the conservation of migratory ungulates identifies habitat fragmentation associated with human activities as a major threat (Berger 2004; Benítez-López *et al.* 2010). Most information relative to the NWT indicates that habitat fragmentation could be tied to heavily used roads and transmission corridors (which act as partial barriers to movement), with reduced activity near active mines (e.g., Boulanger *et al.* 2012), communities and roads also representing a degree of functional habitat loss (see *Threats and limiting factors - Disturbances from human activity*, p. 168).

Habitat trends

Recent trends in suitable habitat are being described given that trends for global warming are exceeding some earlier predictions for the Arctic (Derksen and Brown 2012; IPCC 2013). While trends in weather and vegetation are being measured related to a changing climate, it is more difficult to relate those trends to caribou habitat. The trends for habitat change, and how change relates to habitat loss, depend on the adaptability of caribou and the availability of alternative habitats. While caribou are adaptable based on the diversity of habitats that they occupy, little is known about their adaptability at individual scales. In another Arctic herbivore (geese), recent research reveals limits to adaptability. Geese goslings adapted their diet to survive but not to the extent necessary to prevent their body size becoming smaller (Winiarski *et al.* 2012). Thus, the effects of changes in habitat on caribou ecology and population dynamics are poorly understood.

Superimposed on the longer term trends of a warmer climate since the 1970s are decadal climatic patterns, which are the result of larger scale atmospheric patterns such as the Arctic Oscillation. This increases the complexity of interactions between a generally warming climate and decadal climatic patterns. Decadal oscillation phases coincide with changes in caribou abundance, suggesting that climate has some role in caribou cycles through cumulative effects on habitat (Zalatan *et al.* 2006; Joly *et al.* 2011); however, the relationships between decadal patterns and caribou abundance differed among Alaskan herds (Joly *et al*. 2011). Decadal patterns in habitat trends can be seen in trends in winter habitat. The long term trend in area burned for the Taiga Plains and Taiga Shield increased from the 1960s until the 1990s and decreased in the 2000s.

The total area burned as a result of lightning ignitions increased over the last 40 years (Krezek-Hanes *et al.* 2011), possibly due to warmer temperatures during the fire seasons in the 1990s. No reports were found relating the decadal trends in caribou winter habitat to the decadal trends in areas burnt. The frequency of large fire years like 2014 in the NWT may become a larger concern in the future as a warming climate may lead to a higher frequency of drought years when large fires are common, with possible negative implications to caribou winter ranges in the north (e.g., Alaska, Joly *et al.* 2012).

Trends in caribou calving and post-calving habitat can be measured through satellite imagery. Across the western Arctic there is an increasing trend in shrub cover (Cornelissen *et al.* 2001; Hudson and Henry 2009), which could displace important forage species like lichen. For the Bathurst herd, trends in habitat have been assessed over a time frame closer to the duration of three generations (Chen *et al.* 2012; Chen *et al.* unpubl. data; Chen *et al*. 2014). When the Bathurst herd females arrive on the calving ground, lichens are a large part of their diet (Griffith *et al.* 2001). Lichen coverage decreased significantly from 44% to 22% of the total calving ground area from 1990 to 2000, possibly because of shrub encroachment and accumulated grazing potential. Immediately after calving (11-30 June), females switch to greening vegetation. Although there is high annual variation of greening vegetation and no significant trend, it increased 55% from 1985 to 2006. During summer (11 Jun-20 Sep) in 1985-96 there was a

significant increase in mean foliage biomass, but forage quality (using leaf nitrogen as an index) decreased during that time. Chen *et al*. (2014) developed a composite indicator for summer range condition using data from satellite imagery and climate records that explained 59% of the variation in late-winter calf: female ratio for the Bathurst herd between 1985 and 2012 (Fig. 24, below). Similar trends are likely for the ranges of the more western herds in the NWT because climate trends, especially warmer springs and winters, are similar for the Arctic and Taiga Plains and Taiga Shield ecozones (Zhang *et al.* 2011).

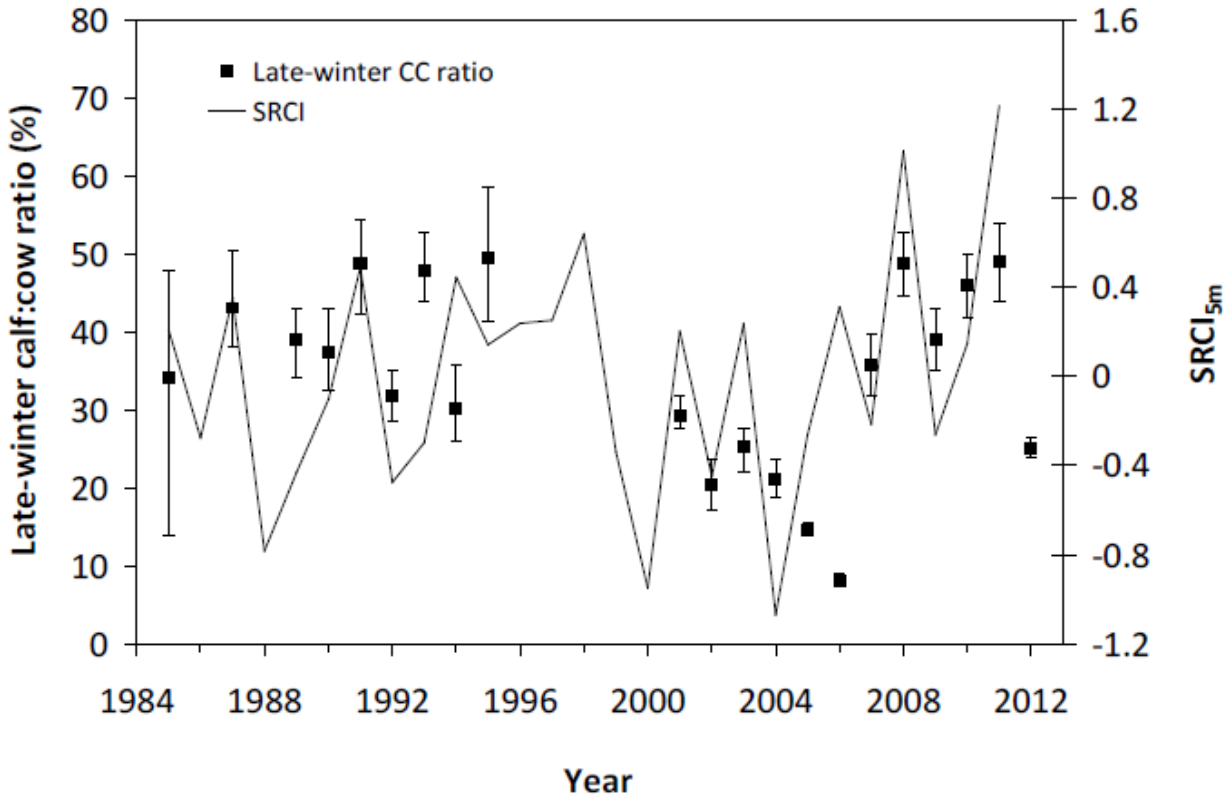
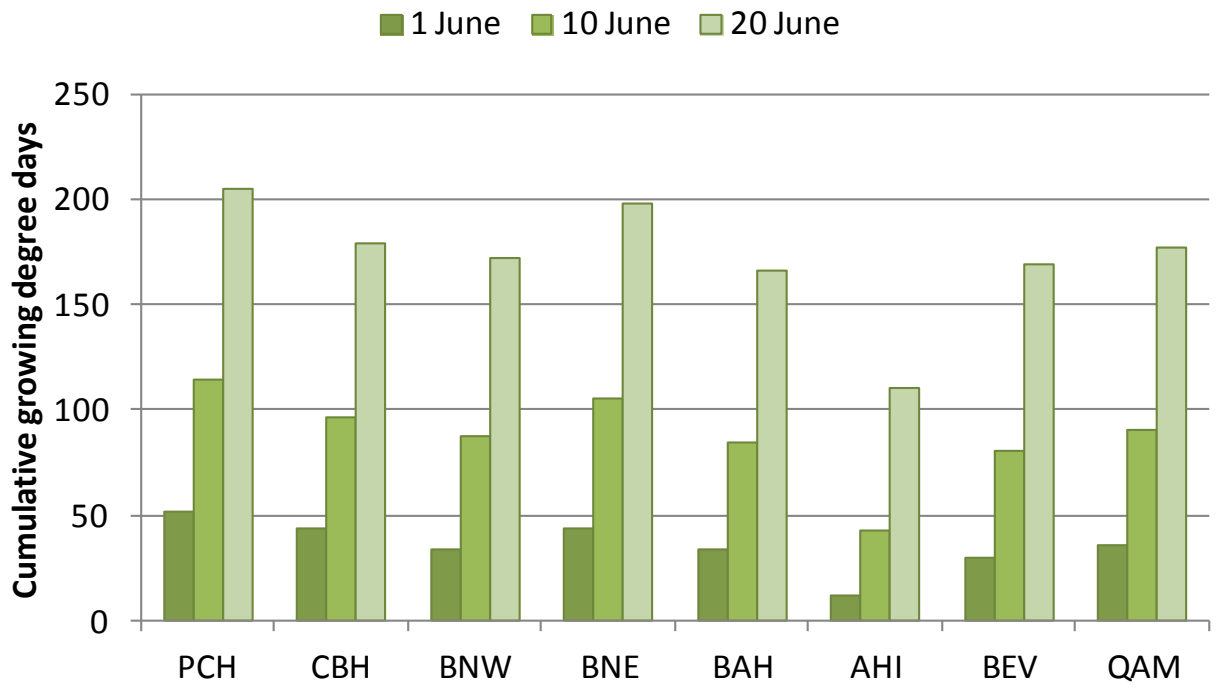


Figure 24. Summer range condition index (SRCI; higher values indicate better condition, June 11-20) and late-winter calf:female ratio for the Bathurst caribou herd during 1985 to 2012. Changes in late-winter calf:female ratio correspond to previous summer's range conditions with a time lag of about two years. Note that late winter calf:female ratios from 2007-2012 are likely inflated because of a change in adult female survival during the time series. Reproduced from Chen *et al.* 2014.

Snow conditions like depth, density and ice content, influence forage availability for caribou. Chen *et al.* (unpubl. data) reported that the Bathurst winter range has a trend toward warmer fall and late winter air temperatures, which, while reducing the annual maximum snow depth, increases the probability of thaw-freeze events (which influences the ice-in-snow indicator). Overall, the ice-in-snow indicator had a significant positive relationship with April-October air temperature, indicating an increase in 'hard' snow or icy crust in the snowpack under a warming climate (Chen *et al.* unpubl. data). Studies are currently examining the influence of changing snowpack characteristics on caribou distribution (Tait Consulting 2013).

Predicting the consequences of trends in habitat will be herd-specific as trends will be superimposed over a marked northwest-southeast gradient in climate across the NWT. The western NWT, being more subject to Pacific maritime influences, is warmer when compared to the more continental climate in the eastern NWT. This can be seen from data on cumulative plant growing degree days on calving grounds (Fig. 25a, below). The geographic trends for the number of days with freezing rain and rain-on-snow for the winter ranges indicates that the winter range east of Bathurst Inlet toward Hudson Bay have more days with freezing rain or rain-on-snow as they are not quite as cold as the continental interior (Fig. 25b, p. 158).

a.



b.

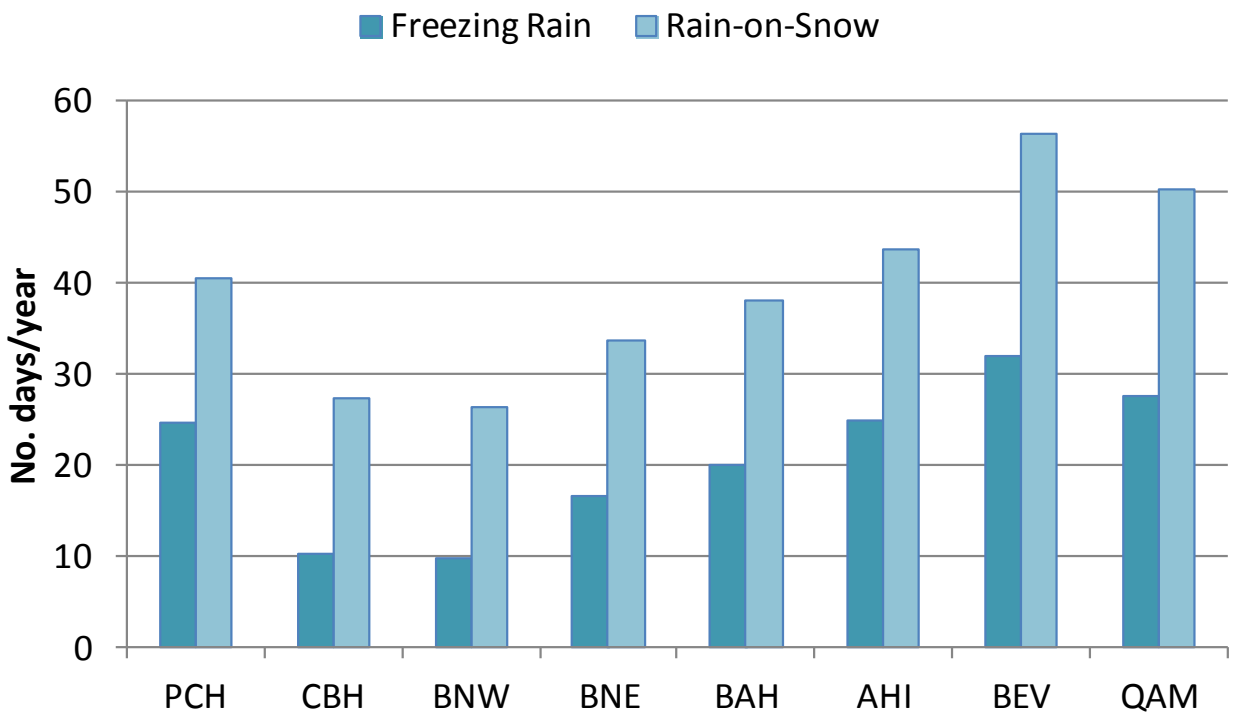


Figure 25. (a) Cumulative plant growth degree days for 1, 10 and 20 June for NWT and NU caribou calving grounds and (b) number of days with freezing rain and rain-on-snow (1987-2005) for winter ranges (annual MERRA data from CARMA 2014). Herd abbreviations: PCH = Porcupine; CBH = Cape Bathurst; BNW = Bluenose-West; BNE = Bluenose-East; BAH = Bathurst; AHI = Ahiak; BEV = Beverly; QAM = Qamanirjuaq.

Distribution trends

The information used to describe distribution is mostly for either the winter or calving ranges. The information available to assess winter distribution trends consists largely of irregular aerial surveys, especially in the 1950s and 1960s. In the 1980s, there was relatively regular coverage of the late winter distribution, especially for the Bathurst and Beverly herds. Considerably more information is available to describe trends in calving distributions through aerial surveys since the 1960s.

After 1996, information on trends in annual distribution was supplemented by the use of satellite-collared females on the Bathurst, Cape Bathurst, Bluenose-West and Bluenose-East herds. Collaring of the Ahiak and Beverly herds began in 1995 but sample sizes were only between one and five females annually until 2005.

Assessing trends in distribution is complicated by the difficulty of distinguishing between changes in the overall historic range and the changes in distribution as caribou numbers increase and decrease. Typically, as barren-ground caribou herds fluctuate in abundance, their distribution (especially winter) correspondingly changes. Most of the basis for this relationship between

abundance and distribution is from analyses of the migratory woodland George River and Leaf River caribou herds in Quebec and Newfoundland (Schaefer *et al.* 2000; Bergerud *et al.* 2008; Couturier *et al.* 2010; Taillon *et al.* 2012). Annual variation further complicates assessment of distribution trends as barren-ground caribou characteristically shift their winter distribution among years (Schaefer *et al.* 2000), and winter ranges often overlap between neighbouring herds (Thomas *et al.* 1998; Schmelzer and Otto 2003; Bergerud *et al.* 2008; Nagy and Campbell 2012).

Trends in annual distribution

Trends in the annual distribution of the four western NWT herds (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West and Bluenose-East) were not available for this assessment. However, the cumulative winter distribution of satellite-collared females within the period 1996-2004 (Nagy *et al.* 2005) suggested the distribution limits were similar to the generalized historic 'usual' winter ranges (Map 1 *in* Kelsall 1968). However, subsequent to Nagy *et al.*'s (2005) review, abundance for Cape Bathurst and Bluenose-West sharply declined (see *Abundance*, p. 122); therefore, trends in winter distribution could possibly have changed.

Overall, the trend for the southern and southwest portion of barren-ground caribou range is a contraction since the late 1960s (Banfield 1961; Kelsall 1968). For the Beverly herd, Thomas *et al.* (1998) summarised historic information to suggest a longer-term trend toward a reduced southern distribution with a reduction of at least 200 to 300 km between the 1950s and the 1980s (both periods of peak abundance) (Fig. 26, p. 160). Although this somewhat contradicts the pattern of range size, especially the winter range, reflecting herd size, major fires in northern Saskatchewan and the southern NWT in the early 1980s may have contributed to the range retraction. Since Thomas *et al.*'s (1998) report, the distribution has not been mapped during aerial surveys, although in fall 2001, hunters in northern Saskatchewan reported a lack of caribou (Johnson *et al.* 2009). For the Qamanirjuaq herd, satellite collar locations show that since 2010, this herd has sometimes wintered in the southeast NWT, sometimes nearing the southeast of Great Slave Lake (Adamczewski pers. comm. 2015; Croft pers. comm. 2015).

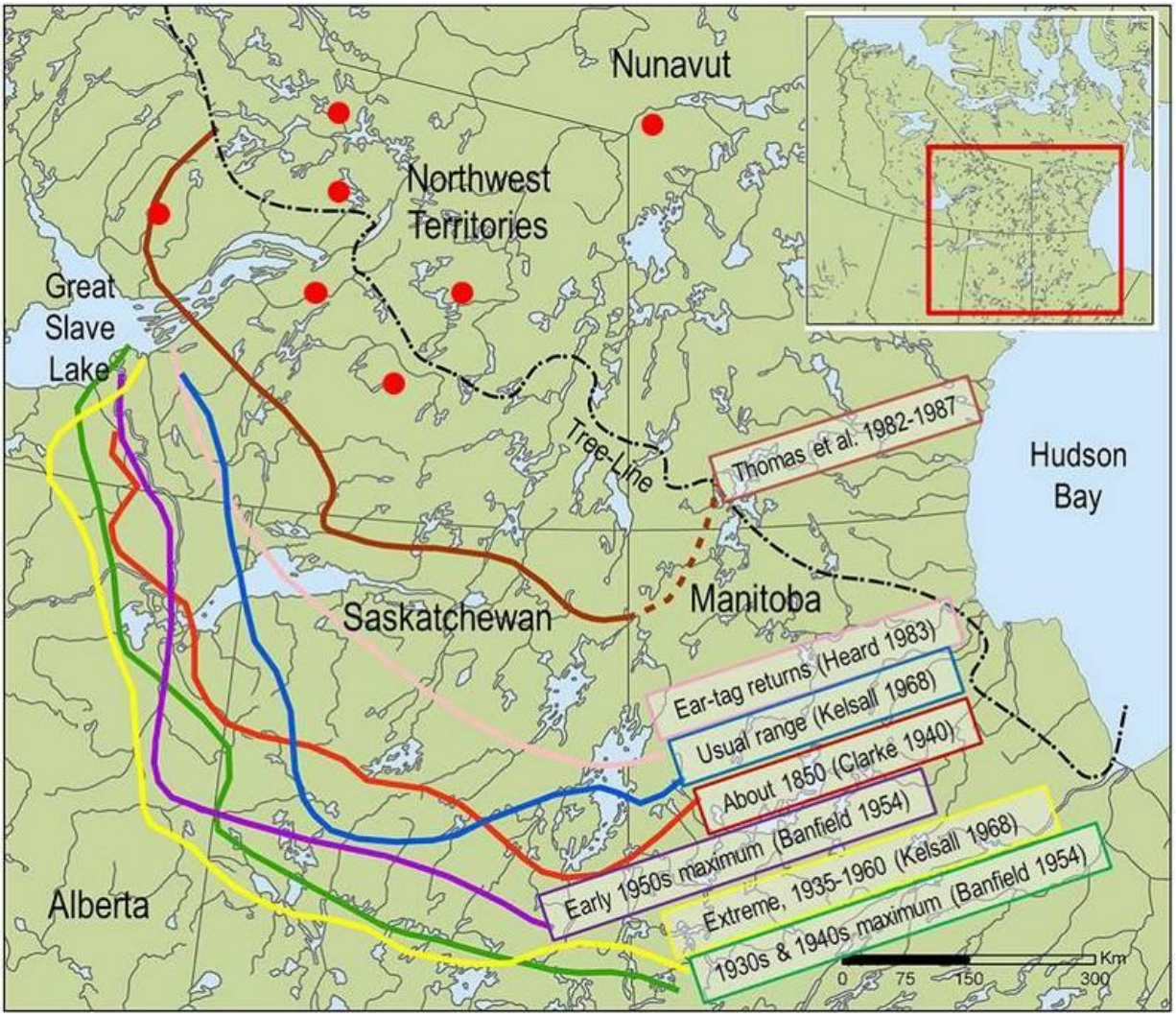


Figure 26. Southern extent of winter distribution for the Beverly herd, 1935 to 1987 (from Thomas *et al.* 1998[12]). Red dots are the mid-February 2014 locations of seven Beverly-Ahiak females collared by ENR in April 2012 (Adamczewski pers. comm. 2014, used with permission) (map amended by B. Fournier, ENR).

In northwestern NWT in the early 1950s, barren-ground caribou were reported as far west as Norman Wells and large numbers of caribou wintered from Fort Norman to south of Wrigley (Kelsall 1968). In 1954, caribou crossed the Mackenzie River by the Horn Plateau near Fort Providence (J. Antoine reported *in* Beaulieu 2012). In winter 2002, barren-ground caribou were reported near Wrigley for the first time in 20 years (T. Lennie pers. comm. *in* Gunn *et al.* 2004).

Those locations are similar to mapped distributions used during two or three out of 10 winters between 1948 and 1960 (Kelsall 1968).

[12] Wording (i.e., usual, maximum, extreme) are from Thomas *et al*. 1998 and indicate that the range circa the 1940s was further west and south than earlier observations.

The longer-term trends in barren-ground caribou wintering on the tundra or tundra-forest transition in the NWT are largely undescribed. Kelsall (1968) reported wintering on the tundra-forest transition north of Great Bear Lake extending on to the tundra in the vicinity of Bluenose Lake during 1950-60. The areas used by the Bluenose-East and West herds and the areas used in 1996-2004 by the Cape Bathurst herd for wintering (Nagy *et al.* 2005) do not completely overlap the distribution mapped by Kelsall (1968) based on a visual inspection of the maps.

For the Bathurst herd, information on the winter distribution prior to 1996 is from aerial unsystematic reconnaissance surveys from 1985-95 (Williams and Fournier 1996). Overlapping areas used annually indicated a high frequency of late winter distribution north and west of Great Slave Lake (Williams and Fournier 1996). Subsequent trends based on satellite-collared females during 1996-2005 suggest first an expansion in the winter range to south of Great Slave Lake in the forested southeast NWT (1997-2001) (Fig. 27, p. 162), then, based on the southern edge of the 90% winter range for the Bathurst herd during 2001-2010, females wintered progressively further north of the 60th parallel (Fig. 28, p. 163; Gunn *et al.* 2011a). This trend toward wintering north of the East Arm of Great Slave Lake is reflected in a shift to wintering northwest of Great Slave Lake after winter 2000-01 (Fig. 27, p. 162; Gunn *et al.* 2011a, 2013a).

Bathurst caribou wintering southeast of Great Slave Lake in 2000 may have been part of the expansion and/or shift of the winter distribution south and west into the taiga and tree-line transition zone since the late-1990s. In April 1996, five females collared on the tundra east of Bathurst Inlet subsequently migrated east and calved along the Queen Maud Gulf coast (Gunn *et al.* 2000). During winter 1997-98, those females shifted their distribution south from the tundra to the tree-line transition zone southeast of Great Slave Lake. Based on females collared in 2000 and 2001 (Fig. 29a and b, p. 163), the winter distribution of collared females that calve along the coastal Queen Maud Gulf appears to have increased since 1998, further south and west (Gunn and D'Hont 2002). In 2005 (Gunn *et al.* 2013a) and 2006-08 (Johnson *et al.* 2008; Adamczewski *et al.* 2015), more collars were fitted to females and those females and the winter distribution overlapped that recorded in 2001-02 (Gunn *et al.* 2011b).

Between 1996 and 2005, there was no trend in the size of the winter range based on the satellite-collared females (Gunn *et al.* 2013a). Subsequent to 2005, information has not been compiled. Herd abundance has declined, so further changes in distribution are likely.

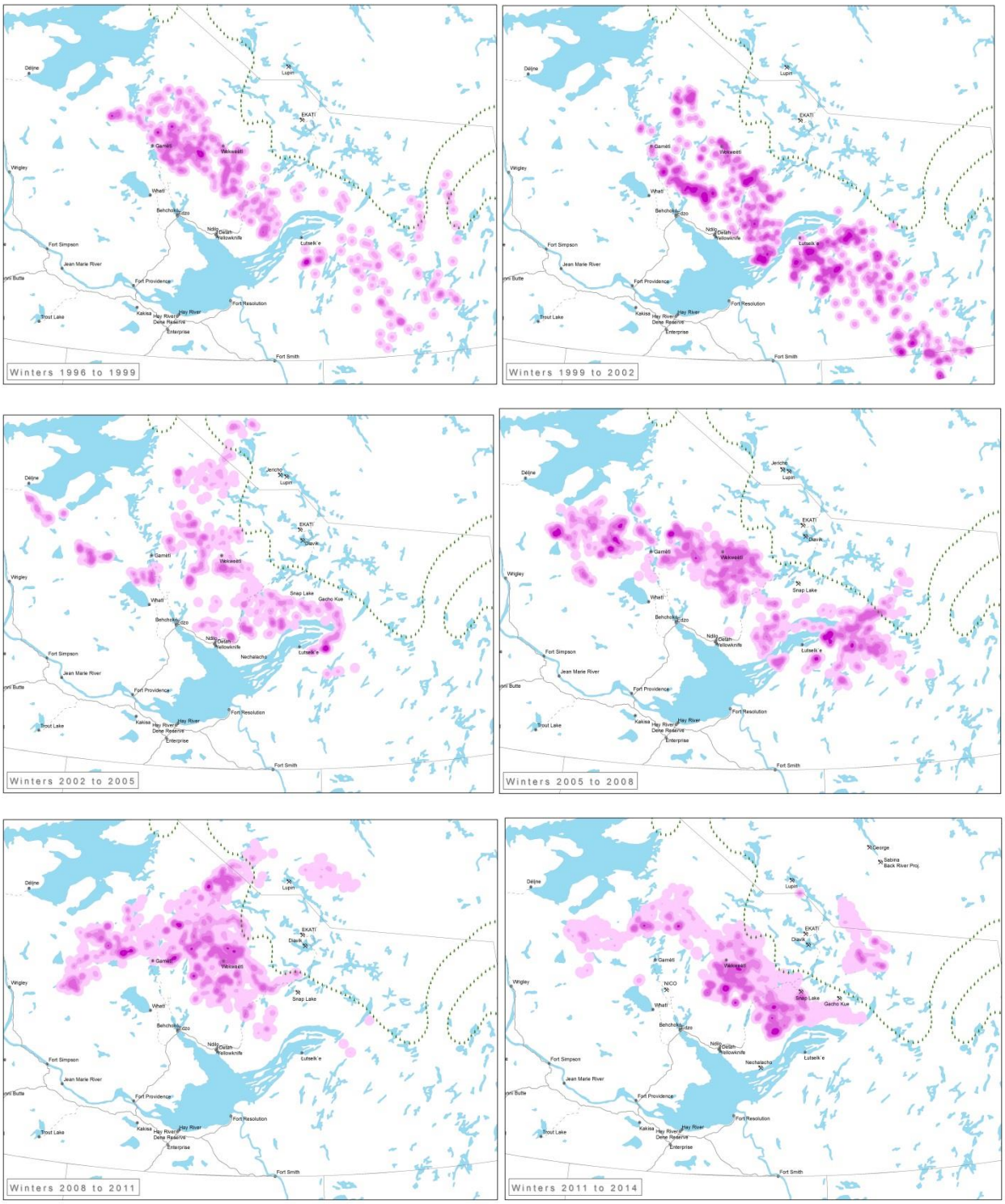


Figure 27. Location of winter (6 December -14 April) range for the Bathurst caribou herd, 1996 to 2014, based on collared females (from left to right, winter range for 1996-99, 1999-2002, 2002-05, 2005-08, 2008-11, and 2011-14) (map by B. Fournier, ENR). Note the general retraction of the southern extent of winter range over time.

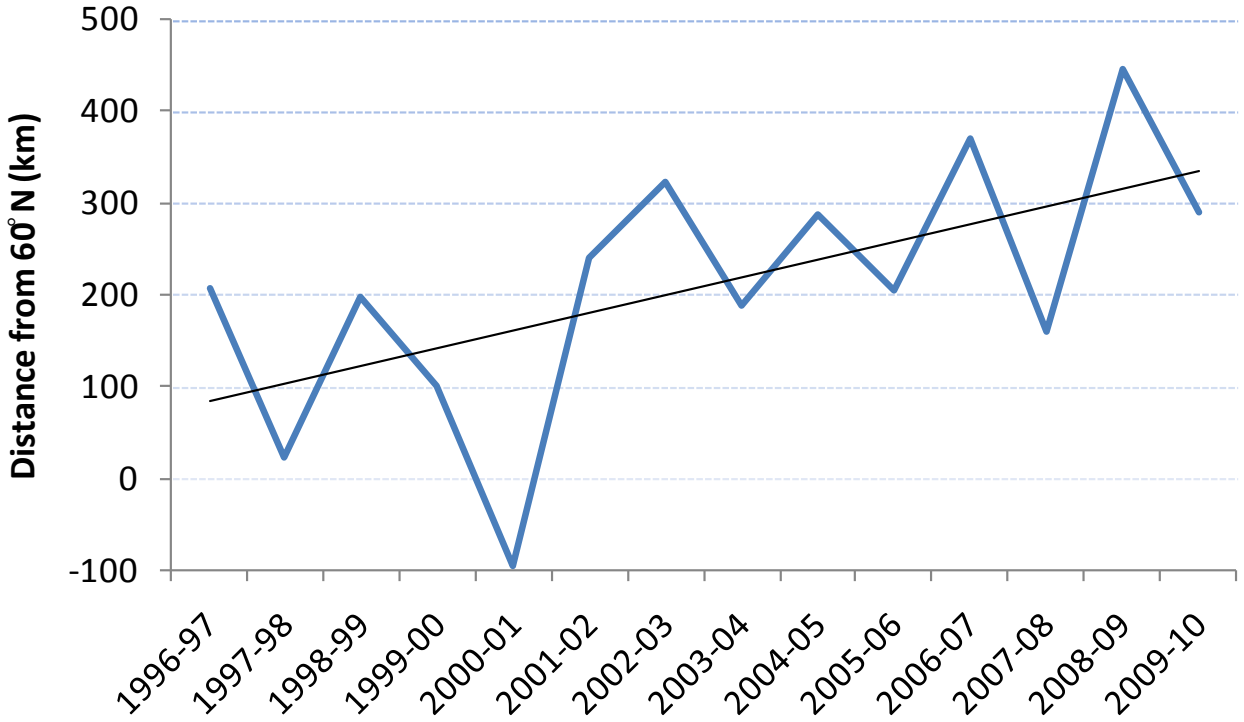


Figure 28. Distance north of 60 degrees latitude from the southern edge of the 90% winter range for the Bathurst herd, 1996-2010 (reproduced from Gunn *et al.* 2011a).

a. b.

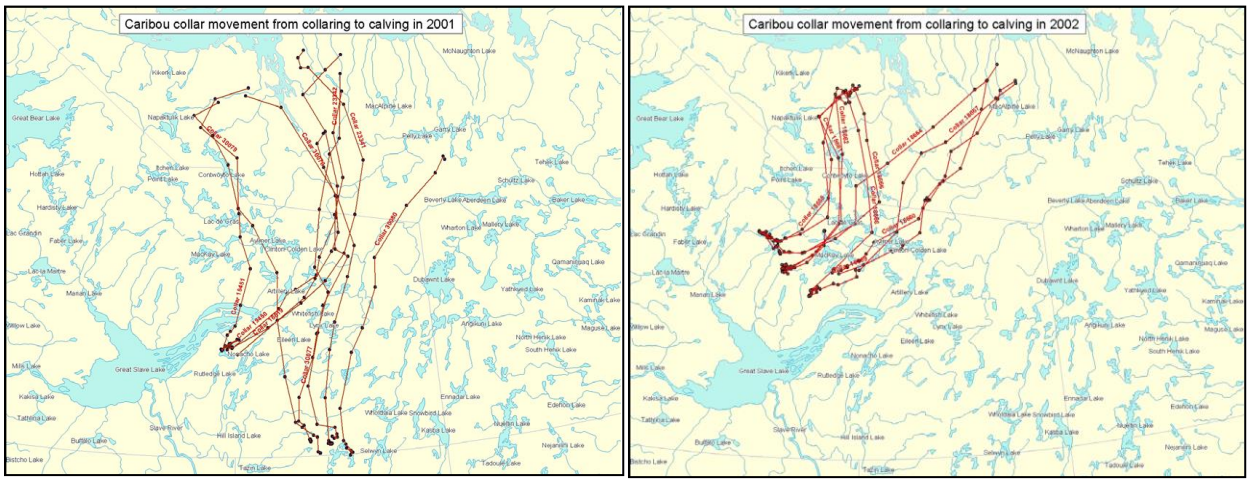


Figure 29. Collaring locations and spring migration routes for females fitted with satellite collars March - 1 June 2001 and 2002, NWT and NU (reproduced from Gunn and D'Hont 2002).

Overlapping winter ranges of the Bathurst and Beverly herds was recognized from ear-tagging (Heard 1985), aerial surveys (Thomas *et al.* 1998) and satellite collars on females (Gunn *et al.* 2013a). Thomas *et al.* (1998) described winter distribution of the Beverly herd for five winters

between 1982 and 1987 based on a series of aerial surveys. They had noted an east to west movement during the winter in relation to snow conditions. Although they commented that the Beverly winter range extended further east and west than expected during the 1980s, they were unable to identify which herd (Beverly or Bathurst) was involved without marked individuals. Even with marked individuals, different interpretations on designating herd identity can still result in uncertainty about the number of herds and whether the herds have been lost.

In summary, while the overall pattern for winter ranges are complicated by the overlap between neighbouring herds, the trend for the Bathurst winter range was to contract northwards from the south as herd size declined. There is little reported on annual shifts in trends for the Beverly, Bluenose-East and Bluenose-West herds and less is known about any trends for the treeline transition/tundra wintering herds such as Tuktoyaktuk Peninsula and Cape Bathurst in the western NWT.

Trends in calving ground distribution and location

More is known about trends in calving distribution as aerial surveys have been relatively frequent and sampled for a relatively long period for some herds. For the Bathurst herd, through aerial surveys and satellite collared females, 24 calving grounds have been mapped over a 42 year period between 1996 and 2007 (Gunn *et al.* 2007, 2012). An additional eight calving ground distribution surveys and three calving ground photo surveys have been undertaken since 2007 (Croft pers. comm. 2015). Trends in distribution of calving and summer ranges are less marked than for the winter ranges as caribou typically show stronger fidelity to both calving and summer ranges (Schaefer *et al.* 2000; Gunn *et al.* 2001; Nagy 2009a and b). The calving grounds are termed ‘traditional’ as successive generations of females typically use the calving grounds.

Nagy (2009b) summarized the surveys of Cape Bathurst, Bluenose-West and Bluenose-East herd calving grounds since 1974. The earlier surveys were systematic surveys to map distribution and numbers; methods to define boundaries varied and were not always reported. More recent systematic aerial transect surveys of the Cape Bathurst and Bluenose-West calving grounds were conducted between 2000 and 2006 (Theberge and Nagy 2001; Nagy and Johnson 2007b; Davison 2015) to estimate calf: female ratios (Nagy and Johnson 2007a and b). As an example of the overlapping annual distribution of calving, four maps from Nagy and Johnson (2007b) for the Bluenose-West herd are reproduced here as a four-panel map (Fig. 30, p. 165). In June 2005, the technique was changed to photographing groups with a radio-collared female (Nagy and Johnson 2007b). Nagy (2009b) mapped the percentage overlap between calving grounds from 1974-76 compared to 1996-2007 for the Bluenose-West and Cape Bathurst herds. Nagy (2009a) noted that it was unclear whether the Bluenose-East herd had shifted its calving grounds further east as the extent of sampling of the area in the 1970s was unknown.

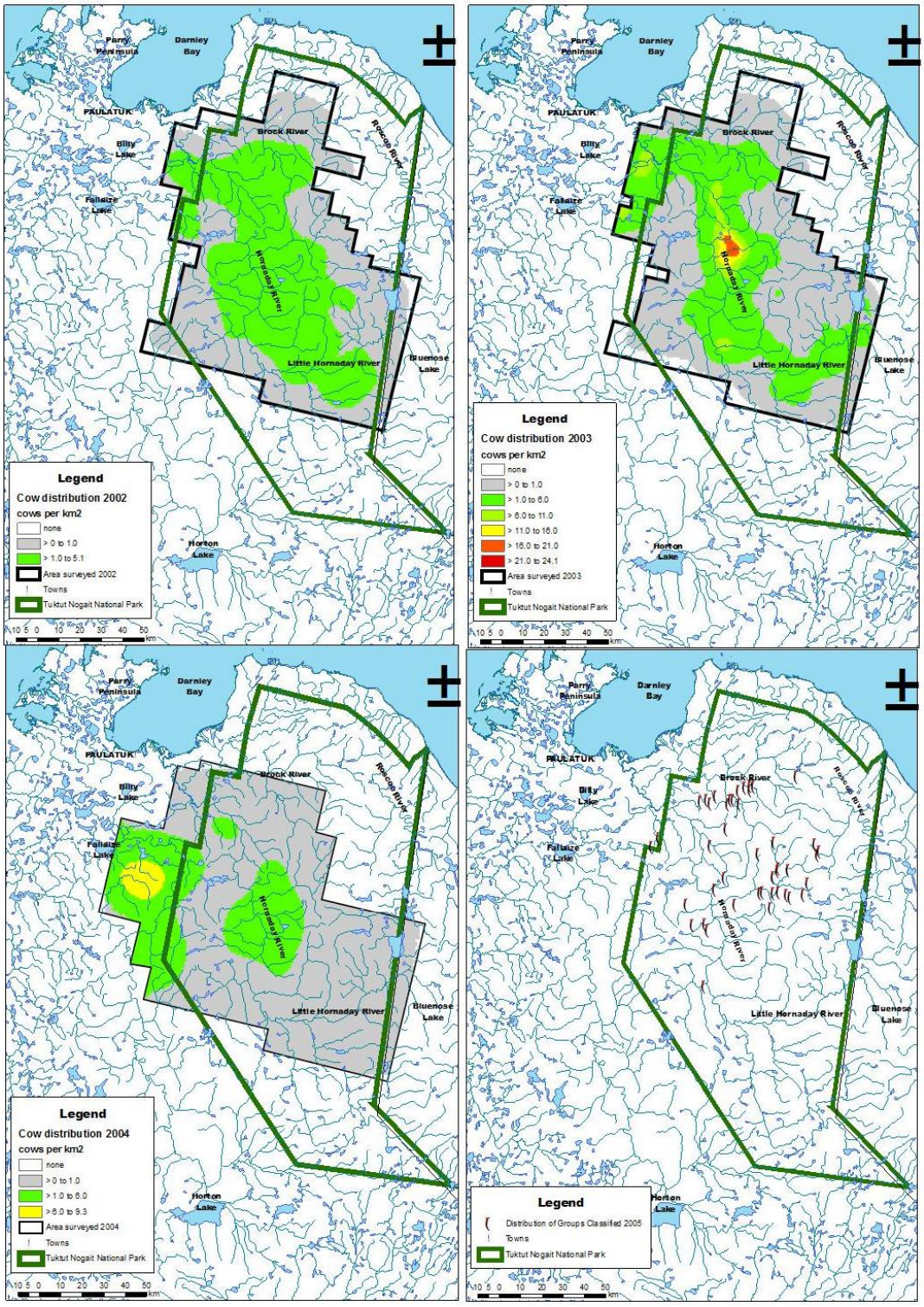


Figure 30. Distribution of females during calving on the Bluenose-West calving ground June 2002-05. Gray is <1.0 females/km^2; light green to red is 1.0-24 females/km^2 based on ordinary kriging analysis to extrapolate between point observations (figure reproduced from Nagy and Johnson 2007b).

Changes in spatial fidelity have occurred (Fig. 31, below) for the Bathurst herd (Gunn *et al.* 2008). Between 1985 and 1995, there was a directional shift of the calving ground from east to west of Bathurst Inlet, moving about 250 km. The shift was during a period when the herd numbered 350,000 or more (peak densities in the high density stratum of 100-200 caribou/km^2; Gunn *et al.* 1997; Gunn *et al.* 2012), which led Gunn *et al.* (2012) to suggest that the shift to an unused calving ground was a consequence of the high densities of breeding females.

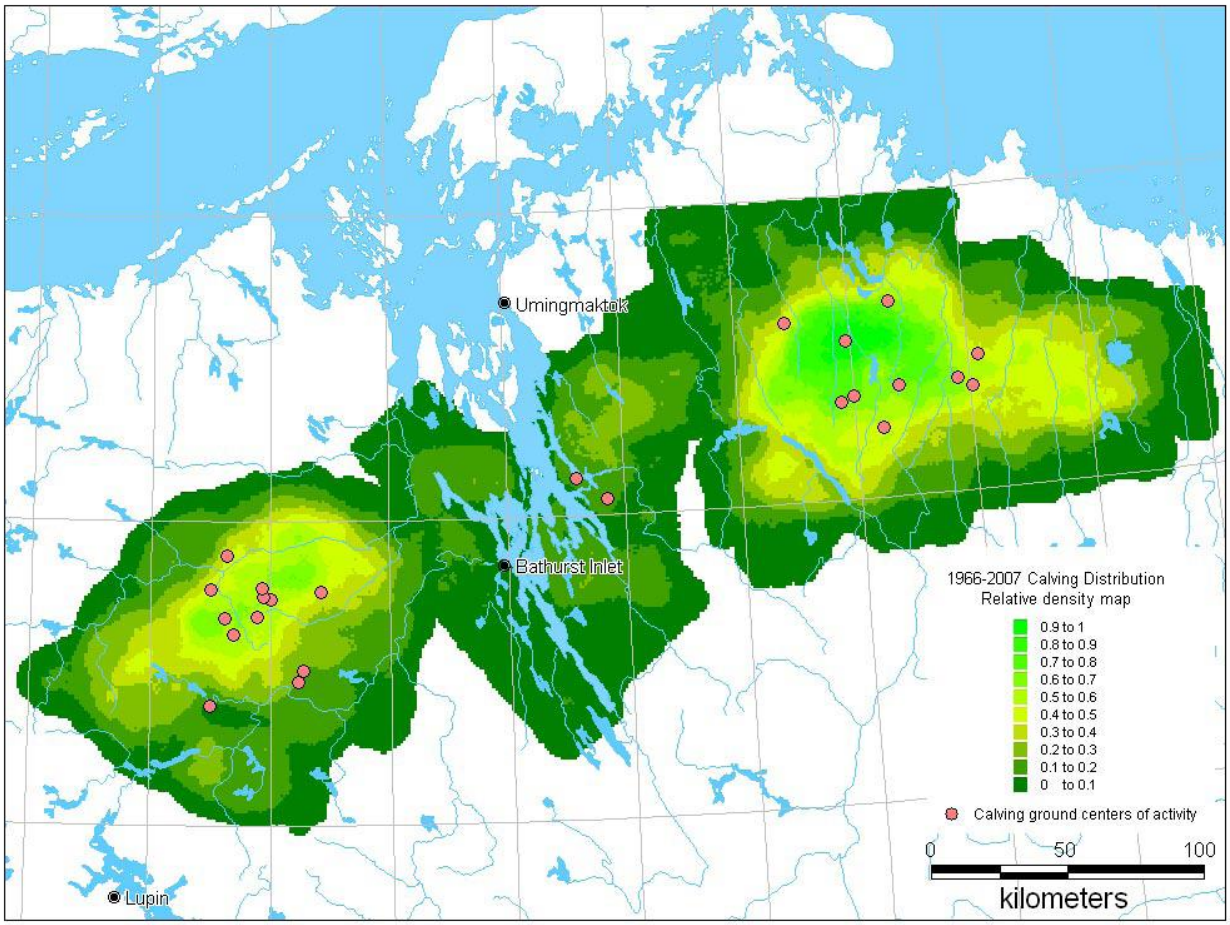


Figure 31. The cumulative density of peak calving grounds based on a moving window analysis of relative densities for the Bathurst herd aerial surveys (1966-90) and satellite telemetry (1996-2007) (reproduced from Gunn *et al.* 2008).

Spatial analyses for the Beverly and Ahiak herds reveal long periods (decades) when consecutive calving grounds overlap (Gunn *et al.* 2007, 2008, 2013a and b). Based on 23 aerial surveys conducted in 1957-94, the location of the Beverly herd's traditional inland calving grounds displayed varying levels of overlap (Fig. 32, p. 167). The area south of Beverly Lake was mostly used by non-breeders and by females in 1957 and 1958, when calving was delayed by a late snow melt (Gunn and Sutherland 1997). It was unknown how much calving was typically south of Beverly Lake between 1957 and 1974, but by 1978 breeding females were not found immediately south or north of Beverly Lake. After 1978, the location of the calving ground was

mapped using the distribution of the breeding females, and between 1978 and 2002 there was a high degree of cumulative overlap (Gunn and Sutherland 1997; BQCMB 2000; Johnson and Mulders 2009). This pattern of overlap continued with the 2006-09 calving grounds, although numbers of breeding females were extremely low (Johnson and Williams 2008; Adamczewski *et al.* 2015). By June 2009 and 2010, there were so few breeding females on the traditional inland calving ground that concentrations could not be defined and by June 2011, no newborn calves were observed (Williams pers. comm. *in* Adamczewski *et al.* 2015).

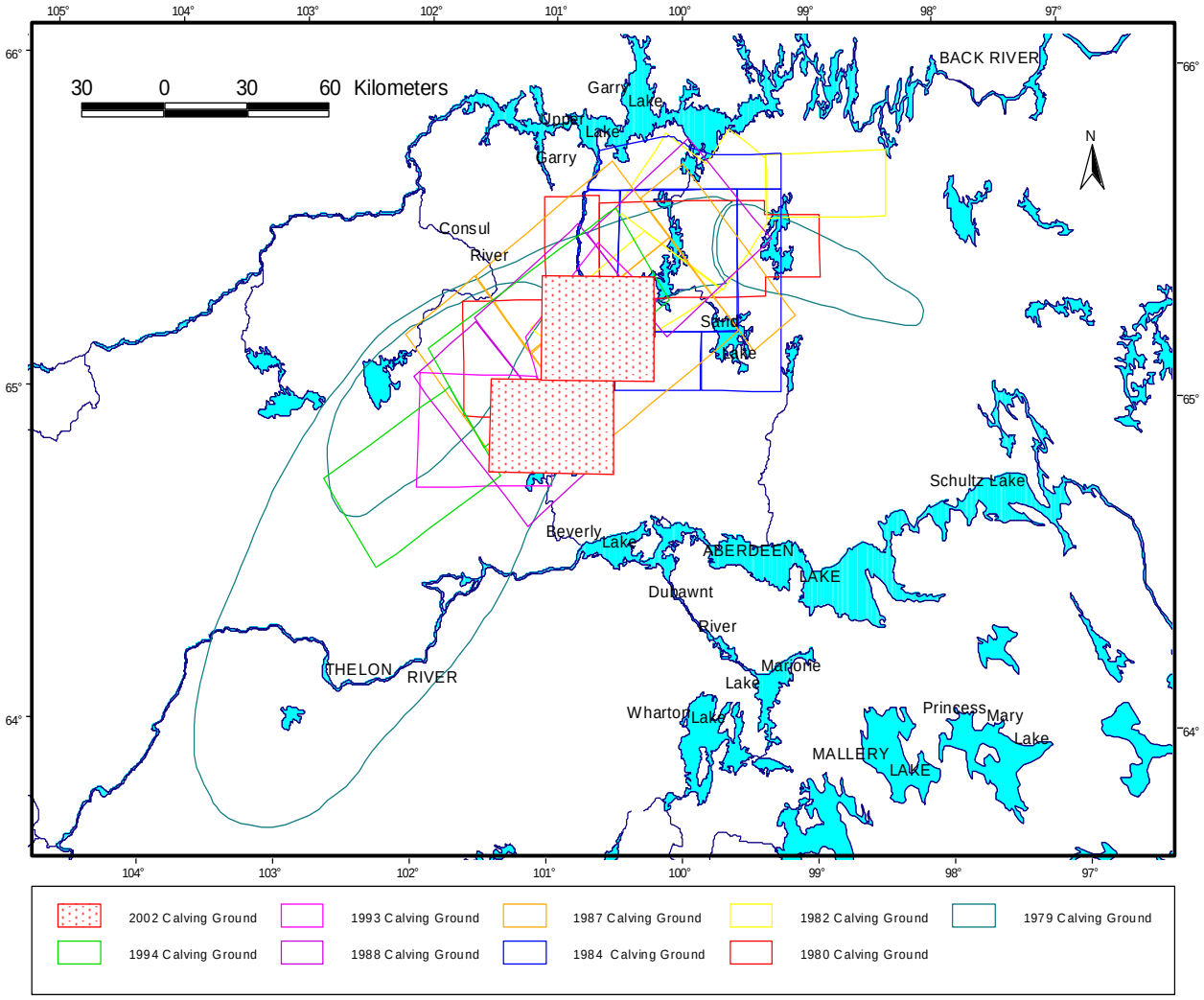


Figure 32. The locations of the Beverly herd's traditional inland calving grounds between 1979 and 2002 (reproduced from Johnson and Mulders 2009).

While the evidence for the 1994-2009 trend in the use of the traditional inland Beverly calving ground is clear as it is based on measurable and declining densities, evidence for what happened to calving Beverly caribou since 1994 is less clear and results in two differing explanations of how the decline occurred (see *Systematic/taxonomic/naming clarifications*, p. 93).

The Ahiak herd's calving ground was mapped in June 1986 and 1996. The two systematic aerial surveys and four satellite-collared females (1996-98) indicated a trend for the calving grounds to have elongated to the west along the coast of the Queen Maud Gulf and extended east across Adelaide Peninsula to Chantrey Inlet (Gunn *et al.* 2000). Subsequent surveys between 2006 and 2008 indicated that the location of the calving ground was similar to 1996 (Johnson *et al.* 2009).

THREATS AND LIMITING FACTORS

Barren-ground caribou are a resilient species adapted to an environment characterised both by annual variation and decadal trends in such factors as the timing of spring melt and plant green-up. People have lived for a long time with barren-ground caribou (e.g., Gordon 2005) and the certainty that their numbers increase and decrease, and that they do return. However, the changing conditions across barren-ground caribou ranges reduce that certainty. The following describes how some of those changing conditions can act as threats to barren-ground caribou populations over the next 25 years (three generations).

For the purposes of this report, 'changing conditions' includes not only the direct threats (forest fires; predation; novel parasites or diseases; over-harvest; industrial development) but also the far-reaching changes in governance and institutional changes for caribou management. Direct threats interact with each other with either additive or compensatory effects and the recognition and mitigation of the threats is through collaborative adaptive co-management. While collaborative adaptive co-management is innovative and the logical approach for the future, it is often challenging when complex, difficult decisions are needed in a timely manner. Also in the context of jurisdictional complexity, the lack of overall land use planning, especially in the context of cumulative effects of industrial developments and human activities represents a potential threat. In particular, the lack of an overall approach to calving ground management has been identified as a specific threat.

Disturbance from human activity

For the Porcupine herd, activity on the winter range, oil and gas exploration in the Eagle Plains basin (Alaska), improved access offered to hunters by the Dempster Highway (NWT and Yukon), and potential future mineral exploration in the Peel River watershed (Fig. 33, p. 169) represent likely threats. Of more significance however, will be an expected decision on oil and gas exploration and development on the coastal plain of the Arctic National Wildlife Refuge. This decision, previously deferred through section 1002 of the *Alaska National Interest Lands Conservation Act* (1980), would allow exploration and development in critical calving habitat used by the herd (PCMB 2016).

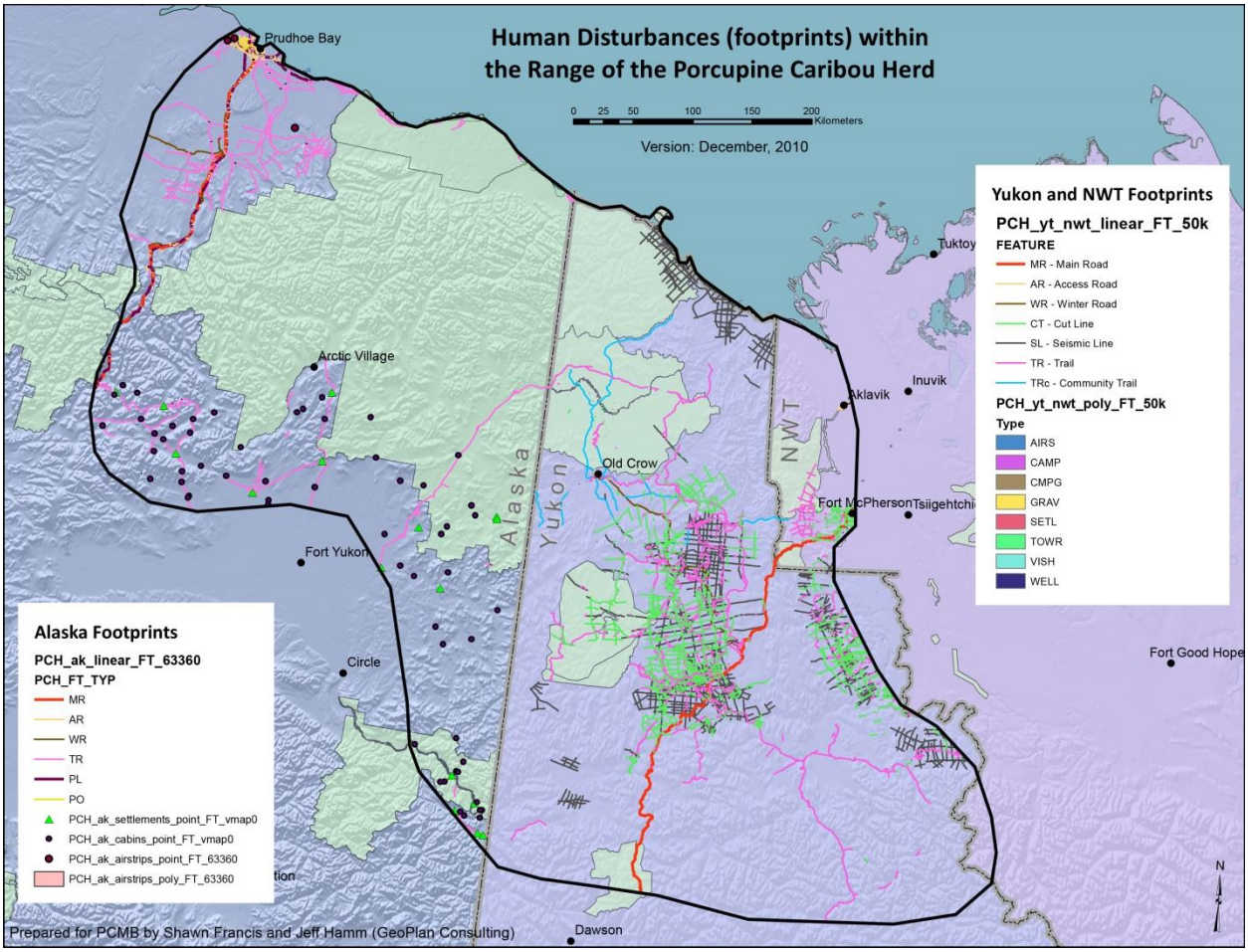


Figure 33. Human disturbance (footprints) within the range of the Porcupine caribou herd (reproduced from PCMB 2016). Linear features and industrial disturbance are not to scale.

Industrial development activities (exploration, mining, and oil and gas) vary over time, in a boom and bust cycle dependent upon the global economy. Following peaks in the 1990s and mid- to late-2000s (prior to the 2008 market crash), exploration and development activity has, for the most part, been declining in the NWT. Little to no 2D and 3D seismic activity has taken place since 2007. As of 2007, mineral leased claims, typically associated with active mines, comprised only 0.7% of the NWT land base. Production licenses, primarily occurring in the Mackenzie Valley, with some also in the Mackenzie Delta and Beaufort Sea, comprise <2% of the NWT land base. There has been some recent increase in prospecting and mineral claims as a result of interest in diamond, gold, base metal, rare earth element, and uranium exploration (ENR 2015).

In addition to established mines (Diavik, Ekati, Gahcho Kue, Jericho, and Snap Lake), several projects are being considered in the North Slave region of the NWT and the Kitikmeot region of Nunavut. Fortune Minerals Ltd.'s NICO Project and Avalon Rare Metal Inc.'s Nechalacho Rare Earth Elements Project have recently completed their environmental assessments (Mackenzie

Valley Review Board [MVRB] 2016a and b). The projects will be constructed near Whatì and Yellowknife, respectively, and fall within the summer range of the Bathurst herd. In the Kitikmeot region of Nunavut, on the post-calving ranges of the Beverly and Ahiak herd, MMG Resources Inc. is proposing the construction of a zinc/aluminum/lead mine at Izok and High lakes (Izok Corridor Project), an all-season road, and a port facility at Grays Bay on the Coronation Gulf (MMG Resources Inc. 2012). On the Beverly herd's summer range, a uranium mine has also been proposed (Nunavut Impact Review Board [NIRB] 2014). Exploration activities by Tundra Copper Corp. and Crystal Exploration (APEX Geosciences) in the core calving areas of the Bluenose-East and Bathurst herds, respectively, were approved by NIRB in 2015 (NIRB 2015a and b). Within the core calving area of the Qamanirjuaq herd, mineral exploration by Anconia Resources Corp. was approved by NIRB in 2012 (NIRB 2012). This is in additional to the recent position taken by the Nunavut Government, opposing blanket protection for barren-ground caribou calving grounds (Kivalliq Wildlife Board 2016). Although entirely within Nunavut, the transboundary nature of barren-ground caribou herds makes potential future impacts from these projects relevant to the assessment of barren-ground caribou in the NWT.

In terms of linear disturbance, a 28 km all-weather road through the central barrens is currently under construction and there is the possibility of an all-weather road connecting a deep-water portion of the Arctic coast to interior resource developments. The Jay pipe expansion at Ekati mine will likely increase traffic on the Tibbitt to Contwoyto winter road (MVRB 2014). Further, the GNWT has proposed the extension of Highway 4 into the Slave Geological Corridor and is prioritizing the development of the Mackenzie Valley Highway from Wrigley to Tuktoyaktuk (Department of Transporation [DOT] 2016), which would provide increased access to the winter range of the Cape Bathurst herd and pass near the ranges of the Bluenose-West and Bluenose-East herds (ACCWM 2014). For examples of proposed and operational all-season roads, see Table 8 (p. 171).

Table 8. Proposed and operational all-season roads associated with mines on tundra ranges of barren-ground caribou in the NWT (modified *from* COSEWIC 2016).

Herd	Road type	Operation	Road km	Start-up year	Access
Qamanirjuaq	Ore haul road pit to plant	AEM Meliadine[1]	24	Proposed	Public
Lorillard and Ahiak	Supply road from Baker Lake	AEM Meadowbank[1]	107	2010	Public
	Ore haul road to pit to plant	AEM Meadowbank (Whale Tail extension)[2]	c. 50	Proposed	Private
Bathurst	Ore haul road pit to plant	DDEC Ekati (Misery Rd)[3]	27	2001	Private
	Ore haul road pit to plant	DDEC Ekati (Sable Rd)[3]	20	2019	Private
	Ore haul road pit to plant	DDEC Ekati (Jay Rd)[3]	5	2022	Private
	Ore haul road pit to plant and supply road to winter road to Yellowknife	BIPAR Phase 2 to[2] Contwoyto Lake	132	Postponed	Public
	Ore haul road pit to plant	MMG Izok to Grays Bay Road and Port[2]	80	Postponed	Private
	Road for resources from Contwoyto L to port	GN and KIA Grays Bay Road and Port (Phase 1)	270	Proposed	Public
	Road for resources from Yellowknife to Contwoyto Lake	Road and Port (Phase 2)	c. 600	Proposed	Public
Beverly-Ahiak	Ore haul road pit to plant and supply road to port	BIPAR Phase 1 Back River[2] and Hackett[2]	85	Postponed	Public
	Ore haul road pit to plant and supply road to port	Doris North[1]	16	2008	Private
Porcupine	Public highway	n/a	736	1979	Public
	Northern Cross[4]	Oil and gas well development	c. 95	Proposed	Private

[1] Listed as completed environmental assessments (NIRB 2014).
[2] Listed as active environmental assessments (NIRB 2014).
[3] Listed as completed environmental assessments (MVEIRB 2014).
[4] Listed as active environmental assessments (YESAB 2016).

Of the NWT's barren-ground caribou herds, the Bathurst herd likely faces the most pressure from human activities. Exploration activity within the Bathurst range increased rapidly through the early to mid-2000s to peak at 95 exploration camps in 2006 (Fig. 7.5-3 *in* De Beers Canada 2010). Mainly covering 1996 to 2010 with more limited data from prior to 1996, approximately

250 previous and existing industrial developments occur within the Bathurst herd's annual range, from lodges and small mineral exploration camps to fully developed mines and communities (Table 7.5-1 *in* De Beers Canada 2010). Winter roads, all-season roads and highways totalling over 2,100 km in length also occur within the Bathurst herd's range. Modeling human development scenarios shows that the number of proposed or constructed roads as part of mine developments is increasing on tundra ranges mostly, for the Bathurst herd (Fig. 34, below).

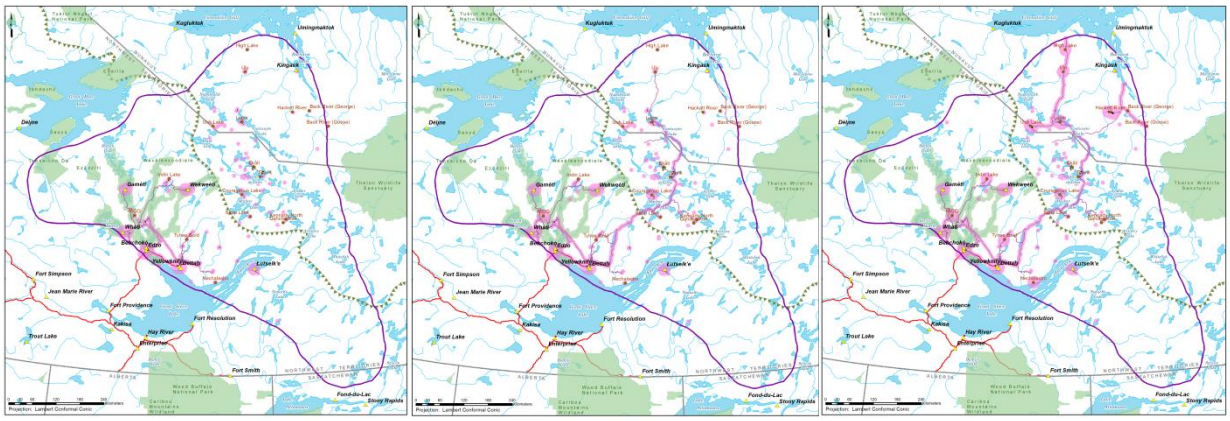


Figure 34. Three future human development scenarios for the range of the Bathurst herd (from left to right, showing the outcome of the scenario in 2040: declining development, continuing development, and increasing development). All three focus on different levels of mineral exploration and development activity, and their associated transportation infrastructure. They extend 24 years into the future and were developed based on proposed projects and transportation concepts either in assessment, planned, or with a reasonable likelihood of occurring (Clark *et al.* 2016).

With respect to oil and gas activities, the proposed Mackenzie Gas Project (the Parsons Lake Anchor Field, including associated infrastructure such as the airstrip, lateral and pipeline corridor), could increase camps, winter roads and aircraft flights on the winter ranges of the Cape Bathurst and Bluenose-West herds (Joint Review Panel 2010). However, this project has been delayed until 2022, making this threat less imminent than it otherwise would have been.

Caribou respond to human activities, especially those associated with industrial exploration and development (Wolfe *et al*. 2000; Cameron 2005; Cameron *et al*. 2005; Stankowich 2008; Vistnes *et al*. 2008; Boulanger *et al.* 2012). Disturbances, such as low level aircraft flights, people on foot and vehicles can increase caribou energetic costs if these activities interrupt caribou foraging or cause the caribou to move away in response to the disturbance (Weladji and Forbes 2002). Roads can potentially affect caribou by increasing disturbance, creating partial barriers to movement, and increasing access for harvesting (Wolfe *et al*. 2000). Studies from the two diamond mines in the Lac de Gras area within the Bathurst herd's summer range have suggested that a 14 km zone of influence exists within which caribou abundance is less than what would be expected without the developments (Boulanger *et al.* 2012). As the number of mines increases, the zones of influence cover an increased proportion of post-calving and summer ranges for the Bathurst herd. There still remains considerable uncertainty about when, how and if there is a

threshold for cumulative effects at which clear and predictable effects on herd size and trend can be expected (Mackenzie Valley Environmental Impact Review Board [MVEIRB] 2013, 2016).

Each of the major projects that are subject to environmental assessments include cumulative effects assessments but they are proponent rather than issue-driven and have not made a significant contribution to managing cumulative effects (Gunn *et al*. 2011c). Concerns about cumulative effects and limits to development footprints are an on-going concern. The recommendations of the Joint Review Panel (2010) recognized the threat of a major development (the Mackenzie Gas Project), and included range management plans for the winter ranges of the Cape Bathurst and Bluenose-West herds, which included linear and area density development thresholds. Driven by the GNWT, efforts are currently underway to develop a Bathurst caribou range (habitat) plan, which would consider cumulative impacts to Bathurst caribou habitat within caribou management planning, land use permitting, land use planning, and environmental impact assessment (Clark pers. comm. 2014; Bathurst Caribou Range Plan Working Group 2016).

Climate change

Climate change signals are particularly strong in the Arctic and the Mackenzie Valley (IPCC 2014). Although evidence is already strong for changes such as an increase in shrubs (Myers-Smith *et al.* 2011), changes to the ecology of barren-ground caribou due to climate change will be complex, consisting of positive and negative effects, most of which are interacting and non-linear (Cebrian *et al.* 2008; Chen *et al.* 2014).

Caribou may be susceptible to heat stress (Soppela *et al.* 1986): days with mean daily temperatures exceeding 25˚C are infrequent for the Bluenose-East, Bathurst, and Qamanirjuaq herds and the number of days when temperatures exceeded mean +2 SD for the 1990s was similar to the 2000s. The summer of 2014 stands out with more high temperature days experienced by the three herds than in previous records from 1979 to 2014 (CARMA 2014).

Recent climate and weather trends indicate warmer temperatures, longer snow-free periods, deeper maximum snow depths, warmer ground with associated changes in nitrogen dynamics and increased plant growth. Over the last 30 years, temperatures have risen over 2˚C for the Taiga Plains, especially in winter and spring (ESTR Secretariat 2011). These temporal trends are based on data from weather stations, which are few across caribou ranges. However, there is also the MERRA spatial dataset, which is applied to caribou seasonal ranges at the scale of 1/2 degrees latitude by 2/3 degrees longitude (Russell *et al*. 2013).

Chen *et al.* (2014) found indicators of summer forage (leaf biomass, phenology, and nitrogen content), derived from remote sensing and weather data, were correlated with population change in the summer season for the Bathurst herd, suggesting that weather and summer range conditions can act as severe limiting factors to population-level dynamics for barren-ground caribou. A climate envelope was measured at which lower availability of summer range forage

explained some of the variation in productivity 2-3 years later in the Bathurst herd (Chen *et al.* 2014).

Many plant productivity trends for barren-ground caribou are driven by decadal climatic patterns, which are the result of larger scale atmospheric patterns, such as the Arctic, North Atlantic (NAO) and Pacific Decadal Oscillations. Correlation between changes in caribou abundance and dominant decadal patterns has been mostly documented through the effects of winter foraging conditions in Alaska, other parts of eastern Canada and Scandinavia (Forchhammer and Post 2004; Zalatan *et al*. 2006; Joly *et al.* 2011; Weladji and Holand 2006; Bastille-Rousseau *et al.* 2013). Weladji and Holand (2006) reported that reindeer age classes born following a high NAO winter index were lighter in summer and early winter, and had a lower absolute growth rate than cohorts born after cold and dry winters (low NAO winter index; State Climate Office of North Carolina 2016).

Plant growth has increased over the last three decades by 20-26% based on satellity imagery (Normalized Difference Vegetation Index; NDVI) correlated with field measurements (Epstein *et al*. 2012). The increases in plant biomass are strongest along the mainland Arctic coast (Cape Bathurst and Queen Maud Gulf areas). However, lichen-dominated communities had consistently lower NDVI trends than vascular plant-dominated communities (Olthof and Pouliot 2010). In addition, the trends for increasing net plant productivity may not mean an increase in forage quality as, for example, the amount of solar radiation (or cloud cover) and temperature also affect the levels of compounds such as tannins in plants, which affects forage quality (Weladji *et al.* 2002). Thus, the conditions that promote greater primary productivity may also lower the quality of some of the vegetation as food for herbivores (e.g., see Chen *et al.* 2014).

Progress is being made in correlating individual fitness through energetic and protein allocation models. Such models permit exploring interactions between changes in forage availability, diet quality and both internal and external parasites (Russell *et al*. 2005; White *et al.* 2013). Modeling at the individual scale and exploration of corrlations between herd scale indicators and weather will contribute toward predicting more detailed effects of global warming (Berteaux *et al.* 2006).

Future climate change may act as a continuing threat for barren-ground caribou through a complex mechanism involving shifts in timing of greening, lower summer forage quality, and subsequent lower calf production and reproductive potential of females, then population declines.

Harvest sustainability

The Porcupine herd is increasing, which implies that currently harvest is sustainable. The Porcupine Caribou Management Board (PCMB) has also established a Harvest Management Plan, which includes an annual meeting where recommendations on harvesting for the

subsequent year are put forward for public consultation and responses from the parties to the management agreement (PCMB 2010a). This collaborative and precautionary approach reduces the likelihood of harvest becoming unsustainable.

For the Cape Bathurst and Bluenose-West herds, severe restrictions on harvesting (see *Positive influences*, p. 180) likely halted further declines, in combination with improved calf recruitment beginning in 2007-09 (Adamczewski *et al.* 2009). A closure of commercial, outfitted, and resident harvest has been in place for the Bluenose-East herd since 2006; however, the herd continues to decline. Harvest on the Bluenose-East herd was known to have increased in 2010 when Bathurst harvest was reduced (Adamczewski pers. comm. 2014). After public hearings in the Sahtú and Wek'èezhìı regions, harvest by communities has been reduced (Tłı̨chǫ Government and GNWT 2016a and b; WRRB 2016a and b).

A large reduction in harvest of the Bathurst herd, along with improved calf survival, likewise resulted in at least an initial stabilization in numbers from 2009-2012; however, the herd continues to decline. Since December 2016, after public hearings, total allowable harvest on the Bathurst herd has been set at zero within Wek'èezhìı (Tłı̨chǫ Government and GNWT 2016a; WRRB 2016a). A key change from previous periods of caribou scarcity is increased access on winter and all-season roads, along with high-powered snow machines, which means that this potential threat may need to be managed in the long term. The extent of the threat will depend on the success of monitoring to detect trends in adult survival (from natural mortality including predation, and from harvest estimates for each herd) and trends in productivity, and then the availability of that information to decide on hunting levels relative to the desired rate of population increase.

Harvest levels on the Beverly, Ahiak, and Qamanirjuaq herds are poorly documented and compiled harvest data are incomplete. Resident harvest is limited to one male per year on the NWT portions of the Beverly and Ahiak herds, and closure of the commercial and outfitted harvest remains in place in the NWT for these two herds as well. There are no restrictions on aboriginal harvest of any of these herds (see *Positive influences*, p. 180).

Wounding loss is a threat of unknown magnitude, but is recognized as a factor affecting caribou populations. For example, the BQCMB has factored in a wounding loss of 25% to their harvest estimate (Campbell *et al.* 2010). Wounding loss is not tracked and has not been factored in to other herd harvest estimates in this report (Valkenburg *et al.* 1994).

Forest fires

With the exception of large lakes and rivers, wildfire represents the most visible factor driving habitat fragmentation and change, impacting forage availability and movement (Thomas and Kiliaan 1998b) (discussed further in *Habitat requirements*, p. 103, *Habitat fragmentation*, p. 153, and *Habitat trends*, p. 155).

Avoidance of high density burn areas by barren-ground caribou is well established (Barrier and Johnson 2012). Site selection in the winter range often favours mature forest stands (Barrier and Johnson 2012). These mature forest stands have better high quality forage availability, more favourable snow conditions, and offer better predator protection than younger forest stands (Barrier and Johnson 2012).

In the NWT, regeneration of lichen-supporting forest stands can take 70-230 years (Seccombe-Hett and Walker-Larson 2004). Wildfire cycles shorter that the regeneration time of a given region can stall forest stands in earlier seral stages, resulting in lower quality winter habitat for barren-ground caribou.

Forest fires disturb an average of 600,000 ha of NWT forest annually. The annual total area burned fluctuates each year, but a weak trend indicates a slight reduction in both total area burnt and the number of fires larger than 200 ha between 1988 and 2008 (ENR 2015). This does not account for the particularly severe fire season seen in the NWT in 2014, where 385 fires impacted approximately 3.4 million ha (ENR 2014). It is predicted that climate change will result in an increase in the frequency and intensity of fires, due to hotter, drier summers that provide a longer fire season (Soya *et al.* 2007).

Parasites and diseases

Parasites and diseases are a potential and complex threat under a warmer climate. Many parasites, including warbles and bot flies, have transmission phases that are temperature dependent either for the development time, the infective stage or the activity of an intermediate host. An index based on summer temperatures for the activity of warble flies has significantly increased on the Bathurst herd's range (Witter *et al.* 2012b). Warmer temperatures may not favour all parasites, such as gastro-intestinal worms (Hoar *et al*. 2012). Warmer climate will not only affect the existing parasites and diseases but also increase the likelihood of invasive species (Davidson *et al.* 2011). Kutz (2007) indicated that climate change may increase the incidence of parasites and diseases (Table 9, p. 177).

Table 9. Parasite and disease species and groups affecting barren-ground caribou, number of species and groups where climate change is predicted to have high to moderate effects, and level of concern from climate change (summarized *from* Kutz 2007).

Parasite disease species and groupings	No. current species/groups	No. possibly Invasive	Probable effects of climate change	
			High	Moderate
Insects and ticks	7	2	7	0
Protozoa (single-celled parasites including *Besnoitia*, *Giardia*)	8	1	2	2
Intestinal worms	3	1	4	
Muscle worms	6	2	7	
Bacteria (including *Brucella*, foot-rot)	3	4	1	3
Insect-transmitted diseases	2	2	2	1

Laaksonen *et al.* (2010) measured how fatal outbreaks of *Setaria* in Finnish reindeer occurred when temperatures were above average, thus increasing the level of mosquito activity (responsible for the transmission of the parasite). *Setaria*, a blood parasite recorded recently in barren-ground caribou, is of concern, but very little is known about its ecology (Kutz *et al.* 2004, 2013). Laaksonen *et al.* (2010) point out the complexity of various factors having to coincide to result in an epidemic. Such complexities and the fact that climate change will also likely affect vegetation, extent of fires, presence of other ungulates and predators, etc., indicate that predicting future trends in parasites and diseases will be difficult. The potential for shared diseases and parasites is a reason for concern about the spread of white-tailed deer (*Odocoileus virginianus*) into the NWT (Veitch 2001).

Predation

As discussed in *Interactions* (p. 114), predators, in particular wolves, figure prominently in barren-ground caribou population dynamics, affecting survival and reproduction and therefore abundance. There are few estimates of the rate of predation on barren-ground caribou herds, although it is understood to be quite substantial and to disproportionately affect calves on calving grounds (Miller and Broughton 1974; Miller *et al.* 1985, 1988; Clarkson and Liepins 1992; Hayes and Russell 2000; Griffith *et al*. 2002). While there have been reports of increases in the number of predators (see *Traditional and Community Knowledge Component - Interactions*, p. 26), recent scientific information suggests a declining trend in the population of wolves and of active den sites, at least within the summer range of the Bathurst herd (Cluff pers. comm. 2015; Klaczek *et al*. 2015). Likewise, Klaczek *et al*. (2015) observed no adaptive response to contracting summer Bathurst caribou range, with wolves continuing to select den sites in esker-rich areas, despite the increasing distance between the dens and prey base. This lack of adaptive

response during a period of key pup growth may adversely impact pup survival and population growth among wolves.

Predator control has been considered as a tool for short-term recovery of caribou populations. Ultimately however, there is little evidence of effectiveness over the long term (ACCWM 2014).

Management complexity

In the NWT, caribou management involves interactions among many government agencies, co-management boards, various organizations, and industrial interests. Caribou seasonally migrate throughout extensive ranges and this can lead to inter-jurisdictional complexity between political, land management and wildlife management agencies.

Delays in obtaining information, such as herd size and composition and harvest levels, affects the ability of governments and co-management boards to rapidly respond to declines. When declines are initially reported, there is an understandable desire to first confirm and then an obligation to consult on the declines before taking actions. The Bathurst herd's decline was first identified in 2003, but limited actions were undertaken until 2010, by which time the decline had accelerated and population size was further reduced (Boulanger *et al.* 2011).

Currently, range management planning and harvest management are incomplete and plans have developed slowly. A management approach that is more reactive than proactive, along with a lack of timely implementation of management actions, threaten caribou conservation, because the ability to effectively react to changes in caribou numbers and their environment is delayed.

One of the outstanding ecological characteristics of barren-ground caribou is their seasonal migrations, in which the females travel hundreds of kilometers in a single season. Migrations are an adaptive strategy of caribou in response to their predators, parasites, and availability of forage. There is a risk that caribou herds will lose their ability to cope with environmental changes and human activities if their ability to find space is compromised or restricted. Land-use planning and management, including environmental assessments and monitoring, are within a complex structure of land tenure and jurisdictional responsibilities. The net effect is a threat to caribou as land use planning for caribou seasonal ranges is fragmented and partial. In particular, despite decades of concerns, calving grounds remain mostly unprotected although the Bluenose-West herd's calving grounds are largely protected by Tuktut Nogait National Park. Developments on calving grounds are a potential threat as almost all the females of a herd are in one relatively small area during calving.

Contaminants

While most chemicals and metals are at low concentrations, the levels of mercury in kidneys have increased over time for the Porcupine herd, which is a potential concern as there are considerable uncertainties about atmospheric trends in mercury and implications for Arctic

ecosystems (Gamberg 2009). Contrastingly, there was a declining trend in mercury and various radionuclide concentrations in the kidneys of Cape Bathurst caribou between the mid-1990s and early 2000s, although aluminum concentration increased during this time (Larter *et al.* 2010).

Contaminants are not currently considered a threat as contaminant levels in caribou tissue are generally low based on monitoring under the Northern Contaminants Program (Elkin and Bethke 1995; Braune *et al.* 1999; Gamberg *et al.* 2005; Gamberg 2009) and subsequent studies (Larter and Nagy 2000; Larter *et al*. 2010). Determining trends across the NWT is difficult as the sample size, frequency and timing of sampling varies among herds. The Qamanirjuaq herds was sampled in 1993, 2006 (Gamberg 2009), 2013-14 and 2014-15 (Gamberg 2015). The Beverly herd was sampled in 1994, 2000, 2008 (Gamberg *et al.* 2008), the Bluenose herds (Cape Bathurst, Bluenose-West, Bluenose-East) in 1994, 1998, 2002 (Bluenose-East only) (Macdonald 2002), 2005-06, and 2012 (Bluenose-East only) (Macdonald 2012). The Bathurst herd was sampled in 2005-06 (Gamberg *et al.* 2005; Gamberg 2009) and 2007-08 (Gamberg *et al.* 2008; Morris *et al.* 2014), and the Cape Bathurst herd in 1994-95 and 2000-01 (Larter *et al.* 2010). A larger-scale study, looking at caribou and reindeer herds throughout Alaska, Canada and Greenland examined radionuclide concentrations over a 40 year period (Macdonald *et al.* 2007). Variation in concentrations of heavy metals among herds is apparent, possibly related to the proportion of lichen in the diet (Larter and Nagy 2000).

Novel chemicals (from either local sources or from sources subject to long-distance transport) that accumulate in the environment are another potential threat. Brominated flame retardants (used in plastics, textiles, and electronic equipment to make them less flammable) and fluorinated surfectants (used as stain repellents and in paints and polishes) have increased since the 1980s (Stow *et al*. 2004). Detectable levels of such persistent organic pollutants have been reported for wildlife in the Dehcho region of the NWT (Larter *et al.* 2014).

Lichens are important in caribou diets and are well-known for the propensity to accumulate atmospheric contaminants (Thomas *et al.* 1992). Monitoring at the NWT diamond mines has revealed increased levels of some metals in lichens on the summer range of the Bathurst caribou herd (Enns 2012). During the environmental assessments for mines, dust generated by mine activities, including roads, has been listed as a potential threat. Dust is carried by wind, rain and/or snow onto vegetation, which includes caribou forage. Increased levels of some metals were measured in faecal pellets of caribou found in the vicinity of an abandoned gold mine on the Bathurst winter range (MacDonald and Gunn 2004). Similarly, elevated levels of metals were found in the faecal pellets and tissues from caribou of the Western Arctic herd collected near the Red Dog base metal mine (O'Hara *et al*. 2003). The levels of metals were not considered to be a risk for human health but there is the potential for adverse effects on caribou health. Dust-contaminated forage may be a factor in caribou showing reduced probability of use in the vicinity of the diamond mines on the Bathurst herd's range (Boulanger *et al*. 2012).

Cumulative effects

Most barren-ground caribou herds are now at low points in their abundance and they are facing cumulative effects from multiple interacting threats that are unprecedented (Boulanger *et al.* 2012; Campbell *et al.* 2014; Cameron *et al.* 2005). These include increased development and industrial activity, more advanced hunting equipment as well as increased access, and a changing climate. Each major development project that is subject to environmental assessments includes a cumulative effects assessment, but these are proponent-driven and have not made a significant contribution to managing cumulative impacts for caribou (Gunn *et al*. 2011c). Also, these assessments rarely consider the full range of activities that might act on populations of caribou in a cumulative way (Johnson *et al.* 2005). Although some herds have management plans in place, a key challenge is the lack of long-term management plans for all herds, especially in the context of cumulative effects of industrial developments and human activities. In particular, the lack of an overall approach to calving ground management is a specific issue of concern.

POSITIVE INFLUENCES

Collaborative co-management has allowed for cooperative/joint management planning for caribou. In some cases, agreement among management authorities has resulted in management actions, including harvesting restrictions for commercial, outfitted, resident and aboriginal hunting, which contribute to addressing caribou declines, as well as the development of co-management plans for barren-ground caribou herds in the NWT.

As discussed previously (see *Interactions*, p. 114 and *Threats and limiting factors*, p. 168), harvest restrictions are in place for a number of barren-ground caribou herds across the NWT.

Harvest of the Porcupine caribou herd is led by a harvest management plan. This plan establishes a total allowable harvest based on the status of the herd and requires harvest reporting for all Parties to the plan. Currently, there is no harvest limit or sex selected harvest requirement for aboriginal harvesters. Licensed hunters may harvest up to two males (PCMB 2010a, b; PCMB 2016).

The Tuktoyaktuk Peninsula herd benefitted from the removal of domestic reindeer from the peninsula in 2001. NWT resident, outfitted, and commercial harvest was suspended in 2006. Inuvialuit harvest is unrestricted except during April 1-June 15, when harvesting is suspended to permit the migration of the Cape Bathurst herd (Davison *et al.* 2014; ENR 2016a).

The management of the Cape Bathurst, Bluenose-West, and Bluenose-East herds is guided by *Taking Care of Caribou: Cape Bathurst, Bluenose-West, and Bluenose-East Barren-ground Caribou Herds Management Plan* (ACCWM 2014). This plan was developed in response to declines in these herds and is intended to address long-term management needs. It includes provisions for management within the natural range of variation, conservation and management

of caribou habitat, and respectful and sustainable harvest. Action plans will be developed for each herd as well. Prior to this, all Cape Bathurst harvest was suspended in 2007. Commercial, outfitted, and resident hunts were closed for the Bluenose-West and Bluenose-East herds in 2006. Aboriginal harvest of the Bluenose-West herd is limited by quota (345 animals for the Inuvialuit, 345 for the Sahtú, and 22 for the Gwich'in). An 80% male-only harvest is recommended. As of 2016-17, Belarewíle Gots'ę Ɂekwę: Délı̨nę Caribou Conservation, a Délı̨nę Got'ı̨nę Plan of Action has set a harvest threshold of 150 for the Bluenose-East herd (Délı̨nę Ɂekwę Working Group 2016). Délı̨nę is the main Sahtú community harvesting this herd. In the Wek'èezhìı area, the 2013-14 subsistence harvest was reported as 167 Bathurst caribou and 1,474 Bluenose-East caribou (Barren-ground Technical Working Group 2015). As of 2016-17, harvest levels have been set at zero for the Bathurst herd (Tłı̨chǫ Government and GNWT 2016a; WRRB 2016a) and 750 for the Bluenose-East herd (Tłı̨chǫ Government and GNWT 2016b; WRRB 2016b) within Wek'èezhìı.

In 2010, commercial, outfitted, and resident hunts on the Bathurst herd were closed in response to accelerated population decline (ENR 2016a). A *Joint Management Proposal for Bathurst and Bluenose-East Caribou* was prepared by ENR and the Tłı̨chǫ Government and submitted to the WRRB, in 2010. This document proposed a short term reduction in mortality of Bathurst caribou focusing on hunter harvest, with the understanding that other factors also influence mortality. Parties agreed to an annual harvest target of 300 caribou from the Bathurst herd, with at least 80% male-only harvest (Tłı̨chǫ Government and GNWT 2011; GNWT 2015). A similar annual harvest target agreement was reached with the Yellowknives Dene First Nation in late 2010 (Adamczewski pers. comm. 2015). As of 2016/17, after public hearings, total allowable harvest on the Bathurst herd has been set at zero within Wek'èezhìı (Tłı̨chǫ Government and GNWT 2016a; WRRB 2016a). Longer term, a Bathurst caribou range plan is under development (Bathurst Caribou Range Plan Working Group 2016). This collaborative, multi-partner process will see the development of a plan that will make recommendations on managing the cumulative effects of human disturbance.

Management guidance for the Beverly and Qamanirjuaq herds is provided by the *Beverly and Qamanirjuaq Caribou Management Plan 2013-2022* (BQCMB 2014). This document includes provisions for education, research advancement, and monitoring. The Beverly and Ahiak herd were afforded some protection through the 2010 closure of NWT commercial, outfitted, and resident hunts within their ranges. This closure was partially rescinded in 2014, with harvest limited to one male-only resident harvest. There are no restrictions on aboriginal harvest (ENR 2016a).

Currently, there is no commercial harvesting of any NWT barren-ground caribou herd.

Specific co-management structures have also been built to address concerns with some barren-ground caribou herds. These structures include the ACCWM, PCMB, the International Porcupine Caribou Board (IPCB), and the BQCMB. The ACCWM was established to exchange

information, help develop cooperation and consensus, and make recommendations regarding wildlife and wildlife habitat issues that cross land claim and treaty boundaries. ACCWM membership consists of WMAC (NWT), GRRB, SRRB, Wek'èezhìı Renewable Resources Board (WRRB), Kitikmeot Regional Wildlife Board, and Tuktut Nogait National Park Management Board (ACCWM 2014). The PCMB is an advisory committee that provides herd management recommendations to those agencies responsible for managing the herd and gathers and communicates information about the herd to users. Its membership includes the Gwich'in Tribal Council (GTC), Na-cho Nyak Dün First Nation, Vuntut Gwitchin First Nation, Tr'ondëk Hwëch'in First Nation, Inuvialuit Game Council (IGC), GNWT, Government of Yukon, and Government of Canada (Canada) (PCMB 2016). The IPCB administers the 1987 bilateral (Canada and United States (U.S.)) *Agreement on the Conservation of the Porcupine Caribou Herd* and provides advice to Canada and the U.S. on the protection and management of Porcupine caribou. The NWT, through the GNWT, is responsible for nominating one of the members of the ICMB (Environment and Climate Change Canada 2016). The BQCMB was the first caribou co-management board created in North America. It provides a multi-jurisdictional and multi-cultural forum (Government of Nunavut, GNWT, Government of Saskatchewan, Government of Manitoba, Government of Canada, and traditional users) for the coordinated management of Beverly and Qamanirjuaq caribou (Cizek 1990; BQCMB 2016).

Under development is a Bathurst Caribou Herd Cooperative Advisory Committee. While the membership composition of the committee is still being determined, the committee is expected to have a structure and mandate similar to that of the BQCMB. One of its primary roles will be to contribute to the development of a management plan for the Bathurst herd, which will replace the now out of date 2004 management plan (Elkin pers. comm. 2016).

Although not a formal co-management structure, CARMA (2014) is a network of scientists, co-managers, community leaders and caribou harvesters that was formed in 2004 to better understand how global change is impacting migratory tundra caribou and the people that depend on them. This organization can also facilitate inter-personal and agency discussions and data exchange among those concerned with caribou management.

Current and proposed habitat protection for barren-ground caribou in the NWT can be found through existing protected areas (Fig. 35, p. 183), areas established through the Protected Areas Strategy, range planning processes, and through regional land use planning processes. Restrictions on development vary among land management regimes, but many include some form of restriction on resource development.

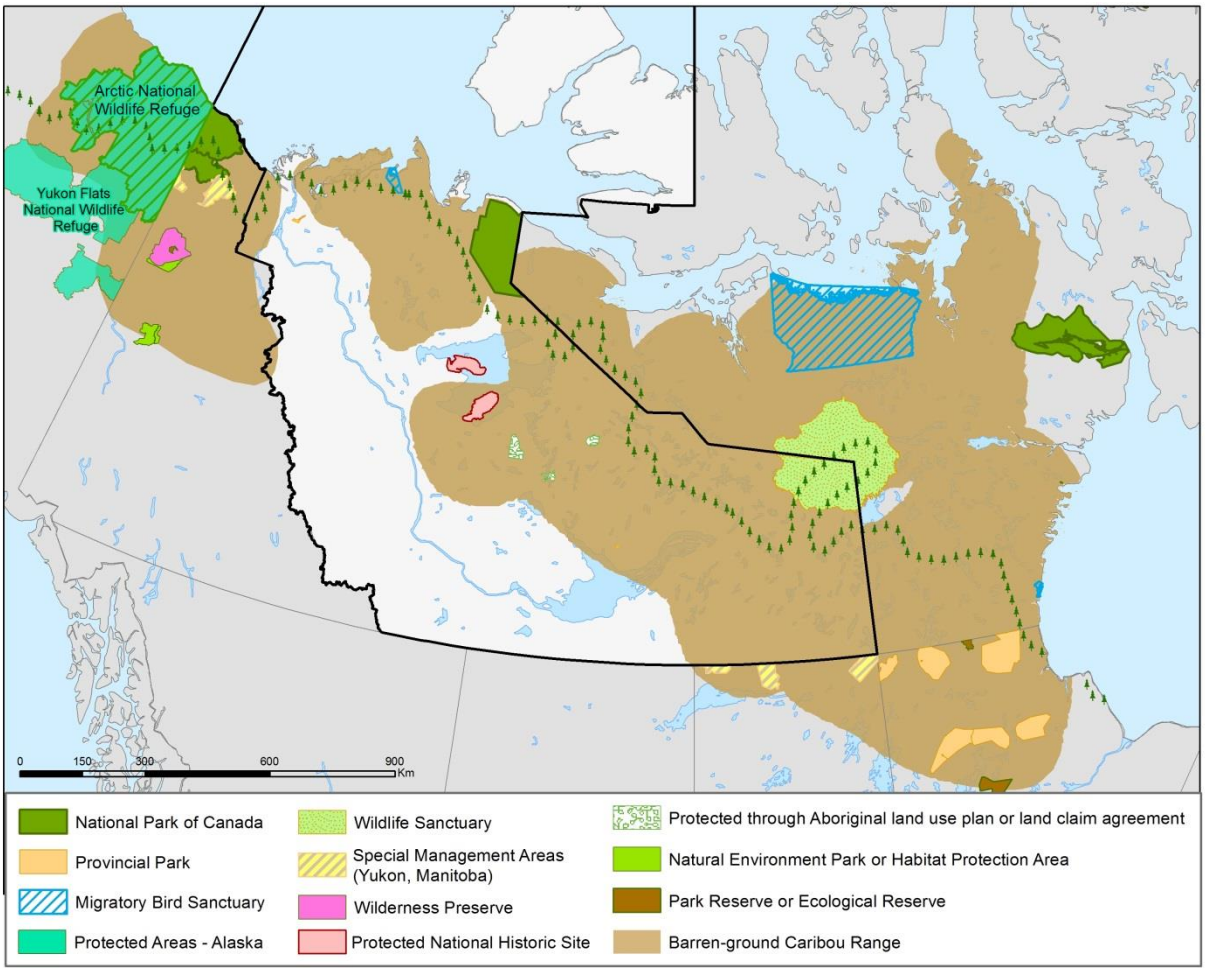


Figure 35. Areas providing permanent habitat protection within the range of barren-ground caribou. Barren-ground caribou range is from Fig. 6 (p. 99). Data for protected areas from the Canadian Council on Ecological Areas' Conservation Areas Reporting and Tracking System and the United States Geological Survey's Protected Areas Database of the United States.

Areas within the NWT of likely significance to barren-ground caribou include Thaidene Nene (proposed national and territorial parks around the East Arm of Great Slave Lake), Ezodzıtı (protected through the Tłı̨chǫ Final Agreement) (ACCWM 2014), the Thelon Game Sanctuary, Edaı́ı́la (Caribou Point, Great Bear Lake, identified in the Sahtú Land Use Plan), Saoyú-ʔehdacho National Historic Site (ACCWM 2014), Tuktut Nogait National Park (Community of Paulatuk *et al.* 2008; ACCWM 2014), and Yambahti (Yamba Lake, where the Tłı̨chǫ̀ Government has submitted a formal request and proposal to the GNWT to sponsor the area as a Critical Wildlife Area; NWT Protected Areas Strategy 2012). Within Nunavut, the Queen Maud Gulf Migratory Bird Sanctuary encompasses most of the Beverly (coastal calving ground only) and Ahiak calving grounds. A new NU park adjacent to Tuktut Nogait National Park is being discussed by Kugluktuk, the Kitikmeot Inuit Association, and the Nunavut Planning Commission (ACCWM 2014). Portions of the Porcupine caribou herd in the Yukon are also offered some protection from Ivvavik National Park (Community of Aklavik *et al.* 2008; Community of Inuvik *et al.*

2008; Parks Canada 2016) and the Old Crow Flats Special Management Area (Technical Working Group and Management Committee for the Parties 2006).

Land use plan zoning provides some protection to barren-ground caribou herds throughout the NWT. Under the Gwich'in Land Use Plan, barren-ground caribou are offered protection through special management zones (approximately 33% of the Gwich'in Settlement Area (GSA)) and conservation/heritage conservation zones (approximately 10% of the GSA). While development is permitted in special management zones, it is limited by specific conditions in each zone designed to protect identified values (Gwich'in Land Use Planning Board 2003). Zones of particular interest include:

- Vàdzaih (Porcupine Caribou Special Management Zone): protection of Porcupine caribou habitat and migration corridor in the GSA.
- Gwatoh Taii Tshik (Stoney Creek Special Management Area): partial protection of Porcupine caribou migration corridor, water, and heritage resources.
- Transportation Special Management Zone: conditions to protect Porcupine caribou from transportation-related disturbances along the Dempster Highway: Yukon/NWT border to the Peel River.
- Ddhah zhit han, Eneekaii han, Chii gwaazraii (Rat, Husky and Black Mountain Conservation Zone) and Dachan dha'aii jik/Vitreekwaa viteetshik (James Creek/Vittewkwa River Conservation Zone): partial protection of the Porcupine caribou migration corridor.
- Kahii luk, Nagwichoonjik, Dachan choo gehnjik (Travaillant Lake, Mackenzie/Tree River): partial protection of the wintering grounds of Bluenose caribou.

The Sahtú Land Use Plan offers barren-ground caribou similar zone-based protections (with special management zones and conservation zones comprising approximately 48% and 11% of the Sahtú Settlement Area, respectively). Many of the special management and conservation zones include barren-ground caribou as a value to be respected. For these areas, the importance of caribou is recognized through a general conformity requirement (Sahtú Land Use Planning Board 2013).

The Tłı̨chǫ Land Use Plan, released in 2012 by the Tłı̨chǫ Government, is supported by the 2013 *Tłı̨chǫ Land Use Plan Law*, enacted in 2013. Five land use planning zones are established: wehexlaxodıale (land exclusion zone), dèk'èasıìɔedaà (habitat management zone), gowhadǫ̀ yek'e t'u k'e (traditional use zone), Tłı̨chǫ̀ nawoo kè dèt'ahot'ìı (cultural heritage zone), and asu haxowu gha enehatǫ (enhanced management zone). Each zone offers varying levels of protection depending upon the values that they are designed to preserve (Tłı̨chǫ̀ Government 2012).

In the Inuvialuit Settlement Region, six community conservation plans set out guidelines for land

and resource use in their respective regions. Lands are categorized according to the degree of protection they are felt to require (A, B, C, D, and E, with degree of protection increasing from Category A to Category E). Special Designated Lands of importance to barren-ground caribou include: Bluenose-West caribou herd winter range (Category E); eastern North Slope, east of Babbage River (Category D) (Community of Aklavik *et al*. 2008; Community of Inuvik *et al*. 2008; Community of Tuktoyaktuk *et al.* 2008); Fish Hole/Cache Creek and Big Fish River (Category D/E) (Community of Inuvik *et al*. 2008); Bluenose-West caribou core calving and post-calving grounds (Category D) (Community of Paulatuk *et al.* 2008); and Cape Bathurst caribou core calving and post-calving grounds (Category D) (Community of Paulatuk *et al*. 2008; Community of Tuktoyaktuk *et al.* 2008). In addition to these land protection categories, conservation measures aimed specifically at barren-ground caribou are beneficial. These include supporting certain management planning initiatives, protecting important habitat from disturbance, ensuring harvest is sustainable, and discouraging meat wastage (Community of Aklavik *et al.* 2008; Community of Inuvik *et al.* 2008; Community of Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008).

The draft Nunavut Land Use Plan includes provisions for the protection of core calving areas, post-calving areas, migration corridors, water crossings, and rutting areas. Once approved, the land use plan could act as a positive influence on Nunavut caribou herds, including the four herds shared with the NWT (Qamanirjuaq, Bathurst, Bluenose-East, and Beverly). Development applications that are submitted prior to land use plan approval, however, will be grandfathered and not subject to the protection provisions included in the land use plan (Nunavut Planning Commission 2016).

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Status and Ranks

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	G5TNR – Species secure, subspecies not yet assessed (NatureServe)		
Canada	NNR – Not yet assessed (NatureServe Canada 2002)	Threatened (COSEWIC 2016)	
Northwest Territories	Sensitive (NWT General Status Ranking Program 2011)	**Not at risk – Porcupine caribou (2017)** **Threatened – Barren-ground caribou (2017)**	**To be determined**
Adjacent Jurisdictions			
Nunavut	SNR –Not yet ranked		
Saskatchewan	S3S4 – Vulnerable/rate to uncommon or Apparently Secure		
Yukon	SNR – Not yet ranked		

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Biography of Preparers

Adam Bathe

(Blyth and Bathe Consulting)

After graduating with a B.A. in Anthropology, Adam worked for a number of consulting companies on projects related to natural and cultural resource management.

Before establishing Blyth & Bathe, Adam worked for a large consulting company. One of the major projects he worked on there was to develop a massive annotated bibliography containing all of the relevant reports on cumulative impacts from the oil sands. This project included local and traditional knowledge. With the same company, he worked on the "Mark of the Métis" project, where elders and resource users throughout the Wood Buffalo region were interviewed on their way of life. Different reports were developed for each family, community, and region as a whole.

With Blyth & Bathe, Adam has developed a wealth of experience delivering community-based environmental monitor training across the NWT and an extensive background in traditional knowledge consulting work. He has worked on several traditional knowledge projects that feed into the regime described by the *Mackenzie Valley Resource Management Act*, the most recent being traditional knowledge work for the renewal of Enbridge's land use permit.

John Blyth

(Blyth and Bathe Consulting)

John Blyth has worked as an anthropologist, instructor, and environmental consultant for seven years, beginning with his work on the Smith's Landing Traditional Use Study and flowing into his years of instructional work with Aurora College as a firearms instructor and as a traditional knowledge researcher.

John has extensive experience instructing and training environmental monitors, instructing more than a dozen month-long environmental monitor courses. John is also certified through Environment Canada and the Canadian Rivers Institute to manage projects based around the Canadian Aquatic Biomonitoring Network (CABIN) protocols for the assessment of stream health. John has received training on conducting water sampling from Taiga Labs, as well as other sampling protocols such as caribou scat sampling and ENR caribou health and body condition sampling. John has completed several traditional knowledge projects, including studies for Enbridge Pipelines and Devonian Metals.

John has extensive experience in both cultural resource management and community-based education. This has included the research, interviews, data collection, and analysis for Smith's Landing First Nation's Traditional Use Study.

Biography of Preparers

Anne Gunn

(B.A., Ph.D., Independent consultant, Salt Spring Island, BC).

Anne has over 30 years of experience with caribou field studies, management and research. She has experience with caribou status assessment and recovery planning and has considerable field experience with barren-ground caribou.

Kim Poole

(M.Sc., R.P.Bio., Aurora Wildlife Research, Nelson, BC).

Kim has 30 years of wildlife research and management experience in northern and western Canada, 15 years of which was spent in Yellowknife with the territorial government. He has considerable experience with caribou in both British Columbia and NWT/NU, having worked on impact assessments, movement and distribution modelling, survey design and implementation, surveys, and habitat studies. Anne and Kim have drafted the NWT SARC reports on Peary caribou and Dolphin and Union caribou.

Appendix A

DEFINITIONS USED IN THIS REPORT

Annual calving ground	The area occupied by parturient caribou from birth through the initiation of foraging by calves - at about 3 weeks after birth (Russell *et al.* 2002).
Antlered female	A female with 1 or 2 hard antlers during or after calving.
Breeding females	A female that is with hard antler prior to or during peak of calving, or a non-antlered female with calf at heel (see text for more discussion).
Calf	During calving ground surveys, calves are newly born individuals, days old.
Calving ground	The area occupied by the parturient barren-ground caribou from calf birth through the initiation of foraging by calves (Russell *et al.* 2002).
Concentrated calving area	The area of relatively high use within an annual calving ground (Russell *et al.* 2002).
Delineate calving ground	To draw the boundary around the peak calving ground during a systematic reconnaissance survey.
Density	Number of caribou per unit area – in this report, caribou/km^2 (based on aerial survey observations during transect survey).
Dispersion	Pattern of spatial distribution (typically scale dependent as to whether clumped, random or spaced).
Distribution	The area occupied by the 'population' during a specific season – requires definition of boundaries.
Extent of calving	The outer perimeter of all known annual calving grounds (Russell *et al.* 2002).
Kriging	An interpolation mapping technique that employs smoothing of the data being presented.

Non-antlered female	A female with no hard antlers. Non-pregnant females drop their antlers earlier in the spring, and depending upon nutrition, may have antler buds during the calving season. Parturient females usually drop their antlers within 1 week after calving (Whitten 1995).
Parturient females	Pregnant females prior to parturition; also used as females that have recently calved (post-partum).
Parturition	The act of calving.
Peak of calving	The date (median) when approximately 50% of the females had calved (Russell *et al.* 2002). Determination during surveys is based on observations of calves with parturient females (e.g., Nishi *et al.* 2007); from satellite collar data is determined from changes in movement rates by collared females (Fancy and Whitten 1991).
Peak calving ground	The area used by parturient females during calving in a particular year (Gunn *et al.* 2008).
Peak calving grounds	The outer perimeter of all known peak calving grounds (i.e., covering multiple years; Gunn *et al.* 2008).
Segment	A 5-km or 10-km section of a transect (usually 800 m wide) used to sum counts and densities of caribou observed on transect.
Stratification	To further define areas of relatively similar densities (of breeding females) within the delineated calving ground, and to re-survey those strata to obtain more precise estimates.

TRADITIONAL KNOWLEDGE DEFINITIONS

AKAITCHO REGION

Yellowknives Dene First Nation

Past knowledge of the land – and the impacts past generations had – is an important part of how future generations use the land and is integral to respecting the land, the water and the air.

http://ykdene.com/about-us/traditional-knowled-ge/

GWICH'IN REGION

Gwich'in Tribal Council

http://reviewboard.ca/upload/ref_library/GTC%20FINAL%20TK%20POLICY%202004.pdf

The Gwich'in recognize and value the fact that living on the land for many millennia has provided them with an extensive body of knowledge, values, beliefs and practices that many people today refer to as traditional knowledge. This knowledge, which has been passed down orally and through personal experience and spiritual teachings, is the foundation of Gwich'in identity and survival. It continues to have relevance today and draws its' strength from being used, revised and continuously updated to take into consideration new knowledge. The Gwich'in hold this knowledge in trust for future generations in the belief that this knowledge is of benefit to themselves and all humanity. The Gwich'in believe the best way to ensure its survival is to continue to use it and share it in a matter that respects this knowledge.

DEHCHO REGION

Dehcho First Nation

The collective intellectual property of Dehcho First Nations' members to Stories, Customs, Experiences, Knowledge, Practices, Beliefs and Spiritual Teaching passed on by our parents from our ancestors. This Knowledge will continue to exist and be passed on to our children and future generation. The rights to this knowledge must be protected.

http://www.reviewboard.ca/upload/ref_library/DCFN%20TK%20research%20protocol.pdf

Dehcho Land Use Planning Committee

Traditional knowledge is defined as knowledge and values which have been acquired through experience, observation, from the land or from spiritual teachings, and handed down from one generation to another.

http://www.reviewboard.ca/upload/ref_library/Dehcho_tk_policy.pdf

Sambaa K'e Dene Band

For the purposes of this policy, yúndút'ǫ̀h includes:

• The collective and evolving stories, experiences, practices, knowledge, and beliefs of our ancestors that developed from a close relationship with the land and are held in trust by our elders for future generations, and

• Knowledge and information gained thr ough previous experiences with land and resource development in this area and through contemporary land use activities and practices.

http://www.nwtwaterstewardship.ca/sites/default/files/Tk%20policy%20Sambaa%20K'e%20Dene%20Band.pdf

INUVIALUIT REGION

Inuvialuit Regional Corporation

Inuvialuit have lived on the land for thousands of years. Inuvialuit culture, language and subsistenc e practices are derived from intimate knowledge of the land and its rootedness in a close physical and spiritual relationship with the land. This cultural knowledge and way of life is often referred to as Traditional Knowledge. It is the foundation of the culture and identity of Inuvialuit.

Because this knowledge is rooted in a way of life, the term "traditional" refers to its continuity with the past; however, it is knowledge that is constantly used, updated, revised and accommodated to changing situations and circumstances. Like every culture, Inuvialuit culture and knowledge is in constant development as cultural values and beliefs must negotiate and accommodate new circumstances and situations. (page 3)

https://nwtresearch.com/sites/default/files/inuvialuit-regional-corporation.pdf

MÉTIS NATION

NWT Métis Nation

"Traditional Knowledge" or "TK" means the beliefs and knowledge about the Indigenous Métis traditional way of life and observations about the environment, which has been transmitted from generation to generation by oral or written communication.

http://nwtmetisnation.ca/wp-content/uploads/2016/02/TKpolicy.pdf

SAHTÚ REGION

Ɂehdzo Got'ı̨nę Gots'ę́ Nákedı/Sahtú Renewable Resources Board*

Traditional Dene ideology or traditional knowledge consists of a spiritually based moral code or ethic that governs the interaction between the human, natural and spiritual worlds. All things are related and, to become a true Dene, a balanced relationship with the earth and the creator must be maintained. The land and its resources should be tended for the benefit of future generations. A number of general principles and specific rules exist that regulate human behavior towards

nature.

Although traditional knowledge is difficult to define due to its dynamic nature, it is important to note that it is a factual knowledge, based on direct observation and experience, and shared within the community and over generations.

http://srrb.nt.ca/index.php?option=com_content&view=article&id=99&Itemid=559

*the Board is currently sponsoring a Working Group initiative to develop Traditional Knowledge Research Guidelines, and may soon revise the definition based on the outcome of this work.

TŁĮCHǪ REGION

Dedats'eetsaa: Tłı̨chǫ Research and Training Institute

Indigenous scholars have suggested that traditional knowledge unifies theory and practice and that it cannot be separated from a way of being and a way of doing. TK as a way of knowing is a method of reasoning that is most appropriate for complexity, as it seeks to make sense of diverse variables. It also purposely integrates subjective ways of knowing such as spirit, values and compassion. This range of descriptions has led some observers to conclude that it is not a proper field of study at all. Others argue that the prefix "traditional" is completely misguided, as this suggests something that is static, rigid, fixed and unchanging when in fact it is fluid and generative, integrating the weave of pattern and variation into new ways of knowing.

http://www.research.tlicho.ca/highlights/what-traditional-knowledge

NORTHWEST TERRITORIES

Government of the Northwest Territories

Traditional knowledge - knowledge and values, which have been acquired through experience, observation, from the land or from spiritual teachings, and handed down from one generation to another.

http://www.enr.gov.nt.ca/sites/default/files/documents/53_03_traditional_knowledge_policy.pdf

Mackenzie Valley Review Board

Traditional Environmental Knowledge is about the knowledge and experience that aboriginal people have acquired through living on the land. This knowledge has evolved over the years and is current.

http://www.reviewboard.ca/upload/ref_library/1247177561_MVReviewBoard_Traditional_Knowledge_Guidelines.pdf

CANADA

Assembly of First Nations

Aboriginal Traditional Knowledge is not a concept that is easily defined or categorized. However, it can be generally described as the customary ways in which aboriginal peoples have done or continue to do certain things or activities, as well as the new ideas or ways of doing things that have been developed by Aboriginal peoples which respect their traditions, cultures and practices. Many of these customary ways have been passed on from generation to generation and are considered sacred. This unique body of knowledge is culturally based, context specific, holistic and differs from nation to nation.

The Royal Commission on Aboriginal People (1996) has also described indigenous knowledge as "oral culture in the form of stories and myths, coded and organized by knowledge systems for interpreting information and guiding action...a dual purpose to manage lands and resources and to affirm and reinforce one's relationship to the earth and its inhabitants."

ATK can also be seen as the summation of all knowledge, information, and traditional perspectives relating to the skills, understandings , expertises, facts, familiarities, justified beliefs, revelations, and observations that are owned, controlled, created, preserved, and disseminated by a particular Indigenous nation. ATK is comprised of a holistic body of knowledge and it remains the sole right of the community to determine what knowledge establishes their ATK. It is important to note that these are general definitions and do not necessarily reflect or conform to the definitions held by ATK holders. However; the definitions rightfully illustrates the complexities in defining ATK, these challenging aspects will provide the basis of this discussion paper and will be re-examined and discussed further in relation to IPRs.

http://www.afn.ca/uploads/files/env/atk_and_ip_considerations.pdf

INTERNATIONAL

United Nations Inter-Agency Support Group (IASG) on Indigenous Issues

Traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds.

http://www.un.org/en/ga/president/68/pdf/wcip/IASG%20Thematic%20Paper_%20Traditional%20Knowledge%20-%20rev1.pdf

World Intellectual Property Organisation

Traditional knowledge (TK) is knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity.

While there is not yet an accepted definition of TK at the international level, it can be said that:

TK in a general sense embraces the content of knowledge itself as well as traditional cultural expressions, including distinctive signs and symbols associated with TK.

TK in the narrow sense refers to knowledge as such, in particular the knowledge resulting from intellectual activity in a traditional context, and includes know-how, practices, skills, and innovations.

Traditional knowledge can be found in a wide variety of contexts, including: agricultural, scientific, technical, ecological and medicinal knowledge as well as biodiversity-related knowledge.

http://www.wipo.int/tk/en/tk/

EXTENT OF OCCURRENCE

As noted in *NWT Distribution* (p. 98), the 'extent of occurrence' encompasses the geographic distribution of all barren-ground caribou within the NWT (SARC 2010). The 'extent of occurrence' is the area contained within the shortest continuous boundary that encompasses all known, inferred, or projected sites of present occurrence, excluding cases of vagrancy. Simply put, it is a measure of the widest possible current range of the species. The extent of occurrence for the eight central/eastern herds of the NWT (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq), calculated using a single minimum convex polygon encompassing the annual range of all herds and excluding the portions of their annual range not within the NWT, was approximately 787,473 km^2. The extent of occurrence for the Porcupine herd, calculated in the same manner was 21,337 km^2. Figure 36 (below) shows the minimum convex polygons for both the total range of the subspecies and excluding the portion of their annual range not within the NWT.

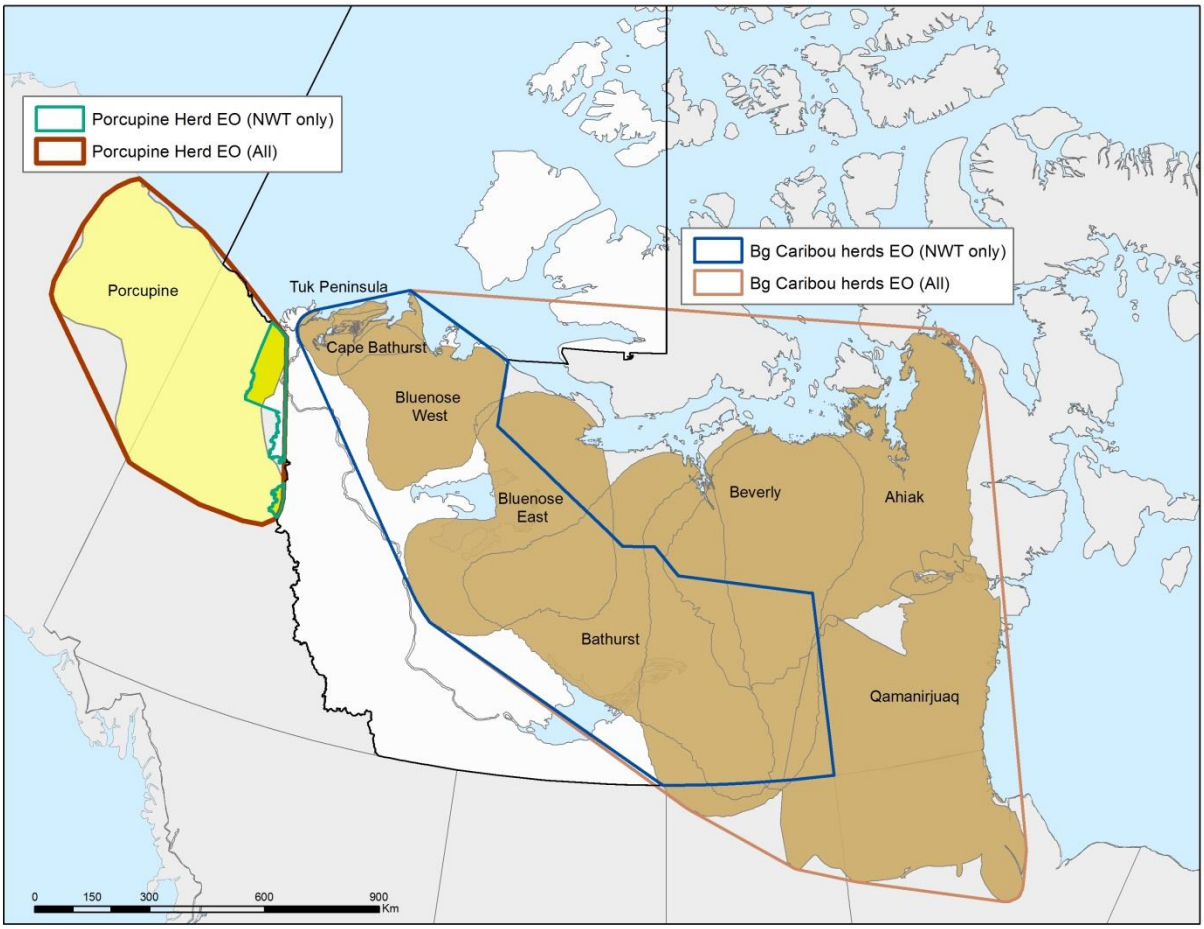

Figure 36. Minimum convex polygons used for calculation of extent of occurrence (see *NWT Distribution*, p. 98). Orange line around eight central/eastern herds (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-

East, Bathurst, Beverly, Ahiak, and Qamanirjuaq) represents total extent of occurrence. The blue line within that area represents extent of occurrence for these herds excluding the portions of their annual range not within the NWT. Likewise, the red line around the range of the Porcupine herd represents the total extent of occurrence for this herd; the light green line within that area represents the NWT extent of occurrence.