Tı̨ch'ádíı hé Gots’edı (Living with Wildlife)
Caribou Predators and Competitors

Submission to the 2021 Délı̨nę Public Listening Session

Government of
Northwest Territories

Table of Contents

Introduction

The Sahtú Renewable Resources Board (SRRB) has invited the Government of the Northwest Territories (GNWT), Department of Environment and Natural Resources (ENR) to participate in the public listening sessions addressing the question "What is the most effective way to conserve caribou?" The second public listening session in this series will address the question "What should people's role be in maintaining healthy relations between caribou and other wildlife?"

ENR recognizes that caribou in the Sahtú have complex relationships with other animals, plants, people and the land that have developed over thousands of years. Human activity can affect the natural balance between caribou and the ecosystem. Stories, observations and knowledge collected from Indigenous and community knowledge holders and information collected using western science provide some insight into how caribou interact with other species, including humans, but there is much that is not known or understood.

This document provides a summary of information available to ENR on the interactions between caribou in the Sahtú and three of the species that have important relationships with caribou - muskoxen, moose and wolves. It also provides examples of some actions people can take to support healthy ecological relationships between caribou and these other species being maintained. The information presented in this document has been drawn from the Indigenous, community and scientific knowledge compiled for status reports on barren-ground caribou, northern mountain caribou, boreal caribou, muskoxen and moose, as well as information gathered for boreal caribou recovery actions, wolf management actions and other wildlife monitoring and research projects carried out by biologists in the NWT and elsewhere.

One of ENR's roles in the co-management of wildlife in the Sahtú includes providing information to the SRRB to help inform decision making. It is hoped that the information presented here will be useful to the SRRB as it considers ways to conserve caribou in the Sahtú, and to communities as they develop community conservation plans.

Muskoxen

What do we know about muskoxen in the Sahtú?

Muskoxen crossed into North America about 90,000 years ago, when the Bering Strait was dry land. When the last glacier covered North America, about 21,000 years ago, muskoxen survived in ice-free areas or 'glacial refugia' in the northern Arctic islands and Greenland. As the ice melted, muskoxen spread throughout northern Canada and Greenland before moving westward into Alaska. Before 1900, muskoxen were found across much of the NWT (Figure 1), including most of the Sahtú, and were traditionally harvested for food, clothing and tools (Barr as cited in Windbourne and Benson 2021).

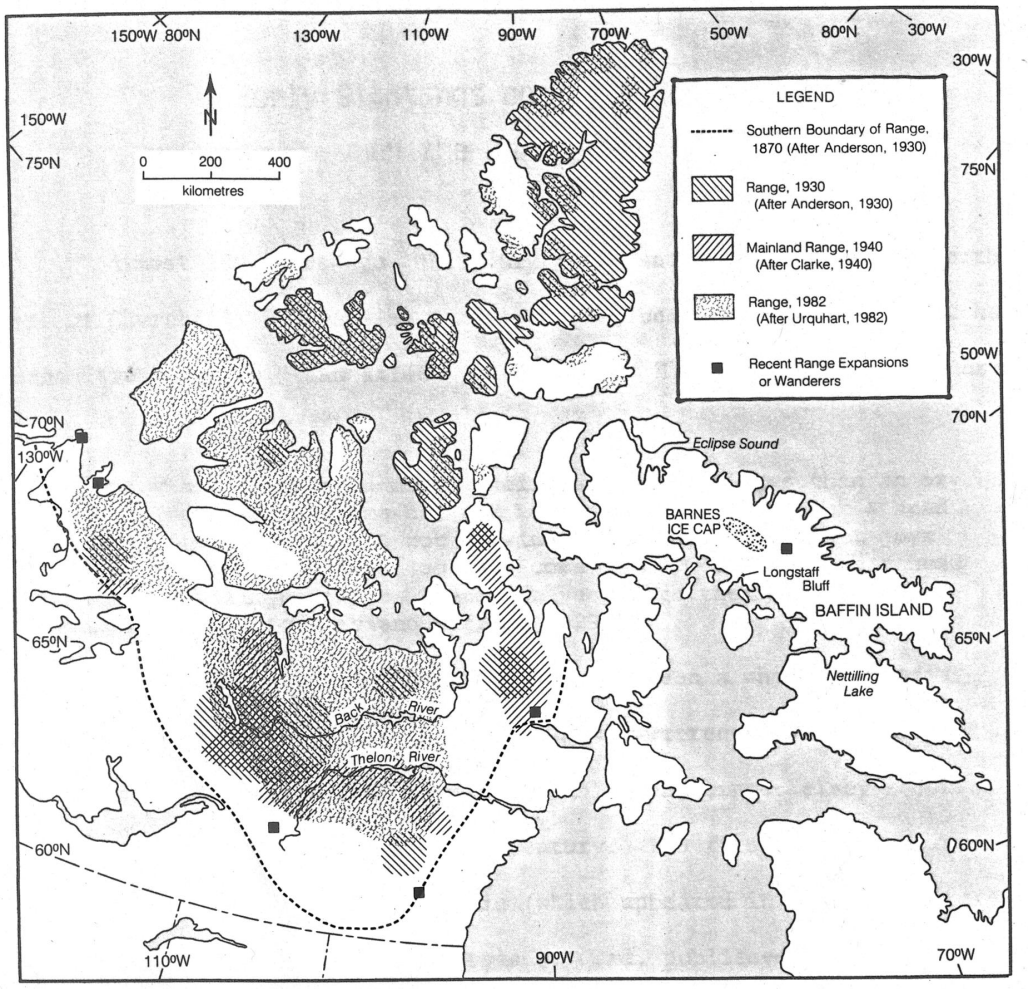

Figure 1. Approximate range of muskoxen in the NWT/NU, pre-1860 and early to mid-1900s (from descriptions in Barr 1991).

The 19th century brought about heavy harvesting of Muskox to provide hides for the commercial fur trade and food to commercial whaling stations. Over half the total number of hides traded between 1861 and 1916 (9364 hides) came from the posts of the Mackenzie district; far from the nearest tundra (Barr 1991). By the early 1900s, muskoxen had disappeared from most of NWT, and in the Sahtú only a small population north of Great Bear Lake remained (See Figure 1). To help the species recover, the Canadian government put strict protection measures in place, starting with a hunting ban with very limited exceptions, for Indigenous harvesters, in 1917. A complete hunting ban was imposed in 1924, after which hunting muskoxen, and possessing muskox meat or hides, became illegal. After decades of protection, muskoxen have returned to most of the areas where they were found before the 1800s (Barr as cited in Windbourne and Benson 2021).

The small population of muskoxen north of Great Bear Lake managed to survive into the 1920s. At first, there were only rare sightings of muskoxen between Great Bear Lake and Paulatuk on the arctic coast, but, by the 1930s, groups of between 10 and 100 muskoxen were seen in this area. The population began to grow rapidly in the early 1960s and by the

1970s the population was estimated to be in the hundreds. By the mid-1980s, the population had grown to between 4,000 and 5,000 (Barr 1991).

Other muskox populations in the Gwich'in and Sahtú areas also increased during that time and by 2014, people from Aklavik, Tulít'a, Fort Good Hope, and Déljne talked about an expansion of muskoxen into new areas and an increase in numbers of muskoxen in recent years (ACCWM as cited in Winbourne and Benson 2021).

Today, muskoxen are found throughout the arctic islands and in many areas of the mainland (Figure 2). West of the Mackenzie River, muskoxen were reintroduced in 1970 to the North Slope of Alaska and have spread eastward to the Richardson Mountains. They are sometimes found in the Mackenzie Mountains along the Yukon border. East of the Mackenzie River, muskoxen are found along the coast east into Nunavut, and south to Tulít'a. There seems to be a gap in the population east of Great Bear Lake but this may be because this area is remote and difficult to survey (Gunn et al. in prep).

Many zones established in the Sahtú Land Use Plan are identified as muskox habitat or otherwise important areas for muskox or muskox harvest.

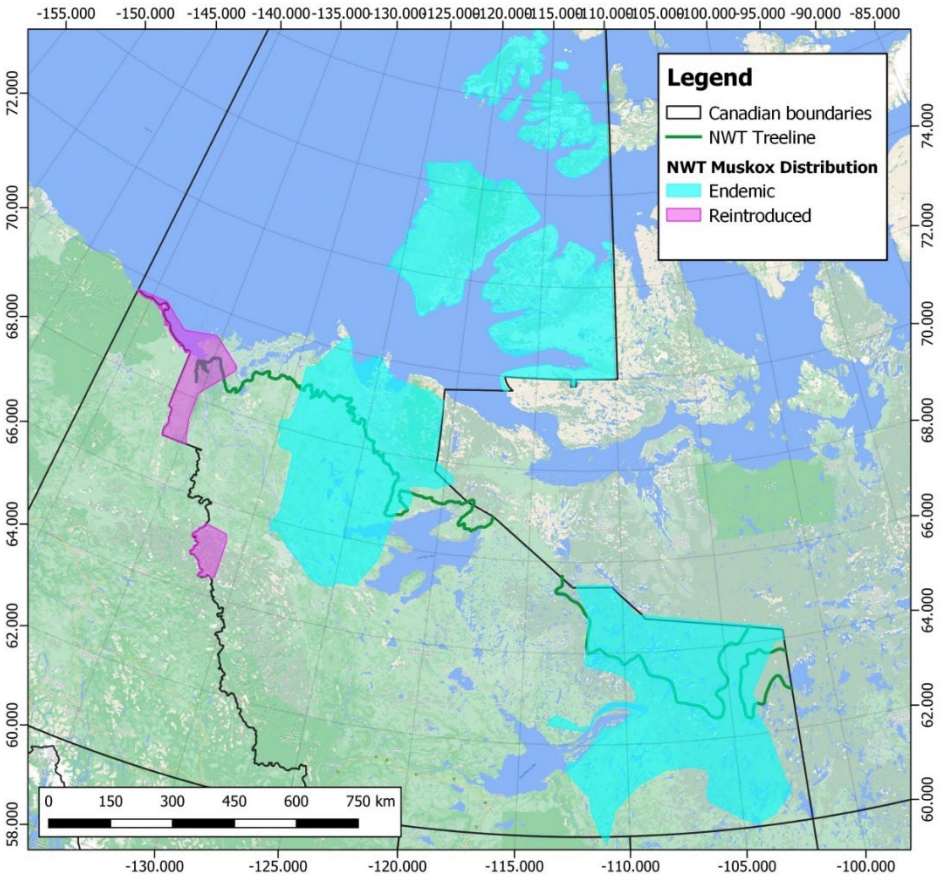

Figure 2. Overview of current distribution and origin (endemic or native to the area vs reintroduced) populations of muskox within the Northwest Territories.

While muskoxen are often considered a tundra species, they also occur in the transition zone between tundra and boreal forest. In the Sahtú, muskoxen have shifted from staying in the barren-lands to also being found below the treeline (ACCWM as cited in Windbourne and Benson 2021). The current distribution of muskoxen extending into the boreal forest west of Great Bear Lake, almost to the Mackenzie River near Norman Wells, is recent. During the 1900s, muskox distribution barely reached the Anderson River except for an occasional observation of muskoxen below the treeline (Gunn et al. in prep).

In 1997, in response to reports that muskoxen were expanding their range and requests for outfitted muskox tags in the Great Bear Lake area, a muskox survey was flown in the northeastern portion of the Sahtú Settlement Area (see Figure 3). The survey estimated there were 1,460 (ranging from 540 – 2380 animals) adult muskoxen in the survey area with a density of 2.6 muskoxen per 100 km^2 (Veitch 1997). Due to the limited number of surveys and varying survey methods used previously, it was not possible to determine a population trend from the 1997 survey, but the survey did show that the muskox range was expanding and high-density areas had changed over the previous decade. Earlier surveys had seen high densities of muskox near Estabrook, Stopover Lakes, Horton Lake and Upper Omstead Creek. The 1997 survey saw very few animals in the Estabrook, Stopover or Horton Lake areas but high densities in the Smith Arm area, Omstead Creek Eskers area and at Bebensee Lake (Figure 3).

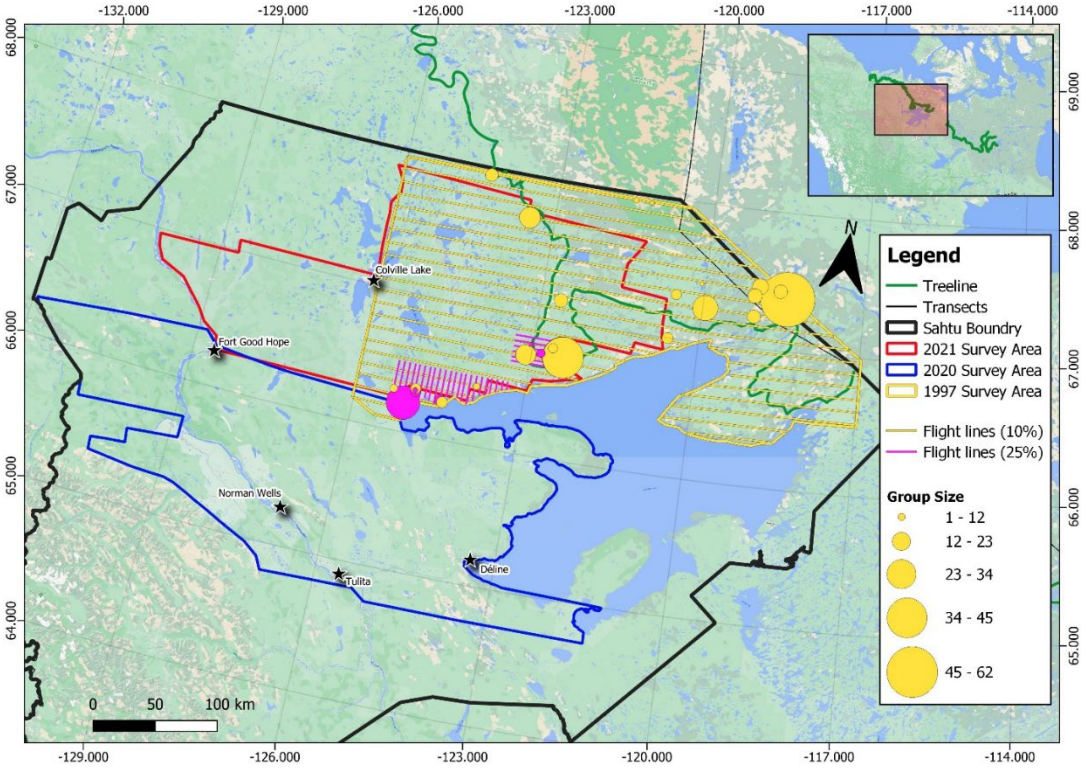

Figure 3. Flight lines and muskox observations during the 1997 muskox survey (yellow lines). Areas covered by the 2020 (blue lines) and 2021 (red lines) muskox surveys are shown for comparison.

In March 2020, ENR carried out a moose and muskox survey over 55,228 km^2 of the southern Sahtú, including west of the Mackenzie River. The area covered by the survey spanned from 15 km north of Fort Good Hope to 20 km south of Tulít'a, and east-west from the Saoyú- ʔehdacho National Historic Site on Great Bear Lake to the foothills of the Mackenzie Mountains (See Figure 4).

In March 2021, a second survey was flown to estimate the number of muskoxen in the northern portion of the Sahtú region (Rentmeister and Chan in prep). This survey covered the area north of Fort Good Hope to the Inuvialuit Settlement Region, west to the Mackenzie River and east to the Dease Arm of Great Bear Lake (Figure 4).

The total population estimated from the two surveys was 5793 individuals (ranging from 3385 to 9912) with most of the muskoxen observed below treeline. The average group size for the two surveys was 9.6 animals, with the average being 8.0 in the southern part of the survey and 11.9 in the north. The average density in the entire combined study area was about 5.4 muskoxen/100 km^2. Since no muskoxen were seen south of the Great Bear River or west of the Mackenzie River, the muskox range in the study area is believed to be bounded by the Great Bear and Mackenzie Rivers. The density estimate for this smaller area was approximately 6.7 muskoxen/100 km^2.

Within the study area the percentage of calves observed was 5.6% (47/832 muskoxen seen). This varied between the 2020 and the 2021 survey area, which had calf percentages of 6.8% and 4.3% respectively. On transect, the 2020 survey had 14 groups with calves out of 55 groups seen, while the 2021 survey had 10 groups with calves out of 33 groups seen.

Muskoxen were not distributed evenly across the study area, with the highest density of muskoxen found north-east of Norman Wells and north of Tulít'a, in areas surrounding Kelly, Mahoney, and Willow Lake.

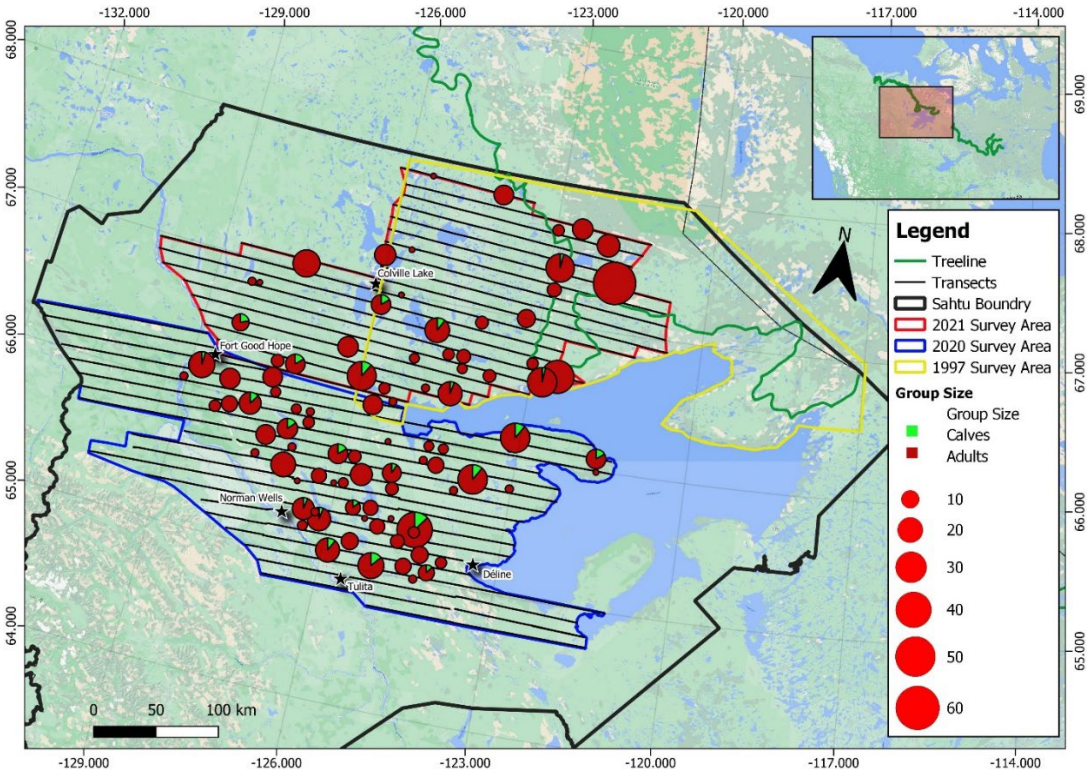

Figure 4. Muskox observations on transect during 2020 and 2021 aerial surveys of the Sahtú Region, where the yellow outline represents the 1997 survey area, the blue represents the 2020 survey area, and the red represents the 2021 survey area (Rentmeister and Chan in prep).

There have been a small number of reports of muskoxen seen west of the Mackenzie and south of the Great Bear rivers, however, these are rare and there are no indications that muskox populations have been established as a result of crossing these rivers (Rentmeister and Chan in prep).

These results indicate that the muskox population in the Sahtú is abundant and likely stable. Low calf percentages do not suggest that the population may decline, but suggest that the population may not respond well to increases in predation, harvest, or disease.

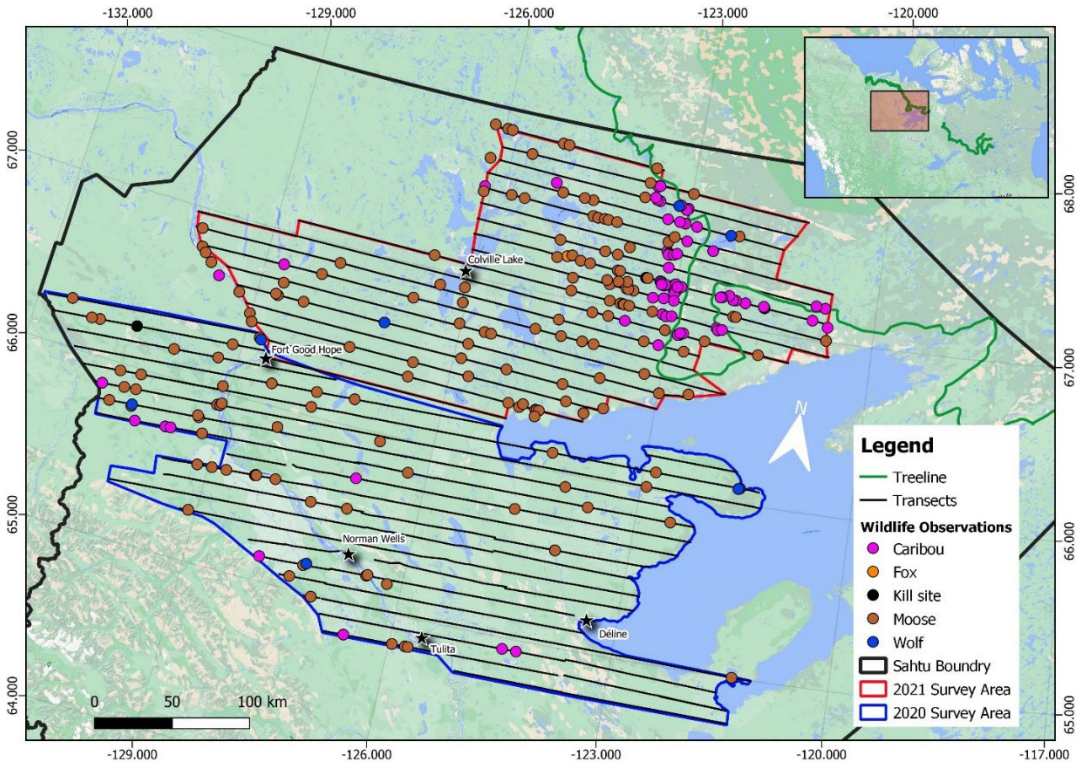

Figure 5. Wildlife observations other than muskox seen on transect during 2020 and 2021 aerial surveys of the Sahtú Region, where the blue line represents the 2020 survey area and the red line represents the 2021 survey area (Chan Unpublished data).

Disease is one of the factors that can affect muskox populations. Hunters say that muskoxen tend to have more internal parasites than other species hunted in the area (Winbourne and Benson 2021). Several diseases (for example those caused by *Erysipelothrix rhusiopathiae, Yersinia pseudotuberculosis)* and parasites (for example *Umingmakstrongylus pallikuukensis*) have been linked to death or weakness in muskoxen in Banks and Victoria Islands (Kafle et al 2020).

Pathogens are likely to move northward with climate change and may spread new diseases to muskox populations in the Sahtú (Kafle et al. 2020). Local outfitters have not reported signs of sickness or disease in the muskox populations surrounding Great Bear Lake (Winbourne and Benson 2021), but in 2020/2021, two disease related muskox deaths were reported between the communities of Tulít'a and Fort Good Hope and two other reported muskox deaths are suspected to be related to disease (Rentmeister and Chan in prep).

What do we know about the relationship between muskoxen and caribou?

As muskox populations expand, they are being observed more frequently in areas used by both boreal and barren-ground caribou. The relationships between muskoxen and caribou

are unclear, and it is uncertain how increasing muskox populations may affect caribou populations. Sahtú communities are concerned that if muskoxen expand into areas south of the Great Bear River, or west across the Mackenzie River there could be negative consequences for caribou, moose, and Dall's sheep (Rentmeister and Chan in prep). During the 2020 and 2021 muskox surveys, observers also recorded observations of caribou and other wildlife (Figure 5). The area of greatest potential overlap between muskoxen and barren-ground caribou appears to be along the treeline north and east of Colville Lake in the winter while the boreal caribou and muskoxen ranges overlap east of the Mackenzie River.

Much of the recorded Indigenous and community knowledge about interactions between muskoxen and caribou has been gathered from Inuvialuit harvesters in the arctic islands and describes relationships between muskoxen and Peary and Dolphin and Union caribou. These sources suggest muskoxen and caribou may interact in four different ways (Winbourne and Benson 2021):

1. *Caribou and muskoxen compete for food and space:* multiple sources, across multiple communities, said that muskoxen and caribou eat the same food and large numbers of muskoxen and caribou are not usually found close to each other at the same time. Some reported that muskoxen and caribou seem to cycle; for a period of time muskoxen will multiply, then they begin to die-off or disappear and caribou increase. Caribou and muskoxen don't multiply in large numbers at the same time.

2. *Caribou avoid muskoxen:* some sources reported that when muskoxen move into an area, caribou change their migration routes to avoid the muskoxen, possibly because of their strong smell.

3. *Caribou and muskoxen do not compete for food or space and/or experience similar threats/cycles:* Ulukhaktok harvesters said caribou and muskoxen do not compete. On the Yukon North Slope, Inuvialuit have observed that good muskox habitat can also be good caribou habitat and, as muskox numbers have increased, muskoxen are more and more often spotted foraging in places people would also expect to see caribou, like Herschel Island.

4. *Muskoxen, caribou, and their predators interact in complex ways:* Some sources suggest muskoxen may be influencing the normal predator-prey relationship between wolves and caribou. Wolves are an important predator of both muskoxen and caribou. In the past, low caribou numbers would lead to a decrease in the number of wolves. However, an increase in the number of muskoxen in an area may allow a wolf population to survive and possibly grow even when caribou are fewer.

Similarly, most scientific studies that look at the relationship between caribou and muskoxen have focused on the Arctic islands where large numbers of muskoxen overlap with Peary caribou populations (Larter and Nagy 1997, 2004):

- Studies in the Canadian arctic islands during the 1960s and 1970s, when muskox populations were relatively low and Peary caribou numbers were high, suggested that caribou and muskoxen are able to live together without eating the same food because of different body adaptations and ways of feeding.
- Research done in the 1990s on Banks Island, in opposite conditions (when muskox populations were high and caribou numbers were low), found the diets of muskoxen and Peary caribou were similar, especially during high snowfall years. The researchers were concerned that muskoxen might overgraze willows (when their numbers were very high) making them unavailable to caribou in summer when caribou rely on willows as an important source of food.
- Results from a study in 2017 suggest that caribou and muskoxen have lived together on Banks Island at different times and under different conditions by being flexible in what they ate so they avoided direct competition for food (Munizzi 2017). In this work, researchers studied carbon and nitrogen signatures in the bones of caribou and muskoxen from archaeological sites over the last 4000 years.
- Disease could have an impact on muskox at a population level and there are several diseases that are shared between caribou and muskox (for example Brucella, Varestrongylus eleguneniensis, Erysipelothrix, etc). Disease transmission and range are changing with climate change. It is likely that muskox populations are more vulnerable to these diseases than caribou but there is little known about the possibility of passing disease between these two species directly or indirectly. Research and monitoring in this area will be important for population monitoring and food security. Important references on muskox diseases in the Arctic include Tomaselli et al. 2016, 2018, Kafle et al. 2020, Mavrot et al. 2020.

The most recent and comprehensive work on caribou-muskox interactions has been on the Yukon North Slope, where researchers studied caribou and muskox collar locations collected between 2016 and 2019 (Carter 2020). The researchers found muskox and caribou interactions appear to be minimal based on limited interaction during the summer between muskox and caribou, and very little overlap in the type of habitat selected by each species. Muskoxen tended to strongly avoid the tussock habitat commonly used by caribou, preferring higher elevations further from water. This work also found overall impact of muskox on vegetation to be low (Carter 2020).

It is not clear whether these observations and research results can be applied in the Sahtú where caribou types, habitat conditions and food resources are different from the high Arctic and the Yukon North Slope. Very little work has been done on muskox populations below treeline due to their recent range expansion.

Muskoxen and Mountain caribou

There is very little known about potential interactions between muskoxen and mountain caribou. As of 2008, the only recorded observation of a muskox in the Mackenzie Mountains was in 1997, when a lone bull muskox was reported at the northern end of the

Mackenzie Mountains. It is uncertain whether this bull came from the existing Sahtú population or the reintroduced North Slope population. It is possible that muskoxen may expand their range and increase their overlap with mountain caribou in the future.

Muskoxen are now increasingly being seen in the Northern Richardson Mountains as the reintroduced Alaskan population expands its range, and have been seen several times close to groups of Dall's sheep. A group of 46 muskoxen was observed in 2003 in a Dall's sheep survey block, 52 muskoxen were reported during a moose survey in March 2006, and a maximum of 98 were counted during the June 2006 Dall's sheep survey, also in the same area (Lambert Koizumi et al. 2011). More recently, 71 muskoxen (57 adults and 14 calves) were counted during the 2014 Dall's sheep survey (Davison and Callaghan 2018), and 29, including 2 calves, were counted during the 2017 sheep survey (Davison et al. 2018). The effect of muskoxen on Dall's sheep in this area has not been investigated, although Gwich'in elders and harvesters from Aklavik, Fort McPherson, and Inuvik have reported concerns of potential negative interactions between them.

The overlap of muskoxen and sheep in some areas may allow for the spread of some diseases between the two species. A 2009 report that looked at the risk of disease transmission from domestic livestock to wild Dall's sheep and mountain goats, identified a few diseases and parasites that can infect both muskoxen and Dall's sheep (Garde et al. 2009). Other research has found a sheep lungworm (*Protostrongylus stilesi*) that can live in both Dall's sheep and muskoxen (Hoberg et al. 2002).

The spread of disease between muskoxen and mountain caribou has not been well studied. This may be an area for future investigation if muskoxen increase their presence in the mountain caribou range.

Muskoxen and Boreal caribou

Muskoxen and boreal caribou are often found in the same area in the Sahtú, but the relationships between the two species and their habitat use has not been studied by biologists (Jorgensen 2021).

In a 2001 study on boreal caribou conducted with Gwich'in, Sahtú, and Inuvialuit Indigenous and community knowledge holders (Zimmer et al 2002 cited in SARC 2012), some people said that muskoxen cause boreal caribou to abandon areas because of their hair, the noise they make, or because of parasites they transmit in their feces. Other people said they have seen boreal woodland caribou and muskoxen feeding on the same plants in the same places without competition or exclusion.

Indigenous and community knowledge sources also said that moose, muskoxen, wood bison, barren-ground caribou and other species can affect the interactions between boreal caribou and their predators (SARC 2012). Participants in a Sahtú Indigenous knowledge study said they have seen an increase in wolf populations in recent years, as well as increases in the abundance of prey species like moose, muskoxen and beavers. These participants said that increases in prey species like muskoxen and moose can result in less predation on boreal caribou, which has a positive effect on the boreal caribou

populations. However, if the number of other prey decrease, predators will hunt boreal caribou. It is unclear if an increase in alternate prey is currently supporting more predators in the Sahtú area (McDonald 2010). The scientific information on the ecology of muskoxen below treeline is currently limited.

Muskoxen and Barren-ground caribou

Communities have expressed concerns about the possible negative effects of muskoxen on barren-ground caribou herds. During community engagement sessions held by the Advisory Committee for Cooperation on Wildlife Management (ACCWM) to develop a management plan for the Bluenose-East, Bluenose-West, and Cape Bathurst caribou herds (2007 – 2013), some Sahtú community members noted that since muskoxen have come into the area, there had been more wolves and no caribou (ACCWM in Windbourne and Benson 2021).

In the Indigenous and community knowledge collected for the Species Status Report on Muskoxen in the NWT (Winbourne and Benson 2021), some people raised concerns that since muskoxen have moved into the Mahoney Lake area of the Sahtú, there are no caribou. Prior to about 2010, barren-ground caribou sometimes came to that area in the winter. More recently, this area has primarily been used by boreal caribou. There were also concerns raised that, because muskoxen don't move around as much as caribou and are able to eat a more varied diet, including all the grasses, they may be a stronger competitor in some areas forcing caribou out. Some people reported that muskoxen dislodge some plants at the root, or they may paw lichen into the ground, disturbing the soil and causing damage to delicate caribou habitat. They said that, overall, habitat quality decreases for caribou after an area is used by muskoxen. One resident from Fort Good Hope said that the scent muskoxen leave on the landscape stays a long time, you can smell them even a week after they have gone by and maybe that's keeping caribou away, adding that this effect is compounded by caribou's powerful sense of smell (Winbourne and Benson 2021).

One of the big game outfitters in the Sahtú, who offered hunts around Caribou Point and the north shore of Great Bear Lake, observed that in his area muskoxen and barren-ground caribou do not seem to compete for resources. He noted that muskoxen don't seem to be damaging the habitat because muskox and caribou are seen in the same area at the same time. Although caribou numbers in his area have declined, the small number of muskoxen has stayed the same suggesting there is no connection between changes in muskox and caribou numbers (Winbourne and Benson 2021).

Others have also reported that there does not appear to be a relationship between increasing muskoxen and the number of caribou, bears or wolves which suggests that the presence of muskoxen is not increasing the level of predation on caribou (Nguyen 2016 cited in Windbourne and Benson 2021). Recent work in Nunavut (Tomaselli et al. 2018*a*) supports the finding that caribou and muskox numbers and distribution have peaked and declined at the same time over long periods of time, suggesting they do not compete but may be subject to similar environmental stresses.

There is little scientific information on the relationships between muskoxen and barren-ground caribou for areas within the Sahtú. Within the taiga, relationships between muskoxen and caribou use of habitat are unknown and biologists have not studied other effects such as whether there is an overlap in diet (especially grasses and sedges), whether muskoxen push caribou out of an area, whether increased muskox numbers result in more predation, or whether parasites and diseases are shared between the two species (SARC 2017).

In response to concerns raised by hunters in Aklavik about the impact of reintroduced muskoxen on the Porcupine caribou herd, of the Yukon North Slope, researchers analysed collar locations collected between 2016 and 2019. They found muskox and caribou interactions appear to be minimal based on limited interaction during the summer between muskoxen and caribou (less than 1% of collared caribou encountering a muskox between May 1st and August 31st), and very little overlap in the type of habitat selected by each species. Muskoxen tended to strongly avoid the tussock habitat commonly used by caribou, preferring higher elevations further from water. The greatest overlap in habitat use was in rock-lichen wetlands and floodplains (Carter 2020).

Muskoxen and Barren-ground Caribou Habitat

One of the major concerns from communities is the effect of muskoxen on caribou either through direct competition for food or the degradation of caribou habitat (Carter 2020, Winbourne 2021). Research into how muskoxen affect the plants they eat is limited and there have been no studies to date on the selection or impact of muskox on vegetation below treeline (Jorgensen 2021). At a regional scale, high densities of muskoxen can continue to live and feed in an area for decades. Studies on northern Ellesmere Island found muskox herds at very high densities (approximately 6 but ranging from about 4 - 8 muskoxen per km^2), only removed a small amount, approximately 4-5%, of available forage during the short summer growing season (2 months). But muskoxen could graze between about 40-50% of the available shoots in meadow stands during the remaining 10 months when there is no growth (Raillard 1992). In Greenland, muskox removed less than 1% of the available grasses and sedges on a weekly basis during the main growing season but in autumn that increased up to ~4.6% as plants slowed and stopped growing (Mosbacher et al. 2016). Recent work has looked at the impacts of muskoxen in three different habitat types and found that muskox impacts on vegetation are low (Carter 2020).

What should people's role be in maintaining healthy relationships between caribou and muskoxen?

As muskoxen continue to return to more areas, the potential for increased interactions between muskoxen and caribou also increases. The relationship between caribou and muskoxen is not well understood but people can support maintaining a healthy

relationship between these two animals by watching for and reporting changes, harvesting at sustainable levels, and learning from research being done in other areas.

Monitoring

ENR monitors the muskox population by doing aerial surveys. The two surveys done in 2020 and 2021 provide a good understanding of the current state of the muskoxen population in the Sahtú (Rentmeister and Chan in prep). This work is part of an ongoing assessment of the distribution and population of muskoxen in the mainland NWT and will be expanded to the North Slave and Beaufort Delta.

Additional aerial surveys in the Sahtú could help estimate muskox population trends. The southern area around Norman Wells, Tulít'a and Déljne is likely to be an important and changing area for muskoxen. This area will be a priority for monitoring to assess trend, health and distribution of muskoxen.

Harvesters and others on the land can also help detect changes in the muskox population by reporting muskox sightings and observations of behaviour, especially for areas where muskoxen have not been seen in the recent past. Community-based monitoring programs, such as the Sahtú Winter Track Survey Project which took place around Tulít'a and Norman Wells (Hodson et al. 2017), and the more recent monitoring program established in the Ts'udé Niljné Tuyeta protected area which uses a combination of Automatic Recording Units (ARUs) and trail cameras, are another way to document new occurrences of muskoxen in areas where they have not been previously documented (Land Needs Guardians 2020).

With a rapidly changing climate, it is likely that the role of diseases in muskoxen will also change. Community involvement in population health monitoring (such as documenting low recruitment, poor body condition, increased disease, and deaths) is critical to detecting changes in wildlife populations (Tomaselli et al. 2018*b*). Existing relationships between ENR, community governments, and academic partners are well-positioned to explore and act upon options for muskox health surveillance.

Harvesting

One of the tools used by co-management partners to manage the relationship between caribou and muskoxen is through regulating hunting. There is evidence that Inuit in both the eastern and western Arctic historically managed the population of muskoxen through harvest to help caribou populations grow (Winbourne and Benson 2021). Changes to hunting regulations can be made as a result of recommendations by the SRRB, which has been the typical approach so far, or by the Minister proposing changes to hunting regulations and seeking the timely advice of SRRB on those proposed changes after considering changes in the number of muskoxen and other indicators of the health of the species.

Indications that the population of muskox in the Sahtú was healthy and potentially expanding resulted in an initial annual quota for a total of 11 muskoxen beginning in the

1994/95 hunting year. After a 1997 survey, a quota increase to 27 animals was recommended (Veitch 1997). Currently, Sahtú participants and General Hunting Licence holders can harvest muskoxen between August 1 and April 15 each year, with no restrictions on the number of animals harvested. According to some Indigenous knowledge holders, the severe declines in muskox populations in the late 1800s and early 1900s and the history of muskox management in the Sahtú has had long term effects on Dene relationships with muskox, and most people no longer know how to hunt and use muskoxen. Many hunters and communities are unaware that muskoxen are a traditionally harvested animal (Winbourne and Benson 2021).

Tags to hunt muskoxen are available to resident and non-resident hunting licence holders under a quota system in the Sahtú. These tags are valid between August 1 and April 15. Five resident tags are available through an annual draw. Thirty-five additional tags are issued to hunters who have approval from a Renewable Resource Council. Non-resident and non-resident alien hunters must hunt with a licenced guide and outfitter and are limited to hunting bulls only.

Regulations require all harvests of muskox to be reported to ENR. During the winter of 2021/2022, ENR and the University of Calgary collected muskox sample kits in an effort to create a baseline for muskox health in the Sahtú. These sample kits were not mandatory. Complete muskox sample kits submitted to the wildlife health monitoring program were reimbursed $150, which is part of a multi-disciplinary approach to monitoring wildlife health, inclusive of local and Indigenous knowledge, community - or harvest-based sampling, and targeted surveillance efforts. Muskox kits that were collected previously are currently being analyzed along with this effort and preliminary results will be provided in 2022.

Research

Given the concerns in Sahtú communities around increasing muskox populations and their potential to spread across the Mackenzie and Great Bear Rivers, ENR has partnered with Wilfrid Laurier University to look at the reasons that contribute to the southward expansion of muskox below treeline. This project will assess what types of habitat are beneficial to muskox and how muskox populations may react to climate change. Findings from this project will also complement work that the SRRB and ENR's Climate Change and On the Land Units are planning in relation to food security, including muskox as an alternative food source in a changing climate.

The University of Calgary and ENR in discussions with the Sahtú communities expanded the long-term wildlife health monitoring program in the winter of 2021/2022 with the goal of understanding the drivers of health for muskoxen. Due to the expanding muskox population, the Sahtú is a high priority region and ENR will be working with both resident and Indigenous harvesters to provide samples.

Samples will be collected to assess and compare the health of muskoxen across a broad geographic range and between increasing and decreasing populations. The University of Calgary currently has long term monitoring programs with the communities of

Ulukhaktok, Kugluktuk, and Cambridge Bay and has proposals to extend these programs to Lutsel K'e, Taloyoak, and Gjoa Haven. In these areas, harvester-based sampling, with individual and group interviews, have been used to gather biological samples, data and Indigenous knowledge which will inform on muskox health and dynamics.

ENR is hoping that the concerns and questions raised by the communities during the Public Listening Session will promote continued discussion and collaboration for future work on wildlife research.

Moose

What do we know about moose in the Sahtú? [1]

Moose are found almost everywhere in the NWT (Figure 6), both in forests and on the tundra, but prefer to be near shallow lakes, ponds and rivers. They are most often found in spruce forests and areas with shallow water where there are willow, birch trees, grasses, water plants and fresh leaves to feed on. These locations provide good quality food, fresh water, and shelter from predators and extreme temperatures.

[1] *Except where otherwise cited, information has been summarized from Environment and Natural Resources. In Prep.* ***Draft*** *Status Report for Moose (Alces alces) in the Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife.*

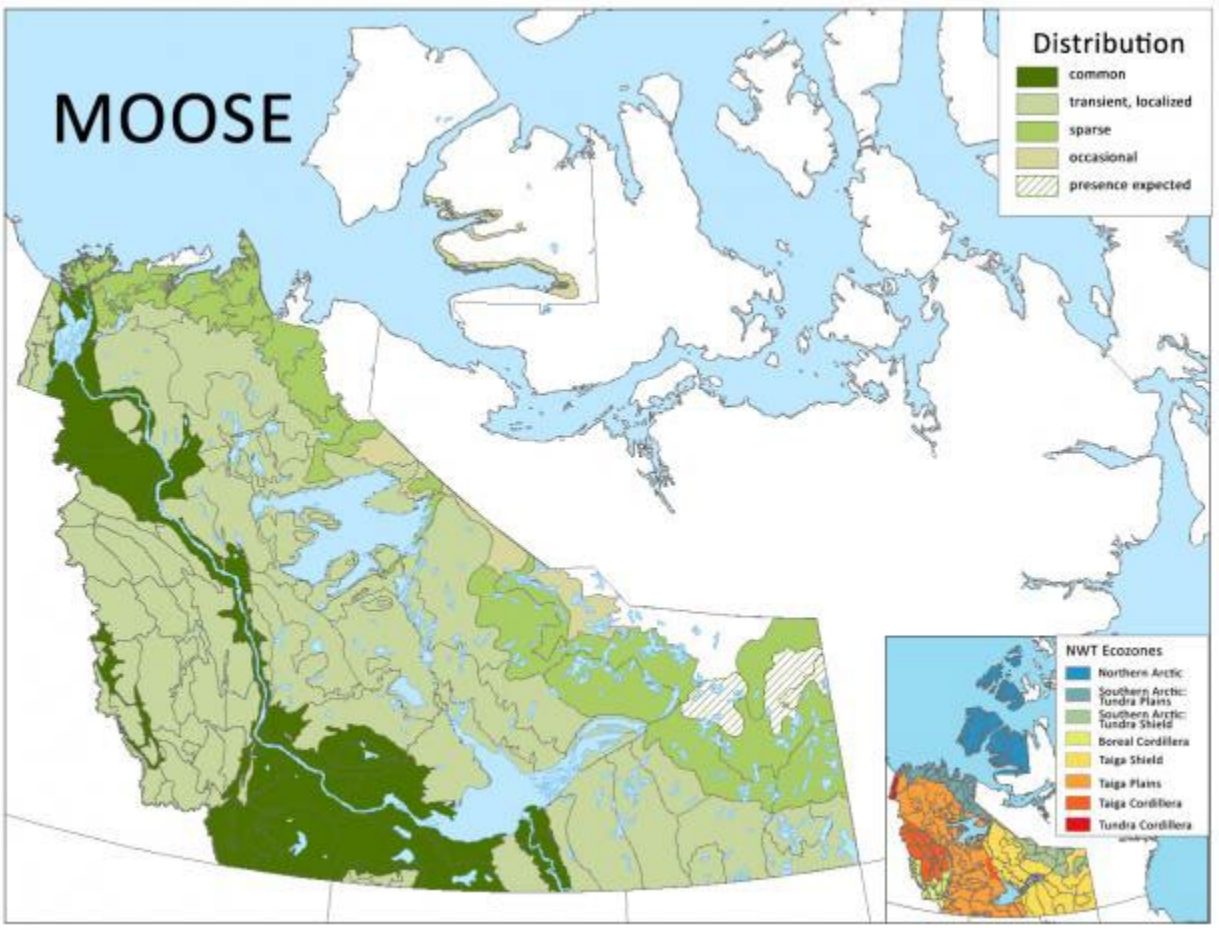

Figure 6. Moose distribution in the NWT by Ecozone.

In the Sahtú, moose are most common along the Mackenzie River valley and the alpine valleys of the Mackenzie Mountains. They are frequently seen on the islands of the Mackenzie River during November and December, where there are lots of sandbar willows to feed on. In Délı̨nę, community members have identified Neregah (North Shore Great Bear Lake Heritage Zone) as an important area for moose (Great Bear Lake Working Group 2005 cited in ENR in prep).

Moose prefer to feed on the fresh leaves and new shoots of willows, birch, grass and water plants. They are attracted to areas that have recently been disturbed by fire, flooding or human activity, and their numbers may increase in disturbed areas once new willows begin to sprout. This usually begins two or three years after a disturbance and continues to provide prime habitat for moose for 10-25 more years. Wildfire is the most significant influence that increases available habitat for moose in the boreal forest.

Observations from Tulit'a and Norman Wells around 2000 indicated there were more moose in the Mackenzie valley than had been seen previously. During a 2016-2019 review of data from the Sahtú Harvest Study and during the 2020 public listening in Colville Lake,

residents in several Sahtú communities also said they were seeing more moose. Community members from Norman Wells said they are starting to see more moose, and in places that they did not see them previously. They are also harvesting more moose than they did in the past. Elders in Fort Good Hope said there were more moose than when they were young and representatives from Colville Lake said they are seeing not only more moose, but also more woodland caribou.

ENR monitors moose numbers using specially designed aerial surveys (Gasway et al. 1981, Kellie and DeLong 2006, Buckland et al. 2015). The first moose surveys in the Sahtú were conducted by the Canadian Wildlife Service between Great Bear Lake and the Mackenzie River in 1953 and along the Mackenzie River Valley in 1956 (Flook and Bryant 1957). These were followed in the 1980s by surveys flown along the Mackenzie River and its tributaries along the proposed Mackenzie Valley pipeline route from Fort Simpson to the Mackenzie delta (Geddes and Duncan 1982, Brakett et al. 1985). Most of these early surveys were limited to small study areas and focused either on important harvesting areas, where high numbers of moose were expected to be found, or areas with proposed industrial resource development. Only an extremely small area of the Sahtú region was covered and only a few areas were surveyed more than once.

Figure 7 shows the areas covered by moose surveys in the Sahtú between 1982 and 2020. The surveys from the 80s and 90s are now dated. Changes to survey methods, study areas, and the small proportion of the Sahtú moose range covered by the surveys, make it challenging to use them to determine moose population trends. As well, some survey estimates were fairly imprecise (had a large confidence interval), also making it difficultto detect statistical changes in population size unless those changes were very large (ENR in prep).

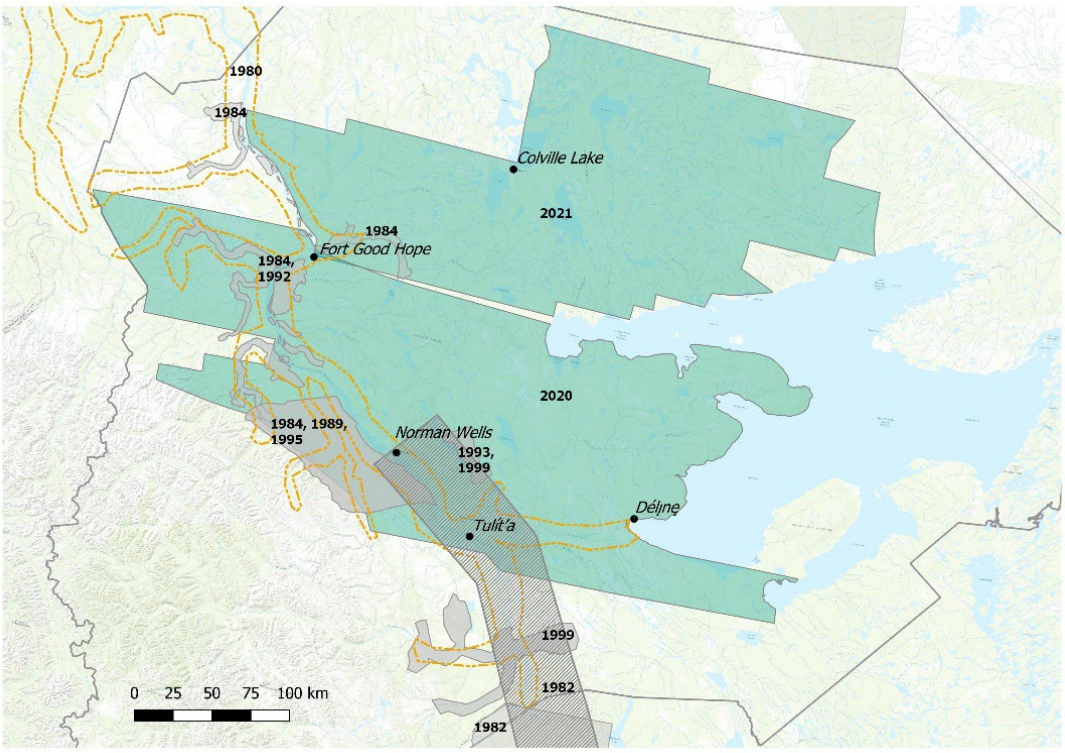

Figure 7. Sahtú region moose survey study areas, 1982-2020, and the years surveyed (ENR 2021).

In March 2020, ENR conducted a moose and muskox survey over 55,228 km^2 of the southern Sahtú, the first survey to estimate moose density in the Sahtú since 1999. Unlike earlier surveys that targeted high quality moose habitat along the river systems using a different survey method, this survey was carried out over a much broader regional scale, incorporating lower quality moose habitat where moose were much less likely to be seen. The survey results estimated there were 1.4 moose/100 km^2 in the area (ENR unpublished data). This was much lower than densities reported from earlier surveys but, because survey methods and study areas were different, and the scale of the survey was so different, it is not possible to compare these estimates to see if moose numbers have changed.

In March 2021, ENR staff, along with observers from Fort Good Hope and Colville Lake, completed a similar survey to estimate the number of muskoxen in the northern portion of the Sahtú region in which moose and caribou observations were also recorded. This survey covered 43,397 km^2 and recorded 121 moose in 92 groups. Preliminary calculations suggest a moose density of about 3 moose per 100 km^2 (ENR unpublished data). This suggests an increase in the moose population in this area since 1997, when the 1997 muskox survey recorded 28 moose in 19 groups and estimated a density of 0.5 moose per 100 km^2 (Veitch 1997).

The average moose density for the Sahtú resulting from the combined 2020 and 2021 surveys is approximately 2 moose per 100 km^2 (ENR unpublished data), similar to moose densities found in the Beaufort-Delta region, (2.2 moose/100 km^2 in 2013 (Davison and Callaghan 2013) and 3.8 moose per 100 km^2 in 2019 (Davison and Callaghan 2019).

Figure 5 (see muskox section) shows locations of wildlife observed during the 2020 and 2021 surveys. Moose were seen throughout most of the area, with a greater concentration in the northeast portion of the survey area, towards the treeline. Most of the caribou seen during the survey were found just inside the treeline near Horton Lake, where their location overlapped with muskox sightings.

Another measure of moose population health is the calf:cow ratio. This is a measure of how many calves are born for every 100 cows (female moose). The calf:cow ratio gives an idea of how many new animals are coming into a population and whether the population is declining, stable or growing. A ratio of 25 calves for 100 cows (25:100) is considered the minimum number of calves for a stable moose population.

The average ratio of calves to cows observed in eight moose surveys conducted in the Sahtú between 1984 and 2001 was 57:100 (ranging from 18 – 100:100), with only one survey having a calf: cow ratio below 25:100 (ENR unpublished data). This suggests the moose population in the Sahtú was stable or growing over that time. Non-resident hunter observations of moose in the Mackenzie Mountains recorded between 1995 and 2017 reported an average of 30 calves for every 100 cows with no trends over time, which also suggests that moose numbers in this area have been stable (Larter et al. 2018).

The ratio of bulls (male moose) to cows is also monitored to make sure there are enough bull moose for successful breeding. In other jurisdictions, 30 bulls for every 100 cows (30:100) is considered the minimum ratio for a healthy moose population. If the number of bulls drops below this, hunting restrictions may be considered.

The ratio of bulls to cows in the eight moose surveys carried out in the Sahtú between 1984 and 2001 ranged from 48 to 151 bulls for every 100 cows, with an average bull:cow ratio of 102:100 (ENR unpublished data). Observations of moose by non-resident hunters in the Mackenzie Mountains between 1995 and 2017 suggest a bull:cow ratio that ranged from 76 bulls for every 100 cows to 136 bulls for every 100 cows with an average of about 104 bulls:100 cows (Larter et al. 2018). This number may be biased because hunters are specifically searching for bulls and the number of cows may be under-reported, but the ratios suggest that, even in areas with outfitted hunts where male moose are specifically targeted, there is no shortage of breeding males.

What do we know about the relationship between moose and caribou?

Moose in the Sahtú are found in the same areas as mountain, boreal and barren-ground caribou but there is little information about the nature of the interactions between them specific to the Sahtú region.

Moose and mountain caribou[2]

Northern mountain caribou are usually found in the mountains, in forested areas where there is lots of lichen for food. Moose tend to prefer lower elevation areas with willow, birch, grass, sedges, and water plants, so moose and mountain caribou likely do not directly compete for food or habitat.

There is little scientific information about the relationships between moose and northern mountain caribou in the Sahtú but according to some Indigenous and community knowledge holders, there may be a relationship between moose and mountain caribou where changes in the number of moose in an area can affect the number of caribou killed by wolves. In the Mackenzie Mountains, moose and northern mountain caribou are part of a predator-prey system that also includes Dall's sheep, mountain goats, wolves, grizzly bears, black bears, wolverine, and lynx. Wolves in mountain caribou range depend mainly on moose for food, only preying on mountain caribou when they get the chance. When moose numbers increase, so do wolf numbers and pack sizes. More wolves could mean it is more likely that wolves will prey on mountain caribou.

Wolf predation on mountain caribou may also increase when moose numbers decline. In winters with deep snow, it is easier for wolves to hunt moose. This can result in a temporary decrease in the moose population. When moose become harder to find, wolves may shift their attention to caribou, increasing the level of predation and reducing the number of caribou. As the number of moose and mountain caribou in an area both decline, the number of wolves also decreases. This interaction between wolves, moose and mountain caribou is called apparent competition (see section below and Figure 8). These interactions can be influenced by changes in habitat leading to increased moose abundance and wolf access in a process known as habitat-mediated apparent competition.

Outfitters in some areas of the Mackenzie Mountains have reported that in some areas the numbers of wolves and size of wolf packs have increased at the same time that moose

[2] *Information summarized from Species at Risk Committee. 2020. Species Status Report for Northern Mountain Caribou (Woodland Caribou [Northern Mountain Population]) (Rangifer tarandus caribou) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.*

numbers have increased, and there are now more, large moose-hunting wolf packs than before.

Moose densities vary throughout their range in the NWT, with the highest surveyed densities around Fort Good Hope, Norman Wells, and Tulít'a (11-17 moose/100km^2; ENR in prep). Even these relatively high moose densities are low compared to moose densities in the southern portion of northern mountain caribou range (23-137 moose/100 km^2 in BC). With low moose densities in the mountain caribou range the extent to which apparentcompetition influences mountain caribou populations in Sahtú is unknown. It is unknown if the muskox population contributes to apparent competition. Currently, the low moose densities in northern mountain caribou ranges in the NWT contribute to range conditions that are favourable for caribou.

Climate change may affect the relationship between moose and northern mountain caribou. With climate change, some new species are expanding their range northward into northern mountain caribou habitat, and some local species are shifting their distribution. For example, some Indigenous and community knowledge suggests that climate change is resulting in more willows at higher elevations. This may attract moose to move to areas of higher elevation where mountain caribou are found, and the wolves may follow.

Moose and boreal caribou

According to some Indigenous and community knowledge sources, moose and boreal caribou are found in the same general locations, but at different times, and they did not interact with each other. Others said moose and caribou each live alone and do not share habitat. There were also different opinions on whether moose and boreal caribou eat the same foods. This suggests the relationships may vary over time and from place to place (SARC 2012).

In most parts of the NWT, boreal caribou tend to be found in areas with dense pine or spruce forest, or in areas of muskeg where they prefer to feed on lichen, especially during winter. This differs from the habitat and deciduous plants typically chosen by moose so there is likely little or no competition for food or habitat (SARC 2012).

Research on boreal caribou in other parts of Canada, and in the southern NWT, suggests that increasing moose populations can have a negative effect on boreal caribou populations, especially where habitat has been disturbed by fire or human activity. New plant growth that follows habitat disturbance can attract and support more moose or deer. An increase in moose or deer can attract more wolves into the area and support a higher wolf population. More wolves in an area can lead to more wolf predation on boreal caribou, which can cause boreal caribou numbers to decline. This is called habitat-mediated apparent competition (Figure 8).

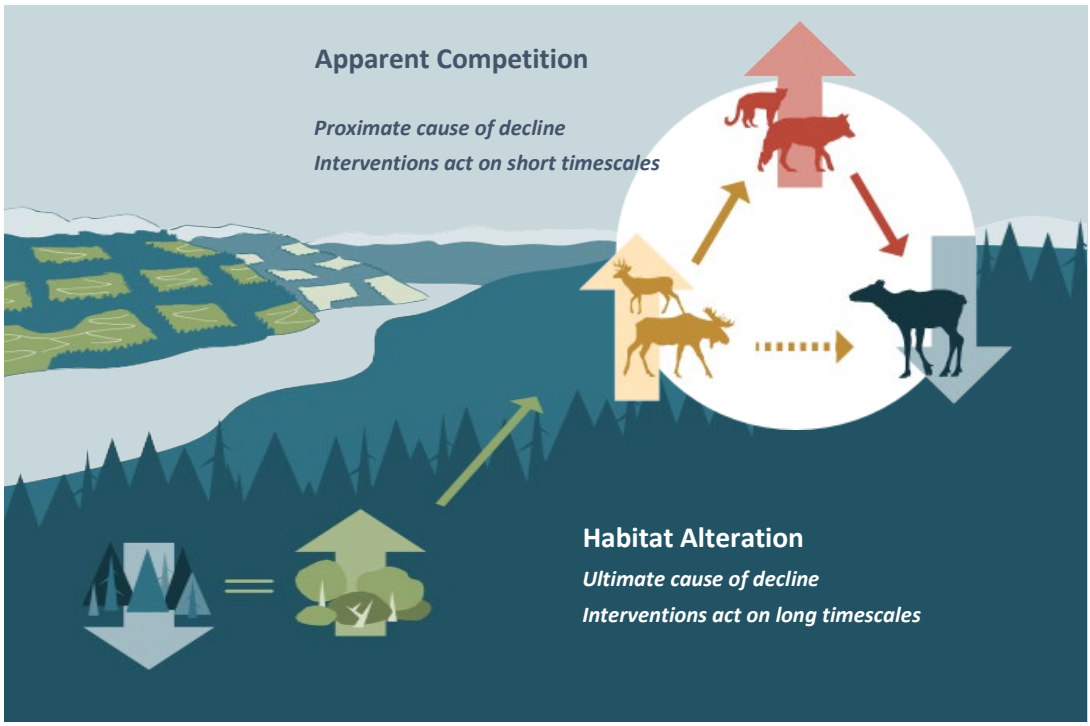

Figure 8. Apparent competition can occur between abundant primary prey (moose and deer) and less abundant alternate prey (boreal caribou). In this instance, the young forests and habitat disturbance provide better moose habitat and lasts for decades. This brings in more wolves and the increased predation on boreal caribou results in population decline. Although, the actual cause of the decline is habitat disturbance, immediate management of wolves and moose is required to help caribou to survive until habitat can be restored (Adapted from Serrouya et al. 2019*).*

A 2021 study (Serrouya et al. 2021) looked at this idea in more detail. The study included 14 areas in the southern NWT and northern BC, Alberta and Saskatchewan, and looked at the relationship between changes in vegetation caused by forest harvesting, moose numbers, wolf numbers and boreal caribou population changes. The researchers wanted to find out why landscape changes caused by forestry and other human disturbance had a negative impact on boreal caribou populations.

Using computer models, they examined six different ways that human disturbance could influence caribou populations:

1. Reduced availability of food caused by removing the forest
2. Increased ability of wolves to move through the cut area resulting in higher predation
3. Direct competition for food by moose
4. “Apparent competition” where increased moose numbers resulted in more wolves, resulting in more predation on boreal caribou
5. A combination of reduced availability of food and apparent competition
6. Direct enrichment where both caribou and moose benefit from increased plant growth following the disturbance.

The results of the study strongly supported apparent competition as the best explanation for decreased boreal caribou numbers in areas disturbed by forestry. An increase in new plant growth after forest harvesting attracted more moose into the area, which resulted in an increase in the number of wolves. More wolves resulted in more predation on boreal caribou, and a decrease in boreal caribou numbers. The researchers found that wildfire had much less impact on caribou populations than human-caused habitat changes. The authors of the 2021 study found that wolf densities higher than 1.8 wolves per 1000 km^2 were likely to negatively affect boreal caribou numbers and that caribou populations tended to decline once moose densities were over 2.9 moose per 100 km^2 in areas disturbed by forestry (Serrouya et al. 2021). Other studies had previously found that wolf densities higher than 6.5 wolves per 1000 km^2 were likely to negatively affect boreal caribou numbers (Bergerud and Elliot 1986).

The idea of apparent competition has gathered wide support for explaining declines in boreal caribou numbers in more southern parts of caribou range where human-caused habitat disturbance, particularly forestry, is relatively high. Researchers in Quebec (Fortin et al. 2017) have suggested that the impact of apparent competition on boreal caribou populations after forest cutting depends on how productive the forest is, and how quickly it grows back.

A long-term study in the Saskatchewan Boreal Shield (McLoughlin et al. 2019), where moose densities ranged from 4.6-5.4 moose/100km^2, however, found no support for the theory of apparent competition in that region. Instead, they found that in northern Saskatchewan, where human disturbance is low but fire disturbance is relatively high, high fire disturbance did not attract larger numbers of moose or wolves. Moose and wolf numbers stayed low and boreal caribou numbers did not seem to change.

The draft status report on moose in the NWT (ENR in prep) suggests there is a lack of evidence to support the idea that apparent competition is affecting boreal caribou populations in areas like the Sahtú, where numbers of moose, boreal caribou, and wolves have remained low and fairly constant at least over the last decade. Moose numbers in the Sahtú are far lower than in the more southern portion of boreal caribou ranges. As well, human-caused disturbance is much lower than in more southern jurisdictions and at current levels, is not yet likely to have caused a substantial increase in moose populations. It is unlikely that moose populations will affect the level of wolf predation on caribou in the Sahtú unless human disturbance causes moose to increase substantially. Predation could possibly become a problem if the landscape is disturbed to a point where the balance between predators and prey shifts. Climate change is likely to accelerate changes in the landscape and predator-prey interactions.

A new study is starting to better understand how boreal caribou, moose, bison, wolves and bears interact with each other and with the landscape in the Mackenzie and North Slave boreal caribou study areas and the Mackenzie bison range. Laval University's Sentinel North program is using GPS and camera collars to collect location information and video of different animal species that are using the same areas around the same time. They will combine these data with satellite images of the landscape, vegetation and

habitat to develop computer models describing how each species uses the landscape based on how they interact with plants, other animals and human developments. These models will also predict the distribution and population size of each species in the future. The results of this research may provide useful information for understanding the way moose, boreal caribou, wolves and bears interact in other areas of the NWT as well.

Moose and barren-ground caribou

Where moose are found in the same areas as barren-ground caribou, moose usually choose different food and habitat types so there is likely no direct competition. As woody shrubs increasingly move into the tundra as a result of climate change, the number of moose on the tundra may increase, which could attract more wolves into the area (SARC 2017).

A 2015 Indigenous knowledge report (Benson 2015) on the Bluenose-West caribou herd suggested wolf numbers had increased in the range of some barren-ground caribou herds, possibly because of an increase in moose and muskoxen. Normally, as caribou numbers decrease, the number of wolves that prey on the caribou also decrease. However, when caribou numbers are low, wolves may prey more on moose and muskox while still continuing to prey on declining caribou herds.

Estimates of wolf densities from aerial den surveys conducted from 1996-2012 in the Bathurst range indicate a stable population of approximately 6-8 wolves per 1000/ km^2 from 1996 to 2002 (Klaczek et al 2016). Between 2003 and 2012, this population steadily declined to an estimated density 2.7 wolves/ 1000km^2. Recent estimates from a 2021 geospatial survey and using the biomass estimation method place wolf densities in the Bathurst winter range around 2 wolves/ 1000 km^2 (Clark et al 2021). While wolf populations generally decline with declining barren-ground caribou populations, predation can still be significant when herds are at low numbers.

What should people's role be in maintaining healthy relationships between caribou and moose?

A review of the traditional and community knowledge literature prepared for this public hearing (Winbourne 2021) found that, overall, Sahtú knowledge holders do not appear to have significant concerns about increasing numbers of moose. People can support keeping this relationship in balance by watching for changes, harvesting at a sustainable level, and protecting caribou habitat.

Monitoring

Monitoring moose and caribou numbers can help managers track changes in their relative numbers. ENR monitors moose using aerial surveys that have been designed specifically to estimate moose numbers, age class and bull:cow ratios. Observations of moose are also recorded on all aerial surveys for large mammals such as caribou and muskoxen.

Harvesters are the eyes and ears on the land and by reporting their harvests and commenting on any changes they see in moose numbers and locations, they can help alert wildlife managers to differences. ENR also receives moose observations from wildlife surveys associated with environmental assessments and land use permit applications, and documents casual observations submitted by residents.

All observations that have a location associated with them are stored in the Wildlife Management Information System (WMIS). These observations are used to determine where moose are found in the NWT. Hunters and others on the land can contribute their sightings and observations to these records.

Harvesting

Moose are an important source of food and clothing in the Sahtú. Currently, Sahtú participants can hunt moose anywhere in the Sahtú throughout the year with no restrictions on the number of animals that can be harvested. General hunting licence holders can also hunt moose without restrictions, except in the special harvesting area, which has a limited season for non-participants. Resident hunting licence holders can harvest one moose a year between September 1st and January 31st in all Sahtu management zones except S/MO/01, which allows resident hunting between September 1st and November 30th. Non-resident hunters can harvest one moose a year between September 1st and October 31st in one of the outfitter areas. Non-resident hunters must use the services of a licenced guide and outfitter.

Changes to hunting regulations can be made as a result of recommendations by the SRRB, which has been the typical approach so far, or by the Minister proposing changes to hunting regulations and seeking the timely advice of SRRB on those proposed changes. If necessary, changes to the hunting regulations can be made to help maintain the balance between moose and caribou populations.

In some parts of the NWT, deer are being seen more often than before. It is possible that a large increase in the number of deer could cause an increase in wolf numbers. There is also concern that, as deer expand their range, they may bring Chronic Wasting Disease (CWD) into the NWT (ENR 2020*a*). CWD is a fatal brain disease that can affect members of the deer family, including white-tailed deer, mule deer, moose, elk and caribou. CWD has not yet been detected in any wildlife species in the NWT or in caribou anywhere in North America.

ENR is working with hunters and neighbouring jurisdictions to prevent the spread of CWD into the NWT. New regulations allow deer to be hunted at any time by all NWT hunters. Licence holders need a tag, must report their harvest, and must provide the head of any deer harvested to ENR for sampling. By reporting any deer seen or harvested, Sahtú harvesters can help detect new occurrences of deer and provide information needed for management decisions.

Wolves

What do we know about wolves in the Sahtú?

Wolves are found in low numbers and densities throughout the NWT including the Sahtú. Within the Sahtú, there are two types of wolves: boreal wolves and migratory tundra wolves. Boreal wolves live in the forests and mountains, and are often found near communities. These wolves have year-round home territories where they live, travel, hunt, breed, and raise pups. They hunt a variety of prey species and depend largely on non-migratory prey like moose. They sometimes prey on boreal or mountain caribou when they have the opportunity. They can also prey on barren-ground caribou as the caribou pass through forested areas during their annual migration (SARC 2012, 2017, 2020). Tundra, or migratory wolves follow barren-ground caribou on their annual migrations. They do not have regular territories during most of the year but are thought to den and raise their pups in the same area year after year (Nishi et al. 2020).

Wolves are pack animals, living in groups that range from two to 16 members. Large groups of up to 30 - 40 wolves have sometimes been reported by community residents, but these are rare. Pack members are normally close relatives. There is usually one breeding pair of wolves, their pups and possibly one or two of their siblings in each pack.

The social structure of a pack is complex and tightly knit, with each member knowing its own rank or position. Some Indigenous and community knowledge holders have reported that packs are getting larger in some areas, possibly because fewer people are out hunting and trapping wolves (SARC 2017).

Wolves have 4 – 6 pups a year, and can sometimes have more than one litter in a pack. They can travel long distances and move into new areas if local wolves leave or are removed. These characteristics allow wolf numbers to quickly increase again if their numbers decline. The experience in Alaska and Yukon is that wolves can annually withstand losing 30-40% of their numbers within a year without substantially changing overall population size (Wolf Feasibility Assessment Technical Working Group 2017).

Throughout the winter, wolf packs travel many kilometres, feeding where they find prey and resting when they are tired, or when extreme temperatures and storms cause them to seek shelter. Winter travel routes include game trails, ridges, seismic lines, frozen waterways, roads and snowmobile trails, which likely make travelling easier in deep snow.

There has been concern in some communities that wolf numbers are increasing and packs are getting larger. Before 1983, wolf sightings near Délı̨nę were relatively rare, but since then wolves have been regularly sighted and there are wolf dens near the community. The increase in wolf numbers around Délı̨nę happened at the same time that the Bluenose-East and Bluenose-West barren-ground caribou herds returned to the Délı̨nę area; wolves came with the herds. It is not clear whether the number of wolves near the community has decreased as caribou numbers have declined. In 2019, one of the Mackenzie Mountain outfitters reported there were more large wolf packs in the north Mackenzie Mountains than previously (SARC 2017). While there are some reports of increasing wolf populations, recent information suggests a declining trend in wolves and number of active den sites on the Bathurst caribou herd range (Klaczek et al. 2016).

Wolves are hard to see from the air, especially in forested areas. Although wolves travel in packs they are found at very low densities across the landscape and tend to avoid humans. These factors, combined with their tendency to be found in groups or packs in some areas and not at all in other areas, make it hard to estimate wolf numbers over large areas. For all of these reasons, ENR has not been able to obtain reliable estimates of wolf numbers or population trends for either the Sahtú or the NWT as a whole. Nor are there reliable estimates of the number of wolves associated with each barren-ground caribou

herd. Most estimates of wolf numbers come from wolf sightings recorded during aerial surveys for other animals like caribou, moose or muskoxen (see Figure 5) and calculating a relative index based on wolves seen per hour or kilometre of flying. For example, the 2021 muskox survey observed approximately 1 wolf for every 8-9 hours of flying compared to 1 wolf for every 6 hours of flying in the 1997 survey. These surveys are not designed for

counting wolves and the sightings give only a very rough idea (an index) of how many wolves may be present in an area (Clark et al. 2021). As a result, ENR is cautious in interpreting any trends unless there are very large differences in the numbers of wolves seen between surveys.

In the absence of good survey information, biologists sometimes count wolf tracks or use local den surveys to get an idea of wolf numbers in a specific area. There have been a number of dedicated wolf surveys carried out in the South Slave, Dehcho and North Slave regions (see Serrouya et al. 2021) where aerial surveys are used to detect wolf tracks in the snow and use these observations to estimate wolf pack size, or to follow the tracks to locate the wolf pack and count the number of wolves in it.

To estimate numbers on a larger scale, biologists sometimes use the number of ungulates (caribou, moose, bison, muskoxen) in an area to estimate how many the wolves those ungulates could support—though this is a relatively rough calculation (Kuzyk and Hatter 2014). Using this method and the estimated size of caribou populations, biologists estimated there would be 138 (range of 120 – 155) wolves on the Bluenose East herd winter range and 55 (range 43 – 66) wolves on the Bathurst herd winter range in 2020 (Nishi et al. 2020). Including an estimate for moose on each winter range increases the estimated number of wolves by 9 – 10 on each range (ENR 2020).

In March 2021, ENR conducted an aerial survey of the Bathurst caribou herd winter range to test the geospatial moose survey method for estimating wolf numbers. Because there was a large amount of overlap with other barren-ground caribou herds on the Bathurst herd range at that time, a relatively high density of wolves was expected to be seen within the survey area. However, the geospatial survey method resulted in an estimate of only 89 wolves (31 - 147, 95% confidence limits) or 2 wolves/1000 km^2 on the Bathurst winter range, with relatively low precision (Clark et al. 2021). This is compared to the 142 wolves (2.25 wolves/1000 km^2) estimated in the North Slave Wolf Harvest Incentive Area for 2021 using the biomass method (Clark et al. 2021). The North Slave Wolf Harvest Incentive Area included the wintering range of the Bathurst and Bluenose-East barren-ground caribou herds.

What do we know about the relationship between wolves and caribou?

Wolves and Northern Mountain Caribou[3]

In the Mackenzie Mountains, wolves and northern mountain caribou are part of a predator-prey system that also includes moose, Dall's sheep, mountain goats, grizzly bears, black bears, wolverines, and lynx. The relationships within this system are not well documented. Although wolves are the main predator of mountain caribou, wolves rely mostly on moose and only kill mountain caribou when they get the chance.

In winter, northern mountain caribou are usually found at low elevations in forested areas where there is plenty of lichen for food. They tend to be physically separated from moose which prefer areas with many willow and alder. This separation may help mountain caribou reduce the risk of wolf predation.

In April and May, mountain caribou begin to move to higher elevations and scatter into smaller groups to have their calves. At this time of year, wolves are concentrated at den sites at lower elevations to have their pups, so calving caribou are less likely to come into contact with wolves. This reduces the risk of predation when caribou calves are most vulnerable. After calving, the cows come together in larger groups in open areas where there is plenty of food, fewer biting insects and wolves can be spotted a long way off.

By following the trails made in the snow by moose and caribou, wolves are able to save energy, making it easier for them to chase and tire out their prey. In deep snow years, wolves can successfully hunt more moose, which can result in a significant decline in moose numbers. When moose become harder to find, wolves may shift their attention to caribou, resulting in a temporary decline in caribou numbers. As the number of moose and caribou decline, wolves also decline.

Wolf predation is a natural part of the northern mountain caribou ecosystem and is not currently considered a threat to mountain caribou in the Sahtú. Caribou, moose and wolf numbers may change from year to year, but overall, this relationship appears to be in balance.

Predation could become a concern if the ecosystem is disturbed in a way that significantly changes the relationship between predators and prey. Human disturbances like forest harvesting or other land clearing could attract and support more moose into an area, which could, in turn, attract more wolves. An increase in wolves could increase predation

[3] *Information summarized from Species at Risk Committee. 2020. Species Status Report for Northern Mountain Caribou (Woodland Caribou [Northern Mountain Population]) (Rangifer tarandus caribou) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.*

on mountain caribou. Similarly, an increase in disturbances like roads or seismic lines could make it easier for wolves to hunt mountain caribou, increasing predation pressure.

Climate change may also affect the relationship between wolves and northern mountain caribou. As temperatures increase, the type of plants preferred by moose may increasingly be found in mountain caribou habitat. Increased shrub growth has already been seen in alpine and arctic tundra ecosystems. Increased shrub growth could replace lichens and allow moose populations to increase, resulting in an increase in wolf populations.

Wolves are not the only predators on caribou. Bears also prey on caribou, although they tend to focus more on caribou calves than adult caribou, and their influence may be restricted to a shorter period of the year. Grizzly bears have also been seen to kill a significant number of caribou in the summer and fall, when they kill mature animals as well as calves.

Wolves and Boreal Caribou[4]

The relationships between wolves and boreal caribou are similar to the relationships between wolves and mountain caribou. Boreal caribou and wolves in the Sahtú are part of a complex predator-prey system that also includes moose, muskoxen, barren-ground caribou, and grizzly bears, black bears, lynx and other prey species. Boreal wolves prey mostly on moose but are also an important predator on boreal caribou when there is an opportunity.

Changes in population numbers of other prey species, like moose, can impact the interactions between boreal caribou and their predators. Throughout much of boreal caribou habitat in the rest of Canada, researchers have seen that when the numbers of other prey species like moose are low, the number of wolves is also low and the predation rate of wolves on boreal caribou is low. When the numbers or concentrations of other prey species increase, the number of wolves increases and as a result, wolf predation on caribou increases.

The main reason for increased moose numbers in most areas is habitat disturbance. Moose are attracted to new growth in areas that have been recently disturbed by fire or human activity. As more moose move into an area, they attract more wolves. More wolves in the area means more opportunity for wolves to prey on boreal caribou. This phenomenon is called “apparent competition” and is thought to be the reason for most boreal caribou declines in Canada.

A 2016 study (Serrouya et al. 2016) that included study areas in the southern NWT, examined the relationship between human caused habitat disturbance, wolf numbers and

[4] *Except where otherwise cited, information is summarized from Species at Risk Committee. 2012. Species Status Report for Boreal Caribou (Rangifer tarandus caribou) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.*

changes in the number of boreal caribou in the area. The study found that the bigger the human disturbance in an area the more wolves there were, and the more wolves there were, the lower the rate of caribou population growth (Serrouya et al. 2016).

A more recent study looked at this idea in more detail. The relationship between the change in vegetation caused by forest harvesting, the number of moose, the number of wolves and changes in boreal caribou numbers were looked at in 14 areas with boreal caribou in the southern NWT and northern BC, Alberta and Saskatchewan (Serrouya et al. 2021). Researchers found strong support for apparent competition as the best explanation for decreased boreal caribou numbers in areas disturbed by forestry.

Human caused land disturbance in the Sahtú is much lower than in some of the southern areas where these studies took place, and there is no evidence that moose populations have increased to a point where they may affect predator levels. Both wolf and moose numbers are relatively low throughout the Sahtú. Both moose and wolf populations would have to increase substantially to affect the level of predation on boreal caribou (ENR in prep).

Participants in a Sahtú Indigenous knowledge study published in 2010 (McDonald 2010) said they had seen an increase in wolf numbers in recent years, as well as increases in prey species like moose, muskoxen and beavers. They said increases in prey species like muskoxen and moose can result in fewer boreal caribou being taken by predators, and that this is having an effect on the boreal caribou populations. If there is a decrease in the number of other prey, predators will hunt boreal caribou. These observations suggest the relationship between wolves and boreal caribou in the Sahtú may differ from areas where there is greater habitat disturbance.

Linear disturbances can also affect predation more directly. Roads and seismic lines become travel routes, making it easier for wolves to hunt. When snow is deep, boreal caribou will travel along packed routes and snow machine trails and wolves will follow. In summer, wolves can also travel twice as fast on conventional seismic lines than in forests making them more efficient hunters. Caribou come into contact with wolves more often as they get closer to roads so increased highway access and oil and gas development in the Sahtú could increase predation.

In addition to wolves, black bears and grizzly bears also prey on boreal caribou. The Dehcho region has been monitoring boreal caribou using collars since 2004 and of the 97 mortality events investigated, 2 were attributed to bears, 70 to wolves, and 25 to either natural causes, harvest, or unknown causes. Bears represented approximately 2% of the adult mortality cases compared to 72% attributed to wolves (ENR unpublished data).

However, research in Alaska showed that the majority of bear predation occurred on calves during the calving season with the most predation happening within the first 45 days of birth (Brockman et al. 2017), and research in Quebec (Bastille-Rousseau et al. 2011), Newfoundland (Bastille-Rousseau et al. 2016), and Alaska (Brockman et al. 2017) have estimated bears can represent between 20-60% of calf mortality cases examined. There is currently no data within the NWT on caribou calf predation by bears. The work

currently underway with Laval University's Sentinel North program in the North Slave region may help shed some light on this interaction.

Wolves and Barren-ground caribou[5]

The boreal wolves that live in the forests of the Sahtú can prey on barren-ground caribou as they pass through the forests during their annual migration. However, barren-ground caribou likely provide only a small part of their diet.

Migratory wolves are different. There is a close relationship between migratory wolves and barren-ground caribou. Wolves are the main predator on barren-ground caribou, and barren-ground caribou are the main source of food for migratory wolves. However, the impact of wolves on barren-ground caribou herds is not well understood.

From late summer, through the fall and winter, migratory wolves follow the barren-ground caribou herd migrations. In spring, the wolves move north with the migrating caribou herds, but stop when they reach their denning areas, usually in esker rich areas south of the caribou calving grounds. The caribou continue traveling north to their calving grounds. Wolves stay in their denning area from late April through early summer to birth and raise their pups. By late August, once young wolves are large and strong enough to travel with the pack, wolves start travelling longer distances to hunt. By late October the wolf pack joins up with the caribou herd again and stays with the herd throughout the winter.

Recent analysis of wolf collar data on the Bathurst and Bluenose-East caribou herd ranges showed complex seasonal relationships among multiple caribou herds and wolves (Caslys Consulting Ltd. 2021). Data collected from wolf collars in 2020 and 2021 showed that while some wolves do appear to be associated with one caribou herd, following them during their annual north-south migrations, other wolves travelled in an east-west direction and interacted with more than one herd. Collecting and analysing more years of collar data may improve the understanding of the relationships between migratory wolves and caribou herds.

Wolves can successfully hunt barren-ground caribou of all sexes and ages year-round. A pack of wolves will chase a large herd of caribou and look for any animal caught off guard, that stumbles, or appears weak. Wolves will generally take calves, or caribou that are old or in poor health (Husseman et al. 2003). However, community members note that wolves are also capable of killing healthy caribou and that the idea that wolves only prey on the weak and injured is false.

---

[5] *Except where otherwise cited, information is summarized from Species at Risk Committee. 2017. Species Status Report for Porcupine Caribou and Barren-ground Caribou (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds) (Rangifer tarandus groenlandicus) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.*

There is little recent information on predation rates on barren-ground caribou in the NWT. However, predation rates are highly dependent on the density of prey and on the number of prey available per predator (Holling 1959, Akcakaya 1992). During the late 1980s, radio-collared wolves were tracked on 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 just under a caribou every 10 days per wolf and, on average, a single wolf can eat 23 – 29 caribou a year (Hayes and Russell 2000, GNWT and Tlicho Government 2020). Of the harvested wolves in winter 2021 with contents in their stomachs, 86.8% was caribou (Clark et al 2021).

Barren-ground caribou have developed strategies for dealing with wolf predation. During winter, caribou avoid wolves by spending time on frozen lakes where they are able to spot and smell wolves from a greater distance and move to avoid them. Indigenous and community knowledge holders note that barren-ground caribou can help protect themselves from wolves by kicking them. At certain times of the year, barren-ground caribou males protect females and calves by travelling on either side of the herd.

When caribou come together in large groups, especially on the calving grounds, newborn calves are particularly vulnerable. Caribou reduce the risk of wolf predation at this critical time by travelling to calving grounds that are further north than the eskers where wolves den. The calving grounds are usually large flat areas where wolves can be seen and smelled for long distances. Calving in a large group also provides some protection against wolves and other predators.

The impact of wolf predation probably differs among herds, but wolf numbers and barren-ground caribou numbers are closely linked. Generally, when wolf numbers are high, barren-ground caribou populations decrease. When barren-ground caribou numbers are low, wolf populations usually decrease.

Wolf den surveys on the Bathurst herd showed a significant decline in both wolf pup survival and the number of dens being used between 1996 and 2010. This decline is believed to be directly linked to the decline in Bathurst caribou numbers. A study that looked at the response of wolves to the declining Bathurst caribou herd found that wolves did not change their denning behaviour as the size of the Bathurst caribou summer range decreased and moved northeastward and the distance between their den sites and the caribou herd became greater. Reduced access to prey during denning may have had a negative impact on pup survival and wolf population growth (Klaczek et al. 2015).

Barren-ground caribou go through natural population cycles that last for 30 to 60 years. These cycles can be hard to predict and don't always follow the same pattern. The causes of these fluctuations are not known but they are likely driven by a combination of climate, food availability, predation, and parasites.

When caribou numbers are low or declining, wolf predation probably has a greater negative impact on the herd than it would have when caribou numbers are higher. This has been a concern for the Bathurst and Bluenose-East caribou herds where numbers

have declined to the lowest levels on record. Even though research has shown that the number and productivity of wolves on the range of the Bathurst herd has declined since 2000, the remaining wolves may still be having a significant impact on both the Bathurst and Bluenose-East herds, preventing the herds from increasing in number. Community members have expressed concerns that wolves continue to put pressure on barren-ground caribou populations and are causing the herds to continue to decline.

Barren-ground caribou are also preyed on by grizzly bears, particularly during calving when calves are the most vulnerable. Wolverine, lynx, and eagles may also hunt barren-ground caribou.

What should people's role be in maintaining healthy relationships between caribou and wolves?

Monitoring

Harvesters are the eyes and ears on the land. By reporting their sighting and harvests, and commenting on any changes they see in wolves, harvesters and others on the land provide important information to wildlife managers such as the RRCs, SRRB and ENR for consideration. Monitoring wolf numbers can help managers track changes in their relative numbers and help with decisions about whether harvest levels should be increased or decreased. Wolf observations are also provided to ENR from wildlife surveys associated with environmental assessments and land use permit applications, and documents casual observations.

All observations that have a location associated with them are stored in the Wildlife Management Information System (WMIS) and all these sources are used to determine where wolves are found in the NWT. Hunters and others on the land can contribute their sightings and observations to these records.

Harvesting

One of the main tools available to manage the relationship between caribou and wolves is harvesting. Changes to hunting regulations can be made as a result of recommendations by the SRRB, which has been the typical approach so far, or by the Minister proposing changes to hunting regulations and seeking the timely advice of SRRB on those proposed changes , after considering changes in wolf and caribou numbers and other indicators of the health of each species.

Sahtú participants can hunt and trap wolves throughout the Sahtú all year round, with no limit on the number of wolves they can harvest. General Hunting Licence holders can also hunt and trap an unlimited number of wolves between August 15th and May 31st in the Sahtú.

Resident hunting licence holders can hunt but not trap wolves between August 15th and May 31st in the Sahtú. A tag is needed for each wolf harvested, but there is no limit on the number of tags available to each hunter.

Non-resident and Non-resident Alien hunters can hunt up to 2 wolves each season in the outfitter zones between July 25th and April 15th, and one wolf in S/WF/01 between August 1st and April 15th. A tag is needed for each wolf harvested and the hunter must use the services of an NWT outfitter and guide.

Indigenous and community knowledge holders have suggested that hunters and trappers should be encouraged to harvest more wolves to reduce the impact of predation on barren-ground caribou (ACCWM 2014). During community engagement sessions in 2007-2013 held by the ACCWM to develop a management plan for the Cape Bathurst, Bluenose-East and Bluenose-West caribou herds (ACCWM 2014), Sahtú community members said wolf numbers had increased and packs were large. They said wolf predation was the biggest issue for caribou and there may be a need to consider predator bounties and incentives.

In June 2009, when the Bathurst caribou calving ground survey showed a significant decline in the population of the herd, the GNWT offer an incentive of $100 per skinned wolf carcass to encourage wolf harvesting and decrease the number of wolves in the territory. When the 2012 and 2015 Bathurst herd calving ground surveys showed a continuing decline in the size of the herd, the wolf incentive harvest was increased to $200 for a skinned wolf, plus an additional $400 for a pelt prepared to traditional standards and an additional $350 for pelts meeting the requirement for a prime fur bonus as part of the Genuine Mackenzie Valley Fur Program. This incentive is available throughout the NWT.

In 2019-20, payment for wolves harvested in the North Slave Wolf Harvest Incentive Area increased to $1,200 for each wolf for both Indigenous and resident hunters plus additional payment (dependent on eligibility) for skinning to traditional standards and prime fur bonus. These incentives were increased in an effort to increase harvest of wolves and reduce predation on the Bathurst and Bluenose-East caribou herd winter ranges in the North Slave region, given the significant ongoing declines in these two herds.

Wolf Management Actions

In some situations, where caribou numbers have declined to very low levels and wolf predation is considered to be a contributing factor, additional actions to reduce wolves may be needed. The Bathurst and Bluenose-East herds have declined significantly in recent years and are now at their lowest recorded numbers since surveys began in the 1980s. Harvest restrictions, wolf harvesting incentives and efforts to manage development and protect important caribou habitat were put in place but the herds continued to decline. In 2019, the Wek'èezhìi Renewable Resources Board (WRRB) indicated the 20% rate of annual decline for the Bathurst and Bluenose-East herds was so serious that waiting any longer to implement wolf management would make recovery of the herds even more difficult (GNWT and Tlicho Government 2020).

In response to these concerns, ENR and the Tłı̨chǫ Government worked together to develop a proposal for a coordinated approach to wolf management actions to reduce wolf predation on the two caribou herds (GNWT and Tlicho Government 2020). A thorough review of predator management approaches undertaken in other jurisdictions was done (Russell 2010, McLaren 2016). Experience from other places where wolf management actions have taken place suggests wolf numbers need to be reduced by 60 – 80% and must be kept low for at least five years to see any improvement in caribou survival and an increase in herd numbers (Wolf Feasibility Assessment Technical Working Group 2017). . This is because wolves have a high reproductive potential (large litters and a potential for more than one litter per pack), the ability to disperse huge distances, and high rates of predation on targeted prey species. These characteristics allow wolf populations to quickly rebound once management actions are no longer applied.

The technical feasibility of different wolf management options was also looked at by a working group with membership from the GNWT, WRRB and Indigenous Governments. The proposal developed by ENR and the Tłı̨chǫ Government was based on this work and approved by the WRRB as a pilot project for 2020.

The pilot project took three main approaches (Nishi et al. 2020):

1. Enhanced support for wolf harvesters and the traditional economy
2. Aerial wolf reductions
3. Monitoring, research and assessment

The 2020 pilot project was successful in meeting the removal targets for the Bathurst caribou herd winter range and removing 45% of the estimated number of wolves on the Bluenose-East caribou herd winter range. Nunavut harvesters with harvesting rights in the NWT harvest a majority of the wolves removed from the ground, harvesting 57 wolves. In areas where wolves and caribou could be reached by snowmachine, experienced hunters with expert knowledge of the landscape and caribou-wolf movements were successful in harvesting wolves. Where harvesters were using winter roads to hunt wolves, success depended on how many caribou and wolves were located near the road. Travelling conditions also influenced success. At the end of the season, aerial removals were used to supplement the ground harvest in order to reach removal targets.

A public review of the pilot program was held by the WRRB in fall 2020. Building on the lessons learned during the pilot project, ENR and the Tłı̨chǫ Government received approval from the WRRB with 20 recommendations for a four-year program of wolf management actions on the winter ranges of the Bathurst and Bluenose-East caribou herds (WRRB 2021).The WRRB directed the two governments to focus on continued support of ground harvest (not aerial removals) for a total of five years to reduce predation rates and support an increase in caribou survival rates.

In 2020/2021, two hunting camps specifically for harvesting wolves were set up in the Enhanced Wolf Harvest Incentive Area, one with Tłı̨chǫ hunters and one with Inuit harvesters from Kugluktuk. A total of 135 wolves were harvested from the ground, with

both Tłı̨chǫ and Inuit harvesters being much more successful than the previous year. Success may have been influenced by the fact that the Bathurst, Bluenose-East and Beverly herds had more overlap in their winter ranges in 2021 than 2020, bringing more wolves into the area.

A wolf collaring program was also undertaken to monitor how wolves travel among caribou on their winter ranges, determine whether wolves return to the same den sites and travel with the same caribou herd year after year, and help focus wolf removal efforts. The analysis also showed that wolves and caribou are highly overlapped during winter and summer but during the calving period and when wolves are denning they are separated.

In a recent paper by Clark and Hebblewhite (2021), the authors looked at 62 reports on predator removal to see how successful removing predators has been on improving the survival and growth of ungulate prey populations like elk, deer and boreal caribou. They found that removing predators through management actions caused an overall increase of about 8% in the prey populations, although results varied between different populations and locations. They found that the positive effect of predator removal was slightly higher for declining populations of endangered species where wolf predation is likely having a greater negative impact than it would on a species with a stable population. The authors suggest that high removal rates are needed to effectively reduce numbers of predators and that removal of predators, in addition to other treatments, could lead to increases in population growth for endangered species.

The conclusions of Clark et al (2021), suggest the North Slave Region Wolf Management Program may lead to positive effects on Bathurst and Bluenose-East caribou. The North Slave program has been carefully designed to address concerns raised in Clark and Hebblewhite (2021) and incorporates extensive data collection, analysis and review on an annual basis to detect and evaluate program outcomes and adaptively manage over the life of the program.

The wolf management actions undertaken in the North Slave region by the GNWT and the Tłı̨chǫ Government were in response to community concerns about the number of wolves on the landscape and their impact on barren-ground caribou, given the extremely low numbers of caribou in the Bathurst and Bluenose-east herds, and recommendations from the WRRB to include wolf management as part of the overall approach to recovery of these caribou herds. ENR currently has no plans to implement enhanced wolf management actions in the Sahtú region but should there be further significant declines in caribou numbers ENR may discuss options for additional actions with the SRRB and Sahtú communities.

Protecting Caribou Habitat

Currently the populations of boreal caribou in the NWT is considered self-sustaining overall, but declines have been observed in southern parts of the NWT range (Conference of Management Authorities 2017). In the Sahtu Settlement Area, the boreal caribou population was reported to be stable to increasing in 2010 (McDonald 2010). Recovery strategies have been developed under federal and territorial Species at Risk Acts (Environment Canada 2012, Conference of Management Authorities 2017). The National Recovery Strategy sets a target of maintaining at least 65% of the NT1 (Northwest Territories) range in an undisturbed condition. The NWT Recovery Strategy calls for the development of regional range plans focused on managing human disturbance with the goal to "ensure a healthy and sustainable boreal caribou population across their NWT range that offers harvesting opportunities for present and future generations".

Habitat disturbance is thought to be the main factor leading to boreal caribou declines across much of Canada (GNWT 2019). Cleared areas, especially roads and seismic lines, make it easier for wolves and bears to travel through the forest and locate prey. Disturbances like wildfire and timber harvesting result in younger forests that are attractive to other prey like moose and deer. If there is enough young forest to increase the number of other prey species, wolf numbers may also increase, leading to more predation on boreal caribou. The best way to support maintaining healthy relationships between moose, wolves and caribou is to manage landscape changes in a way that ensures there is always enough undisturbed habitat available to boreal caribou.

This is the goal of the Sahtú Todzi Nene Plan (Boreal caribou range plan). The Sahtú Todzi Nene Plan will be a long-term, living document to help communities, decision-makers and land resource users manage activities on the land in a way that supports healthy Todzi (boreal caribou) populations using a combination of Indigenous knowledge and western science. The plan will also consider socio-economic factors, natural and human disturbance, and climate change.

The Sahtú Todzi Nene Plan is one of five separate range plans that are being created for the NWT. Plans are also being produced for the Gwich'in, Inuvialuit, Wek'èezhìı, and southern NWT areas. Collectively, these plans are designed to meet requirements under the NWT Recovery Strategy for Boreal Caribou to ensure adequate habitat across the NWT to maintain a healthy and sustainable population of boreal caribou.

The Todzi Nene plan will be co-created by all five Sahtú communities, in collaboration with regional Sahtú organizations, the GNWT and relevant federal government departments. ENR will work with the SRRB and the Sahtú Secretariat Incorporated (SSI) to co-facilitate the range planning process in the Sahtú. Communities will be involved with all major discussions and decision making for the plan. ENR will support capacity-building to help

bring important voices to the table, including leadership, elders, knowledge holders, technical advisors, youth, women and other interested parties from the wider community.

The plan will identify areas that are important to boreal caribou and provide the information needed to help manage activities on the land so that at least 70% of boreal caribou habitat in the Sahtú remains undisturbed by fire and human activity over time.

The GNWT is encouraging a partnership approach to develop the plan and invites Sahtú communities to incorporate valuable Indigenous and local knowledge to support range planning for Todzi. The GNWT wants to hear from Sahtú communities about how they would like to see their knowledge incorporated into the plan.

References

Advisory Committee for Cooperation on Wildlife Management. 2014. We Have Been Living with the Caribou All Our Lives: A Report on Information Recorded during Community Meetings for *"Taking Care of Caribou: The Cape Bathurst, Bluenose-West, and Bluenose-East Barren-ground Caribou Herds Management Plan."* Yellowknife, NT.

Afema, J. A., K. B. Beckmen, S. M. Arthur, K. B. Huntington, and J. A. K. Mazet. 2017. Disease complexity in a declining alaskan muskox (*Ovibos moschatus*) population. Journal of Wildlife Diseases 53:311–329.

Akcakaya, H. 1992. Population cycles of mammals: evidence for a ratio-dependent predation hypothesis. Ecological Monographs 62:119–142.

Barr, W. 1991. Back From the Brink. Arctic Institute of North America.

Benson, K. 2015. Gwich'in Knowledge of Bluenose West Caribou. Fort McPherson, NT.

Bergerud, A. T., and J. P. Elliot. 1986. Dynamics of caribou and wolves in northern British Columbia. Canadian Journal of Zoology 64:1515–1529.

Brakett, D., W. Spencer, G. Baird, J. A. Snowshoe, E. Krutko, L. Males, and P. Latour. 1985. Moose surveys in Mackenzie River Delta, valley and tributaries, 1980. File Report No. 48. Yellowknife, NT.

Buckland, S. T., E. A. Rexstad, T. A. Marques, and C. S. Oedekoven. 2015. Distance sampling: Methods and applications. S. T. Buckland, E. A. Rexstad, T. A. Marques, and C. S. Oedekoven, editors. Springer, Cham, Switzerland.

Carter, L. 2020. Muskox (*Ovibos moschatus*) Habitat Associations and Interactions with Caribou (*Rangifer tarandus*). McGill University.

Caslys Consulting Ltd. 2021. GNWT Wolf Movement Analysis Phase 2. **Draft**. Summary Report.

Clark, K., J. Nishi, H. D. Cluff, S. Shinga, S. Behrens, N. Jutha, R. Abernethy, and R. Mulders. 2021. **Draft** Technical Report Wolf (Dìga) Management Program January – May 2021. Manuscript Report No. XX. Yellowknife, NT.

Clark, T. J., and M. Hebblewhite. 2021. Predator control may not increase ungulate populations in the future: A formal meta-analysis. Journal of Applied Ecology 58:812–824.

Clarkson, P. L., and I. Liepins. 1992. Inuvialuit wildlife studies: western arctic wolf research project progress report April 1989 - January 1991. Manuscript Report No. 54. Yellowknife, NT.

Davison, T., and K. Callaghan. 2013. Moose (*Alces alces*) population size and density in the Inuvik Region of the Northwest Territories, Canada. Rangifer 33:123.

Davison, T., and K. Callaghan. 2018. Survey of Dall's Sheep in the Northern Richardson

Mountains: June, 2014. Yellowknife, NT.

Davison, T., and K. Callaghan. 2019. Moose (Alces alces) population size and density in the Inuvik Region of the Northwest Territories, Canada, March 2017. Manuscript Report No. 280. Yellowknife, NT.

Davison, T., K. Russell, and E. Belanger. 2018. Survey of Dall's Sheep in the Northern Richardson Mountains: June, 2017. Yellowknife, NT.

Environment and Natural Resources. 2020*a*. Wildlife Diseases. <https://www.enr.gov.nt.ca/en/services/wildlife-diseases>.

Environment and Natural Resources. 2020*b*. Incorporating precision of empirical data on ungulate biomass to estimate wolves on winter ranges of Bathurst (BAH), Bluenose-East (BNE), and Beverly (BEV) caribou herds.

Environment and Natural Resources. 2021. **Draft** Status Report for Moose (*Alces alces*) in the Northwest Territories. Yellowknife, NT.

Flook, D. R., and J. E. Bryant. 1957. Aerial survey of moose, Mackenzie District, NWT, March 1956 with comparisons to surveys in January and December 1953, March 1954, and February 1955.

Fortin, D., F. Barnier, P. Drapeau, T. Duchesne, C. Dussault, S. Heppell, M. C. Prima, M. H. St-Laurent, and G. Szor. 2017. Forest productivity mitigates human disturbance effects on late-seral prey exposed to apparent competitors and predators. Scientific Reports 7:1–12. Springer US.

Garde, E., S. Kutz, H. Schwantje, A. Veitch, E. Jenkins, and B. Elkin. 2009. Examining the risk of disease transmission between wild Dall's sheep and mountain goats, and introduced domestic sheep, goats, and llamas in the Northwest Territories. Yellowknife, NT.

Gasway, W. C., S. D. Dubois, and S. J. Harbo. 1981. Estimating moose abundance and composition. Fairbanks, Alaska, USA.

Geddes, F. E., and J. A. Duncan. 1982. Late winter moose surveys along the Mackenzie River and Norman Wells pipeline route.

Government of the Northwest Territories. 2019. A Framework for Boreal Caribou Range Planning. Yellowknife, NT.

Government of the Northwest Territories, and Tłı̨chǫ Government. 2020. PR (Wolf 2020): 017 - GNWT & TG's Revised Joint Proposal on Management Actions for Wolves (dìga) on the Bathurst and Bluenose-East Barren-ground Caribou (ɔekwǫ̀) Herd Winter Ranges: 2021 – 2024.

Gunn, A., B. Fournier, J. Williams, and J. Adamczewski. 2021. **Draft** Technical Status Report for Muskoxen (Ovibos moschatus) in the Northwest Territories.

Hayes, R. D., and D. E. Russell. 2000. Predation rate by wolves on the Porcupine caribou herd. Rangifer Special Is:51–58.

Hoberg, E. P., S. J. Kutz, J. Nagy, E. Jenkins, B. Elkin, M. Branigan, and D. Cooley. 2002.

Protostrongylus stilesi (Nematoda: Protostrongylidae): Ecological isolation and putative host-switching between Dall's sheep and muskoxen in a contact zone. Comparative Parasitology 69:1–9.

Hodson, J., D. Simmons, J. Hanlon, H. Sayine-Crawford, S. Behrens, and J. Tigner. 2017. Multi-species monitoring using winter track surveys in the Sahtú Settlement Region - CIMP162. Final Report.

Holling, C. S. 1959. Some characteristics of simple types of predation and parasitism. The Canadian Entomologist 91:385–398.

Jorgensen, A. 2021. Wildlife Forage Recovery Following Boreal Wildfire. Wilfrid Laurier University.

Kafle, P., P. Peller, A. Massolo, E. Hoberg, L. M. Leclerc, M. Tomaselli, and S. Kutz. 2020. Range expansion of muskox lungworms track rapid arctic warming: implications for geographic colonization under climate forcing. Scientific Reports 10:1–14. Nature Publishing Group UK.

Kellie, K. A., and R. A. DeLong. 2006. GeoSpatial Survey Operations Manual. Fairbanks, Alaska, USA.

Klaczek, M. R., C. J. Johnson, and H. D. Cluff. 2015. Den site selection of wolves (*Canis lupus*) in response to declining caribou (*Rangifer tarandus groenlandicus*) density in the central Canadian Arctic. Polar Biology 38:2007–2019. Springer Berlin Heidelberg.

Klaczek, M. R., C. J. Johnson, and H. D. Cluff. 2016. Wolf–caribou dynamics within the central Canadian Arctic. Journal of Wildlife Management 80:837–849.

Kutz, S., T. Bollinger, M. Branigan, S. Checkley, T. Davison, M. Dumond, B. Elkin, T. Forde, W. Hutchins, A. Niptanatiak, and K. Orsel. 2015. Cross-Canada Disease Report: *Erysipelothrix rhusiopathiae* associated with recent widespread muskox mortalities in the Canadian Arctic. Canadian Veterinary Journal 56:560–563.

Kuzyk, G. W., and I. W. Hatter. 2014. Using ungulate biomass to estimate abundance of wolves in British Columbia. Wildlife Society Bulletin 38:878–883.

Lambert Koizumi, C., J. Carey, M. Branigan, K. Callaghan, Y. Fish, and W. Branch. 2011. Status of Dall's Sheep (*Ovis dalli dalli*) in the Northern Richardson Mountains. Whitehorse, Yukon.

Land Needs Guardians. 2020. Indigenous Guardians partner on climate and wildlife research in the NWT. <https://landneedsguardians.ca/latest/guardians-partner-on-climate-and-wildlife-research>.

Larter, N. C., D. G. Allaire, and R. Mulders. 2018. Mackenzie Mountain Alien Hunter Harvest Summary 2017.

Larter, N. C., and J. A. Nagy. 1997. Peary caribou, muskoxen and Banks Island forage: Assessing seasonal diet similarities. Rangifer 17:9.

Larter, N. C., and J. A. Nagy. 2004. Seasonal changes in the composition of the diets of Peary caribou and muskoxen on Banks Island. Polar Research 23:131–140.

Mavrot, F., K. Orsel, W. Hutchins, L. G. Adams, K. Beckmen, J. E. Blake, S. L. Checkley, T. Davison, J. Di Francesco, B. Elkin, L. M. Leclerc, A. Schneider, M. Tomaselli, and S. J. Kutz. 2020. Novel insights into serodiagnosis and epidemiology of *Erysipelothrix rhusiopathiae*, a newly recognized pathogen in muskoxen (*Ovibos moschatus*). PLoS ONE 15:1–14.

McDonald, R. 2010. Boreal caribou traditional knowledge collection study: Sahtú Settlement Area. A. Hrynkiw and G. Guthrie, editors. Tulita, NT.

McLaren, A. 2016. Wolf management programs in Northwest Territories, Alaska, Yukon, British Columbia, and Alberta: a review of options for manaement on the Bathurst caribou herd range in the Northwest Territories. Report File No. 149. Yellowknife, NT.

McLoughlin, P. D., C. Superbie, K. Stewart, P. Tomchuk, B. Neufeld, D. Barks, T. Perry, R. Greuel, C. Regan, A. Truchon-Savard, S. Hart, J. Henkelman, and J. F. Johnstone. 2019. Population and habitat ecology of boreal caribou and their predators in the Saskatchewan Boreal Shield. Final Report. Saskatoon, SK.

Mosbacher, J. B., D. K. Kristensen, A. Michelsen, M. Stelvig, and N. M. Schmidt. 2016. Quantifying Muskox Plant Biomass Removal and Spatial Relocation of Nitrogen in a High Arctic Tundra Ecosystem. Arctic, Antarctic, and Alpine Research 48:229–240.

Munizzi, J. 2017. Rethinking Holocene Ecological Relationships Among Caribou, Muskoxen, and Human Hunters on Banks Island, NWT, Canada: A Stable Isotopic Approach. Electronic Thesis and Dissertation Repository. University of Western Ontario.

Musiani, M., J. A. Leonard, H. D. Cluff, C. C. Gates, S. Mariani, P. C. Paquet, C. Vilà, and R. K. Wayne. 2007. Differentiation of tundra/taiga and boreal coniferous forest wolves: Genetics, coat colour and association with migratory caribou. Molecular Ecology 16:4149–4170.

Nishi, J., R. Mulders, K. Clark, S. Behrens, R. Abernethy, S. Shinga, and H. D. Cluff. 2020. **Draft** Wolf (Diga) Management Pilot Program Technical Report. Manuscript Report No. XX. Yellowknife, NT.

Raillard, M. 1992. Influence of muskox grazing on plant communities of Sverdrup Pass (79° N), Ellesmere Island, N.W.T., Canada. University of Toronto.

Rentmeister, C., and K. Chan. In prep. Aerial surveys for muskoxen in the Sahtú Settlement Area, March 2020 and 2021.

Russell, D. 2010. A review of wolf management programs in Alaska, Yukon, British Columbia, Alberta and Northwest Territories. Prepared for Yukon Wolf Conservation and Management Plan Review Committee.

Serrouya, R., M. Dickie, C. Lamb, H. Van Oort, A. P. Kelly, C. Demars, P. D. McLoughlin, N. C. Larter, D. Hervieux, A. T. Ford, and S. Boutin. 2021. Trophic consequences of terrestrial eutrophication for a threatened ungulate. Proceedings of the Royal Society B: Biological Sciences 288.

Serrouya, R., H. van Oort, C. Demars, and S. Boutin. 2016. Human footprint, habitat, wolves and boreal caribou population growth rates.

Serrouya, R., D. R. Seip, D. Hervieux, B. N. McLellan, R. S. McNay, R. Steenweg, D. C. Heard, M. Hebblewhite, M. Gillingham, and S. Boutin. 2019. Saving endangered species using adaptive management. Proceedings of the National Academy of Sciences of the United States of America 116:6181–6186.

Species at Risk Committee. 2012. Species status report: Boreal Caribou (*Rangifer tarandus caribou*) in the Northwest Territories. Yellowknife, NT.

Species at Risk Committee. 2017. Species Status Report for Porcupine Caribou and Barren-ground Caribou (Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq herds) (Rangifer tarandus groenlandicus) in the Northwest Territories. Yellowknife, NT.

Species at Risk Committee. 2020. Species status report for Northern Mountain Caribou (Woodland Caribou [Northern Mountain Population]) (Rangifer tarandus caribou) in the Northwest Territories. Yellowknife, NT.

Tomaselli, M., C. Dalton, P. J. Duignan, S. Kutz, F. van der Meer, P. Kafle, O. Surujballi, C. Turcotte, and S. Checkley. 2016. Contagious ecthyma, rangiferine brucellosis, and lungworm infection in a muskox (*Ovibos moschatus*) from the Canadian Arctic, 2014. Journal of Wildlife Diseases 52:719–724.

Tomaselli, M., S. C. Gerlach, S. J. Kutz, and S. L. Checkley. 2018*a*. Iqaluktutiaq voices: Local perspectives about the importance of muskoxen, contemporary and traditional use and practices. Arctic 71:1–14.

Tomaselli, M., S. Kutz, C. Gerlach, and S. Checkley. 2018*b*. Local knowledge to enhance wildlife population health surveillance: Conserving muskoxen and caribou in the Canadian Arctic. Biological Conservation 217:337–348. Elsevier.

Veitch, A. M. 1997. An aerial survey of muskoxen in the northern Sahtu Settlement Area, March 1997. Norman Wells, NWT.

Wek'èezhìı Renewable Resources Board. 2021. PR (Wolf 2020): 173 - WRRB's Reasons for Decisions Related to a Joint Proposal for Dìga (Wolf) Management in Wek'èezhìı.

Winbourne, J. 2021. Traditional and Community Knowledge Literature Review for the 2021 SRRB Public Listening : "Tı̨ch'ádíı hé Gots'edı – Living with Wildlife : Caribou Predators and Competitors ."

Winbourne, J., and K. Benson. 2021. Species Status Report (Traditional and Community Knowledge Component) for Muskoxen (*Ovibos moschatus*) in the Northwest Territories. Yellowknife, NWT.

Wolf Feasibility Assessment Technical Working Group. 2017. Wolf Technical Feasibility Assessment : Options for Managing Wolves on the Range of the Bathurst Barren-ground Caribou Herd. Yellowknife, NT.

Additional References

Conference of Management Authorities. 2017. Recovery Strategy for the Boreal Caribou (Rangifer tarandus caribou) in the Northwest Territories. Species at Risk (NWT) Act Management Plan and Recovery Strategy Series. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. 57 pp

Government of the Northwest Territories and Tłı̨chǫ Government. 2020. Government of the Northwest Territories and Tłı̨chǫ Government Joint Proposal on Management Actions for Wolves (Diga) on the Bathurst and Bluenose-East Barren-ground Caribou (Ekwo) Herd Winter Ranges: 2021 – 2024.

Government of the Northwest Territories and Tłı̨chǫ Government. 2021 (a). Joint Response to the WRRB Reasons for Decision Final Report – 2020 Diga Management Proceeding.

Government of the Northwest Territories and Tłı̨chǫ Government. 2021(b). Update on GNWT and Tłı̨chǫ Government Wolf (Diga) Management and Monitoring Actions, Winter 2020-2021

Macdonald, Colin. 2021. Tı̨ch'ádíı hé Gots'edı – Living with Wildlife: Caribou Predators and Competitors. Science Review of Predation and Competition in Caribou in the Sahtú. Prepared for the ʔehdzo Got'ı̨nę Gots'ę́ Nákedı (Sahtú Renewable Resources Board). Unpublished.

Nguyen, L.P. 2016. The Use of Local Ecological Knowledge for Analyzing Changes in Muskox. Arctic Borderlands Ecological Knowledge Society.

Smith, Angus. 2016. "A Summary of Moose Surveys in the Northwest Territories." Wildlife Division, Environment and Natural Resources, Government of the Northwest Territories.

Wildlife Management Advisory Council (North Slope). 2017. Framework for the Management of Yukon North Slope Muskox.

Winbourne, J. 2021. Traditional and Community Knowledge Literature Review for the 2021 SRRB Public Listening: Tı̨ch'ádíı hé Gots'edı - Living with Wildlife: Caribou Predators and Competitors. Prepared for the ʔehdzo Got'ı̨nę Gots'ę́ Nákedı (Sahtú Renewable Resources Board). Unpublished.