STATUS REPORT FOR MOOSE IN THE NORTHWEST TERRITORIES

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Description	
Moose are very large, hoofed mammals found throughout the circumpolar world. Adult male moose are about 2 m tall at the shoulder, 2.5 m long and weigh 540-630 kg. Females are somewhat smaller than males and weigh up to 400-450 kg. The bulk of a moose's weight is in their body, while their legs are comparatively long and thin. Only male moose have antlers, which start to grow when they are two years of age. Antlers are shed each winter and regrown in the spring. Every year the antlers re-grow longer and wider.	Moose are the largest members of the deer family, measuring 1.85-1.95 m at the shoulder and weighing 360-600 kg. Their long legs with relatively small hooves are adapted to walk on soft ground and in snow. Colour of their coat ranges from brown to black. Males have palmate antlers which may reach 165 cm in width, while females are antlerless. An iconic flap of skin called the bell or dewlap hangs under the chin.
Distribution	
Moose are found in all the forested regions of the Northwest Territories (NWT). Moose can generally be found anywhere on the mainland; however, they do show a preference for shallow water in lakes and ponds.	Moose are widely distributed throughout the northern hemisphere in or around boreal regions and are found in every Canadian province and territory except Prince Edward Island. In the NWT, moose are found from the Mackenzie Mountains in the west to the southern Arctic tundra in the east, and from the 60th parallel north to the Mackenzie Delta and Horton River Plains.
Biology and Behaviour	
Female (cow) moose reach maturity between the ages of two and three and will typically have one calf per year. Males (bulls) also generally start breeding at the age of two or three. Calves are typically born nine months after the rut, which occurs in the fall, and will often stay with their mothers on islands where they are more protected from predators and have access to good forage. Wolves are the primary predators of moose, although there are other species that may also prey on them. Moose appear to avoid caribou and bison and generally move away from areas where these animals may be found, even if those areas have good forage present.	Moose are well adapted to the conditions in the boreal forest, including a variety of forest successional stages and climatic conditions. They are ruminant browsers and are able to digest woody materials in their four-chamber stomach. Moose are primarily constrained by their relative inability to withstand heat and require adequate cover or shade. Heat stress is not limited to summer, moose will open mouth pant in winter. Deep snow (>75 cm) impedes their movement, increases respiration and limits access to food. Females are classified as adults when they are sexually mature, typically between 16-28 months of age. Males can reproduce as yearlings but are unlikely to do so and are

	considered subadults until four years of age when they become prime bulls. The average gestation period is 231 days with calves generally born between mid-May and early June. Female moose produce one or two calves each year. Twinning is common and thought to be correlated with habitat quality. Life expectancy of moose in the NWT is unknown but is expected to average seven to eight years. Wolves, grizzly bears and black bears are the major predators of moose in the NWT; however, predation rates are unknown. Moose are an important country food source and are harvested throughout their range; however, information on the amount of harvest is limited. Although susceptible to a number of diseases and parasites, studies indicate a generally low incidence and prevalence of diseases and parasites and that harvested animals generally are in good health and condition. Levels of naturally occurring elements and persistent organic pollutants in the kidneys are low with high cadmium levels in kidneys of moose from the Mackenzie Mountains as the only exception.
Population	
There is no information in the available traditional and community knowledge resources about specific numbers or density of moose in the NWT, although there is a discussion on whether there are more or less than in the past. There is disagreement in the resources and among elders about whether the number of moose is declining, increasing, or stable. Some knowledge holders indicated that moose populations are cyclical and in sync with other animal populations, such as the wolves that prey on moose.	Moose in the NWT are assumed to be of two subspecies, *Alces alces gigas*, restricted to the Mackenzie Mountains, and *A. a. andersoni*, found elsewhere. However, the genetic structure of moose in the NWT has not been studied. They are part of a contiguous distribution of moose across Canada with no apparent barriers to movement between jurisdictions. Aerial surveys to assess moose abundance were conducted as early as the 1950s. Although many surveys were conducted from 1980-2000, they covered different, restricted areas and few areas were surveyed more than once. Over the past two decades the amount of area surveyed and

	the frequency with which the same area is surveyed has increased. Reported local densities of moose from 1980-2000 were 1-17 moose/100 km^2 while reported densities over the past 20 years have been 0-10 moose/100 km^2. Although some of the difference in estimated moose density between these two time periods may be a result of changes in survey methodology, there is some evidence that moose abundance in parts of the South Slave and Beaufort Delta regions declined through the 1990s, but more recently has shown modest increases. Moose density in the Slave River Lowlands declined between 2011 and 2018. There is evidence of an increasing trend in moose density in some parts of the Beaufort Delta, North Slave and Dehcho regions. Trend data is lacking for the Sahtú. Densities reported from NWT tend to be lower than reported elsewhere but fall within the range expected in subarctic regions. Extrapolating from existing surveys to entire ecoregions results in an estimated 22,000-51,000 moose in the NWT.
Habitat	
The most essential aspect of moose habitat is the presence of good quality forage, including abundant grasses, sedges, and most importantly, willows. Moose especially prefer lowland or riverine areas. It is important to note that moose habitats are not static; they change over time due to environmental factors such as wildfire.	Moose use a wide variety of habitats and currently much of the NWT provides available habitat. Wildfire is the most significant disturbance in the boreal zone of the NWT, creating a mosaic of early successional stage habitats which has a positive influence on moose. Prime moose habitat is between 10-25 years post burn. Based on the NWT fire history, a marked increase in prime habitat for moose occurred in 2004 because of forest fires that had occurred between 1979-1994. The approximately 105,000 km^2 of prime habitat will soon begin to diminish as areas burned in the mid- to late-1990s mature. However, prime habitat should begin to increase again by the mid-2020s as the burns from the 2014 fire season advance in their

	successional state to create new high-quality moose habitat. Moose appear to be increasing on the Southern Arctic Tundra, possibly due to recent increases in shrub growth in that ecoregion. Anthropogenic disturbances like communities, roads, cut lines, power lines, pipelines, and resource developments physically fragment habitat and increase access for moose hunters. In the Mackenzie Mountains, moose habitat is more physically constrained to areas that overlap with proposed mine construction and access roads. Habitat in the South Slave and Dehcho could be significantly altered by proposed forestry projects. Although there was a concern that wood bison and moose compete for habitat, studies in the NWT and elsewhere have not found evidence suggesting competition.
Threats and Limiting Factors	
There are several threats to moose in the NWT, including predation and human activities (roads and other linear developments, and oil and gas development). The introduction (or re-introduction) of animals such as bison within moose habitat may be a potential threat, but comments on this topic were very limited. Community members are concerned that as lifestyles change and fewer people spend time on the land, wolf populations may get out of control, causing a decline in the moose population. New infrastructure projects, such as the Tłįchǫ Highway, are seen as potential sources of disturbance to moose populations. The construction of the road, with the resulting noise and dust, may result in moose leaving the area. In addition to the deterrent effect the noise and dust may have, linear development corridors may attract bison (who use the areas as movement corridors), which moose avoid.	Harvest occurs throughout moose range but hunting effort is concentrated near communities and in areas with easy hunter access like roads and river systems. Total annual harvest is unknown but has been estimated at 1000-2000 animals of which an estimated 80-90% is subsistence harvest. Wolves, grizzly bears and black bears prey on moose, however the impact of predation on moose in the NWT is unknown. Moose are an important prey species for maintaining wolf populations, but wolf densities are low in the South Slave and Dehcho regions compared to areas to the south in northeastern British Columbia (BC). Grizzly and black bear predation on calf moose can be substantial and impact recruitment. Increasing grizzly bear abundance in the Mackenzie Mountains could increase predation rates. There is no information on black bears. Diseases and parasites reported in moose are common and of low prevalence; however, a warming climate could support

In the Dehcho, it was noted that there are more hunters harvesting along the highways than in the past. According to community members, oil and gas developments have both positive and negative effects on moose and their habitat. Moose move closer to some developments because the noise will scare away predators. Exploratory seismic lines will have plant regrowth, which creates new habitat for moose. On the other hand, as for road construction, noise from development activity may act as a deterrent to moose, and improved access by roads may increase hunting pressure.	longer periods when parasites are active and increase the potential for new diseases and parasites to establish in the NWT. Winter ticks and tapeworms may impact individual animals, but the likelihood of epizootic episodes constituting a major threat to moose populations is negligible. Levels of naturally occurring elements, radionuclides and persistent organic pollutants in NWT moose were low and no threat to the health of moose or to those consuming meat, except for cadmium. High cadmium levels in the kidneys of moose from the Mackenzie Mountains could potentially impact kidney function though no histological evidence of impacts have been detected. The potential expansion of white-tailed deer into NWT moose range, in addition to providing an increased density of prey for wolves, carries with it the potential for disease transmission and the possibility of increasing mortality in moose. Anthropogenic disturbances, especially roads, can remove habitat, increase access for moose harvest, and increase the chance of vehicle collisions with moose.
Positive Influences	
A positive influence on moose habitat may be the increased prevalence of wildfire in the NWT. The early stages of post-fire succession, with growth of young trees and willows, are the favoured habitat of moose.	Wildfire positively influences moose habitat through the creation of browse-rich early successional stage forests; moose browse in these forests is particularly productive 10-25 years following a fire. Current forest management practices are to allow fires to be a natural part of the ecology of boreal forests in NWT. In 2018, the area of early successional forests (10-25 years post burn) in the NWT was approximately 105,000 km^2. Although it is expected that the area of early successional forests will decrease from 2020-2023, as the large fires from the early 1990s reach later stages of succession, in 2024 the area of early successional forests will increase as the

	large areas burnt in 2014 generate productive moose browse. Protected areas have a positive influence on moose populations through the management and restriction of natural resource development projects and associated anthropogenic disturbances, and elimination of resident and non-resident harvest. As of 2022, 17.3% of the NWT was protected by a federal (e.g., Nahanni, Náátsʼįhchʼoh) or territorial parks, or as Indigenous protected areas (e.g., Edéhzhíe, Ezǫdzìtì), or in areas conserved through conservation zoning (e.g., Thaidene Nëné Wildlife Conservation Area). Land use plans in the Dehcho and in the non-Tłįchǫ lands of Wekʼèezhìı are being developed.

TECHNICAL SUMMARY

Question	Traditional and Community Knowledge	Scientific Knowledge
Population Trends		
Generation time (*average age of parents in the population*) (indicate years, months, days, etc.).	Information not available; females begin to have calves between two to three years of age and may have calves every year after that.	The generation times observed in moose populations (from 4.6 to 10.7 years) matches the distribution of generation times of ungulates that can produce twins. This report uses seven years as the generation time for moose in the NWT.
Number of mature individuals in the NWT (or give a range of estimates).	Information not available in sources.	There are an estimated 17,600-40,700 mature individuals in the NWT.
Amount of change in numbers in the recent past. Percent change in total number of mature individuals over the last ten years or three generations, whichever is longer.	Information not available in sources.	Apart from Arctic Red River and the Slave River Lowlands, data are unavailable over three generations. Inuvik/Tsiigehtchic: +125% (11 years) Richardson Mts: +20.9% (11 years) Mackenzie Gas Line: -60.6% (11 years) Fort McPherson/Peel: +317.9% (11 years) Mackenzie Valley: +5.9% (14 years) Liard Valley: +44.4% (14 years) Taiga Plain North Slave: -19.7% (eight years) Taiga Shield North Slave: +226.7% (12 years) Buffalo Lake: -64.0% (nine years) Slave River Lowlands: -93.3% (32 years, 1986/1987-2018; -93.1% 23 years 1995/1996-2018) Arctic Red River: -73.5% (21 years, 1996-2017; -89.4% 18 years, 1999-2017)

Amount of change in numbers predicted in the near future. Percent change in total number of mature individuals over the next ten years or three generations, whichever is longer.	Possible decline in some areas/possible increases in others, although the magnitude is not described in the available sources.	Predictive modeling was not undertaken for this report.
Amount of change happening now. Percent change in total number of mature individuals over any ten year or three generation period which includes both the past and future.	Information not available; however, it is implied that fluctuations in the past may still be occurring now.	All changes were based on ten year or three generations, see above.
If there is a decline (*in the number of mature individuals*), is the decline likely to continue if nothing is done?	Information not available in sources.	Uncertain whether declines in locations noted above will continue.
If there is a decline, are the causes of the decline reversible?	Information not available in sources.	Causes of declines are unknown.
If there is a decline, are the causes of the decline clearly understood?	Information not available in sources.	No.
If there is a decline, have the causes of the decline been removed?	Information not available in sources.	Unknown. Causes of declines are not known.
If there are fluctuations or declines, are they within, or outside of, natural cycles?	Information not available in sources, but there are notes that wolves contribute to population cycles of moose. Others say that construction and development are contributing to the decline of moose in some regions.	Cannot be determined without further and more frequent comparable surveys designed to measure trend.
Are there extreme changes in the number of mature individuals?	Little information available in sources. There was one comment stating that moose populations had experienced major	No.

	declines in the past but then had recovered.	
Distribution Trends		
Where is the species found in the NWT? Estimated extent of occurrence in the NWT (in km^2).	Throughout the forested regions of the NWT.	1,312,921 km^2
How much of its range is suitable habitat? Index of area of occupancy (IAO) in the NWT (in km^2; based on a 2 x 2 grid).	Much of the range is suitable.	1,007,556 km^2
How many populations are there? To what degree would the different populations be likely to be impacted by a single threat? Number of extant locations in the NWT.	Information not available in sources.	Two assumed: Mackenzie Mountain moose and non-mountain moose.
Is the distribution, habitat, or habitat quality showing a decline that is likely to continue if nothing is done? *Is there a continuing decline in area, extent, and/or quality of habitat?*	Possibly. While wildfire is generally considered beneficial for the production of quality forage, fires of high intensity may result in reduced forage availability and increased habitat fragmentation for a number of years.	No, there is evidence of an increasing extent and quality of habitat over the next generation.
Is the number of populations or amount of occupied area showing a decline that is likely to continue if nothing is done? *Is there a continuing decline in number of locations, number of populations, extent of occupancy and/or IAO?*	Information not available in sources.	No.
Are there extreme fluctuations in the range or the number of populations? *Are there extreme fluctuations (>1 order of magnitude) in number of locations, extent of occupancy, and/or IAO?*	Information not available in sources.	No.

Are most individuals found within small and isolated populations? Is the total population severely fragmented (most individuals found within small and isolated populations)?	No. Moose habitat is spread across all forested regions of the NWT and is generally contiguous in nature.	No.
Immigration from Populations Elsewhere		
Does the species exist elsewhere?	Yes, moose are found throughout the boreal region of North America.	Yes. Moose occur in every province and territory in Canada except Prince Edward Island.
Status of the outside population(s)?	Information not available in sources.	Secure in Yukon, New Brunswick (NB) and Quebec. Stable in BC, Alberta (AB) and Saskatchewan (SK). Declining in Manitoba (MB) and Ontario (ON). Endangered in Nova Scotia (NS) mainland (as of 2019).
Is immigration known or possible?	Information not directly available in sources; however, moose were noted to be able to travel long distances and no barriers were identified.	Immigration is likely but has not been documented.
Would immigrants be adapted to survive and reproduce in the NWT?	Information not available in sources.	Yes.
Is there enough good habitat for immigrants in the NWT?	Information not available in sources.	Yes. Habitat is contiguous across western and southern NWT.
Is the NWT population self-sustaining or does it depend on immigration for long-term survival?	Information not available in sources.	Self-sustaining.
Threats and Limiting Factors		
Briefly summarize negative influences and indicate the magnitude and imminence for each.	A few threats to moose were identified in the sources, but there was no information on imminence and degree of threats. Potential threats include predation, human activity, and the introduction (or	Harvest is year-round over the entire range and includes all sex and age classes. The magnitude of its impact is unknown but believed to be sustainable at the population level. The impact of harvest at the local level may be severe and not sustainable.

	re-introduction) of animals to their habitat.	Predation by wolves is year-round over the entire range. Predation by bears occurs over the entire range during the snow-free season and may be focussed on newborn calves. Increasing alternate prey may result in creased wolf predation on moose. Increasing grizzly numbers and predation on moose calves in the Mackenzie Mountains could impact recruitment. The impact of predation is unknown and currently assumed to be sustainable. Parasites, disease, and contaminants are found throughout moose range, and are similar to those found in moose elsewhere. The current incidence and impact of parasites and disease in moose of the NWT is low and at the individual level. The likelihood of epizootic episodes constituting a major threat to moose populations is negligible. A warming climate in the NWT has the potential to increase the incidence and diversity of parasites currently present and to introduce new ones as they extend their range northward. The level of contaminants, radionuclides and persistent organic pollutants is low, except for cadmium in the organs of moose from the Mackenzie Mountains. Cadmium occurs naturally there, but elevated levels of this element in moose does not appear to impact kidney function.

		The impact of parasites, disease, and contaminants is assumed to be negligible at the population level. Anthropogenic disturbances, roads and resource development activities can physically fragment the habitat and increase access for harvest and predators. More roads and traffic may increase the number of moose killed by vehicles. However, the geographical scope of anthropogenic disturbance currently is negligible, current severity of its impact is unknown but assumed to be negligible at the population level. Road development is expected to increase in future, completing the Mackenzie Valley all season road is a high priority. The impact of roads may be greater in the Mackenzie Mountains than elsewhere in moose range. Proposed resource development projects in the NWT could significantly alter moose habitat, in particular the development of a forestry industry in the Dehcho and South Slave Regions.
Positive Influences		
Briefly summarize positive influences and indicate the magnitude and imminence for each.	Increase in wildfire may lead to the development of new moose habitat and increase the availability of forage.	Wildfire positively influences moose habitat through the creation of browse-rich early successional stage forests. Prime moose habitat occurs 10-25 years post-burn. Current forest management practices are to allow fires to be a natural part of the ecology of boreal forests in NWT therefore maintaining a patchwork of successional stages

		in the forested part of moose range. Although the amount of prime moose habitat (*ca.* 105,000 km^2) is expected to decrease from 2020-2023, as the large fires from the early 1990s reach later stages of succession, it will increase in 2024 as the large areas burnt in 2014 become prime moose habitat. Wildfire has a huge impact on creating and maintaining moose habitat. Protected areas have a positive influence on moose populations through the management and restriction of natural resource development projects and associated anthropogenic disturbances, as well as through the elimination of resident and non-resident harvest. As of 2022, 17.3% of the NWT was protected by a federal (e.g., Nahanni, Nááts'įhch'oh) or territorial parks, or as Indigenous protected areas (e.g., Edéhzhíe, Ezǫdzìtì), or in areas conserved through conservation zoning (e.g., Thaidene Nëné Wildlife Conservation Area). Land use plans in the Dehcho and in the non-Tłı̨chǫ lands of Wek'èezhìı are under development and would provide some protection of additional lands.

TRADITIONAL AND COMMUNITY KNOWLEDGE COMPONENT

PREAMBLE

Very few comprehensive sources of published traditional (TK) or community knowledge (CK) of moose in the NWT were available at the time this report was prepared. As a result, the report relies extensively on a few core reports, such as the extensive *Nanh' Kak Geenjit Gwich'in Ginjik: Gwich'in Words About the Land* (Gwich'in Elders 1997) and *Traditional Dene Environmental Knowledge: a Pilot Project Conducted in Ft. Good Hope and Colville Lake, NWT, 1989-1993* (Johnson and Ruttan 1993). It is also important to note the potential seasonality of the TK material. Information on moose and their life cycle in fall, winter, and spring is quite limited in the available sources because the statements reflect harvesters' experience of hunting by boat during the open water season, with some limited statements about harvesting in the winter.

Due to the limitations of available relevant sources, the information in this report is strongest for the Sahtú region and the Gwich'in Settlement Area and more limited for the Dehcho, North Slave and South Slave regions. Moose populations may be shared between the NWT, Yukon, and Nunavut (NU) in some areas, and so information from neighbouring regions has been included in this report when available and appropriate.

While all reasonably available TK/CK was solicited for this report, the scope was limited to best available information and did not include the completion of any primary research or information gathering activities (e.g., interviews). It should be noted that the small amount of available TK/CK information in no way reflects a shortage of knowledge on the part of community members in the NWT; rather, it indicates that only a small portion of that knowledge has been formally transcribed and documented.

Regional, Cultural and Spiritual Significance

Throughout the NWT, moose are recognized as an important species from a cultural perspective. In each region, moose have long been considered a staple food and source of raw materials for everything from toys and clothes to boats and tents.

The number of translations for words related to moose at their various life stages (Table 1) provides a hint of the depth of knowledge held by community members. It should be recognized that the translations are rarely standardized and may vary from community to community, if not within each community. At the same time, these languages and perspectives are not unique to one specific region and ought to be seen as a reflection of the diversity of culture and knowledge within the territory as a whole.

Table 1. Indigenous words related to moose.

Bush Cree		
Mosowa, Môswa	Moose	(NWT Cree Language Program 2015a, b)
Denésǫłiné (Chipewyan)		
Denıı, Denıye, Denı	Moose	(ACFN Elders et al. 2003a; Rice 2012)
Deníyané	Bull moose	(South Slave Divisional Education Council 2012)
Dení ts'úda	Moose cow	(South Slave Divisional Education Council 2012)
Deníaze	Moose calf	(South Slave Divisional Education Council 2012)
Dení ts'ína	Moose orphan	(South Slave Divisional Education Council 2012)
Deníyahgoze	Moose bull (3-4 years old)	(South Slave Divisional Education Council 2012)
Gwich'in		
Denìi or dinjik	Moose	(Gwich'in Land Use Planning Board 2003; Species at Risk Committee 2016)
Egii	Fetus	(Species at Risk Committee 2016)
Ditsik	Calf	(Species at Risk Committee 2016)
Khaideetsik	Young cow	(Species at Risk Committee 2016)
Anechii	2-3-year-old	(Species at Risk Committee 2016)
Dizhyuu	Cow	(Species at Risk Committee 2016)
North Slavey		
Its'é	Moose	(Sahtú Divisional Education Council et al. 2012)
Deyare	Cow	(Sahtú Divisional Education Council et al. 2012)
Itse'eyaa	Calf	(Sahtú Divisional Education Council et al. 2012)
Yarego	Moose (2-3 years old)	(Sahtú Divisional Education Council et al. 2012)
Its'eo	Large bull	(Sahtú Divisional Education Council et al. 2012)
Sallirmiutun		
Tuktuvak	Moose	(Species at Risk Committee 2016)
South Slavey		
Dendıı	Moose	(South Slave Divisional Education Council 2009)
Dendíızhǫ	Bull moose	(South Slave Divisional Education Council 2009)
Meʔa or Dendíıts'éé	Cow moose	(South Slave Divisional Education Council 2009)
Tsía	Moose calf	(South Slave Divisional Education Council 2009)
Dendía	Young moose	(South Slave Divisional Education Council 2009)
Tłı̨chǫ		
Dedıı, Dendıı	Moose	(Tłı̨chǫ Community Services Agency 1996; Species at Risk Committee 2016)
Dedìezhìı or dedìezıı̀	Bull moose	(Species at Risk Committee 2016)
Dedıı̀dets'è	Cow moose	(Species at Risk Committee 2016)
Dedıı̀ts'ìdaa	Young cow	(Species at Risk Committee 2016)
Dedıı̀zǫ̀ǫ̀ or dedıı̀zhǫ̀ǫ̀	Old bull, largest bull moose	(Species at Risk Committee 2016)
Ummarmiutun		
Tuttuvaak	Moose	(Species at Risk Committee 2016)

Moose hide and bones are used for clothing and tools by the Inuvialuit; moose also represent an important alternative food source for the communities when caribou is unavailable. They are preferred over other food sources such as Dall's sheep (Joint Secretariat 2003). This preference for moose in the absence of caribou is reflected in other sources and regions as well (Gwich'in Elders 1997, Joint Secretariat 2003, Kendrick et al. 2005, Andrews 2011, SENES Consultants Ltd. 2018).

Moose are extremely important to the Gwich'in people because the animal has provided them with food, clothing, sewing thread, grease, boats, tents, and tools. Moose skin boats were one of the most important items produced from moose for the Gwich'in people. An expansive discussion of these items and how they were made can be found in *Nanh' Kak Geenjit Gwich'in Ginjik: Gwich'in Words About the Land*. People hunted the animal when caribou were difficult to find and up until recently used the entire animal. Today people usually use only the meat (Gwich'in Elders 1997).

As in other regions, moose are an important resource in the Sahtú for both food and handicrafts, as hides are used for moccasins, winter mitts, and other crafts (Auld and Kershaw 2005). Additional information on their significance within the Sahtú Settlement Area could not be located.

Community members note that although moose can be found throughout the Akaitcho region and that harvest occurs year-round, the best time to hunt is during the fall rut and that there are important areas for harvesting (Haas 2011). According to Denésǫłiné (Łutsel K'e) elders, fall harvest camps could be found in all bays and inlets around Great Slave Lake where the fishing was good, and moose were likely to be sighted (Parlee et al. 2005). After the harvest, some families would stay at Great Slave Lake while others would head to Artillery Lake where they lived year-round. Another source reported that for Łutsel K'e Dene, moose hunting occurred during the summer, along with fishing; caribou were hunted in the winter (Łutsel K'e Dene Elders and land-users et al. 2002). Pierre Catholique, of Łutsel K'e (*in* Kendrick et al. 2005: 181), explained that "[t]here are no caribou some years so [people] stay [at Meridian Lake]. If it's a bad year for caribou, then they could get moose there."

In the past, families would harvest five to six moose per year, and this would provide a sufficient supply of fresh and dry meat to sustain them (ACFN Elders et al. 2003a). In addition to being an integral food source, moose are an important resource in the production of clothing, tools, and toys (ACFN Elders et al. 2003a; Haas 2011).

The Tłı̨chǫ people recognize the importance of the moose and have developed elaborate rules and customs to demonstrate that respect. As Andrews (2011) notes, moose are seen as a significant gift providing meat and hides for clothing, rope, and footwear. Moose can be harvested using different techniques but hitting them over the head is considered disrespectful.

As an integral source of food, moose are to be treated with respect. Johnny Smallgeese, of Wekweètì (*in* Chocolate et al. 2016:43), explains proper harvesting behaviour:

You always respect the animal, bones and stuff like that. Even a young girl there… even the blood, you can't walk over it. Those kinds of stuff… now today people not respectful, even drop blood on the floor stuff like that, people walk over it. That kind of stuff you had to watch. Long time ago, people really, really, watched that stuff. Us we respect the animal, even the bones and stuff like that we watch. I grew up like that and it makes me have more respect for the animal like the skull and all that. I used to bring all the bones in the bush. Even moose, caribou, whatever. I take it in the bush, respect it, put it away, put it out in the bush where nobody goes. Even the moose skull, woodland caribou skull, hang it up on the tree branch, hang it up. Today nobody does that. Go out in the dump there's whole bunch of animal wastes.

Overall, no spiritual significance was attributed to moose in the source material, although one source (Heine and Gwich'in Social and Cultural Institute 2007:26) told of Dinìizhok, a Gwich'in leader, who used moose sinew to travel long distances in a short period of time.

Dinìizhok's travel medicine was edreechi', the sinew from the forearm of a caribou or moose. When he was going to travel, Dinìizhok would put the sinew on top of the fire. The sinew would curl up and shrink from the heat. As the sinew shrank and came together, so stops along Dinìizhok's trails moved closer together as well. Distances could now be covered in a very short time that otherwise would have required several days' travel. Once Dinìizhok reached his destination, the sinew cooled off, uncurled, and regained its original shape, and so did the land.

Such stories may represent a deep spiritual significance that is not generally captured in the development of TK/CK literature.

Source Summary and Discussion of Gaps and Omissions

The main sources for this document fall into three categories: management workshop notes, reports that exist as part of the public registries of the various resource management boards (land and water boards, renewable resource boards, land use planning boards, and the Mackenzie Valley Environmental Impact Review Board) and were used in environmental assessment or permitting processes, and community research documents.

Of these sources, the community research documents were by far the most informative, but these were very limited in number. This is in part due to the significant undertaking that is involved in creating such documents.

The other two main source types were generally limited by their scope. Reports produced as part of the environmental assessment or permitting processes tended to focus on very specific locations and had only occasional comments on the factors relevant to this report. Management workshop notes and reports tended to focus on general concerns but didn't provide details or in-depth analysis of TK/CK perspectives.

With these limited sources to draw from, data gaps are present, to varying degrees, across the whole territory. The Gwich'in and Sahtú regions have the most available information on the status of moose, while the Dehcho, South Slave, Sahtú, and Inuvialuit regions are the least represented in the source material (see *Preamble*).

Whenever possible, this report attempts to focus on sources that represent the voices of the communities. In general, where it was difficult to determine if the opinions expressed were that of the researcher or the community (in scholarly articles for example), these have been omitted.

Lastly, there are a few instances where the source information was unclear in the absence of additional context. In these situations, some non-TK/CK sources were used to add clarity or to fill small gaps in the information presented.

SPECIES OVERVIEW

Names and Classification

Common Name (English)	Moose	
Common Name (French)	Orignal or élan d'Amérique	(Griggs and Griggs 2009)
Cree	Môswa, mosowa	(NWT Cree Language Program 2015a, b)
Denésǫłıné	Denıye, Denıı, Denı	(Rice 2012; South Slave Divisional Education Council 2012)
Gwich'in	Dedìi or Dinjik	(Gwich'in Land Use Planning Board 2003; Species at Risk Committee 2016)
North Slavey	Its'é	(Sahtu Divisional Education Council et al. 2012)
South Slavey	Dendíı	(South Slave Divisional Education Council 2009)
Sallirmiutun	Tuktuvak	(Joint Secretariat 2003)
Tłı̨chǫ	Dedıı or Dendıı	(Tłı̨chǫ Community Services Agency 1996; Species at Risk Committee 2016)
Ummarmiutun	Tuttuvaak	(Joint Secretariat 2003)

The etymology for the word moose, or 'deni' in Denésǫłıné́, comes from the prefix 'de', meaning 'that which is' and the stem 'ni', meaning 'food' (Rice 2012). The Cree word 'môswa' may mean 'eater of twigs', referring to the moose's choice of food (Griggs and Griggs 2009).

The Basque, who were operating whaling stations in Newfoundland, used the word for a deer from their homeland, 'orignac', when they encountered moose (Champlain 1603). French settlers borrowed this word from the Basque (Bakker 2002). This quickly morphed into 'orignal', which is still used in Canadian French, rather than the word 'élan', which would be more commonly used in France (Griggs and Griggs 2009).

The English word 'moose' is derived from the eastern Algonkian dialects where it is said to reference the way in which moose forage (Chamberlain 1902).

Description

Moose are very large, hoofed mammals found in the boreal forests of North America. Adult bull moose stand about 2 m tall and 2.5 m long from nose to tail. Bulls can reach 540-630 kg when fat. Cows are smaller than bulls and can weigh about 400-450 kg at their greatest weight. The layer of fat on their back can be 8 cm thick. The bulk of a moose's weight is in its body, while the legs are long and relatively thin (Johnson and Ruttan 1993; Gwich'in Elders 1997).

Moose can vary in colour depending on age and gender. Bull moose can be almost black while cows tend to be a light brown or partly grey and newborn calves are light brown (Franzmann and Schwartz 1997). Moose are a little darker in the summer because they have shed their faded winter hair by then. They look much skinnier in the summer than in September when they get their winter coats (Gwich'in Elders 1997).

Bull moose will start to grow antlers at two years of age, in March. This growth starts with the appearance of two forks. In September, bulls will rub their antlers against trees to remove the skin on their antlers. They drop their antlers between December and February. Every year the antlers re-grow longer and wider. In general, the older the moose, the larger the antlers. In some cases, moose can have unusually shaped antlers or only one antler (Gwich'in Elders 1997).

Moose have big ears, an enlarged overhanging snout and an elongated flap of skin covered with hair under their chin. The flap looks like a long sack and is larger on bulls than cows (Gwich'in Elders 1997).

Distribution

Moose are widespread throughout most of the boreal regions of North America and are a very important food species for many cultures. Moose are harvested across their range, especially in lowland or riverine habitats (VanStone 1974; Helm and Sturtevant 1981; Wein et al. 1991; Nobmann et al. 1994; Wein 1994).

NWT Distribution

Moose are found throughout the forested regions of the NWT, from the Arctic Ocean to the banks of the Slave River. Within their range, moose can be found anywhere on the land, although some sources, such as the *Proposed Tłı̨chǫ All-Season Project Description Report* (Department of Transportation 2016), note they prefer shallow water along lakes and ponds and can be found anywhere those occur. There have also been sightings of moose recently in Paulatuk (Kyle 2017), which is 100 km north of the treeline. Locals are used to having to travel for about a day to find good moose habitat, so it was a shock to see a pair swimming in the Arctic Ocean near Paulatuk (Kyle 2017). Although it isn't stated directly, it would seem that wherever there is suitable moose habitat there will be moose. This would imply that in the NWT there is a continuous distribution with no known populations that are particularly isolated or distinct.

In some areas near the frontier of their range, moose may be less ubiquitous and are found in more defined areas. For example, within the Gwich'in region they are found along the upper Porcupine River, especially at its junction with Johnson Creek, along the swamps and lakes north of the Porcupine River, below Old Crow Village and east of the lower Bluefish River (Osgood 1963; Hosley 1981; McKennan 1981).

Search Effort

There is little information on search effort due to the limited available sources of TK/CK in many regions (see *Preamble* and *Source summary and discussion of gaps and omissions*).

It seems that most harvesters encounter moose while boating along rivers and lakes and that this has been the primary mode of hunting moose for some time. This may be done opportunistically as people travel on the land for other purposes or as part of intentional moose hunts. Gwich'in Elders (1997) describe the process by which a hunter would track and harvest a moose on foot in the winter, but otherwise all the references to moose hunting indicate that moose are predominantly hunted with the aid of boats.

Parlee et al. (2005) noted that some places will always be good locations for finding moose and harvesters return to these areas each year to hunt moose.

Over the past 50 years there has been a shift in lifestyle, which may impact the data collected in TK/CK studies, as community members may have less direct contact with moose outside the rutting season. Prior to 1968, families took five to six moose per year, which were hunted in late summer before the rut, in winter, and in July and August (ACFN Elders et al. 2003a). In Fort Chipewyan, the shift happened in the late 1960s as families generally took less than four moose per year and tended to hunt before or during the rutting season when moose are fattest (ACFN Elders et al. 2003a).

Biology and Behaviour

Habitat Requirements

Moose live throughout the forested areas of the NWT, but prefer to be near shallow lakes, ponds, and rivers (K'ashó Got'įne Land Corp. 2008; Chocolate et al. 2014; Department of Transportation 2016). These areas tend to have willow, birch, grass, sedges, water plants, and other leaves for the moose to feed on (AMEC Environment & Infrastructure 2013; Chocolate et al. 2014). Moose will move to a different area once all the available forage has been consumed (Gwich'in Elders 1997).

Moose tend not to travel too far inland and like to live on islands and sandbars (AMEC Environment & Infrastructure 2013; Chocolate et al. 2014). Moose return to areas that have experienced forest fires when new willows are sprouting – usually two to three years after the fire (Gwich'in Elders 1997; Benson 2015).

In Délįnę, community members mentioned that Neregah (North Shore Great Bear Lake Heritage Zone) is a very important place for wildlife, including moose, saying that it is a very productive wildlife habitat, and important to many aspects of the moose life cycle (Great Bear Lake Working Group 2005).

The following two sections are based on limited information about seasonal habitat for most regions and may not be representative of the rest of the NWT.

Summer Habitat

Knowledge holders describe moose summer habitat as an area close to water with willow, birch trees, grasses, water plants, and fresh leaves (Johnson and Ruttan 1993). Benny Jeremick'ca, of the Tłı̨chǫ region (*in* Chocolate et al. 2014:33), explains that "[on] warm days during the summer months, moose can be observed walking in the shallow sections of lakes or sitting fully immersed in water. In the summer when we walk in the bush you could see all the ponds with green grass, that's where the moose stay."

Before breeding season starts in September, moose move into higher ground in forested areas, such as the Mackenzie Mountains. These forests are usually a mixture of small black spruce trees, fire-killed dead trees, willows, and Labrador tea on muskeg, where ground cover is predominantly mosses (Johnson and Ruttan 1993).

Winter Habitat

Community members from Fort Good Hope and Colville Lake have stated that moose travel extensively during the winter, rarely staying in one place. They prefer areas that have an abundance of willows, which provide cover along small creeks, and high hills without trees along the high ridges east of the Mackenzie River. Many moose are found on islands along the Mackenzie River during November and December, where there is an abundance of sandbar willows to feed on (Johnson and Ruttan 1993). In the Inuvialuit Settlement Region, they are known to stick close to low-lying patches of willow that provide cover and forage (Community of Aklavik et al. 2008).

Diet and Feeding Behaviour

Moose feed on willows, birch, grass, and water plants (Gwich'in Elders 1997). As the weather warms up in the spring and fresh plants become available, moose stop feeding on woody willow twigs, switching to the leaves and shoots. Once they are able to wade into the ponds, moose will eat water plants, even if they have to submerge their heads to get at them (Johnson and Ruttan 1993; Gwich'in Elders 1997). Gwich'in Elders (1997:45) described moose feeding behaviour in fall and winter:

> *A bull* dinjik *spends lots of time feeding in the lakes, because it helps his antlers grow. In September the willows dry up and* dinjik *go back to feeding on willow twigs. Sometimes in the winter they break off the tops of small trees to get to the very tips of the branches. In the early winter, a* dinjik *may spend three to five days on a lake feeding on muskrat push-ups. When muskrats rebuild them the* dinjik *eats them again.* Dinjik *also dig up grass from under the snow.*

Movements

Moose are well-dispersed throughout the woodlands of the NWT. During spring break-up, their habitat can be susceptible to flooding, so moose will move to higher ground (Gwich'in Elders

1997). In the summertime, food is plentiful in the rich shoreline ecosystems of the territory, so moose tend to stay in one spot until the fall when they go searching for a mate or until they exhaust the food supply in that area. Gwich'in Elders (1997:45) explains that "when [moose] clean part of the country out of food they move to a new place with good willows. Even if there is a good feeding place 160 km away, they will go there. At other times, *dinjik* stay in one place for a couple of months. When one *dinjik* leaves an area because there is no more food, all the other *dinjik* move too."

In August and September, moose travel from the lakes towards rivers to rut. After rutting season, they do not travel as they are very tired and hungry (Gwich'in Elders 1997). In the winter, moose stay along the rivers, where it's easier to eat as the snow tends to be more soft and loose (Gwich'in Elders 1997; Community of Aklavik et al. 2008) and where they can find more protection from the elements than in the barren alpine areas (Community of Aklavik et al. 2008). Wooded areas, primarily mature spruce forests, are also favoured for protection from blizzards and wolves and for the presence of soft snow that makes travelling easier (Johnson and Ruttan 1993).

Discussions on how and if moose travel were varied in the available information and there was no mention of whether moose stay together in groups in one location or whether they travel together. Based on interviews in the Gwich'in Settlement Area, Benson (2015) reported that moose may travel long distances to landscapes that are regenerating after burns, especially during winter before the snow is deep and crusted. Johnson and Ruttan (1993:137), based on interviews in the Sahtú region, noted "moose move from summer habitat near streams, lakes and moist areas, to winter range such as islands in Deh Cho [Mackenzie River], and where the willow growth is good."

Moose will mostly travel for short distances, but longer-range trips (≥40 km) are often undertaken in search of food in the winter (Johnson and Ruttan 1993).

> *They sometimes do travel a long way and I can tell when it's going to travel far. Maybe twenty to thirty miles. It leaves droppings while it is walking. That means he's going very far. When you see this it's no use trying to track it down. He travels just steady until he gets to where he's going, travels around lots during mating season, but in winter it just feeds here and there. During May, a bull moose just stays in one area, for a long time, just feeding and fattening up itself. The cow moose has her calf around this time, so it just stays in one area after giving birth. Sometimes the cow moose doesn't have young ones, (but) they stay in places like this for a long time (Gabe Kochon [Sahtú] in Johnson and Ruttan 1993:138).*

Life Cycle and Reproduction

Different life cycle stages of moose are identified by the different terms in the languages of the Dene, Métis, and Inuvialuit in the NWT. In general, the stages identified include fetus, calf, two to three-year-old cows or bulls, mature cows and bulls, and sometimes the oldest or largest bull.

The resources available did not discuss factors that can influence reproduction, gender and age ratios, generation time, or how long moose live.

Reproductive Strategy and Breeding Habits

Moose reproduce many times throughout their lives. The breeding season is in the fall, from September to October, or even early November (Gwich'in Elders 1997; Johnson and Ruttan 1993). Cows will make a high-pitched humming sound to attract mates, to which bulls will reply at a lower pitch. Bulls will also rub their antlers against trees to make a noise that will attract mates. Bulls have a variety of methods to find cows. Gwich'in Elders (1997:45) explain that "when a bull finds a place where a cow has urinated, he digs the ground trying to find out how long ago the cow was there. Bulls travel for kilometres without eating to find a mate."

Bull moose will eat as much as possible before the fall rutting season. During the rutting season they do not eat, and then in November they start eating again (Franzmann and Schwartz 1997; Gwich'in Elders 1997).

Community members state that breeding bulls are territorial during the mating season. The (breeding) bull controls a large area where he protects and remains with his mate. The bull moose defends his territory from other males (Johnson and Ruttan 1993). He may have to fight off ten to 12 other bulls in order to successfully mate. The bulls fight by locking their antlers together and pushing to win. Once a mate is won, the bull will stay with the cow until mating season ends when they go their separate ways. Only occasionally does a pair stay together after mating (Johnson and Ruttan 1993; Gwich'in Elders 1997).

Development Times

Females begin to have calves at two to three years of age and may have one to two calves every year after that (Johnson and Ruttan 1993; Gwich'in Elders 1997). Bulls generally start to breed at the age of three (Johnson and Ruttan 1993; Gwich'in Elders 1997).

Cows are pregnant for approximately nine months. They travel to rivers or lake islands to give birth in thick brush or wet ravines where they can avoid predators (Gwich'in Elders 1997). Cows especially like islands with grassy meadows as calving areas. They also like to be near muskeg areas and dried out lake beds where food is plentiful (Johnson and Ruttan 1993; Gwich'in Elders 1997).

Calves are born in May or early June and can walk within two to three hours of birth (Gwich'in Elders 1997). They will remain with their mothers for up to three years, with female calves staying longer than males. There will be a moment of interruption to this dependence during rutting when bulls scare calves away to mate with their mother (Gwich'in Elders 1997). Calves nurse for about four months, but also eat solid food, such as leaves, grass, and willows at as early as six weeks of age (Johnson and Ruttan 1993). They learn to eat solids from their mother (Gwich'in Elder 1997).

Cows are very protective of their calves. They isolate themselves and their calf (Johnson and Ruttan 1993; Gwich'in Elders 1997). Calves will follow their mothers for protection, and the mother will call out if they can't see each other. A mother will kick predators or hunters with her front hooves to protect the calf.

Physiology and Adaptability

During the day, moose will stay in the bush near water bodies to feed and lay down (Gwich'in Elders 1997; Chocolate et al. 2014).

When temperatures become too hot for moose, typically in July and August, they will move to areas with mud to remain cool. Moose will also go into the water to cool off when the temperatures rise later in the day, eat the water plants, and get relief from insects such as mosquitos, blackflies, and horseflies (Johnson and Ruttan 1993; Gwich'in Elders 1997; Chocolate et al. 2014). Moose will feed during the day if there is no threat from predators. If there is a disturbing sound indicating a nearby predator, they will wait until night to feed at the water's edge (Gwich'in Elders 1997).

Interactions

Caribou

The nature of the interaction between moose and caribou is unclear. Some community members say that moose will sometimes share caribou habitat, but others disagree, saying, "the moose lives alone, the caribou the same" or "the moose will leave the area where there's a caribou herd" (Johnson and Ruttan 1993:115). The explanations given say moose and caribou don't eat the same food or that moose are sensitive to noise made by the caribou herd (Johnson and Ruttan 1993).

> *I've seen moose and caribou 20 feet apart. One is eating willows, and one is eating grass. So I see that, they don't mind each other (James Firth [Inuvik] in Benson 2015:42).*

> *… some animals prefer to not live around caribou. There is some just like owls, they get disturbed… and they don't like caribou. Just like chickens, and same with moose too, they don't like to live where caribou is, they always run. Caribou make more noise than moose (Anonymous [Tsiigehtchic] in Benson 2015:39.*

Many TK/CK sources indicate that boreal caribou interact with moose and in some cases the interactions are described as competition. In the Dehcho, knowledge holders indicated that moose and caribou generally do not share areas, given different habitat requirements and for predator avoidance (Dehcho First Nations 2011 *in* Species at Risk Committee 2012).

In the South Slave area, moose frequently occur with boreal caribou (Zimmer et al. 2002 *in* Species at Risk Committee 2012). Zimmer et al. (2002 *in* Species at Risk Committee 2012) documented interactions between boreal caribou and moose in the Sahtú, but the results were inconclusive as community members disagreed on whether caribou and moose feed on the same food plants. In general, community members said that moose and caribou share the same habitat but use it at different times.

Inuvialuit community members have observed that moose populations were increasing in areas where boreal caribou were decreasing, but that moose and boreal caribou were generally found in the same areas (Nagy et al. 2002 *in* Species at Risk Committee 2012). In the Gwich'in Settlement Area, based on tracks, moose and boreal caribou can share habitat (Benson 2011 *in* Species at Risk Committee 2012). Most people interviewed by Benson (2015) report that Bluenose [barren-ground] caribou and moose get along.

Wood Bison

Increasing wood bison range and populations are seen as a possible threat to moose by some NWT communities. For instance, residents of Nahanni Butte and Fort Liard have expressed concern that the increasing population of the Nahanni population of wood bison may compete with moose (Larter and Allaire 2007).

In Alaska, Gwich'in speak of how moose moved into their territory around 400 years ago when wood bison were extirpated, or nearly so (Stephenson et al. 2001).

Wolves

Found throughout the NWT, wolves are the primary predator of moose (Haas 2011). Some sources say wolves appear to prefer hunting healthy cows (Thorpe et al. 2001), while others say they go after young or weak individuals (Johnson and Ruttan 1993) or that they just take what they can get and will go after a healthy moose as long as the pack is large enough (Johnson and Ruttan 1993).

Wolves are very effective predators due to their speed and their ability to work in groups. Wolves have the most success killing moose when the moose have trouble traveling, either in the winter when the snow is deep, or in the spring when the snow is crusty and hurts their feet (Gwich'in Elders 1997). A large wolf can kill a moose on its own, but smaller wolves will kill moose in small packs, as Gabe Kochon ([Sahtú] in Johnson and Ruttan 1993:134) describes:

> *Just one wolf can't kill a moose, … sometimes there's seven or eight wolves in one pack. The wolves always hunt by the wind too (usually downwind), depending on which way it blows. The wolves stay hiding, waiting to attack. One chases the moose right to where the rest of the wolves are hiding. The moose is stronger than the wolf so all the wolves have to attack it together or there's no chance of killing the moose.*

It is difficult to protect against a pack of wolves because the animals can, for instance, circle a mother and calf and kill them both (Gwich'in Elders 1997). Moose have therefore developed strategies to defend themselves against wolves. For example, there are sightings of moose near oil and gas developments, which knowledge holders assume is to avoid the wolves, who avoid the equipment (AMEC Environment & Infrastructure 2013). Moose will also stay away from areas if they know wolves are there (Gwich'in Elders 1997).

> *Moose will run to avoid wolves, but if cornered will fight. Large, healthy adult moose can defend themselves by kicking the wolves and breaking the wolf's back or using its antlers to pick up predators and throw them on the ground. For this reason, wolves kill either sick or injured moose that can not run fast, or young, weak calves (Gwich'in Elders 1997:46).*

Wolf population size is possibly linked with ungulate population numbers: wolf numbers may decrease as ungulate numbers decrease (Schramm 2005). There is some concern that as people spend less time on the land due to shifting lifestyles, wolf populations may get out of control, putting extra pressure on moose:

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

Outfitters in the Mackenzie Mountains have noted moose numbers occasionally crash due to wolf predation and it takes five to six years for moose to begin to repopulate the area (Stan Stevens, pers. comm. 27 June 2019).

Bears

Grizzly bears are found primarily in the tundra, alpine, and treeline regions of the NWT. This brings them into frequent contact with moose. "Grizzly bears are adept at hunting larger land-based prey such as caribou, sheep, and moose. The hunting strategy often adopted is one of observe, sneak, and ambush, with grizzly bears using available resources to their advantage" (Species at Risk Committee 2017:49). Grizzly bears are known to hunt moose by ambushing them in water crossings while hiding in the willows (Gwich'in Social and Cultural Institute et al. 2014). "Grizzlies can wrestle and kill even a large bull moose. One Fort McPherson hunter has seen a grizzly bear chase a moose into a river and try and kill it. If a grizzly comes across an animal in the water, it is easier for the bear to kill its prey" (Gwich'in Social and Cultural Institute et al. 2014:37).

In areas of the Mackenzie Mountains where grizzly bear densities are high, outfitters have described intense predation on moose calves by grizzlies and rapid declines in the ratio of calves to cows from spring to summer. In contrast, areas with fewer grizzlies appear to have higher calf to cow ratios in late summer and fall (e.g., Werner Aschbacher, pers. comm. 11 June 2019).

Some community members have reported that with the changing migration patterns of caribou in the Mackenzie Delta, grizzly bears are now hunting more moose. This was quite noticeable in 2006, when the Porcupine caribou herd was further away from Fort McPherson – grizzly bears may have shifted their hunting pressure to moose in the Delta (Gwich'in Social and Cultural

Institute et al. 2014). Grizzly bears generally do not hunt adult moose because they can easily run away, so they tend to attack the young calves (Gwich'in Elders 1997).

Predation on moose by black bears is not mentioned in the source material. Johnson and Ruttan (1993) note this omission may result from either a lack of questioning on the topic in the interviews, reluctance to talk about bears, or little importance being placed on moose and bear interactions, which would be likely to happen during the summer when hunters are less likely to be present to observe these interactions.

Porcupine

Moose have some interactions with porcupines. Both moose and porcupines mate in the fall and a porcupine's mating call sounds similar to moose calls.

> *When bulls hear the porcupine calls they sometimes run towards them. If they find a porcupine and not a cow they sometimes get mad and start thrashing the bushes. Later this bull will be running around with its head full of porcupine quills, or will become crippled from the quills stuck in its feet (Gwich'in Elders 1997:47).*

Wolverines

Wolverines are known to have an extremely varied diet that can include moose (Gwich'in Elders 2001; Benson 2014).

There are a few brief mentions of wolverines sometimes hunting young moose calves. Wolverines will jump on the back of a calf and bite the back of its neck (Johnson and Ruttan 1993; Gwich'in Elders 1997).

Lynx

There was one mention of a lynx killing a moose in the available sources by Antoine Kochon, of the Sahtú region (*in* Johnson and Ruttan 1993:135): "I heard that lynx killed moose; from my grandfather, he said lynx killed the moose by jumping on its neck and biting onto the neck until the moose drops."

Parasites and Diseases

Moose move into the water or highland to avoid biting insects, but no specifics were given regarding impacts on overall health.

> *To get away from mosquitoes in the summer* dinjik *lay down in the water and occasionally roll in mud. Often, they run through the bush to get rid of mosquitoes. When their nose gets covered with mosquitoes, they lower it in the water and blow bubbles to get rid of them (Gwich'in Elders 1997:47).*

STATE AND TRENDS

Population

Abundance

There is limited information in the available resources about abundance of moose within the NWT. There were some observations from Tulít'a and Norman Wells indicating that moose populations had increased in that area (Olsen et al. 2001 *in* Species at Risk Committee 2012). Further north, Heine and Gwich'in Social and Cultural Institute (2007) noted that the Gwich'in from Tsiigehtchic relied more on moose than fish, so their lifestyle differed from Gwich'in in other areas, suggesting a higher abundance of moose in the Tsiigehtchic area. It was suggested that forest fires in the 1990s created habitat that supported more moose (McDonald 2010 *in* Species at Risk Committee 2012).

Trends and Fluctuations

Trends in moose populations are described relatively, in terms of whether there are more or fewer moose than in the past. Sources variously describe moose populations in different areas as declining, increasing, or stable. Some knowledge holders also indicate that moose populations are cyclically tied to other animal populations, such as wolves (ACFN Elders et al. 2003a). These descriptions likely reflect the variety of conditions, the vastness of the study area, and varied personal experiences found in the TK/CK material. As has been noted in other sections, comments on trends and fluctuations in moose populations should be seen as cursory and should simply be used as the basis for further consultation.

In the Mackenzie Delta near Inuvik, Gwich'in Elders (1997) stated that moose populations were up in the region compared to the previous ten-year period, but that there are hardly any moose around the communities of Inuvik or Fort McPherson as those areas have been overhunted. In Aklavik as of late 2007, moose numbers have been seen to be on the rise (Gordon et al. 2008). However, as these reports are ten to 20 years old, it is hard to draw any conclusions about the current state of the population. Rather, these reports simply indicate that harvesters have noticed fluctuations in the past. More recently, there is some indication that moose are considered very abundant, as noted by Gordon et al. (2008:24), "According to the experts, there are moose all over the Delta today. You can run into four or five a day when travelling now. A long time ago you were lucky to see one a week." A community member in from Tsiigehtchic agreed and suggested that moose might even be considered "overpopulated" (Anonymous [Tsiigehtchic] *in* Winbourne et al. 2014:44). There is some discussion about why this apparent population increase happened: it could be that fewer people are hunting than in the past (early 1900s), or it may be an outcome of the limited hunting of cow moose in the 1940s (Winbourne et al. 2014). Gwich'in Elders (1997) noted that there are now (as of the time of the study) fewer moose near communities due to greater hunting pressure there.

In previous generations, hunters were extremely hard pressed to harvest moose because they were scarce. Hunters could spend three or four days on the trapline looking for moose and sometimes find nothing (Winbourne et al. 2014). At that time, hunters would not abandon a moose they were tracking until it was killed (Auld and Kershaw 2005).

> *Before that [1948 and 49], a person could travel 2,500 kilometres and never see a* dinjik *track. There used to be many* dinjik *around Inuvik and Fort McPherson. Now there are hardly any* dinjik *near the communities because people hunt them near town and chase them away (Gwich'in Elders 1997:46).*

In the Dehcho, some delegates to the 2016 wildlife workshop expressed their concern that the moose population was declining. They also noted that there was an increase in hunter numbers and roadside hunting (Environment and Natural Resources 2016).

Unfortunately, there is no trend information available for regions outside of the Gwich'in Settlement Area and Dehcho.

The available sources did not contain specific information on the nature of change, size of change, continuity of trend, population appearance and disappearance, or physiological changes.

Population Dynamics

The available sources did not contain specific information on birth rates, death rates, immigration rates, or changes in body size or condition.

Information obtained from studies in the 1990s suggested that moose populations in the Mackenzie Delta had increased during the previous two decades (see *Trends and Fluctuations* above). The increases in moose populations were believed to be caused by immigration from the south, the expansion of moose habitat as a result of fire, and subsequent forest succession that provided new growth of forage species such as willows.

Habitat

Habitat Availability

Moose habitat availability was not generally commented upon in the available sources. This could indicate that community members did not think there was lack of available habitat, but this cannot be confirmed given the currently available source material.

Habitat Fragmentation

Wildfire is one of the most significant forces influencing wildlife habitat in the NWT. Knowledge holders have stated that the direct effect of fire on moose depends upon the time of the year, particularly early spring, and the intensity of the burn. Antoine Kochon ([Sahtú] *in* Johnson and Ruttan 1993:132) explains, "[Moose] moves away from the area with the forest fire, I guess. I don't think many of them die in the fire but say (if) the fire happened before the end of May, then some calves do die, because they're not strong on their feet then."

Three kinds of burns were identified: crown fires, which burn only the tops, but kill larger trees; 'ground fire' (or surface fire), which only burns low surface vegetation and shrubs, but not large trees; and 'total burns', which burn everything down to the mineral soil. The size and severity of burns affects the rate of plant regrowth or regeneration. As new food plants become available, moose return to feed on them. After burns, moose return to an area at the same rate at which vegetation regenerates.

> *After a crown fire or a light ground or 'surface' fire, grass grows on areas like that right away… After a severe fire where all vegetation is destroyed, it takes a long time before anything grows again… Maybe two years… The trees take longer to start growing again, but the willows grow back really fast, and there's usually lots of regrowth of small trees in areas like that (Hyacinth Kochon [Sahtú] in Johnson and Ruttan 1993:132).*

> *In a severe burn which removes all the surface material down to the mineral soil about four or five years… that long before there's regrowth of willows… After ten years (following fire) the land would look just like it did ten years ago. Everything would be new again, all the burnt bark will be cleaned with wind and the weather. Just like washing the land, everything would be all new (Gabe Kochon [Sahtú] in Johnson and Ruttan 1993:132).*

> *I don't think a moose would go back to that burnt area right away in the (same) summer. There's too much ash and burnt wood. … if willows did grow back in the same season, they could feed in this area in the winter when there's snow (Hyacinth Kochon [Sahtú] in Johnson and Ruttan 1993:132).*

> *… and after that you don't see no caribou – there's no feed; all the food is burnt. No more caribou come around after that. Even Moose (Pierre Benoit [Gwich'in] in Winbourne 2004:46).*

Looking beyond the influence of forest fires, community members say infrastructure developments, such as highways, will fragment the moose population and drive them away from their current habitat. The moose will be deterred by new animal populations, noise, dust, pollution, and traffic (Chocolate et al. 2014). For example, the construction of Highway 3 saw the introduction of bison, which follow the road route. Moose avoid bison, which has a negative impact on hunters who depend on them: "There will be traffic day and night. Buffalo will come in, and moose and woodland caribou are very disturbed by buffalo. The traffic will scare away the animals, and we cannot continue to trap in that area" (Anonymous [Whatì] *in* Chocolate et al. 2014:33).

Habitat Trends

Very few comments about trends in moose habitat were found in the available TK/CK material. While some sources may have commented generally on factors that could drive habitat trends, such as climate change and wildfire, none described how these would impact moose populations. For example, there is a concern that lakes and aquatic systems are drying out as a result of climate change (McLaren and Kelly 2015). Fire is repeatedly commented upon and is said to generally result in short term impacts to the habitat, but no comments were found regarding trends.

Distribution Trends

Distribution trends were not addressed in the available TK/CK sources.

In terms of historical populations of moose, in the Sahtú, there is mention of place names and their relation to moose populations, such as Its'ere Túé (Place of Moose). Place names may indicate moose populations from thousands of years ago, even though no moose are around those areas now (SENES Consultants Ltd. and Délįnę Renewable Resources Council 2012).

THREATS AND LIMITING FACTORS

There are a few threats to moose, including predation, development, introduction of new animals, and re-occupation by some animals of historical ranges that had previously been abandoned.

Wildfire

Although forage comes back quickly following wildfire (Benson 2015) and controlled burns were even used to promote forage availability historically (ACFN Elders et al. 2003a), severe wildfires result in conditions that temporarily delay the development of forage and increase habitat fragmentation for a number of years (Johnson and Ruttan 1993).

Infrastructure (Roads and Utility Corridors)

Although there is little available TK/CK information regarding the potential impact roads and linear disturbance may have on moose, one harvester has indicated that the construction of highways and other roads has a negative effect on the moose population. In particular, the harvester noted that, "existing animal populations would be scared away by the noise, dust, smell, and pollution from the road construction and by the continuous traffic on the road" (Anonymous [Whatì] *in* Chocolate et al. 2014:38). The result would be less hunting and trapping as the animals move to different locations (Chocolate et al. 2014).

It has been noted that grizzly bears, "along with other animals such as moose and sheep, took decades to get used to the highway" (Gwich'in Social and Cultural Institute et al. 2014:55). Observing these animals near the highway, or crossing it, is relatively recent even though the road to Fort McPherson has existed since the late 1970s (Gwich'in Social and Cultural Institute et al. 2014). New construction projects, such as road construction, may disturb moose populations. The construction of roads, with the resulting noise, dust, and pollution could result in moose moving away from the area. "If things are being transported by trucks, gravel and dust will be spread out all over the place. Hunting and trapping will disappear. Those of us who are elders don't want that to happen" (Anonymous [Whatì] *in* Chocolate et al. 2014:38).

These projects also introduce new or formerly present animal populations, such as bison, which cause moose to relocate. Community members state that bison will follow the new roads, which will lead to moose leaving the area as they avoid bison (Chocolate et al. 2014).

In the Dehcho, it was noted that there is an increase of hunters harvesting along the highways. It was implied that this may be resulting in over-hunting in these corridors (Environment and Natural Resources 2016).

Industrial Development

There are concerns that oil and gas development could have a negative impact on moose. Arthur Beck, of Fort Resolution said, "a lot of the moose in our area have moved north because of the smog from Fort McMurray the moose are moving north now" (*in* Bathurst Caribou Range Plan Supporting Document 2017:17). Others have said that these developments attract moose because predators avoid the area (Community of Tuktoyaktuk et al. 2008; AMEC Environment & Infrastructure 2013).

Lack of Respect by Hunters and Over-Harvesting

A number of community members have raised concerns that some hunters are not following traditional protocols for showing respect during the harvest (Gwich'in Elders 1997; Gordon et al. 2008; Chocolate et al. 2016). Examples of this lack of respect include wastage of meat or mistreating the remains of animals:

> *After killing a* dinjik*, the hunter could not let the blood drip on the ground or his clothes. He also could not step over the blood or hair. He always cleaned the place where he killed a* dinjik*… People showed their respect for* dinjik *by the way they cut it up and shared it with other people. When people killed* dinjik*, they used every part of the animal without throwing anything away. The only part not used was the contents of the guts. If the rules were not followed, the animals would keep away from them (Gwich'in Elders 1997:49).*

Respectful hunting practices help prevent over-harvesting and wastage, thereby protecting the moose population. Hunters would follow a moose they shot at to see if it was wounded. If there was a trail of blood, hunters would follow it and kill the animal. Gwich'in Elders (1997:48) expressed the concern that, "Today, some hunters shoot at ten different *dinjik* before dropping one, and do not check if they have wounded the others. Since wounded *dinjik* usually die somewhere, a hunter kills more *dinjik* than he realizes."

Education can help teach adults about respectful harvesting practices, including the sharing of information when regulations change. An Inuvik harvester stated that since people have reduced the harvest of the Bluenose caribou due to new regulations, they are "hammering moose" (Anonymous [Inuvik] *in* Winbourne et al. 2014:73).

Gwich'in Elders (1997) stated that although moose populations were up in their region at the time of the study, the areas near the communities of Inuvik and Fort McPherson had been overhunted.

There is also concern that outfitters are contributing to over-harvesting of moose (Winbourne et al. 2014; Environment and Natural Resources 2016).

The workshop report for the 2016 Dehcho wildlife workshop noted, "that too many prime breeders are being harvested" (Anonymous [Dehcho] in Environment and Natural Resources 2016:35). Similarly, some community members in the South Slave region would like to see more emphasis on hunting bulls. While this would generally result from a cultural shift, some restrictions on harvesting cows could result in a positive outcome (McLaren and Kelly 2015).

Climate Change

The effects of climate change on the moose population are not discussed explicitly in the literature, but there is some indication that climate change is happening, and that nature can handle itself. One individual recognizes climate change as a constant factor that has impacted animal populations during previous generations but asserts that it will balance itself out again. It is unclear what specific changes occurred in the past; instead, the community member focused on addressing the current situation: "Global warming is a big impact. Mother Nature is taking over to look after herself. They'll be back. It happened before – moose, marten – 60 years later now they are overpopulated" (Anonymous [Tsiigehtchic] *in* Winbourne et al. 2014:44).

There is concern that any interventions by the government could negatively impact animal populations and that it should "leave nature alone" (Anonymous [Tsiigehtchic] *in* Winbourne et al. 2014:44).

There is also some indication that lakes and aquatic systems are drying out as a result of climate change (McLaren and Kelly 2015). Knowing that shallow lakes and aquatic systems are preferred moose habitat, one can infer that this change could have a negative impact on moose. Reductions in the snowpack may also have an impact on moose because it may facilitate wolf movements and hunting (Winbourne et al. 2014).

Noise

There are numerous comments in the TK literature about moose disliking or avoiding noise. This often is in reference to the movement of caribou, who are said to be quite noisy. Johnson and Ruttan (1993) even recorded a reference to rabbits being too noisy when feeding in larger numbers.

Elders from the Colville Lake area expressed concern regarding animals being scared away by helicopters (K'ashó Got'ı̨ne Land Corp. 2008). Similarly, moose are said to be disturbed by road noise (Chocolate et al. 2014).

According to one source, moose have become habituated to oil and gas development because of the reduced threat from predators due to the noise (AMEC Environment & Infrastructure 2013).

Predation

Predators, especially wolves, may have a negative impact on moose populations. Community members would like to see what the predation rate would be compared to the harvest rate. They believe the number of moose killed by predators is significantly higher than the harvest. "We need to know this to manage better" (Inuvik resident *in* Benson 2015:36). In the past, hunters would also trap, and therefore control, the predator populations, but now there is "nobody out there, so all those predators are growing, especially the wolves" (Anonymous [Tsiigehtchic] *in* Winbourne et al. 2014:36). Wolf populations are thought to be rising due to a lack of trappers on the land and climate change, resulting in more moose kills. When there is less snow, wolves can move easily through the landscape and attack moose without difficulty (see *Climate Change* above), Winbourne et al. 2014). There is also mention of grizzly bears shifting their focus towards moose when caribou migration patterns shift (Gwich'in Social and Cultural Institute et al. 2014).

Across the territory, traditional knowledge holders commented on the detrimental influence wolves have on moose populations. "Even then, in winter three years ago, there were quite a few wolves in the delta killing off moose. We'd see kills everywhere" (Anonymous [Inuvik] *in* Winbourne et al. 2014:36).

Disease and Parasites

When asked about the health of moose, knowledge holders interviewed by AMEC Environment & Infrastructure (2013) responded that recently they have seen white dots in the meat and lungs or that the lungs seemed to stick to the ribs. This had not been observed previously.

Otherwise, no information was found regarding moose parasites and disease.

POSITIVE INFLUENCES

Wildfire and Climate Change

While there is some disagreement, wildfire and climate change are generally described as positive influences on moose populations in the NWT. Fires result in new habitat and food for moose, while milder winters make it easier for the moose to travel and forage (McLaren and Kelly 2015).

Research

As mentioned by community members in the South Slave region, a positive influence on moose populations could result from more regular moose surveys, more research and monitoring of moose habitat, and research to better understand the link between moose population levels and moose habitat (McLaren and Kelly 2015).

Industrial Development

Some energy developments have a positive impact on moose by creating new habitat for them through the creation of seismic lines. Once the lines are allowed to grow in, the grass and willows attract moose (Benson 2011 *in* Species at Risk Committee 2012).

Change in Hunting Regulations and Management Practices

One Dehcho community member noted that in Teslin, Yukon, the First Nations imposed a five-year ban on hunting moose and that this was seen to have resulted in an increase in the local populations (Environment and Natural Resources 2016).

Community knowledge holders in the South Slave region have described potential future positive influences on moose populations. Some of these include actions associated with future management approaches, for example: obtaining harvest data from hunters; having campaigns to advise hunters to harvest bulls instead of cows, or a moratorium on hunting cows for a specific time frame; introducing harvest limits or restricted access zones; educating hunters on moose distribution; increasing predator trapping and hunting through incentive programs; and opening bison harvest as an alternative to hunting moose (McLaren and Kelly 2015), although this last option may not be feasible as wood bison are listed as a Threatened species under the *Species at Risk (NWT) Act*.

Harvest Reduction and Decline

In some areas, changes in lifestyle may be leading to a reduction in the moose harvest.

> *After 1968 the average number of moose taken per family dropped to 3.26. Fewer people were participating in the hunt and many of the younger generation did not hunt at all. Traditional hunting was drastically reduced as many of the people began to move into Fort Chipewyan (ACFN Elders* et al. *2003b:103).*

It should be noted that this comment on harvest reduction is from Fort Chipewyan and may not reflect a significant factor in the NWT. Further research is needed on this topic.

Harvesting and Indigenous Harvest Management

The idea that local management of wildlife might provide a benefit for moose was not fully articulated in the source materials, although a number of sources suggested people had been successfully traditionally managing moose (Franzmann and Schwartz 1997; ACFN Elders et al. 2003a; Winbourne et al. 2014).

One way people traditionally managed moose was to do controlled burning. For example, Arsene Bernaille told of how his grandfather would light a fire around the edge of Lake Athabasca to promote berry growth and add new habitat for moose (ACFN Elders et al. 2003a).

Additionally, people should avoid hunting cows later in the winter when they had young inside of them (Gwich'in Elders 1997). Traditional Indigenous harvesters were aware that if they hunted pregnant cows, there would be fewer moose in the future (Gwich'in Elders 1997; Winbourne et al. 2014).

ACKNOWLEDGEMENTS

Thank you to all the elders, hunters, and other participants who took part in meetings and traditional knowledge studies, generously providing their knowledge over the years. Their names are included, when possible, in *Traditional/Community Knowledge Contributors*, but it should be recognized that countless others contributed to the source material and that the traditional knowledge and community knowledge therein represents generations upon generations of communities engaged in the development of this knowledge.

TRADITIONAL/COMMUNITY KNOWLEDGE CONTRIBUTORS

Fort Chipewyan: Arsene Bernaille

Fort McPherson: Abe Wilson, Ernest Vittrekwa

Gwich'in: James Firth

Inuvik: Pierre Benoit and three anonymous community members

Łutsel K'e: Pierre Catholique

Sahtú: Gabe Kochon, Antoine Kochon, Hyacinth Kochon

Tłı̨chǫ: Benny Jeremick'ca and three anonymous community members

Tsiigehtchic: three anonymous community members

Wekweètì: Johnny Smallgeese

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Danny Allaire	Wildlife Technician, Environment and Natural Resources, Dehcho Region, Fort Simpson, NT.
Dean Cluff	Regional Biologist, Environment and Natural Resources, North Slave Region, Yellowknife, NT.
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Dr. Nicholas (Nic) Larter	Manager, Wildlife Research and Monitoring, Environment and Natural Resources, Dehcho Region, Fort Simpson, NT.
Stephanie Behrens	Cumulative Effects Biologist, Environment and Natural Resources, Sahtú Region, Norman Wells, NT.
Tracy Davison	Regional Biologist, Environment and Natural Resources, Inuvik Region, Inuvik, NT.

Indigenous Organizations and Wildlife Management Boards:

Alestine Andre	Heritage Researcher (retired), Department of Cultural Heritage, Gwich’in Tribal Council.
Amy Amos	Executive Director, Gwich’in Renewable Resources Board.
Georgina Chocolate	Traditional Knowledge Coordinator, Tłı̨chǫ Government.
Jen Lam	Resource Person, Inuvialuit Game Council.
Jessica Hum	Lands Protection Manager, Tłı̨chǫ Government
Lloyd Chicot	Chief, Ka’a’gee Tu First Nation.
Peter Redvers	Director of Lands, Resources and Negotiations, Kátł’odeeche First Nation.
Priscilla Canadien	Resource Manager, Fort Providence Resource Management Board.
Sean Richardson	Wildlife Coordinator, Tłı̨chǫ Government.
Shin Shiga	Regulatory Analyst, North Slave Métis Alliance.
Tim Heron	Interim Measures Agreement Coordinator, NWT Métis Nation.

BIOGRAPHY OF PREPARERS

Adam Bathe

After graduating with a B.A. in Anthropology, Adam worked for a number of consulting companies on projects related to natural and cultural resource management.

Before establishing Blyth & Bathe, Adam worked for a large consulting company. One of the major projects he worked on there was to develop a massive, annotated bibliography containing all the relevant reports on cumulative impacts from the oil sands. This project included local and TK. With the same company, he worked on the 'Mark of the Métis' project, where elders and resource users throughout the Wood Buffalo region were interviewed on their way of life. Different reports were developed for each family, community, and region as a whole.

With Blyth & Bathe, Adam has developed a wealth of experience delivering community-based environmental monitor training across the NWT and an extensive background in TK consulting work. He has worked on several TK projects that feed into the regime described by the *Mackenzie Valley Resource Management Act*. Adam co-prepared the TK/CK portion of the Species at Risk Committee's *Species Status Report for Barren-ground Caribou (Rangifer tarandus groenlandicus) in the NWT*.

Adam is currently wrapping up his Master of Natural Resource Management degree, where he is researching the effects of wildfire on barren-ground caribou habitat.

John Blyth

John Blyth has worked as an anthropologist, instructor, and environmental consultant for seven years, beginning with his work on the Smith's Landing Traditional Use Study and flowing into his years of instructional work with Aurora College as a firearms instructor and as a TK researcher.

John has extensive experience instructing and training environmental monitors, instructing more than a dozen month-long environmental monitor courses. John is also certified through Environment Canada and the Canadian Rivers Institute to manage projects based around the Canadian Aquatic Biomonitoring Network protocols for the assessment of stream health. John has received training on conducting water sampling from Taiga Labs, as well as other sampling protocols, such as caribou scat sampling and caribou health and body condition sampling. John has completed several traditional knowledge projects, including studies for Enbridge Pipelines and Devonian Metals.

John has extensive experience in both cultural resource management and community-based education. This has included the research, interviews, data collection, and analysis for Smith's Landing First Nation's Traditional Use Study, as well as the compilation of the TK/CK portion of the *Species Status Report for Barren-ground Caribou (Rangifer tarandus groenlandicus) in the NWT*.

Samantha Stokell

Samantha Stokell is a librarian with a background as a journalist in the North. She has a Bachelor of Fine Arts, a post-graduate Journalism certificate, and a Master of Library and Information Studies, with a concentration in First Nations studies. She lived in the NWT working as a reporter, and through her experiences with TK and CK holders decided to pursue her library degree. The specialization in First Nations studies allowed her to delve deeper into the issues facing First Nation communities in the documentation of TK and Indigenous information management. Samantha worked as a librarian at X̲wi7x̲wa Library at the University of British Columbia, the only Aboriginal-focused post-secondary library in Canada. During this time, she developed research techniques that allowed her to find TK documents and Indigenous information that was relevant to students, professors, and community members looking for a First Nation, Métis, or Inuit perspective in their field. Samantha currently lives in Fort Smith, NT.

SCIENTIFIC KNOWLEDGE COMPONENT

SPECIES OVERVIEW

Names and Classification

Scientific Name[1]: *Alces alces*

Common Name (English): Moose

Common Name (French): Orignal, élan d'Amérique

Population(s) or Sub-population(s) in the NWT:

Alaskan moose (*A. a. gigas*)

West-Canadian moose (*A. a. andersoni*)

Classification:

Class: Mammalia
Order: Artiodactyla
Family: Cervidae

Life Form:

Animal, vertebrate, mammal, ungulate

Systematic/Taxonomic Clarifications

This report follows Hundertmark (2016) and uses *Alces alces* as the scientific name of moose in the NWT while recognizing that moose taxonomy is not settled at the time of writing. Whether North American and Eurasian moose are separate species or are in fact subspecies remains a matter of debate (Wilson and Reeder 2005; Geist et al. 2008), and use of *Alces alces* or *Alces americanus* when referring to the North American moose can differ among sources.

The subspecies of moose have been described primarily by reported differences in geographic distribution, cranial measurements, and pelage coloration (Peterson 1952). Analysis of complex genes has shown a low diversity among North American moose (Mikko and Andersson 1995), but analysis of mitochondrial DNA (mDNA) revealed some adherence to the existing subspecies (Hundertmark et al. 2003). Although DeCesare et al. (2020) brings some question into the most southerly subspecific designation *shirasi*, four subspecies of North American moose will be used in this document.

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[1] *Alces americanus* is once again being used as a synonym for *Alces alces* according to the American Society of Mammalogists' Mammal Diversity Database (https://mammaldiversity.org).

Description

Moose are the largest members of the deer family (Cervidae), measuring 1.85-1.95 m at the shoulder and weighing 360-600 kg. They stand on long legs with relatively small hooves adapted to walking on soft ground or in snow (Keller et al. 2009). Their coat ranges from brown to black depending on season, age, social rank, and sex. Males have palmate antlers[2] that range in width from 139-165 cm, wider in exceptional animals, while females are antlerless. Moose also have a flap of skin hanging from their chin, called a bell or dewlap (Franzmann and Schwartz 1997).

[2] Shaped in a manner similar to a hand with extended fingers.

DISTRIBUTION

World and Continental Distribution

Moose are widely distributed throughout the northern hemisphere in or around boreal regions. They are found in Canada, United States (US), Austria, Belarus, China, Czech Republic, Estonia, Finland, Germany, Kazakhstan, Latvia, Lithuania, Moldova, Mongolia, Norway, Poland, Romania, Russia, Slovakia, Sweden, and Ukraine (Figure 1; Jensen et al. 2020).

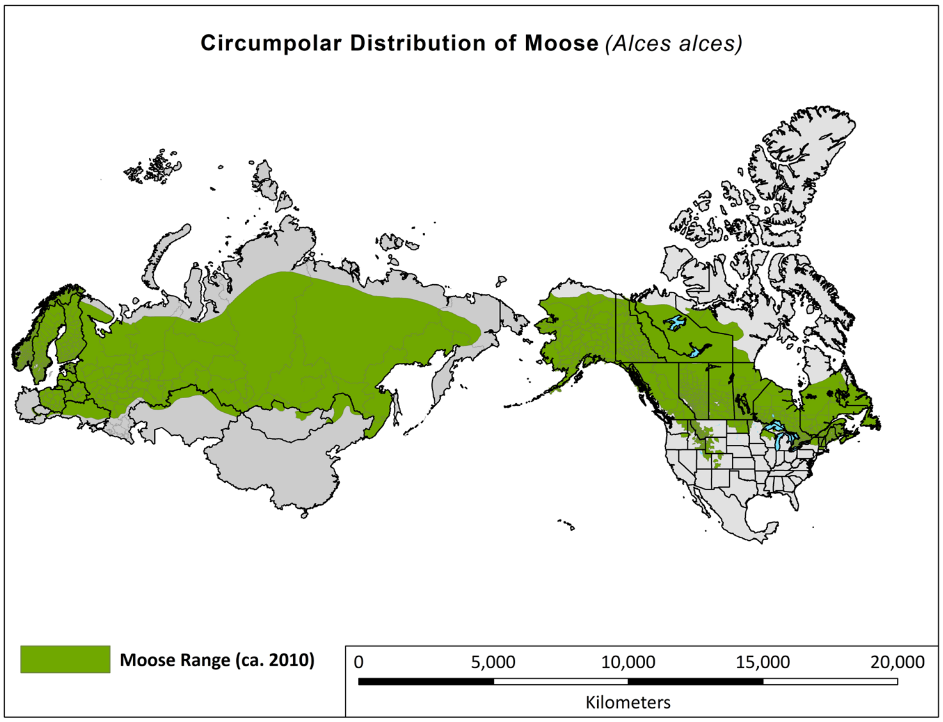

Figure 1. Global distribution of moose. Map provided by W. Jensen, North Dakota Game and Fish Department.

Moose occupy most of Canada's boreal zone and are found in every Canadian province and territory except Prince Edward Island. Outside the boreal zone, moose are currently distributed across southwest Manitoba, southern Saskatchewan and southern Alberta (Bjorge et al. 2018), and are expanding their range in Labrador, Nunavut, and into tundra areas of northern NWT. In the US, moose are found in the northeastern states, around the Great Lakes and in the western states where the southern extent of core range is Colorado and Utah, with the occasional individual being spotted as far south as northern Texas (Hoffman et al. 2006; Franzmann et al. 2007; Timmermann and Rodgers 2017). North American moose fall into four subspecies of *Alces alces* (Hundertmark and Bowyer 2004) two of which occur in the NWT (Graf 1992; CIMP 2012; Carlsson et al. 2015).

- *A. a. gigas:* Northern Canada and the US: Alaska, Yukon, and the Mackenzie Mountains of the NWT
- *A. a. andersoni:* Western Canada and the Great Lakes: British Columbia, Alberta, Saskatchewan, Manitoba, Northwest Territories, Nunavut, western ON, Michigan, Minnesota, North Dakota, and Wisconsin
- *A. a. americanus:* Eastern Canada and the Northeastern US: eastern Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland and Labrador, Maine, New Hampshire, Vermont, Rhode Island, Massachusetts, New York, and Connecticut.
- *A. a. shirasi:* Southwestern Canada and the western continental US: Alberta, British Columbia, Washington, Oregon, Idaho, Montana, Colorado, Wyoming, Utah and Texas.

NWT Distribution

Moose are widely distributed across the forested regions of the NWT (Figure 2), as well as on the tundra along major rivers and in other areas with concentrations of willows (Treseder and Graf 1985). Moose range in the Northwest Territories extends from the Yukon border in the west to the southern Arctic tundra in the east, and from the 60th parallel north to the Mackenzie Delta and Horton River Plains. In the cordillera regions of the Mackenzie Mountains (western and southwestern NWT) moose tend to be more localised in the valleys and, at certain seasons, in alpine areas where stands of willows are found (Ecosystem Classification Group 2010; McCulley et al. 2017a).

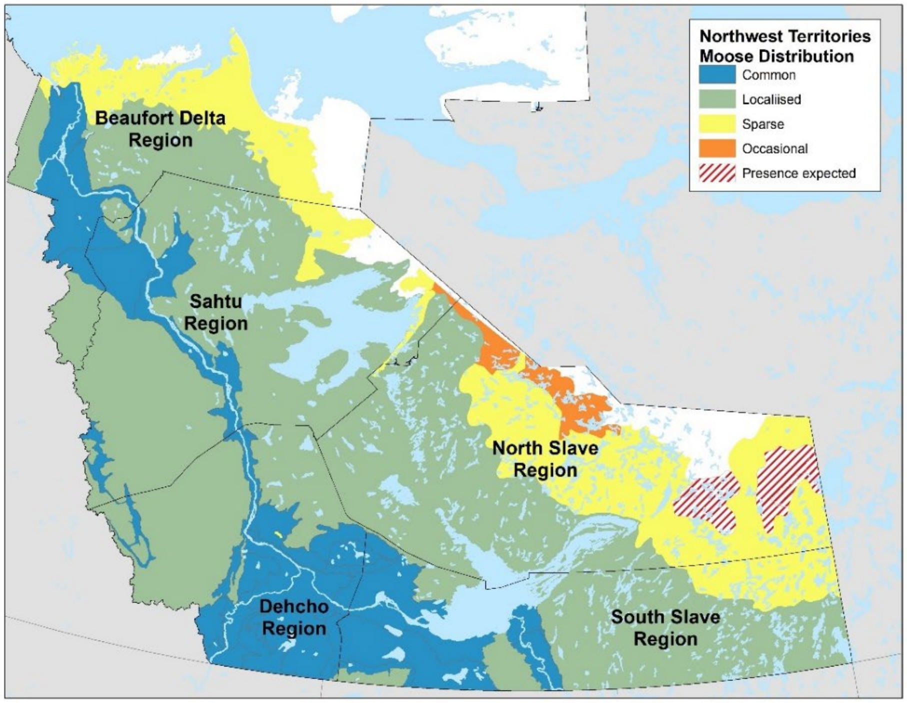

Figure 2. Distribution of moose in the NWT (adapted from the Ecosystem Classification Group (2007, 2008, 2010, 2012).

The current range of moose in the NWT is close to 1 million km^2, and for practical reasons is defined as the total area of NWT level IV ecoregions where moose were observed (Ecosystem Classification Group 2007, 2008, 2010, 2012; Figure 2).

The extent of occurrence in the NWT is 1,312,921 km^2 and was calculated using the range shown in Figure 2. Extent of occurrence of a species is defined as the area contained within the shortest continuous boundary drawn to encompass all the known, inferred or projected sites of present occurrence of that species (Species at Risk Committee 2015). This measure is the area of a convex polygon where no internal angle exceeds 180 degrees drawn around all sites of known, inferred or projected occurrence.

The biological area of occupancy is the total area of habitat occupied by moose in the NWT. As moose range widely and occupy a variety of habitats across the NWT, the biological area of occupancy was estimated as the area within the borders of the ecoregions in which moose are found. The biological area of occupancy is estimated at 996,087 km^2.

The index of area of occupancy is a measure that aims to provide an estimate of area of occupancy that is not dependent on scale and may be compared across taxonomic groups. The index of area of occupancy is measured as the area occupied by all moose based on a grid cell size of 2 km x 2 km. The index of area of occupancy for moose in the NWT is 1,007,556 km^2 or 251,899 grid cells.

Moose in the NWT are often considered to be composed of two distinct populations: those that inhabit the Mackenzie and Richardson Mountains, and those that inhabit the boreal, taiga, and tundra regions to the east. Moose found in the Mackenzie and Richardson mountains are larger in size than those found east of the mountains in the NWT (Larter and Allaire 2017) and are considered to be the *gigas* subspecies (CIMP 2012). Phenotypically they are as large as moose found in the Yukon and Alaska. Moose harvested in the Mackenzie Mountains are in the top 25 Boone and Crocket (n=1) or top 50 Safari Club International (n=3) record books (Larter et al. 2018a), however there is an absence of morphometric and genetic evidence to verify if or how far the *gigas* subspecies extends east from Alaska and the Yukon into the NWT.

Locations

When assessing status, the term location refers to a distinct area in which a single threatening event can rapidly impact all individuals present. The most significant plausible existing threat to moose is from harvest. For the purposes of wildlife harvesting, the NWT is divided into the six Wildlife Management Zones (WMZ), eight outfitter areas, and several other areas related to land claim settlements. However, at this time moose harvest regulations are the same in all areas so the entire NWT can be considered one location.

Search Effort

The distribution of moose in the NWT is reasonably well known from aerial population surveys for moose, from observations of moose during aerial surveys for other species, local and community knowledge and casual observations (CIMP 2012; ECC unpublished data).

Surveys to estimate moose densities have been conducted over a small portion of the NWT (Figure 3). In addition to the Government of the NWT (GNWT) population surveys, some environmental assessments and land use permit applications have conducted moose surveys in localized areas around resource development projects (e.g., Tyhee NWT Corp 2011 pp 216-230). Surveys for other species such as bison, muskox, woodland caribou and barren-ground caribou record observations of moose. These sources provide evidence that moose occur within the study areas but usually do not have enough observation to estimate moose abundance or trends (Golder Associates 2014).

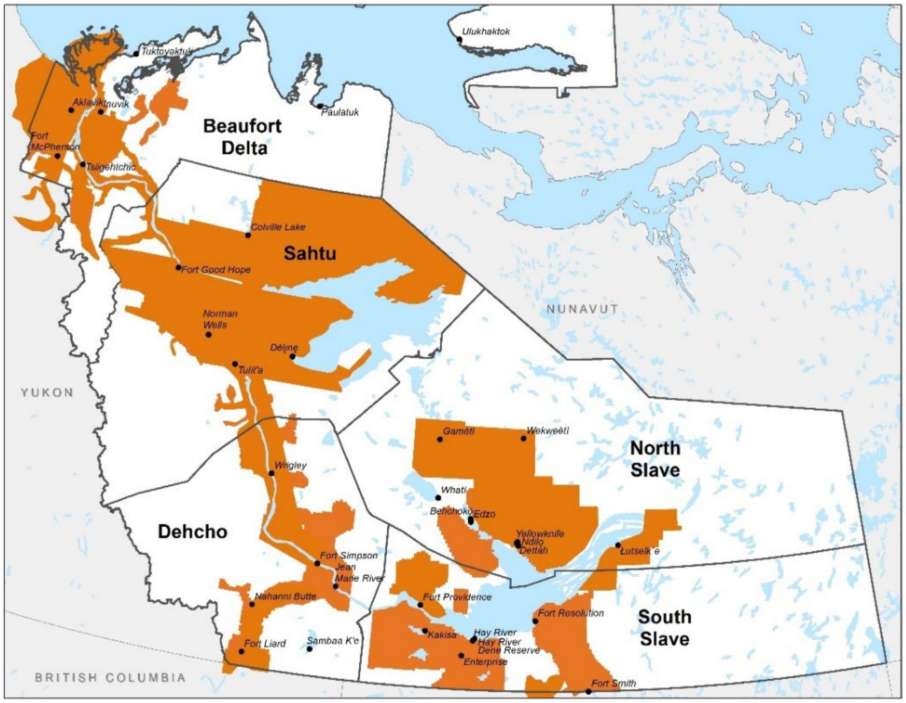

Figure 3. Areas surveyed for moose in the NWT, 1980-2021.

Aerial surveys for moose were conducted as early as the 1950s by the Canadian Wildlife Service (Flook 1953; Flook and Bryant 1957), and in the 1960s by NWT Game Management (Colosimo 1968). During the 1970s through early 1980s many surveys were flown throughout the NWT to assess moose abundance in important harvesting areas and where resource- or road developments were proposed. By the mid-1980s moose surveys in the NWT had become more rigorous and followed the same methods as those used in Alaska which became the standard practice throughout North America (Graf 1992).

The GNWT's Department of Environment and Climate Change (ECC) has been conducting aerial population surveys for a variety of species since the 1970s (Hawley and Antoniak 1983). Moose surveys have been designed specifically to estimate density and abundance, as well as age- and sex ratios. Observations of moose are also recorded on aerial surveys for other species and ECC receives moose observations from wildlife surveys associated with environmental assessments, land use permit applications (e.g., Tyhee NWT Corp 2011 pp 216-230), and casual observations. All georeferenced observations are stored in the Wildlife Management Information System (WMIS) and all of these sources were used to determine moose distribution in the NWT (Figure 2).

Surveys designed specifically to estimate moose density and population characteristics have covered <50% of moose range in NWT (Figure 3). Those conducted from 1980-2000 were mostly constrained to river corridors (Figure 4). Over the past two decades the amount of area surveyed (Figure 5) and the frequency with which the same area is surveyed has increased.

Currently, the two most commonly used survey designs to estimate moose abundance in the NWT are the Gasaway (Gasaway et al. 1986) and the geospatial (which uses finite population block kriging) methods (ver Hoef 2002; Kellie and DeLong 2006). Cluff (2016) used distance sampling to estimate moose abundance in the North Slave Region (Cluff 2016) and other surveys have used distance sampling techniques (Buckland et al. 2001, Armstrong and Boulanger 2016). A survey conducted in the Sahtú in March 2020 used distance sampling to estimate muskox and moose densities (GNWT 2021).

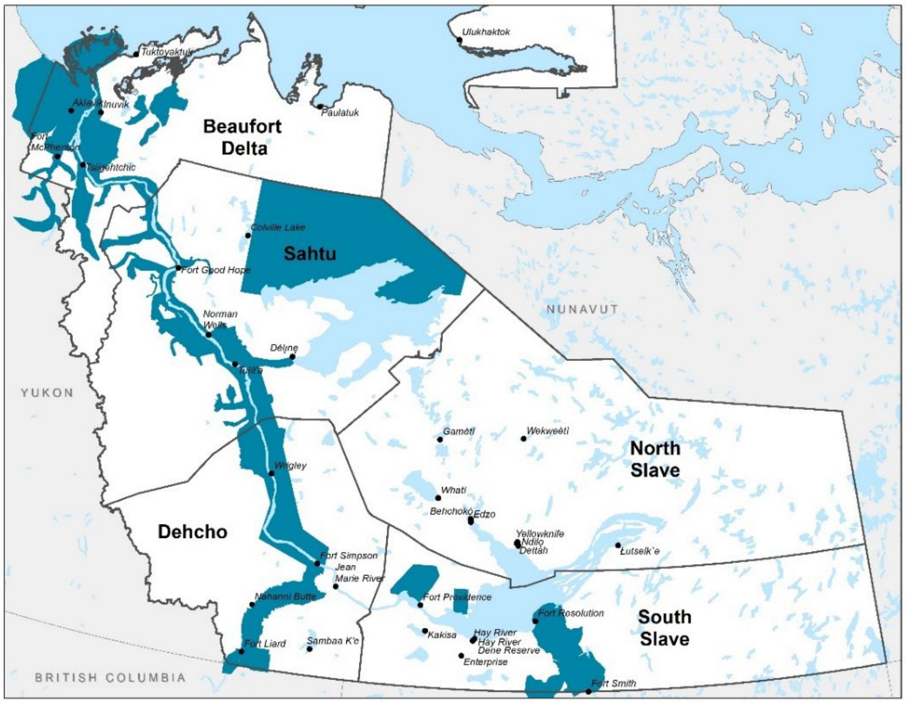

Figure 4. Areas surveyed for moose in the NWT, 1980-2000.

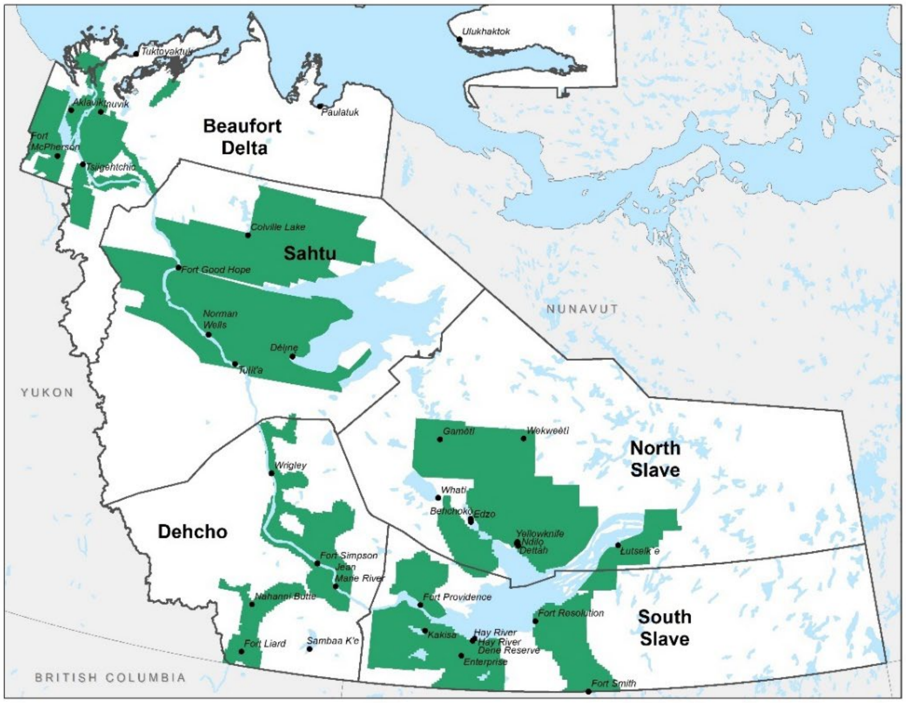

Figure 5. Areas surveyed for moose in the NWT, 2001-2022.

A more detailed description of moose surveys conducted in the different regions follows.

Beaufort Delta Region

The Canadian Wildlife Service conducted moose surveys in the northern Mackenzie District (Upper Mackenzie and lower Delta areas) in 1954, 1955 and 1956 (Flook and Bryant 1957). Strong (1973) and Hunter (1975) conducted surveys in the Arctic Red River area. In 1980, Brackett et al. (1985) conducted a survey of the Mackenzie Delta and lower Mackenzie Valley. Surveys were conducted in the northern Richardson Mountains by the Yukon Territorial Government during the 1980s (Smits 1991), in 2000 (Cooley 2000), and again in 2013 (Yukon Territorial Government unpublished data; Figure 6).

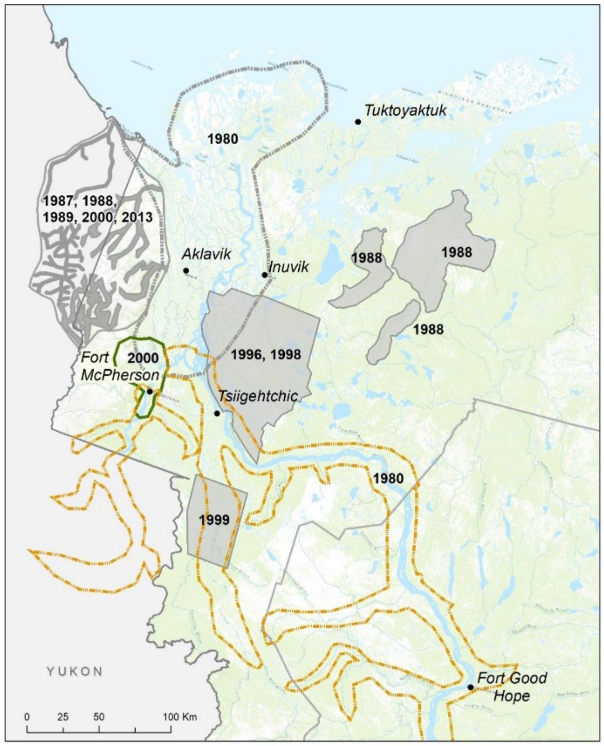

Figure 6. Beaufort Delta region moose survey study areas and years surveyed, 1980-2000. The Yukon Territorial Government surveyed the North Slope study area (west of Aklavik) 1987-2000 and 2013. The 1980 survey of the Mackenzie Delta, Mackenzie River and its tributaries was for a proposed gas pipeline.

In 1986, the Rengleng River area was surveyed (Stenhouse and Kutney unpublished data cited in Graf 1992). The Inuvik-Tsiigehtchic and the Arctic Red River (Tsiigehtchic) areas were surveyed in 1996-1998 (Benn 1999, Chetkiewicz et al. 1998, Marshal 1999; Figure 6). The Fort McPherson area was surveyed in 2000 (Benn and Firth 2001; Figure 6).

A survey conducted in the Gwich'in Settlement Area in March of 2006 covered areas that had previously been surveyed and was used to compare densities over time (Lambert 2006). In 2011 a large survey area (~ 22,300 km^2) delineated into eight blocks was surveyed using the geospatial method and Gasaway estimator (Davison and Callaghan 2013; Figure 7). A 2017 survey employed the same methods and covered much of the same areas studied in 2011 (Davison and Callaghan 2019). Although not all the same areas were flown in both surveys–areas were adjusted based on community requests–a reanalysis of the 2011 survey provides a comparison of the results from similar areas.

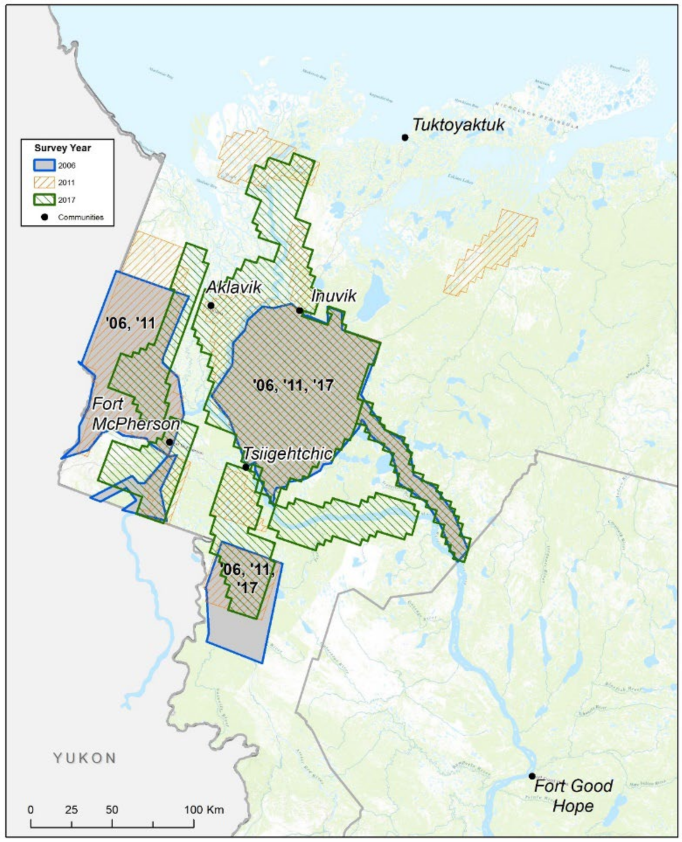

Figure 7. Beaufort Delta region moose survey study areas and years surveyed, 2006-2017. The 2006 survey area is outlined in blue (Lambert 2006), the 2011 survey in brown (Davison and Callaghan 2013) and the 2017 survey is outlined in green (Davison and Callaghan 2019).

Most of the northern and eastern parts of the region are classified as tundra (Ecosystem Classification Group 2012) and much of the northern part of this region has not been surveyed to estimate moose abundance in over 30 years; the eastern part has never been surveyed for moose. Even though there has been an increasing number of observations of moose on the tundra, they are still at low densities and currently there are no plans to estimate moose abundance there.

Sahtú Region

The Canadian Wildlife Service conducted surveys in December 1953 between Great Bear Lake and the Mackenzie River and March 1956 along the Mackenzie River Valley (Flook and Bryant 1957). In 1980, Brackett et al. (1985) surveyed the Mackenzie River and its tributaries north from the Keele River up to and including the Mackenzie Delta (Figures 6, 8) followed by a 1982 survey of the proposed pipeline route from Fort Simson to Norman Wells (Geddes and Duncan 1982).

Most surveys (Figure 8) were limited to small study areas along the Mackenzie River and the lower reaches of tributaries flowing from the Mackenzie Mountains, such as the Keele and Redstone rivers (Jingfors et al. 1987a, Latour 1992a, MacLean 1994a, Veitch et al. 1995, Veitch 1998, Swallow et al. 2003). Apart from a 2,910 km^2 study area west of Norman Wells, which was surveyed three times, only a few areas have been surveyed more than once (Figure 8) and cover only a small portion of the region.

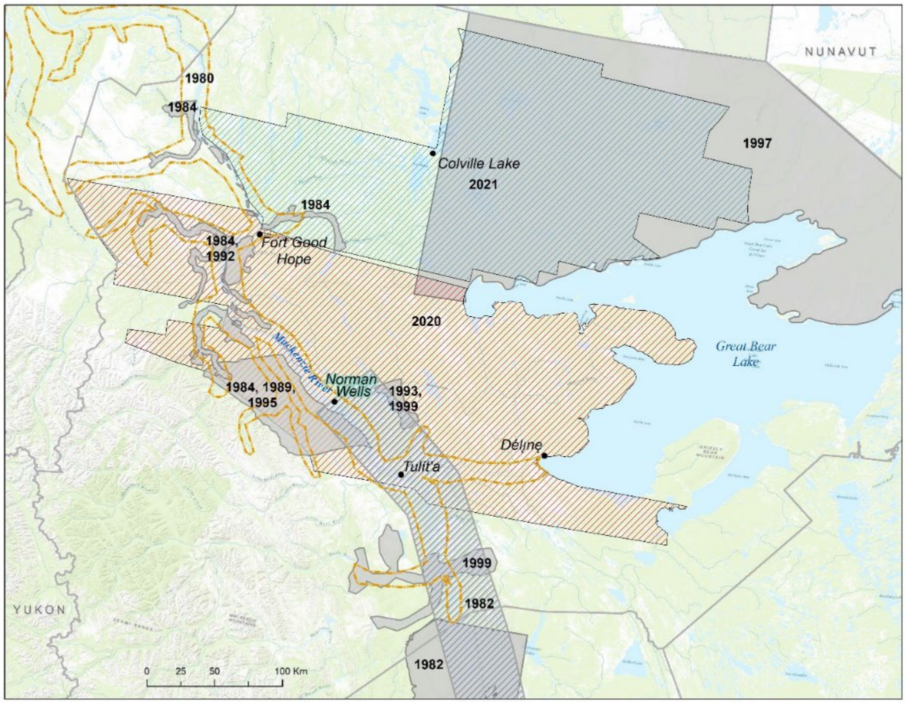

Figure 8. Sahtú region moose survey study areas and years surveyed, 1982-2021. The 1980 and 1982 surveys of the Mackenzie River and its tributaries were for a proposed gas pipeline.

In March 2020, a line transect survey for muskox and moose covered a 55,228 km^2 area of the southern Sahtú (GNWT 2021; Figure 8) and estimated densities using distance sampling methods (Buckland et al. 2001). This was the first survey to estimate moose density in the Sahtú since 1999. The estimate of 1.4 moose/100 km^2 was orders of magnitude lower than surveys of much smaller study areas conducted over 20 years previously using the Gasaway technique (Gasaway et al. 1986). Veitch (1997) conducted a line transect survey for muskox over a 55,818 km^2 area north and east of Great Bear Lake toward the barrenlands (Figure 8). Using moose observations from this survey, he estimated 0.5 moose/100 km^2.

Dehcho Region

A 3,300 mi^2 (*ca.* 8,550 km^2) area bounded by the Mackenzie River, Liard River and the Nahanni range was surveyed for moose in January 1953 by the Canadian Wildlife Service (Flook 1953). This was the first recorded moose survey in the NWT and its results justified an increase in hunter harvest. Subsequent surveys were conducted in December 1953 and March 1956 to monitor the impact of harvest (Flook and Bryant 1957). The December survey also included the Mackenzie River Valley to Wrigley and Trout, Mills, Willow, Bulmer, Greasy, Fish, Keller, and Blackwater Lakes. Flook (1963) conducted a survey for big game, including moose, in the Mackenzie Mountains to assess the feasibility of outfitting in the area.

With the realignment of 449 km of the Canadian Arctic Gas Pipeline, a survey was conducted along the new route from the Petitot River north to the river between two mountains in 1975/1976 (Wooley and Wooley 1976). Other early surveys were conducted in response to the construction of the Liard highway in 1978/1979 (Decker and Mackenzie 1980; Donaldson and Fleck 1980) and resource development in 1982 down the proposed pipeline route from Fort Simpson to Norman Wells (Geddes and Duncan 1982; Figure 9).

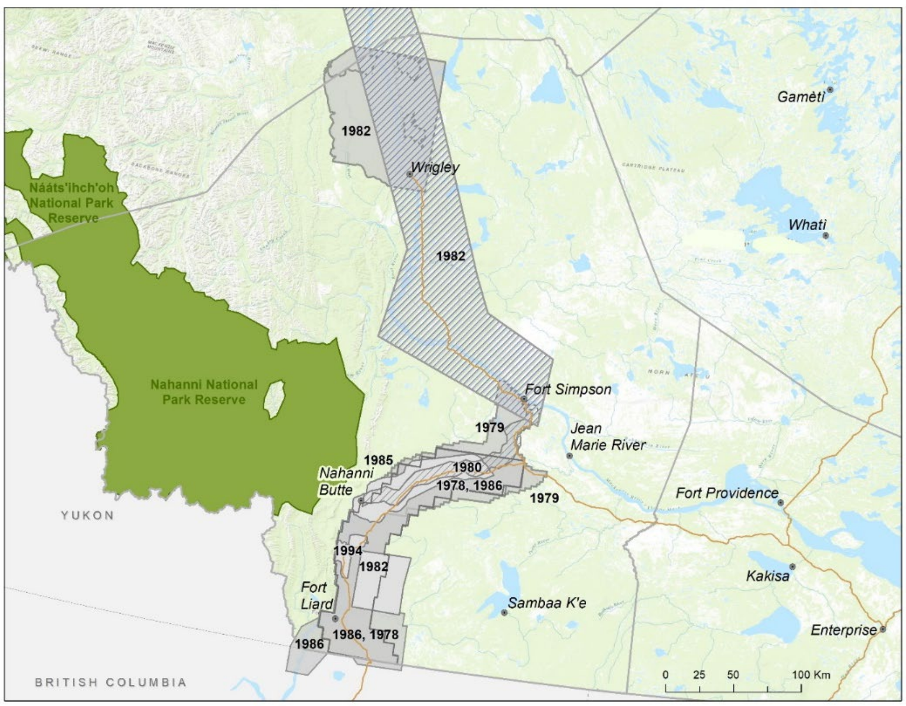

Figure 9. Locations and years of moose surveys in the Dehcho region, 1978-1994.

As part of an intensive Fort Smith region moose management program, surveys were conducted in the lower Liard and Wrigley areas in 1980, 1981 and 1982 (Hawley and Antoniak 1983), and again in the lower Liard in 1985 and 1986 (Case 1992). In 1994, an area near Flett Mountain was surveyed. Most surveys studied areas of significant size (2,000-7,500 km^2) and were designed to sample quadrats (Gasaway et al. 1986).

A long-term moose monitoring program for the Dehcho region initiated in the early 2000s created two large study areas: one in the Mackenzie River valley from Blackwater River in the north to Jean Marie River in the south (*ca.* 23,300 km^2), and the other in the Liard River valley from Poplar River in the north to the BC-NWT border in the south (*ca.* 9,100 km^2) (Figure 10;

Larter 2009). Large-scale geospatial surveys were conducted in both study areas in winters 2003/2004, 2011/2012, and 2017/2018 (Larter pers. comm. 2018a). The original survey area from 2003/2004 was modified slightly starting in 2011/2012. The area surveyed around Bulmer Lake was reduced, a small area in the Nahanni Park Reserve was omitted, and the survey was extended east along the Mackenzie River (Figure 10). The surveys in winter 2017/2018 were repeated, being flown in both November 2017 and February 2018. This was done to ensure the most accurate estimate of adults and to guard against a delayed winter affecting animal distribution especially in the Liard area.

Small-scale geospatial surveys were conducted in winters 2004/2005 through 2010/2011 and in 2013/2014 and 2015/2016. These surveys were much smaller studies focused on areas of community interest, within the bounds of the large survey study areas (Figure 10; Larter 2009).

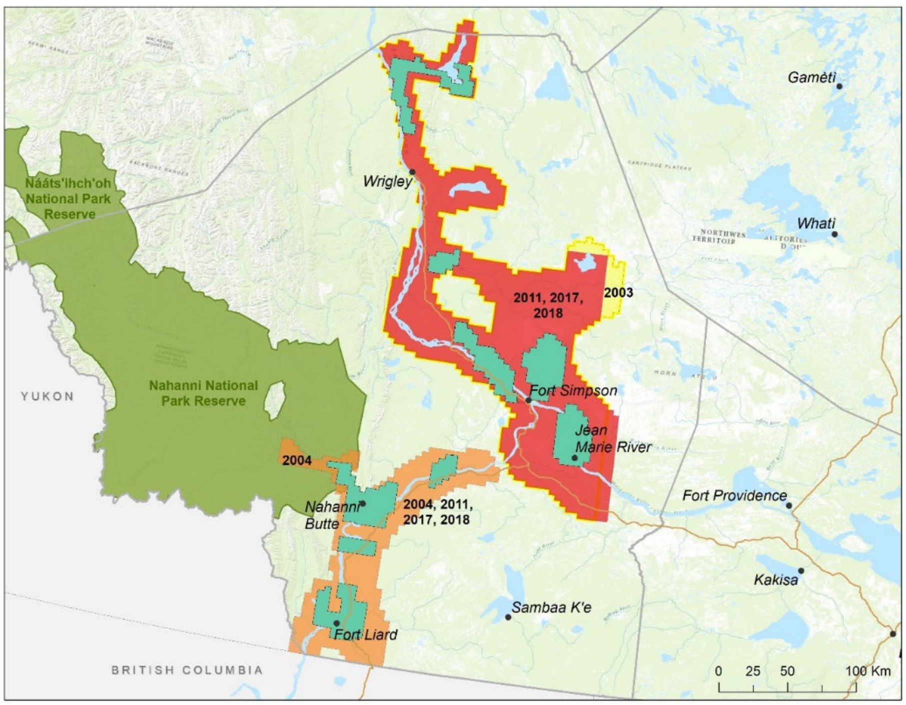

Figure 10. Locations and years of moose surveys in the Dehcho region, 2003-2018. Small scale surveys (nine teal-coloured blocks) were surveyed in 2004-2010, 2013 and 2015.

Although a substantial area of the Dehcho region has been surveyed for moose over the past 20 years, the Mackenzie Mountains and much of the east side of the region, including the Sambaa K'e area have not (Figures 9 and 10).

North Slave Region

Early surveys were conducted by Douglas (1962), Lines (1968) and Baker (1974) in the Yellowknife area and northwest. In 1979, as part of a moose management program, eight blocks of 125-140 km² were surveyed: four each in the Taiga Shield and Taiga Plains habitats (Treseder and Graf 1985).

In 1989, a moose survey was conducted over an approximately 3,500 km² area north of Yellowknife in the Taiga Shield. The survey was used as a test to evaluate whether satellite imagery could assist with block stratification to improve surveys (Case and Graf 1992).

In 2004, geospatial moose surveys were conducted in large areas of the Taiga Plains (6,700 km²) and Taiga Shield (17,585 km²) (Figure 11). The Taiga Plains study area was increased to 8,005 km² for 2007 and 2012. The Taiga Shield survey area included the 1989 survey area. Surveys were conducted in these same two areas in 2007 and 2012. In 2016, a much larger area of the Taiga Shield, including east of Łutsel K'e (58,274 km²), was surveyed using distance sampling. The 2016 survey covered the greatest area of any moose survey in the NWT even though an area of 10,920 km² was not surveyed due to inclement weather (Figure 11; Cluff 2016).

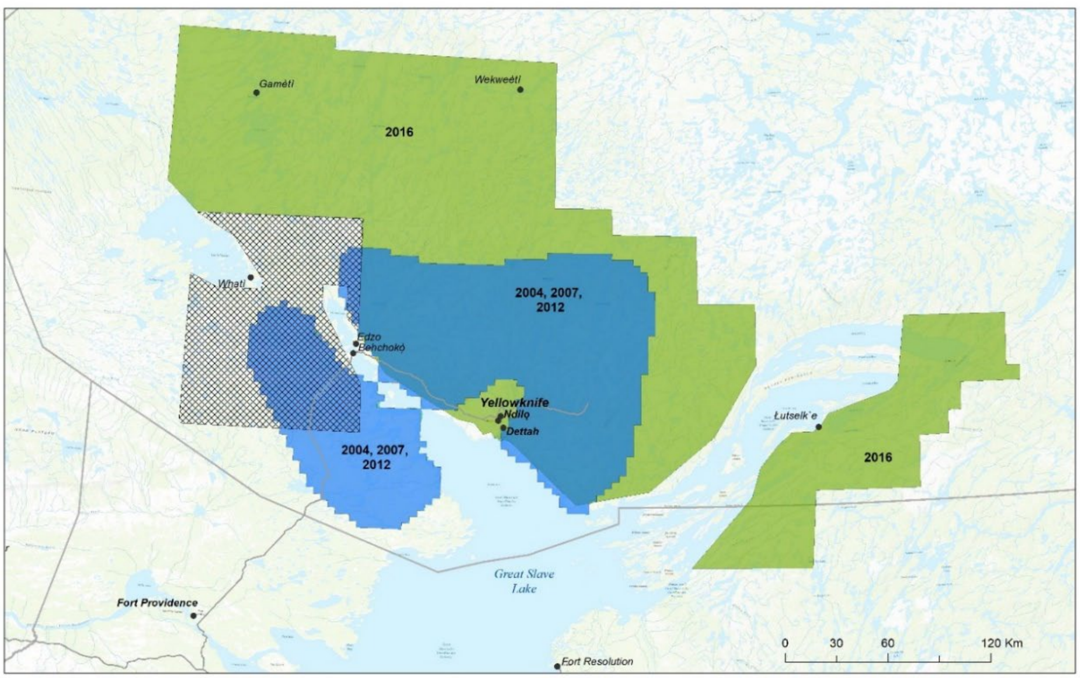

Figure 11. Locations of moose surveys in the North Slave Region, 2004-2019. Blue blocks were surveyed in 2004, 2007, and 2012; the Taiga Plains study area is the block to the west of Great Slave Lake and the Taiga Shield is north and east of the lake. The 2016 survey area is shown in green except the hatched area was not surveyed due to inclement weather (Cluff 2016).

South Slave Region

Many moose surveys have been conducted in different parts of the South Slave region from as early as the mid-1960s: the Slave River Lowlands (Kuyt 1963; Jacobson 1982; Treseder and Graf 1985), the Mackenzie Bison Sanctuary area (Malfair 1965; Rippin 1971a), the Hay River area (Colosimo 1968; Lines 1969; Chowns 1980) the Fort Smith area (Rippin 1971b; Manchur

1973) and the Pine Point area (Stewart 1980). Surveys during this period typically used the aerial, strip-transect method.

Surveys continued across the region during the 1980s and 1990s. Many surveys were conducted in the Slave River Lowlands (Hawley and Antoniak 1983, Treseder and Graf 1985, Graf and Case 1991 and 1992, Bradley et al. 1996, Bradley and Kearey 1998; Figure 12), and others were conducted in the Fort Providence-Mackenzie Bison Sanctuary area (Treseder and Graf 1985, Shank 1992, Bradley and Johnson 1998, Bradley et al. 1998; Figure 13). Surveys during this period generally used quadrat sampling and the Gasaway method (Gasaway et al. 1986). Survey areas varied in time and location, often only providing point estimates, however, in some areas inferences were made about trends in abundance.

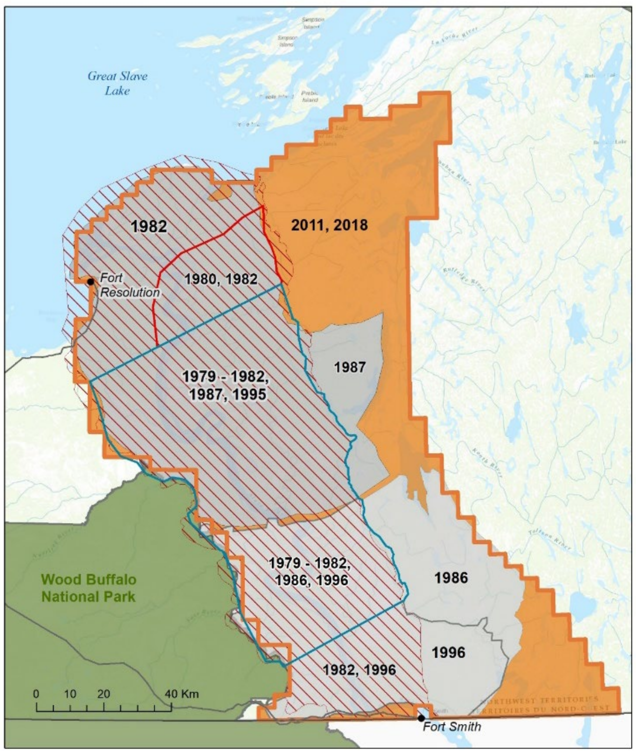

Figure 12. Moose surveys in the Slave River Lowlands area, 1979-2018. The survey area (in brown) was enlarged in 2011 to include the Slave Plain (Taiga Shield Mid-Boreal) ecological region.

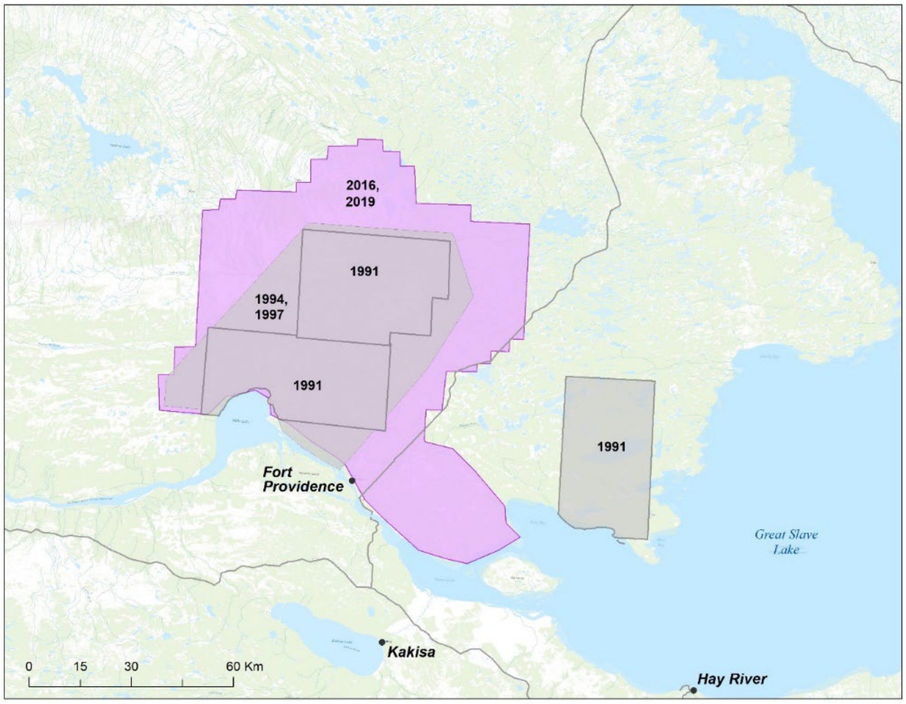

Figure 13. Moose surveys in the Fort Providence area, 1991-2019.

Since 2000, moose survey methodology has generally changed to the geospatial technique (ver Hoef 2002). These surveys tend to cover larger areas and have been used for repeatable studies of important areas of moose range in the region such as the Slave River Lowlands and adjacent Taiga Shield (Figure 12; ECC unpublished data), the Fort Providence area (Figure 13; Kelly and Cox 2017a, Kelly pers. comm. 2019) and Buffalo Lake and Kakisa areas (Figure 14; Kelly and Cox 2017b, Kelly and Parker 2020 pers. comm., ECC unpublished data).

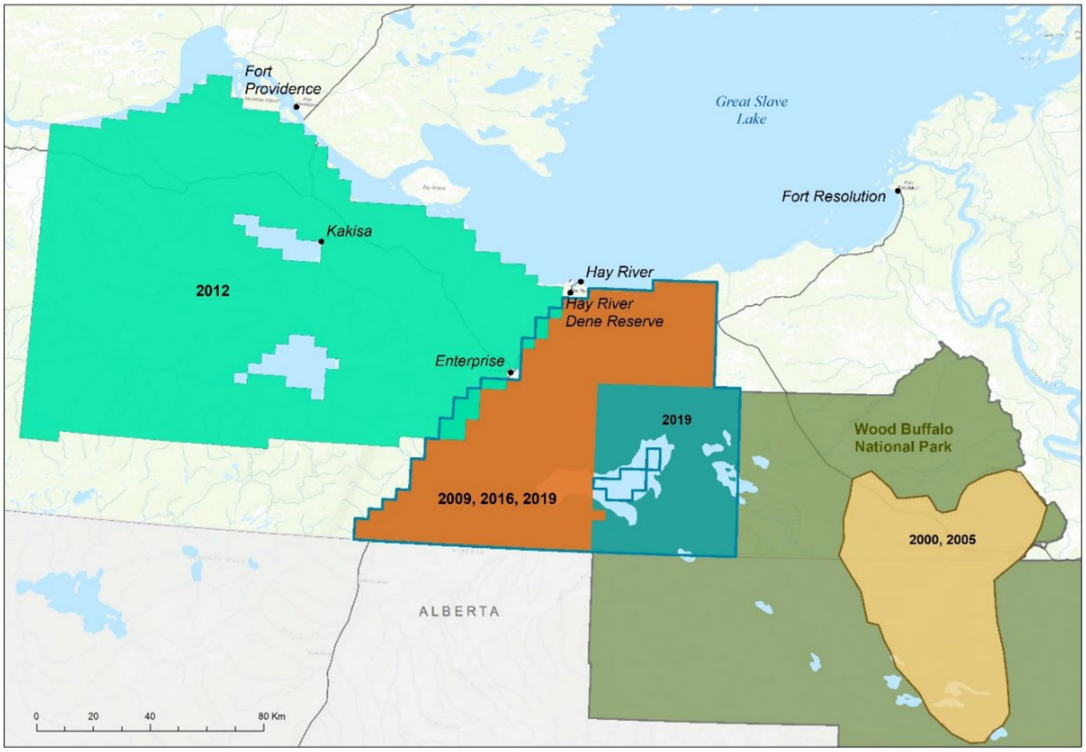

Figure 14. Moose surveys in the areas of Kakisa, Buffalo Lake and Wood Buffalo National Park (WBNP) 2009-2019. The 2019 Buffalo Lake survey area included the original area, in brown, and the northwest corner of WBNP, in teal. Two survey areas from southern WBNP were completely in Alberta and not included on this map.

There has been a substantial amount of both historical and more recent (2009 to present) survey activity covering much of the western half of the South Slave Region (Figure 14). The surveyed areas fall almost exclusively in the Taiga Plains ecoregion. To date surveys have been conducted in only a small area of the Taiga Shield ecoregion east of the Slave River Lowlands (Figure 12).

Biology and Behaviour

Habitat Requirements

Habitat requirements for moose in the NWT have not been studied specifically, but it is likely that general descriptions of habitat requirements elsewhere in North America apply here.

The full range of moose habitats includes boreal forest, mixed wood forest, large delta flood plains as well as tundra and subalpine shrub areas and stream valleys (Telfer 1984). The dynamics of the boreal forest are controlled by wildfire and because of this the mosaic of habitats represents the major environments in which moose evolved (Peterson 1955, Kelsall and Telfer 1974).

In the NWT, moose occur primarily in boreal and mixed forests and alpine valleys of the Mackenzie and Richardson Mountains, but also occur in willow-rich riparian areas of the tundra

(Telfer 1984, Franzmann and Schwartz 1997) and have been observed well above treeline near the Arctic coast.

Habitat selection can vary temporally. Moose may select mature coniferous forests in winter for thermoregulation (Dussault et al. 2004) or to avoid deep snow (Franzmann et al. 2007) and different habitats may be selected during the calving season or the rut. Habitat patch diversity is important for seasonal habitat selection. In general, moose follow a seasonal pattern of habitat selection that begins in open upland and aquatic areas for quality forage in the spring, moving into areas of closed canopy in the summer, then in early winter back into open areas with high shrub concentration, and finally into areas of mature forest during the winter for protection from predators and for access to better forage and less snow (Franzmann and Schwartz 1997).

In the taiga and tundra portions of the NWT, habitats where moose are most likely to be found include spruce forest, creek bottoms, burned areas, willow- or alder-dominated landscapes, and cutlines (Latour 1992b). These locations provide quality forage, fresh water, and shelter from predators or extreme temperatures (Peterson 1955, Allen et al. 1987, Eastman and Ritcey 1987, Joyal 1987, Thompson and Euler 1987). Quality forage for moose primarily consists of woody browse, including willow (*Salix* spp.), aspen (*Populus tremuloides*), and birch (*Betula papyrifera*) (Franzmann and Schwartz 1997).

Moose are not uniformly distributed across the landscape in the cordillera regions due to extensive bedrock barrens and permanent ice. Here, moose tend to be concentrated in the valleys and, at certain seasons, in alpine areas with stands of willows (Ecosystem Classification Group 2010, McCulley et al. 2017a).

Moose populations increase in response to new growth of shrubs and other forage following wildfires, flooding, or other disturbances that reset plant community succession to early seral stages (Swallow et al. 2003). The optimal successional stage for moose varies among sites and depends on conditions such as soil, moisture, aspect, elevation, and original vegetation type (Morgan et al. 2016), but forest stands ten to 25 years post burn generally provide prime habitat.

Mature coniferous forests provide shelter from deep snow and extreme temperatures, as well as protection from predators. The coniferous tree canopy intercepts falling snow which reduces depth of snow on the ground allowing moose to move and find forage more easily (Coady 1974, Peterson and Allen 1974, Poliquin et al. 1977, Welsh et al. 1980, Veitch et al. 1995).

Although moose are well-adapted to move through snow, excessively deep snow hinders movements, which increases energy expenditure and limits access to food. In northwestern BC, areas with snow depths exceeding 70 cm for longer than two weeks were found to be unsuitable for moose (Ardea Biological Consulting 2004). In a general review of moose in North America, Timmermann and McNicol (1988) observed that mobility was restricted when depths exceeded

65 cm and depths >90 cm were considered critical. Franzmann and Schwartz (1997) reported that snow depths exceeding 71 cm resulted in impaired mobility. In the boreal forests of the NWT's Dehcho region mean February snow depths were only occasionally 70 cm or more (Larter et al. 2017a).

It is hard to tell how often moose make use of closed forests because it is difficult to spot them or their tracks due to the dense canopy (Veitch et al. 1995), however numerous studies have found that moose move into closed canopy habitats as winter progresses in many areas of North America (Peek 1997, p. 362). The ideal forest age for moose winter habitat is between ten- and 25-years post-fire (Veitch et al. 1995, Veitch 1998, CIMP 2012).

Flood plains and deltas may have abundant forage for moose because flooding and ice scouring frequently disturb plant communities, keeping habitats in early successional stages, and deciduous shrubs (especially willows) grow well near waterways. Examples of this can be found in numerous areas along the Mackenzie and Liard Rivers and their many tributaries and islands. During late winter, moose have been observed on islands kept snow-free by the wind. Aquatic feeding areas provide forage high in protein and sodium (Jordan et al. 1973, Jordan 1987), which helps moose to replenish their body weight after the winter. Access to this kind of fresh forage is so important that it influences spring movements of moose throughout their range (Schwartz et al. 1987, Franzmann and Schwartz 1997). Aquatic areas may also be used to minimize heat stress during the summer (see *Physiology and Adaptability*). Moose move into areas with lakes, streams, and ponds, as well as young forest stands throughout the summer and into the fall for forage and relief from heat (Crête 1977, Telfer 1978, Joyal 1987, Sæther and Andersen 1990).

In late May to early June, females choose calving locations that will protect and hide their calves. These tend to be areas with a low density of other moose, but with shelter and food for the small calves, and may include timber stands, clear-cut areas, islands, or peninsulas (Jackson et al. 1991).

Moose, especially males, tend to cluster in open habitats with large quantities of shrubs after the rut and in early winter when the snow is still shallow (Franzmann and Schwartz 1997). Groups as large as 20, and density estimates as high as 35 moose/100 km^2 in some small areas were observed during an early November survey north of Fort Liard (ECC unpublished data).

Movements

Moose move throughout the year their movements are influenced by the reproductive cycle, snow depth, cover, forage, and predator avoidance. Movement rates vary by season, age, sex, size, and nutritional and energy requirements (McCulley et al. 2017a). Moose move the most during the rut and summer and least in late winter (Garner and Porter 1990). In the Yukon, the range between low and high periods of movement is between 2.8-3.3 km/day. The greater movement in the rut, especially by males, is related to the search for mates. Increased movement in summer is related to the search for aquatic vegetation (Joyal and Scherrer 1978) or mineral licks (Tankersley and Gasaway 1983). Dramatically reduced movements in winter, especially by large males, is related to energy conservation and the influence of deep snow (Coady 1974, Miquelle et al. 1992, McCulley et al. 2017a).

Moose in some populations are known to migrate, i.e., make seasonal movements between habitats, and these often involve changes in elevation (e.g., Demarchi 2003, Cooley et al. 2019). In the cordillera area of the NWT, moose tend to move across elevation gradients in response to changing weather conditions and snow depth. Moose were found at their highest elevations during the rut and early winter. They moved lower to avoid deep snow as winter progressed and stayed at low elevations through early spring when vegetation began growing again (Smits 1991, McCulley et al. 2017a). In the Taiga Plains, female moose have been observed to move to large islands in the Mackenzie and Liard rivers to calve during spring break-up in order to avoid predation (Decker and Mackenzie 1980, Geddes and Duncan 1982, Ecosystem Classification Group 2010).

Movements of moose in the NWT may be impeded by deep snow, large lakes, and bedrock barrens and permanent ice in the cordillera (see *Habitat Fragmentation*) (Smits 1991, Johnson and Hayes 2003, Ecosystem Classification Group 2010, McCulley et al. 2017a). Beyond these, there are no significant natural or anthropogenic barriers to moose movement within the NWT. Moose may disperse long distances following disturbance events such as wildfire when cover and forage are initially removed (McCulley et al. 2017a). There are also reports of vagrancy in moose (Hoffman et al. 2006).

Life Cycle and Reproduction

Moose less than a year old are calves and are considered recruited into the population after surviving their first winter. Yearlings are 12-24 months of age, but females are classified as adults when they are sexually mature, typically between 16-28 months of age (Arsenault 2000). Males can reproduce as yearlings but are unlikely to do so, and are considered subadults until four years of age, when they become prime bulls (Arsenault 2000).

Maximum life expectancy across the continental distribution ranges from 20-27 years; mean life expectancy ranges between seven to eight years in hunted populations (Rea and Child 2007), and 12-15 years for males and 15-20 years for females in non-hunted populations (Arsenault 2000).

Moose harvested by non-residents in the Mackenzie Mountains from 2003-2018 were between three to 15 years old (mean 7.7 years, median 7.0 years, n=139, all male); the majority were five to nine years (Figure 15A; Larter et al. 2018a).

The range in age of moose harvested by Indigenous hunters in the Mackenzie and Liard River valleys from 2005-2016 was 0-12 years (mean 4.8 years, median 4.0 years, n=25) for females and 0-13 years (mean 3.2 years, median 2.0 years, n=54) for males (Figure 15B; Larter et al.

2018b, ECC unpublished data). Moose harvested by hunters in the South Slave region from 2009-2013 ranged from 0-12 years old (mean 4.5 years, median 4.0 years, n=9) for females and 0-8 (mean 3.5 years, median 3.5 years, n=18) for males (Figure 15C; ECC unpublished data). Unfortunately, the age distribution of the Indigenous harvest of 21 moose from the Sahtú is unavailable for comparison, but the average ages were relatively comparable, 3.9±0.6 (n=12) for females and 4.9±0.7 (n=9) for males.

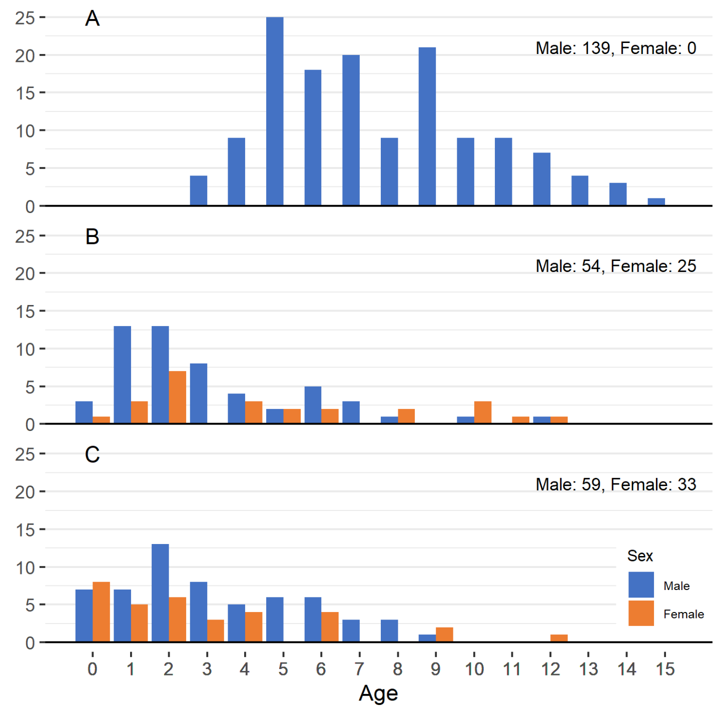

Figure 15. Age distribution of moose harvested in the NWT. (A) Moose harvested by non-resident hunters in the Mackenzie Mountains (2002-2017; n=139; ECC unpublished data), (B) by Indigenous hunters in the Dehcho Region (2005-2016; n=79; ECC unpublished data), and (C) by hunters in the South Slave Region (2009-2013; n=27; ECC unpublished data).

Life expectancy of moose in the NWT is likely similar to that of hunted populations elsewhere (seven to eight years, Rea and Child 2007). A study of radio collared moose in the NWT's Sahtú region found the generation time was about 6.9 years (Stenhouse et al. 1995). The life cycle of moose is rapid compared to other similar-sized ungulates due to their high reproductive output. It is believed that the high reproductive output has evolved in response to the unpredictable environmental conditions of early successional habitats preferred by moose (Gaillard 2007).

The mating strategy of bull moose varies depending on the density of cows in the region. In high density areas, male moose adopt a harem strategy and attempt to attract and defend a group of females against competing males. In low density areas like the NWT, moose tend to form pairs, with the male staying with the female until mating has occurred (Arsenault 2000, Environment Yukon 2016). Following successful breeding, the male subsequently leaves and attempts to seek out another mate.

Female moose go into estrous during the fall rut. The first estrous cycle begins in early September and if not impregnated, females reabsorb the endometrium and cycle again. The time between estrous cycles ranges from 22-28 days and may continue from early September until late November or early December, but the peak of the rut is the last week of September or first week of October (Arsenault 2000, Environment Yukon 2016).

The average gestation period is 231 days (range = 216-240 days; Arsenault 2000). The calving period has not been documented for moose in the NWT, but in Yukon the median date for calving is 25 May (Environment Yukon 2016). In Denali National Park, Alaska, calving was highly synchronous with the mean date of birth 25 May (SD 5.7 days) over a four-year period and 95% of births occurred within a 16-day period (Bowyer et al. 1998). In SK, calves are generally born between mid-May and early June and female moose typically produce one or two calves each year (Arsenault 2000).

Calves are entirely dependent on their mothers' milk during the time immediately after birth, gradually transitioning to forage over the summer. By late August they are foraging entirely on solid foods (Arsenault 2000) and are weaned in the fall (Schwartz 1997), but calves remain with their dam for their first year. Females usually breed for the first time as two-year-olds (28 months), but they may breed as yearlings if they are in particularly good health.

Although twinning is common, twinning rates vary widely across North America and are thought to be correlated with habitat quality and environmental carrying capacity (Gasaway et al. 1992). Franzmann and Schwartz (1985) documented a 70% twinning rate for moose in highly productive, recent burnt habitat versus 22% in an older burn. They also reported a moose with triplets. In the NWT, twinning rates, reported as the proportion of females with twins out of the total number of females observed, was documented from 45 surveys conducted from 1984-2020 and ranged from 0-47% (Appendix A). Most of the higher twinning rates (>10%) were reported from surveys conducted in the 1980s and 1990s. A study in the 1990s that followed 30 radio collared females over a four-year period documented an average annual twinning rate of 32% (range 25-36%) (Stenhouse et al. 1995). This is the only instance where the twinning rate was derived from known individuals over multiple years. Twinning rates for moose in interior Alaska ranged from 0-47% from 1960-2005. In all years when the twinning rate was >30%, there was active wolf control (Boertje et al. 2010). Pimlott (1959) summarized North American data and reported 5-28% twinning rates. In three regions in Sweden twinning rate ranged from 17-63% (Markgren 1982). Twinning rates in NWT would appear to fall within the range of those found for moose elsewhere. There have been no reported triplets in the NWT, unlike in Alaska (Franzmann and Schwartz 1985; Bowyer et al. 1998).

The age- and sex class composition of moose populations in the NWT is not well known due to the difficulty of accurately differentiating between calves and yearlings and between females and antlerless males in aerial surveys conducted in February and March. Late-winter surveys often do not report ratio data because of this uncertainty. However, calves can be distinguished from adults even in late winter and the number of calves:100 cows derived from survey data can be used to estimate recruitment. A ratio of 25 calves per 100 cows is the benchmark minimum for a sustainable, unharvested population in British Columbia (Ministry of Forests, Lands and Natural Resource Operations 2015).

Most surveys (76%, *n* = 50) in the NWT between 1984-2019 reported from 30-65 calves:100 cows, well above the benchmark used by BC for sustainable moose populations. Only two surveys reported a ratio less than the benchmark ratio for sustainable populations (of 25 calves:100 cows). Nine small-scale geospatial surveys were conducted in November over a 12-year period in the same survey area along the Mackenzie and Liard River valleys as part of a moose monitoring program (Larter 2009; ECC unpublished data). The ratio of calves:100 cows ranged from 30-50 for this hunted population and the trend was relatively stable over that time (Figure 16), similar to values from larger surveys in 2003/2004, 2011/2012 and 2017/2018 (see *Population Abundance*). Calf ratios reported for the Taiga Shield in the NWT (range 41-77) were substantially higher than the 16-23 reported for moose in SK's boreal shield (McLoughlin et al. 2019), however the SK survey was conducted in February-March, so moose had been subject to three months more predation than those in the NWT survey.

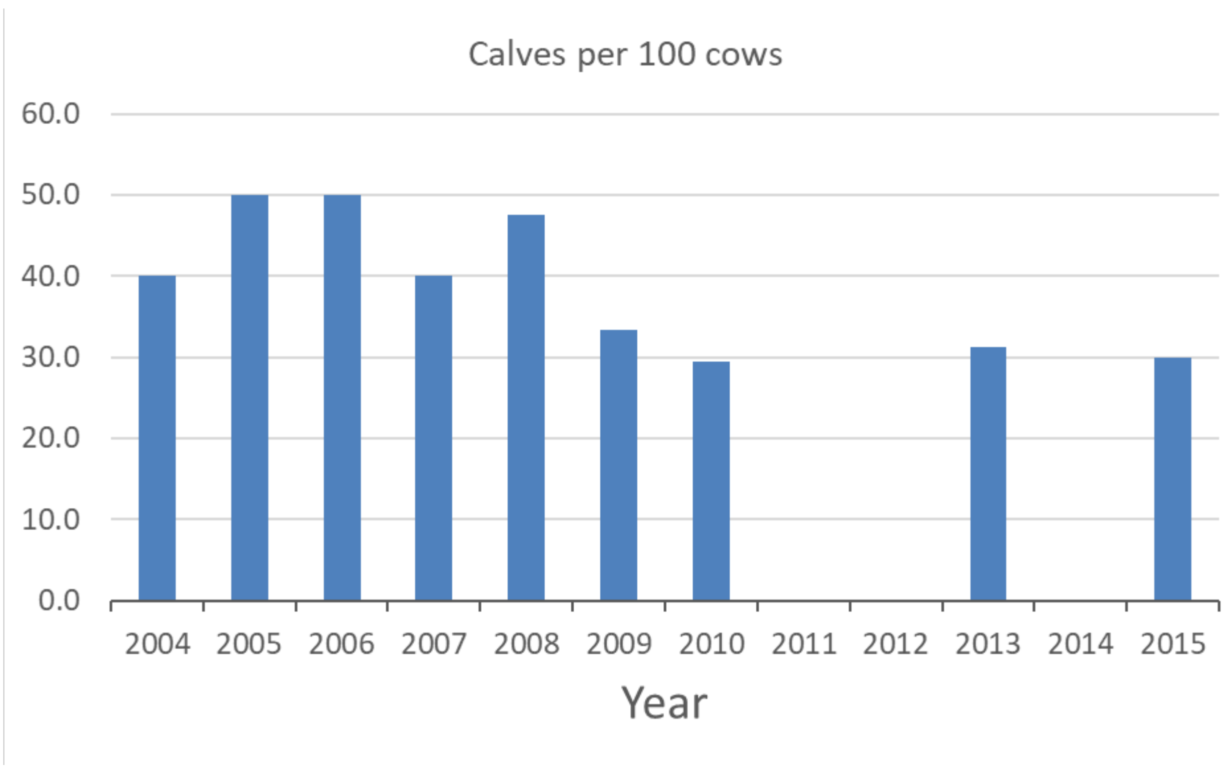

Figure 16. The ratio of calves to adult female moose reported for nine small-scale geospatial surveys in the Dehcho region. Surveys were conducted in November along the Mackenzie River and Liard River valleys between 2004 and 2015 (ECC unpublished data).

Hunters' observations of moose in the Mackenzie Mountains have been recorded annually from 1995-2017. Although ground-based, hunter observation data of large mammals has its inherent weaknesses and assumptions (Larter 2012), when collected in a similar way over an extended period of time, these data can be used to explore various demographic parameters that may otherwise be unknown and have been used to assess northern mountain caribou populations in the Mackenzie Mountains (Larter 2012 and 2018b). On average, 13% of moose observed in the fall were calves, there were 30.4 calves:100 cows, and 104 bulls:100 cows over the 22-year period of the study (Figure 17).

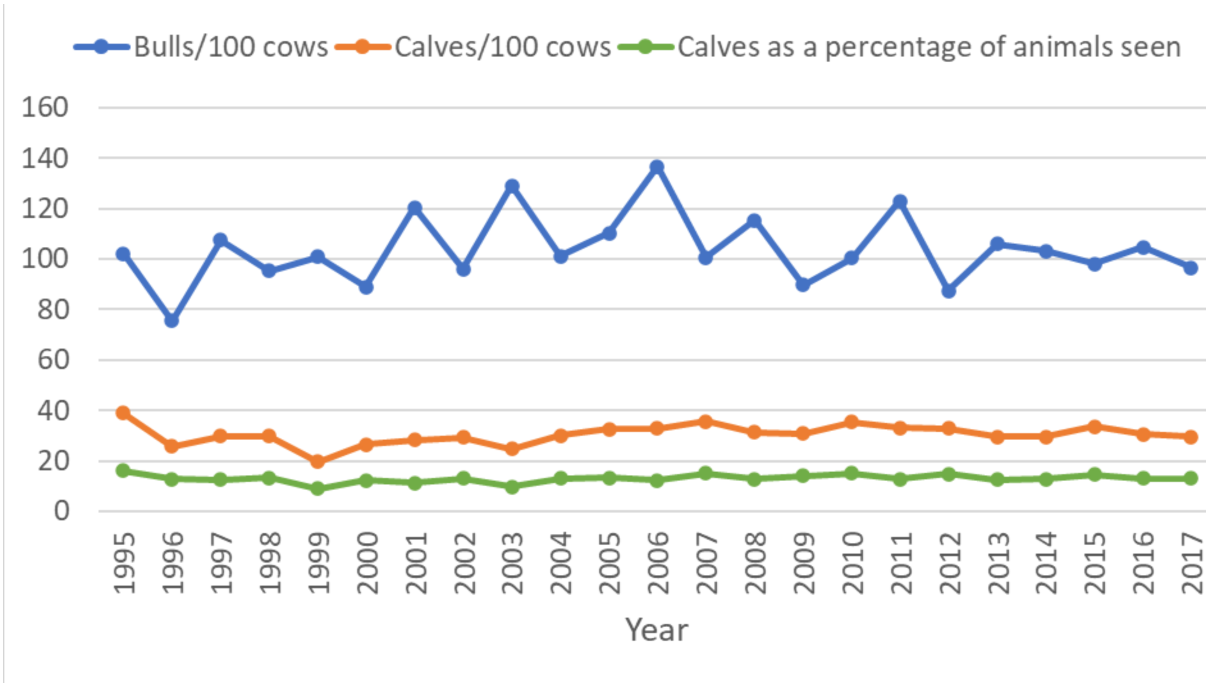

Figure 17. Ratio of calves and adult males to cows observed in the Mackenzie Mountains. Observations were made from the ground between mid-July and mid-October by non-resident hunters, 1995-2017 (ECC unpublished data).

The ratio of males to adult females can vary greatly in moose, even in populations that are not hunted (Environment Yukon 2016). This ratio is used by moose managers to trigger management actions related to sex-biased harvest. The Yukon uses 30 males:100 females as a threshold where harvest restrictions are invoked to ensure that there enough males to maintain adequate breeding success (Environment Yukon 2016). In BC, the threshold is 30 males:100 females in areas of high density moose populations and a 50 males:100 females in areas of low density moose populations (Ministry of Forests, Lands and Natural Resource Operations 2015).

The ratio of males to adult females estimated from surveys in the NWT between 1984-2019 has varied widely (range 25.5-205 males:100 adult females, Appendix A). Numerous surveys reported as many or more males observed as females (34%, n = 51), but small sample sizes may have been a factor in seven reports where the ratio was >150. Only 2/51 surveys reported a ratio below the thresholds used by Yukon and BC to trigger harvest management. Ratios reported for the Taiga Shield (mean 61.8, range 41-77 males:100 females) was higher than the 57.1 (95% CI: 44.4-69.9) reported from the Boreal Shield in SK (McLoughlin et al. 2019). The mean of 104 males:100 adult females reported for moose in the Mackenzie Mountains (Figure 17) may be biased because hunters there are searching specifically for males, but it is well above the 30 males:100 females threshold of other jurisdictions. It is unlikely that local or regional moose populations in the NWT were in danger of not having enough breeding males.

Physiology and Adaptability

Moose are well adapted to the conditions in the boreal forest, including a variety of forest successional stages and climatic conditions (Ecosystem Classification Group 2007, 2010 and 2012, CIMP 2012). The moose is a large-bodied ruminant and generalist browser especially adapted to feeding on their most common foods: willows (*Salix* spp.), paper birch (*Betula papyrifera*) and aspen (*Populus* spp.) (Renecker and Schwartz 1997). Their digestive system is well suited to their habit of selecting foods that are high in cell-soluble sugars, which are easily digested in the rumen, and high in lignin but low in cellulose (fiber) (Renecker and Schwartz 1997). Timmermann and McNicol (1988) reported that a 425 kg moose with a basal metabolic rate of 6,550 kcal/day would require a dietary intake of 11,000 kcal/day. Of course, energy requirements and expenditures vary with season. There was much research with "tame" moose in the 1980s at the Kenai Moose Research Center devoted to nutrition and energetics (e.g., Regelin et al. 1981 and 1985). The findings of studies in Alaska and elsewhere on moose nutritional requirements and energetics are most likely applicable to moose in the NWT.

As evidenced by their wide range and occurrence in mixed grasslands, aspen parklands, open tundra and desert scrublands, moose are able to withstand a wide variety of climatic conditions, but in particular, extreme cold weather (Smits 1991, McCulley et al. 2017b). Moose are primarily constrained by their relative inability to withstand heat, and their southern extent is largely defined by regions where temperatures do not exceed 27˚C for extended periods of time, and where adequate cover or shade is available (Timmermann and McNicol 1988, McGraw et al. 2012). During summer, moose respiration rates increase as temperatures rise above 14˚C, and open mouth panting begins when temperatures exceed 20˚C (Renecker and Hudson 1986). Moose can also experience heat stress in winter when moose begin to increase their respiration rate as temperatures exceed -5˚C with open mouth panting beginning at temperatures above -2.2˚C (Renecker and Hudson 1986).

With their long legs, moose can travel and forage in snow of moderate depths but are impeded by excessively deep snow. Snow depths >70 cm limit their access to food and cause moose to increase energy expenditure when moving (see *Movements*). The moose's long legs make it easy for them to step over obstacles such as shrubby willows and some fallen trees that may impede predators.

Interactions

Interactions with Predators

The major predators of moose in the NWT are wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), and black bears (*Ursus americanus*) (Veitch et al. 1995, Franzmann et al. 2007, McCulley et al. 2017b, Species at Risk Committee 2017). In systems where wolves, grizzly, and black bears co-exist with a light to moderate human harvest, moose populations exist at low density (Gasaway et al. 1992).

Wolves are present throughout the range of moose in the NWT, but the impact of predation on moose populations is unknown. In areas with additional alternate ungulate prey (e.g., boreal caribou, wood bison, elk, white-tailed deer, mule deer) wolf predation can have a different impact on alternate prey populations (e.g., Larter et al. 1994, Serrouya et al. 2017). In some parts of North America, wolf predation has been shown to constrain moose populations at low densities (Gasaway et al. 1992, Brown 2011) and experimental reductions of wolf populations in the Yukon resulted in increased moose densities through higher juvenile and adult survival rates (Hayes et al. 2003).

Grizzly bears occur in most of moose range in the NWT, and are absent only from the eastern, non-mountainous part of the Dehcho region, the southwestern third of the North Slave region and all but the northeastern-most portion of the South Slave region (Species at Risk Committee 2017). Moose calves are particularly susceptible to bear predation, with calves under two months old being at greatest risk (Bowyer et al. 1998, Environment Yukon 2016). Little is known about grizzly bear predation rates on moose in the NWT. Outfitters in the Mackenzie Mountains have noted intense predation by grizzlies on moose calves in higher elevation valleys and marked reductions in the ratio of calves to adult females from early summer to fall (Werner Aschbacher, pers. comm.). In Alaska, grizzly bears are a significant predator on moose calves accounting for as much as 73% of calf mortality (Ballard 1992, Ballard et al. 1981, Ballard et al. 1991). In Yukon, adult moose are at greatest risk of predation from grizzly bears during the rut period (McCulley et al. 2017b).

Little is known about black bear predation rates in the NWT, but in other regions, black bears have been observed to be an important predator of moose (Veitch et al. 1995). In certain parts of Alaska including the Kenai Peninsula and Koyukuk/Nortina National Wildlife Refuge, 35% and 40% of calves were killed by black bears (Franzmann et al. 1980, Osborne et al. 1991, Joly et al. 2015). Messier (1994) predicted that moose productivity and density may be diminished by bear-induced calf mortality.

Interactions with Humans

Moose are one of the most important sources of country food (Decker and Mackenzie 1980, RWED 2004) and one of the preferred prey species of harvesters in the NWT. Harvest occurs throughout moose range, but is more concentrated near communities, along roads, and the major river corridors of the Taiga Plains and Taiga Shield resulting in low densities in certain areas (Graf and Case 1991 and 1992, Johnson and Hayes 2003, Larter pers. comm. 2018a).

Data are limited on moose harvest by Indigenous hunters with little being publicly available in the NWT. In the Inuvialuit Settlement Region harvest of moose by Inuvialuit beneficiaries from 1988-1997 averaged 28 animals per year (Joint Secretariat 2003). The mean annual harvest by beneficiaries in the Gwich'in Settlement Area from 1995-2001 was 41 (Gwich'in Renewable Resources Board [GRRB] 2009). Data from the Sahtú harvest study remains confidential and unavailable to the public.

Non-resident hunters are permitted to harvest moose only in the Mackenzie Mountains and are restricted to harvesting bulls (ECC 2021a and 2021b). Resident hunters typically harvest moose on unoccupied crown lands, as hunting by non-beneficiaries in settled land claim regions is subject to the terms in the respective final agreements including obtaining permission to hunt on private lands. Non-resident and resident hunters cannot harvest on federal lands such as national parks and can harvest by permission only on private lands as set out in final agreements.

Parasites, Disease and Body Condition

Moose in North America are subject to a variety of parasites and diseases including viruses, bacteria, protozoans, cestodes, nematodes, ticks and flies, along with skeletal pathology. In the NWT, moose are potentially subject to anthrax, brucellosis, contagious ecthyma (orf), lymphoma, winter tick, warbles, liver fluke, lumpy jaw, abscesses, tuberculosis, papillomas, ringworm, muscle and liver tapeworms, hydatid disease, and Erysipelas.

Of the numerous agents of disease in moose, two are known (winter ticks *Dermacentor albipictus*; Jones et al. 2019) or are suspected (meningeal- or brain worm *Parelaphostrongylus tenuis*; Lankester 2010) to have the potential to significantly impact moose populations in North America. Pathogens or parasites that may impact food safety or are transmissible to humans are brucellosis, *Toxoplasma gondii*, and *Echinococcus granulosus* (Franzmann et al. 2007). Moose social behaviour, where for much of the year adults avoid each other, and their generally low densities minimize the probability of disease transmission between individuals through direct contact.

Winter tick is firmly established in the NWT as far north as the Sahtú (Figure 18; Kashivakura 2013). Winter ticks were first reported in moose in the southern NWT in the 1970s (Samuel 1989). There were few reports until the 2000s after which the number of reports increased in the North Slave and the Sahtú regions (Figure 18; ECC unpublished data). Interestingly, there continue to be few reports from the Dehcho region; elder harvesters rarely saw "ghost moose" (moose that appear pale due to hair loss caused by grooming to relieve irritation from ticks), but one was reported in the 1950s (ECC 2008). Severe winter tick infestations result in hair- and blood loss, decreasing the ability of moose to withstand cold temperatures, weakening animals and increasing susceptibility to infections. Additionally, grooming time and restlessness increase which can in turn reduce feeding time, body condition and growth. The effects of ticks are more acute for younger moose (Samuel 2004). Severe winter tick infestations have resulted in high mortality in moose calves in the northeastern US (Jones et al. 2019), and have been implicated in die-offs of moose in Alberta (e.g., Pybus 1999). Die-offs are often rapid and widespread but brief (Samuel 2007).

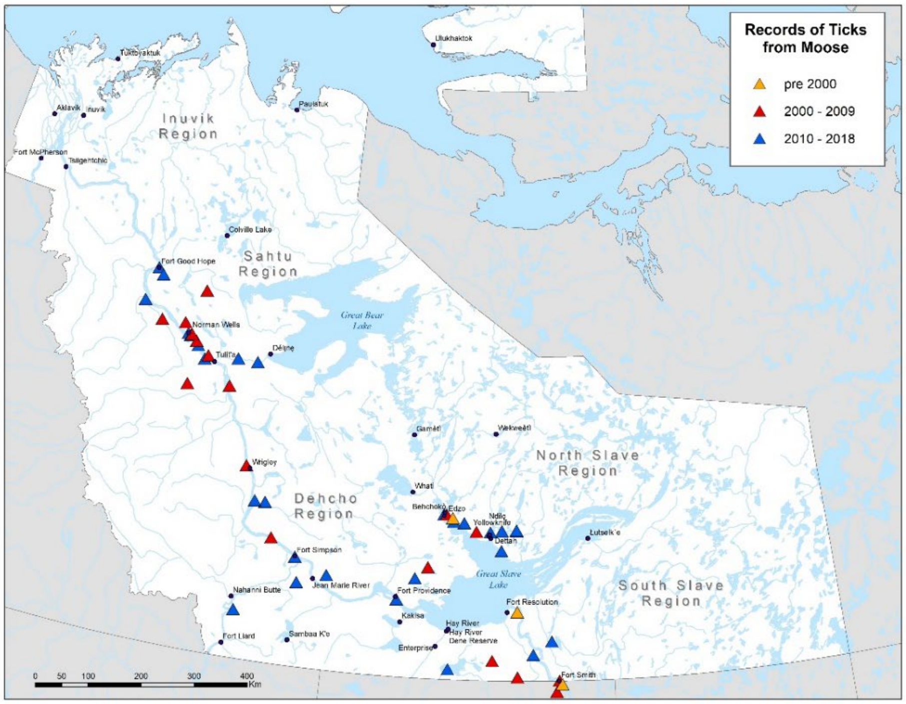

Figure 18. Winter tick distribution in the NWT. Occurrences were reported to ECC, 1975-2018 (ECC unpublished data).

Hydatid disease, caused by the parasite *Echinococcus granulosus*, has been documented in the NWT. It requires two hosts: the intermediate host is a herbivore such as moose, bison, or caribou, and the definitive host is a canid (wolves, dogs, coyotes) (Schurer et al. 2014). Typically, infections are found in the lungs and ultimately restrict animal endurance (Schurer et al. 2014). Stenhouse et al. (1995) observed extensive infections of hydatid cysts in the heart, lungs, liver, and intestine of moose in their study in the Sahtú. Three of 11 mortalities were of unknown causes and had such infections Stenhouse et al. (1995).

Anthrax (*Bacillus anthracis*) is a bacterium that causes acute, fatal disease. Infection in moose has only been seen at the times of outbreaks of the disease in bison (Choquette 1970, Elkin et al. 2020). Dead moose were found during outbreaks in the Slave River Lowlands, Mackenzie, and Wood Buffalo National Park bison populations, and some tested positive for anthrax (Elkin et al. 2020, p. 2-3). How many moose die during anthrax outbreaks and how this contributes to moose population dynamics is unknown. Only a limited number of cases of lymphoma have been reported and a single case of brucellosis has been confirmed (Fenton pers. comm. 2018).

ECC has received several reports of bacterial infections relating to injuries sustained by moose during the rut, from attempted predation, or from instances when they have been impaled by sharp branches. Moose may also have bacterial infections in their mouths and associated lymph nodes due to the coarse nature of the woody browse they consume (Fenton pers. comm. 2018). The presence of papilloma (a wart-like skin growth), tapeworms in the liver (*Taenia* spp.) and muscles (*Taenia krabbei*), leg worm (*Oncocerca cervipedis*) and warble fly larvae (*Hypoderma bovis*) have also been reported. It is suspected these conditions have limited impact to individual moose health (Fenton pers. comm. 2018).

The newly emerging disease Erysipelas (*Erysipelothrix rhusiopathiae*) has been found in moose elsewhere and was diagnosed in three moose from Algonquin Park in ON (Campbell et al. 1994). Blood samples have shown that boreal caribou in the southern NWT have been exposed to Erysipelas (ECC unpublished data), but it has not been reported in moose in the NWT and its potential impact is unknown.

Larter (2009) reported low prevalence of disease and parasites from fecal samples of 41 moose from the Dehcho region. None tested positive for *Giardia* or *Cryptosporidium. Nematodirus* eggs were present in 31 of 41 fecal samples (76%), but most positive samples had <10 eggs/g. The greatest infestation was 21 eggs/g found in a two-year-old male.

Larter (2009) also found moose harvested in the Dehcho region to be in good body condition. Condition as scored subjectively in the field by hunters ranged from good to excellent (Table 2) and corresponded well with high measures of bone marrow fat and kidney fat indices (McGillis 1972).

Table 2. Age and condition of moose harvested in the Dehcho Region, NWT, September 2005-March 2007. First Nation (FN) hunters submitted samples of male and female moose. Guided harvesters in the Mackenzie Mountains (Mtn) were not permitted to harvest female moose. From Larter (2009).

	n	Average	Range
Age[1]	60	5.2	0-14
FN male	28	3.6	0-12
FN female	15	5.6	0-12
Mtn male	17	7.4	4-14
Body Condition Score[2]	55	Excellent (21)	Good (34)
FN male	24	Excellent (7)	Good (17)
FN female	13	Excellent (6)	Good (7)
Mtn male	18	Excellent (8)	Good (10)
Kidney Fat Index	48	47.1	0-155.8
FN male	25	50	5.2-155.8
FN female	12	57.5	15.3-142.2
Mtn male	11	29	0-57.8
Marrow fat (%)[3]	39	72.7	10.8-96.6
FN female	25	69.6	10.8-92.0
FN female	14	78.4	53.3-96.6

[1] Calves were age 0 years.
[2] Body condition was subjectively scored by harvesters in the field. Categories were poor, fair, good and excellent.
[3] Marrow fat was measured from ankle (metatarsal) bones submitted by First Nation hunters.

The presence of diseases and parasites in samples collected from moose harvested between 2011 and 2016, as part of a study on contaminants (Larter et al. 2016; 2018b), was similar to those collected between 2005-2007 (Larter 2009) with no positive tests for *Giardia* or *Cryptosporidium* (n=37), *Nematodirus* occurred at low egg counts in 6/37 samples, 7/35 samples had low egg counts of *Moniezia*, and Protostrongylous larva were found in 3/35 samples. The harvested animals were again in good condition: 37/41 described as being in good or excellent condition, mean femur marrow fat content of 78.2% (n=37) and the mean ratio of fat weight/kidney weight was 1.12.

From 2004-2014, body condition of harvested moose was evaluated as part of the Sahtú Wildlife Health Monitoring study (Carlsson et al. 2015). Subsistence harvesters were trained to collect data using standardized protocols and pre-prepared sampling kits. Unfortunately, fewer than 30 of the 84 sampling kits from individual moose could be used for different analyses. Of the available information, few hunters scored body condition as skinny (n=27, all males). Marrow fat indices were above 70% (n=17) and 18/26 moose (both male and female) had kidney fat indices >50%; 7/8 fall backfat measures were at least 30 mm. The average age was 3.9±0.6 years (n=12) for females and 4.9±0.7 (n=9) for males (Carlsson et al. 2015).

The Sahtú Wildlife Health Monitoring study provided baseline information on a wide array of diseases and parasites and contributed to the development and validation of blood collected on filter paper for the use in wildlife serology (Curry et al. 2014). Blood serology findings included: the first record of *Neospora caninum* in moose, with a 16.1% seroprevalence (n=31), evidence of exposure to alphaherpesvirus with 2/9 positive, and no positives for pestivirus (n=5). Fecal parasitology findings included: the discovery of a filarioid nematode legworm *Onchocerca cervipedis* – the first record in moose in the NWT – found in 21.4% of sampled moose (n=28; Verocai et al. 2012), the discovery of a previously uncharacterized, genetically distinct species of protostongylid nematode, *Varestrongylus eleguneniensis*, (Kutz et al. 2007), and no presence of Eimera (n=14). The overall prevalence of parasites revealed by fecal parasitology (i.e., eggs, oocysts, or larvae from helminths and protozoans) was low, with Nematodirinae eggs being the most prevalent (similar to the findings in the Dehcho; ECC unpublished data).

ECC developed a moose health and condition monitoring program in the NWT's South Slave region from 2009-2013. Part of this study evaluated baseline body condition like the studies in the Sahtú and Dehcho regions. Hunters were asked to rate body condition of moose they harvested. Only 11% of reports (n=53) rated condition as poor and all were of males; no females were rated in poor condition. The depth of backfat averaged 13.9 mm (range 5-25 mm) for non-calf females (n=14) and 23.9 mm (range 2-75 mm) for non-calf males and was deeper pre-rut than post-rut as expected. Kidney fat indices (KFI; McGillis 1972) >30% generally indicate good body condition. Most harvested moose (68%; n=56) had KFI's >50% (range 8-261%) with only seven having KFI's ≤30% (two calves, one yearling, one adult female and three adult males). Mean femur marrow fat was 82.2% (range 31.1-96.0%, n=56). Marrow fat less than 20% in an adult moose would indicate severe nutritional stress (e.g. Ballard 1995). Mean femur marrow fat over 80% suggests most of the moose in the sample were in good nutritional condition.

This study also provided baseline information on parasites. Examination of 42 livers showed an incidence of 9.5% (4/42) with *Taenia* tapeworms, 14.3% (6/42) of suspected *Setaria*, (a threadlike worm) and no evidence of either *Echinococcus granulosus* or liver fluke (*Fascioloides magna*). These findings show a low intensity of infection and low infection prevalence (ECC unpublished data).

The findings from all three regional studies are consistent in that most harvested moose were in good body condition and were relatively free of diseases and parasites. Where present, they were common and at low levels. These results are also consistent with research elsewhere that found harvested moose are generally healthy and harvester sampling programs are a good way to collect health information, although the data are specific to the season(s) when moose are typically harvested (Carstensen et al. 2019).

Interspecific Interactions

Concern has been raised that competition for habitat exists between moose and bison. In the NWT, bison were re-introduced near Fort Providence in 1963, and reintroduced in the Liard River valley near Nahanni Butte and Fort Liard in 1980, 1989 and 1998. Shank (1992) surveyed the moose and bison populations around Fort Providence and was unable to find any evidence suggesting competition between the two species. Both the bison and moose populations in the Liard Valley increased between 2002-2017 (Larter pers. comm. 2017 and 2018a) as they did in the Mackenzie bison range between 2013 and 2019 (ECC unpublished data) suggesting interspecific competition between moose and bison was not impeding either species at that time. In the Yukon, Jung et al. (2018) found that in early winter moose selected for sub-alpine and shrub dominated habitats, whereas bison selected wet sedge meadows; in the late winter, moose selected drainages above tree line or river valleys, whereas bison selected south facing grassy slopes and wet sedge meadows. Ultimately, with low habitat and diet overlap, it is unlikely that moose and bison compete for habitat or forage (Jung et al. 2018). There was some evidence that when the Mackenzie bison population was increasing to peak numbers in the late 1980s and early 1990s, the amount of bison prey available for wolves was such that wolf predation on moose in the area was causing a decline in moose numbers (Larter et al. 1994).

In some jurisdictions moose have been shown to cause declines in woodland caribou abundance (Seip 1992, Hervieux et al. 2014, Serrouya et al. 2017) even though some studies show little resource overlap between moose and woodland caribou (Anderson et al. 2018, Christopherson et al. 2019). The hypothesis, which has generally been termed habitat-mediated apparent competition (Serrouya et al. 2019), is that habitat disturbance (primarily anthropogenic) has played a role in increasing the abundance of alternate prey (especially moose and white-tailed deer) for wolves and increased the predators' ability to travel through boreal forest habitat to the detriment of boreal and mountain caribou populations. In addition, wildfires may increase the impact on caribou populations (DeMars et al. 2019). Although the apparent competition hypothesis has gathered wide support (Environment Canada 2012), a long-term study in the SK Boreal Shield, where moose densities ranged from 4.6-5.4 moose/100 km^2, could find no support for it (McLoughlin et al. 2019). Currently, there is no evidence for apparent competition between moose and caribou in the NWT. Moose densities are generally low (1-7 moose/100 km^2), white-tailed deer are rare and there has been no increase in their numbers to provide more alternate prey. Wolf densities are low, 0.6-1.6 wolves/1,000 km^2 in the Hay River Lowlands (ABMI 2017) and 0.6-1.4 in the Pine Point-Buffalo Lake area (ABMI 2018) and somewhat higher in areas where bison are an alternate prey, 4.8-5.3 wolves/1,000 km^2 in Liard (Serrouya et al. 2016) and 7.2-9.4 wolves/1,000 km^2 in the Slave River Lowlands (Dickie and Serrouya 2019). The amount of anthropogenic disturbance is low relative to fire disturbance in the NWT and are much lower than in other jurisdictions: e.g., linear feature densities of 0.4 km/km^2 in the NWT versus >1 km/km^2.

The potential expansion of white-tailed deer into NWT moose range, in addition to providing an increased density of prey for wolves, carries with it the potential for disease and parasite transmission and the possibility of increasing mortality in moose. Both mule deer and white-tailed deer in Alberta are known to carry chronic wasting disease and transmission to moose has been documented there (Government of Alberta 2013 and 2021). Chronic wasting disease is a prion disease that ultimately results in early mortality of infected animals and once established in an area, is extremely difficult to eradicate (Alberta Fish and Wildlife 2014). Meningeal worm (brain worm, *P. tenuis*) has a wide distribution in eastern and central North America where it occurs in 50-90% of white-tailed deer but has not been discovered west of SK (Lankester and Samuel 2007, Wasel et al. 2003). In moose, *P. tenuis* causes the neurologic disease parelaphostrongylosis or “moose sickness” but has a much less pronounced effect on white-tailed deer, its usual host. Parelaphostrongylosis has been implicated in declines in moose populations at different times and places in North America, coincident with high densities of white-tailed deer (Lankester 2010). However, moose populations persist in the presence of infected deer when deer densities are low (Lankester 2010).

Intraspecific Interaction

In predator-mediated environments, moose competition for forage and suitable habitat is low to non-existent (Messier 1994, Brown 2011). Moose in systems without predation are more likely to be constrained by competition for forage. Male moose compete during the rut for access to reproductive opportunities and these competitions are not without consequences to the individual’s survival. Males may be nutritionally stressed after the rut and more susceptible to predation or to starvation during the winter. Injuries from fighting occur that may affect immediate or long-term survival and on rare occasions males lock their antlers and perish together.

Moose calves and their dams form a bond and stay together for the first year of the calf’s life. Female moose chase away yearling moose that try to nurse along with a calf of the year.

State and Trends

Population

Abundance

The North American moose population is currently estimated at approximately 1 million animals with almost 800,000 in Canada (Timmermann 2003, Timmermann and Rodgers 2017). Surveys to estimate the total number of moose in the NWT have not been carried out. Extrapolating the results of existing surveys to the entire ecoregion the survey was in produces estimates of abundance ranging from 22,000-51,000.

Jensen et al. (2018) used data from Timmermann (2003), which included data from the NWT to model moose density and abundance across North America (Figure 19). This method showed that from 1980-2010, the highest moose densities were found within a 300-750 km wide band stretching from central Alaska across the Prairie Provinces, through southern Ontario and Quebec, to northern Maine, New Brunswick and Newfoundland.

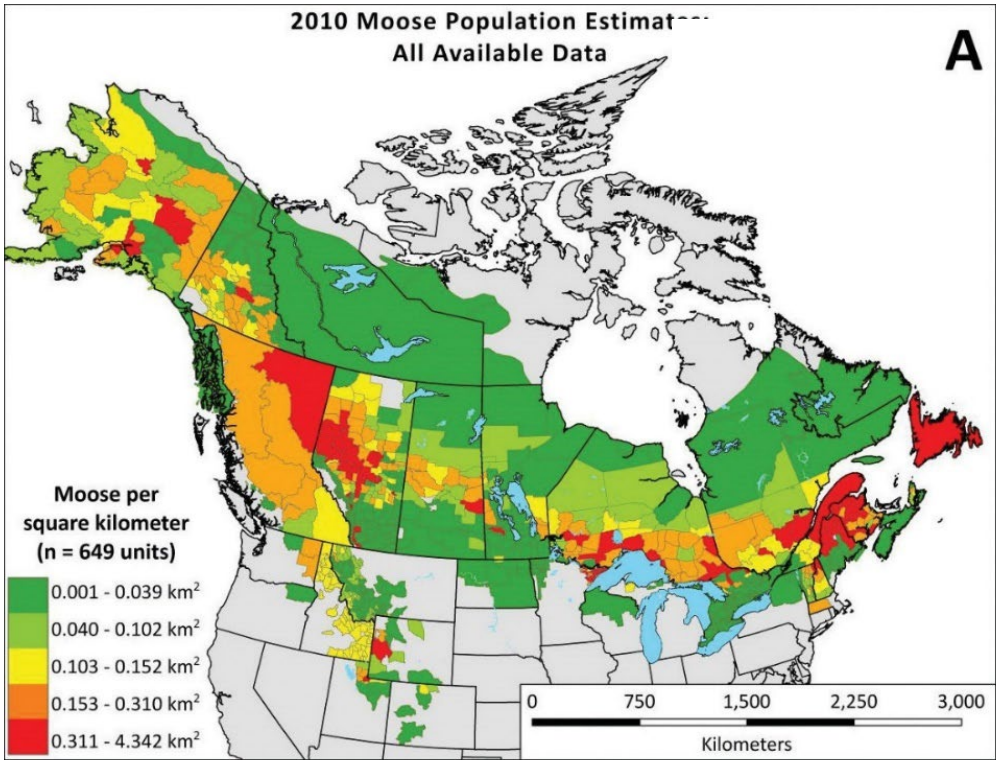

Figure 19. Moose population density estimates by management unit in North America (*ca.* 2010). Map reproduced from Jensen et al. (2018) and represents all available management unit data (n=649).

Treseder and Graf (1985) provided the first estimates of moose density in the NWT based on surveys from the 1960s, 1970s, and early 1980s. Average densities ranged from 3-9 moose/100 km^2. Treseder and Graf (1985) defined low density as ≤3 moose/100 km^2, moderate density between 3-8 moose/100 km^2 and high density as ≥8 moose/100 km^2. Franzmann et al. (2007) summarized general densities across the species range as <12 moose/100 km^2 in subarctic areas, 12-31 in better ranges, and 40-100 in excellent ranges. Moose densities in the Yukon generally range between 10-25 moose/100 km^2 of suitable moose habitat (Environment Yukon 2016). Density estimates from the NWT fall within the subarctic to better range categories, however Messier (1994) found densities in the NWT and Saskatchewan to be similar and some of the lowest reported (n=27). Survey data from the NWT show a dramatic range in density estimates (Appendix B). A high of 17 moose/100 km^2 was reported in a 1991 survey of Mills, Mink and Falaise Lakes (near Fort Providence; Shank 1992), a 1992 survey of Fort Good Hope (MacLean 1994b) and a 1995 survey of Norman Wells (Veitch et al. 1995). Low densities of 1.3 moose/100 km^2 were reported for a 2016 survey of Buffalo Lakes (Kelly and Cox 2017b), 1.2

moose/100 km^2, from a 2011 survey of the Liard Valley (Larter pers. comm. 2018a) and 0.9 moose/100 km^2 from a 2018 survey of the Slave River Lowlands (ECC unpublished data). Larter (pers. comm. 2018a) speculated the low density in the Liard Valley was a result of a delayed snowfall which caused moose to remain at higher elevations and not move into the valley.

Surveys in the NWT that reported moose densities greater than 10/100 km^2 were all conducted prior to 2000. Earlier surveys used a variety of methods, although mostly Gasaway et al. (1986); none used the currently preferred geospatial or distance methods (ver Hoef 2002; Buckland et al. 2001). More importantly the pre-2000 surveys were of small study areas and were conducted in areas where moose were known to be concentrated. One study reported a density estimate of 46/100 km^2 based upon only the area of "moose habitat" in the study area (Smits 1991). Some surveys included a sightability correction factor (e.g., Shank 1992), but others did not. Most surveys conducted after 2000 were designed to be more representative of larger landscapes and tend to produce estimates lower than pre-2000 surveys that studied small areas of known moose concentrations (Appendix B).

Trends and Fluctuations

Moose population densities, trends and status across the NWT were first described by Treseder and Graf (1985). Based on surveys conducted during the 1960s, 1970s, and early 1980s they reported a declining trend in the Liard Valley with densities of 6-13 moose/100 km^2 and a declining trend for the Slave River Lowlands with an average of 5 moose/100 km^2. For the Mackenzie Delta and Yellowknife areas trend in density was uncertain, but densities were low (<3/100 km^2).

In 2012, the Preliminary State of Knowledge Report of Valued Components for the NWT Cumulative Impact Monitoring Program (NWT CIMP) reported trends in moose populations (CIMP 2012). CIMP (2012) reported moose populations in the Sahtú region had increased due to extensive forest fires in the 1990s. In the Dehcho for the years 2004-2011 they reported stable calf: cow ratios and because moose harvesting continued to be successful this suggested moose populations in the Dehcho area were stable. In the North Slave region, surveys in 2007 showed that moose populations had remained stable since 2004, but moose densities in the Fort Providence area (South Slave region) had declined between 1991 and 1997. It was concluded that these populations had stabilized at low densities (CIMP 2012).

What follows is the most recent assessment of trend information for each of the five regions.

Beaufort Delta Region

Survey methods and study areas varied among surveys prior to 2000 in this region and did not provide data suitable for determining trend. In 2006, a survey of several areas in the Gwich'in Settlement Area reported densities of 0-3.8 moose/100 km^2 (Lambert 2006) and based upon surveys from 1980-2000 concluded moose densities were low and declining. Surveys conducted in 2011 and 2017 generally covered the same eight blocks in the Gwich'in Settlement

Area and Inuvialuit Settlement Region (Figure 7) and some of the areas surveyed in 2006 (Lambert 2006). The density estimates for blocks ranged from 0.5-9.7 moose/100 km^2 (Figure 20) with an overall density of 2.2 moose/100 km^2 in 2011 (Davison and Callaghan 2013) and ranged from 0.9-14.0 with an overall density of 3.8 moose/100 km^2 in 2017 (Davison and Callaghan 2019). Of the seven blocks with some overlap between surveys (excluding Mackenzie River) two showed a decline: the Inuvik 7(1)(a) and the Mackenzie Gas Pipeline. In the latter survey area, density dropped from 3.3-0.9 moose/100 km^2 from 2011-2017 and showed a declining trend from 2006-2017 (Figure 20). Davison and Callaghan (2019) speculated that moose may have been displaced from the Mackenzie Gas Pipeline area due to construction of the Mackenzie Valley Fibre Link from 2015-2017. The remaining five blocks showed an increase: Mackenzie Delta, Inuvik-Tsiigehtchic, Arctic Red River, Fort McPherson/Peel River and the Richardson Mountains (Figure 20; Davison and Callaghan 2019). The largest increase was observed in the Fort McPherson/Peel River study area.

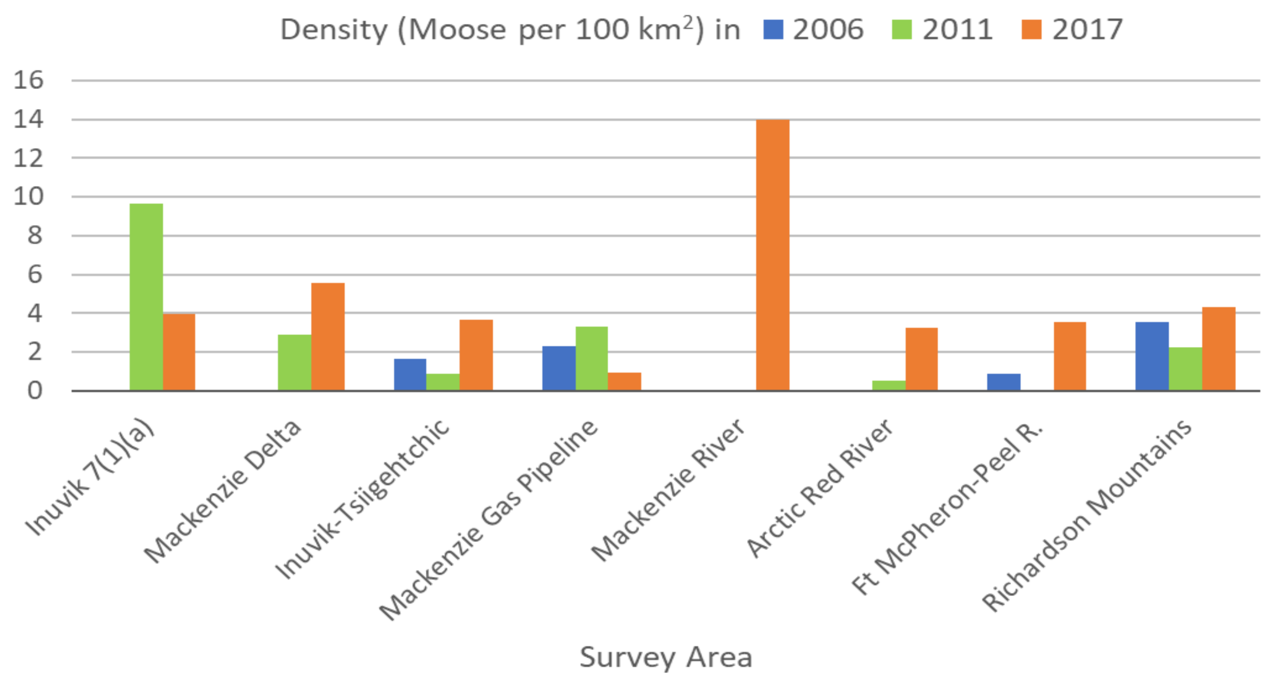

Figure 20. Estimates of moose density in the Beaufort Delta Region, 2006, 2011, and 2017. Survey areas were Inuvik 7(1)(a), Mackenzie Delta, Inuvik-Tsiigehtchic, Mackenzie Gas Pipeline (MGP), Mackenzie River, Arctic Red River, Fort McPherson/Peel River, and Richardson Mountains (from Davison and Callaghan 2019).

Davison and Callaghan (2019) concluded that most of the blocks in the survey showed an increase in densities from 2011. Based upon estimated numbers for five of eight blocks from both surveys, the annual rate of increase in numbers between 2011 and 2017 was 3.2%. Assessing trends in moose densities throughout the Beaufort Delta region is hindered because only a small proportion of the total moose range in the region has been surveyed, small size of some survey blocks (Figure 7) and adjusting study areas between surveys based on community input introduces the potential for biased sampling.

Sahtú Region

There were no moose surveys in the Sahtú region from 2000-2019, which places the earlier surveys more than two generations prior to the most recent estimates in 2020 and 2021. Changes to survey methods and study areas (see Figure 8), and the small proportion of moose range in the region covered by surveys preclude an assessment of moose population trends. Additionally, standard errors around estimates were large for some surveys, making it impossible to detect changes in population size unless those changes were very large. For example, Latour (1992a) stated "The number of moose in the area west of Norman Wells (435±139, estimate ± SE) has remained unchanged since the last survey in 1984 conducted by Jingfors et al. (1987a)."

In 2020 and 2021 surveys used a spatially explicit distance sampling method known as density surface modeling (Miller et al. 2013) and was designed to estimate the numbers of muskox and moose in the southern Sahtú (see Figure 8; GNWT 2021). Moose density was estimated at 1.4 and 3 moose/100 km^2 in the southern in 2020 and northern Sahtú in 2021, respectively (see Appendix B; GNWT 2021).

Dehcho Region

From historical surveys, moose densities in the Dehcho ranged from 6-13 moose/100 km^2 (Hawley 1978, Decker and Mackenzie 1980, Geddes and Duncan 1982, Treseder and Graf 1985). Treseder and Graf (1985) reported that moose densities were declining but remained in the range of 6-13 moose/100 km^2. A large-scale survey of the Liard Valley in 2004 reported a density of 4 moose/100 km^2 (Larter 2009, pers. comm. 2018a). Whether the decline over 20 years is real, as Treseder and Graf (1985) implied, or whether the difference relates to a major change in survey area and survey methodology is unknown.

Following Larter's (2009) survey design, large scale geospatial surveys have been conducted in the two study areas (Liard and Mackenzie) on three occasions (see Figure 10). Larter (pers. comm. 2018a) concluded that moose density in the Liard River Valley was stable or had increased slightly since 2004 (Figure 21). For the Mackenzie River Valley survey area, Larter (pers. comm. 2018a) concluded the best estimates of adult moose density show little or no trend: appearing relatively stable from 2003-2018 (Figure 22).

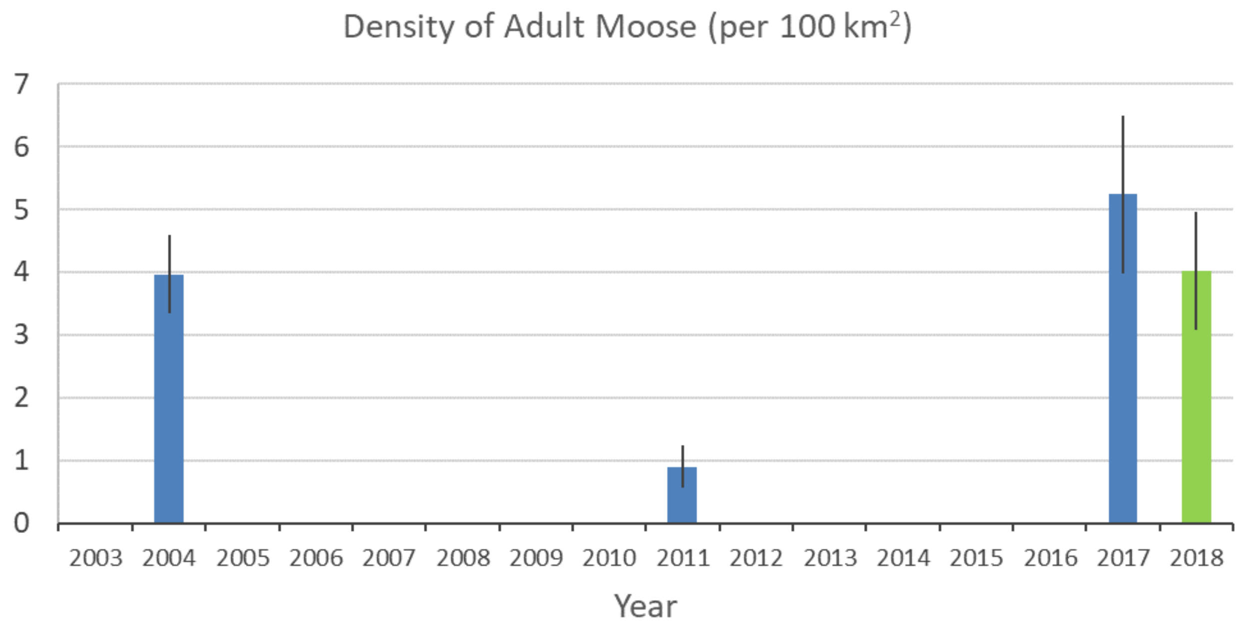

Figure 21. Estimates of adult moose density in the Liard River Valley, 2004-2018. Surveys took place in February 2004, November 2011, November 2017 (phase 1 blue), and February 2018 (phase 2 green). Bars are standard errors. Data from (Larter pers. comm. 2018a).

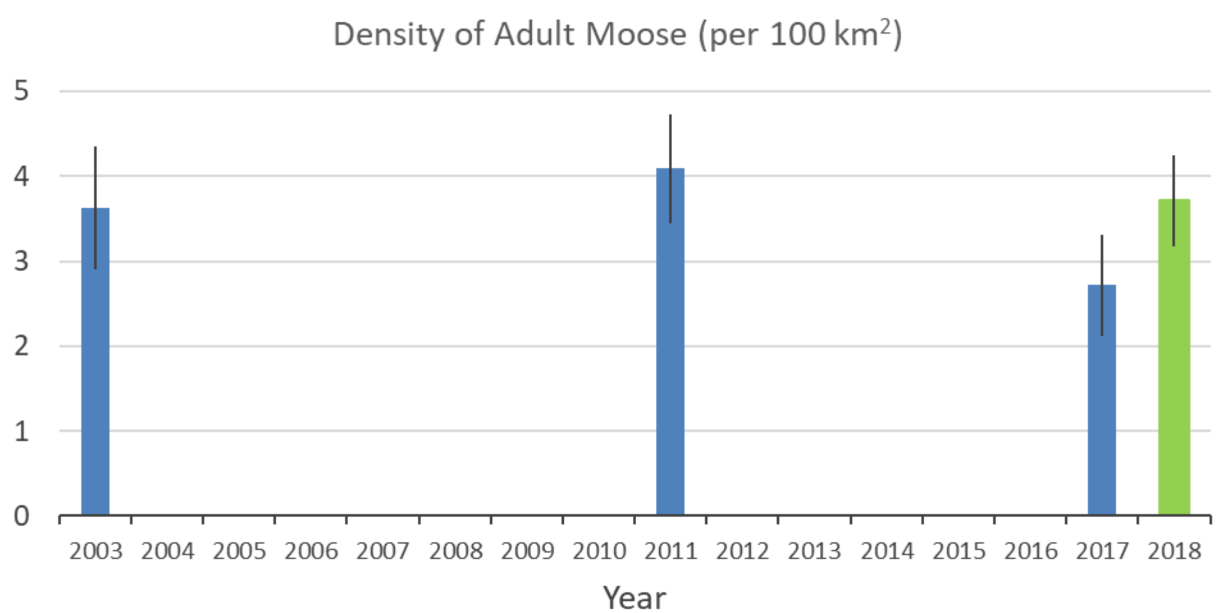

Figure 22. Estimates of adult moose density in Mackenzie River Valley, 2003-2018. Surveys were conducted in November 2003, November 2011, November 2017 (phase 1, blue) and February 2018 (phase 2, green). Bars are standard errors. Data from (Larter pers. comm. 2018a).

North Slave Region

Surveys using the geospatial method (ver Hoef 2002) were conducted in 2004, 2007 and 2012 in the same study areas within the Taiga Plains and Taiga Shield ecoregion portions of the North Slave Region (Figure 11; Cluff 2016). In 2016, a much larger study area encompassing both the Taiga Plains and Taiga Shield (Figure 11) used distance sampling methods to estimate numbers and density of moose. Inclement weather precluded flying *ca.* 10,000 km^2 of the study area, mostly in the Taiga Plains so there was no estimate for that ecoregion in 2016 (Cluff 2016).

Moose density decreased from 2004-2012 in the Taiga Plain ecoregion (Figure 23), dropping from an estimated 3.6 moose/100 km^2 to an estimated 2.9 moose/100 km^2. In contrast, density increased in the Taiga Shield ecoregion from an estimated 1.5 moose/100 km^2 in 2004 to an estimated 4.9 moose/100 km^2 in 2016, with a peak of 5.8 moose/100 km^2 in 2012 (Figure 23). While these data suggest moose density in the Taiga Shield has increased since 2004 it's not possible to statistically compare the two estimates because different survey methods were used in 2004 and 2016 and the results did not include standard errors for estimated density.

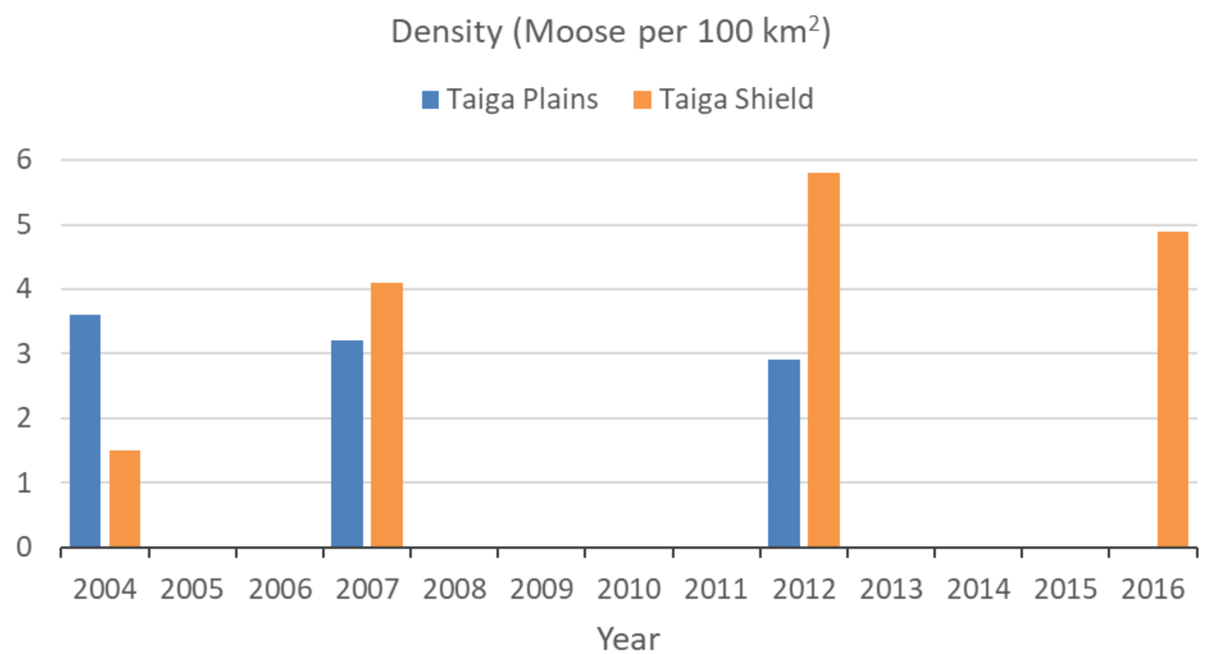

Figure 23. Moose density in the North Slave Region, 2004-2016. The 2016 survey used distance sampling while previous estimates were made using the geospatial method. The Taiga Plains was not surveyed in 2016. Adapted from Cluff (2016).

Comparing estimates from the 2004 and 2012 surveys of the Taiga Plains, the moose population has decreased at an annual rate of 2.7%. Between 2007 and 2012 the rate of decrease was 1.8%. Comparing estimates from the 2004 and 2016 surveys of the Taiga Shield, the moose population has increased at an annual rate of 5.8%. The annual rate of increase was greater (9.3%) between 2004 and 2012 when survey methodology was the same. Following the 2016 survey, Cluff

(2016) indicated that the 2016 density estimate (4.9 moose/100 km^2) should be more representative of current moose abundance throughout much of the North Slave Region.

South Slave Region

Moose densities from surveys in the 1990s were generally higher (3-17 moose/100 km^2) than those from 2009-2019 (0.8-6.3 moose/100 km^2; Figure 24). Differences in survey methods and design, including how study areas were selected, between the pre-2000 and post-2000 surveys may have affected the results. However, because the estimates lack confidence intervals it is not possible to determine if the change reflects a real decline in moose densities between the time periods. Larter et al. (1994) suggested that wolf predation was responsible for declines in moose numbers in the Mackenzie Bison Sanctuary and Mink Lake areas. More recently, based on observations of moose made on bison surveys of the Mackenzie bison range during late winter, moose densities appeared to have dropped between 2012 and 2013 then increased modestly (Table 3). The bison surveys used distance sampling to estimate both bison and moose densities (e.g., Armstrong and Boulanger 2016).

Figure 24. Moose density estimates in the South Slave Region. (A) 1986-1997 and (B) 2008-2019. There were no moose surveys in the region from 1998-2008 (ECC unpublished data).

Table 3. Density of moose in the Mackenzie bison range. Densities were estimated during bison surveys using distance sampling.

Year	Density (moose/100 km^2)	95% Confidence Interval	Source
2012	5.2	3.6-7.3	Armstrong and Boulanger 2016
2013	0.7	0.4-1.2	Armstrong and Boulanger 2016
2016	1.5	0.8-2.7	Armstrong and Boulanger 2016
2019	1.7	1.1-2.7	Armstrong and Schwarz 2019

There was a dramatic decrease in estimated moose density from 17 to 3 moose/100 km^2 over a six-year period from 1991-1997 in the Fort Providence area (Figure 24). The NWT CIMP suggested moose density in the area had stabilized at low levels (CIMP 2012). A survey in 2016 estimated 4.8 moose/100 km^2 corroborating the low levels and documenting there may have been a modest increase in density since 1997 (Kelly and Cox 2017a).

Three surveys for moose were conducted in the area around Buffalo Lake from 2009-2019 (Figure 24; Kelly and Parker pers. comm. 2020) using the geospatial survey method (ver Hoef 2002), with the 2019 survey covering the greatest area. Density estimates were lower in 2016 and 2019 than in 2009 (Figure 24): from 5/100 km^2 in 2009 to 1.3/100 km^2 in 2016 and 1.8/100 km^2 in 2019 (Kelly and Parker pers. comm. 2020). In 2012, moose density in the Kakisa area (Figure 14) was estimated at 2.9 moose/100 km^2 (ECC unpublished data).

Estimated density of moose in the Slave River survey areas dropped from 16 and 11 moose/100 km^2 in the Fort Resolution and Fort Smith areas respectively, in 1986 to 1 and 0.8 moose/100 km^2 in 2019 (Figure 24; ECC unpublished data). However, moose densities in the Slave River area were similar to those in other areas in the southern NWT surveyed between 2003 and 2011 (ECC unpublished data).

Habitat

Habitat Availability

Currently, much of the NWT appears to have habitat available for moose. At the level IV ecoregion scale, moose occupy much of the NWT as confirmed by observations of moose during the reconnaissance flights conducted for the ecosystem classification research. Moose density in peripheral ecoregions is currently unknown because no surveys have been conducted in those areas, but is assumed to be lower than in core habitats (ECC 2021a).

Communities, roads and resource projects (mines, energy, and hydro reservoirs) reduce available habitat (Johnson and Hayes 2003, Bartzke et al. 2015). However, forest resource development may improve habitat for moose by removing old-growth forest and causing an increase in the early successional stage boreal habitats that re-grow following clear-cutting operations (Rempel et al. 1997, Shura and Roth 2013).

The amount of habitat available usually increases following wildfire with the increase in quantity and quality of preferred browse. Moose habitat is at its most preferred between 10-25 years post burn in the NWT and Alaska (Franzmann and Schwartz 1985, Veitch et al. 1995, Veitch 1998, CIMP 2012). Wildfire is the most significant influence that increases available habitat for moose in the boreal forests of the circumpolar world, including in the NWT (Figures 25 and 26; Lord and Kielland 2015).

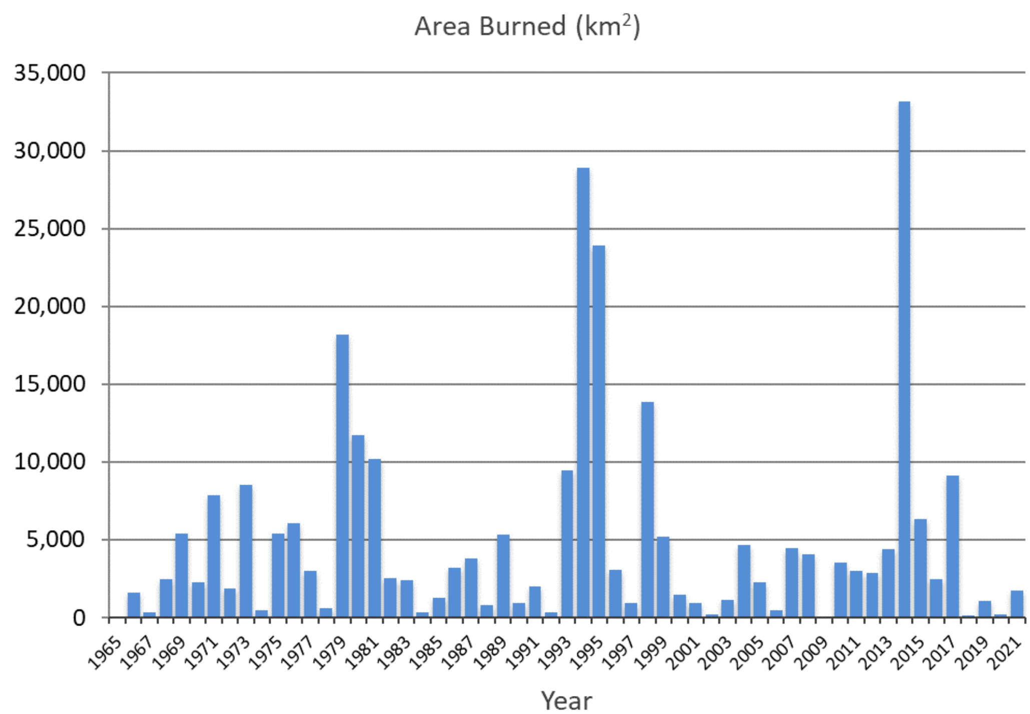

Figure 25. The annual area burned by wildfires in NWT by wildfires, 1965-2021. Data Source: NWT Centre for Geomatics 2022.

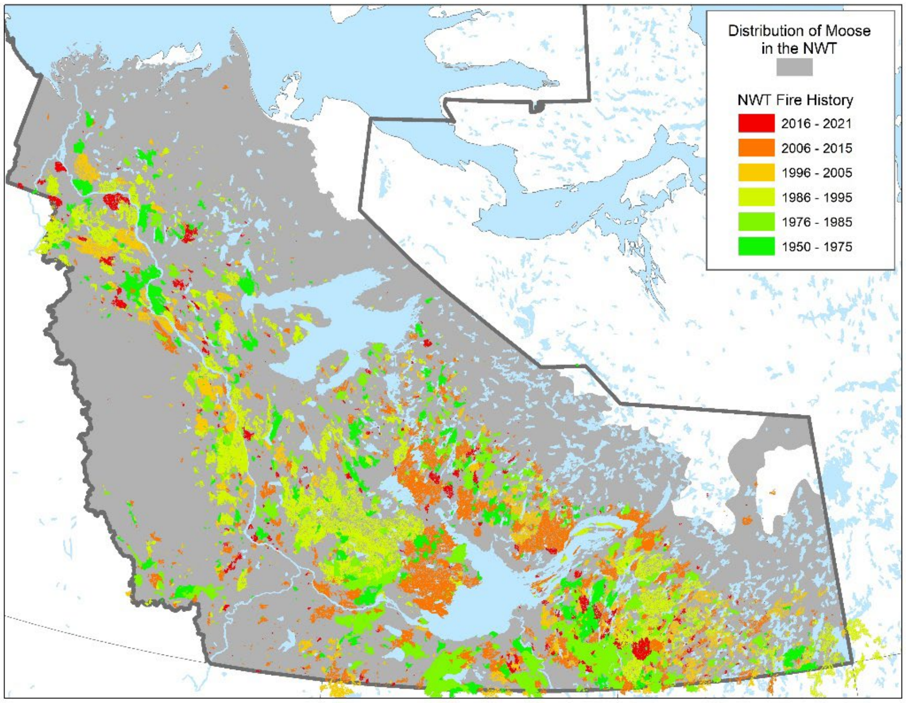

Figure 26. Map of wildfires in the NWT, 1950-2021. Data Source: NWT Centre for Geomatics 2022.

Habitat Fragmentation

Habitat in the NWT is fragmented by anthropogenic sources such as communities, roads, pipelines, powerlines and resource development projects.

Communities contribute to habitat fragmentation when habitat is converted to human-use, and they also lead to increased harvest in surrounding areas (Johnson and Hayes 2003). Roads and other linear developments not only physically fragment the habitat by cutting through it, but by increasing hunter access they increase disturbance and moose harvest (Brown 2011; MVRB 2017). Linear features generally are not considered an impermeable barrier to moose dispersal (Bartzke et al. 2015).

Habitat fragmentation from activities associated with mineral development in the Mackenzie Mountains may have more severe impacts on moose than developments elsewhere. In certain portions of the cordillera, moose habitat is restricted to the vegetated corridors in valley bottoms, the same locations used for the construction of mines and access roads. With moose habitat being more concentrated and physically constrained in the cordillera, small amounts of fragmentation may have a large effect on local moose populations.

Moose are capable of traversing anthropogenic disturbances like roads, cut lines, power lines, pipelines, forestry developments and natural disturbances such as wildfires and blowdowns. Habitat in the NWT is not fragmented to the extent that it prevents movements between local areas or interchange of moose from the NWT and neighbouring jurisdictions (Geddes and Duncan 1982; Latour 1992b; Bartzke et al. 2015).

Habitat Trends

Area burnt by wildfires in the NWT results in more available habitat for moose. A marked increase in the available habitat for moose occurred in 2004 as areas that experienced fires between 1979-1994 reached the stage of succession most suitable for moose: 10-25 years post-fire (Figure 27). This resulting high level of available habitat, approximately 100,000 km², will soon begin to diminish as areas burned in the mid- to late-1990s mature. Available habitat should begin to increase again by the mid-2020s as the burns from the 2014 fire season regenerate and create high quality moose habitat. There is uncertainty in projections of habitat that will be available in the future because areas may burn again thus resetting succession once again. In addition to frequency, fire severity also has an influence on habitat quality following wildfire. Fires are typically mapped as a single large polygon representing a completely burned area, but most fire polygons contain a mosaic of areas of differing burn severity, including unburned patches. Finer scale fire mapping in future may more accurately measure the size and severity of fires.

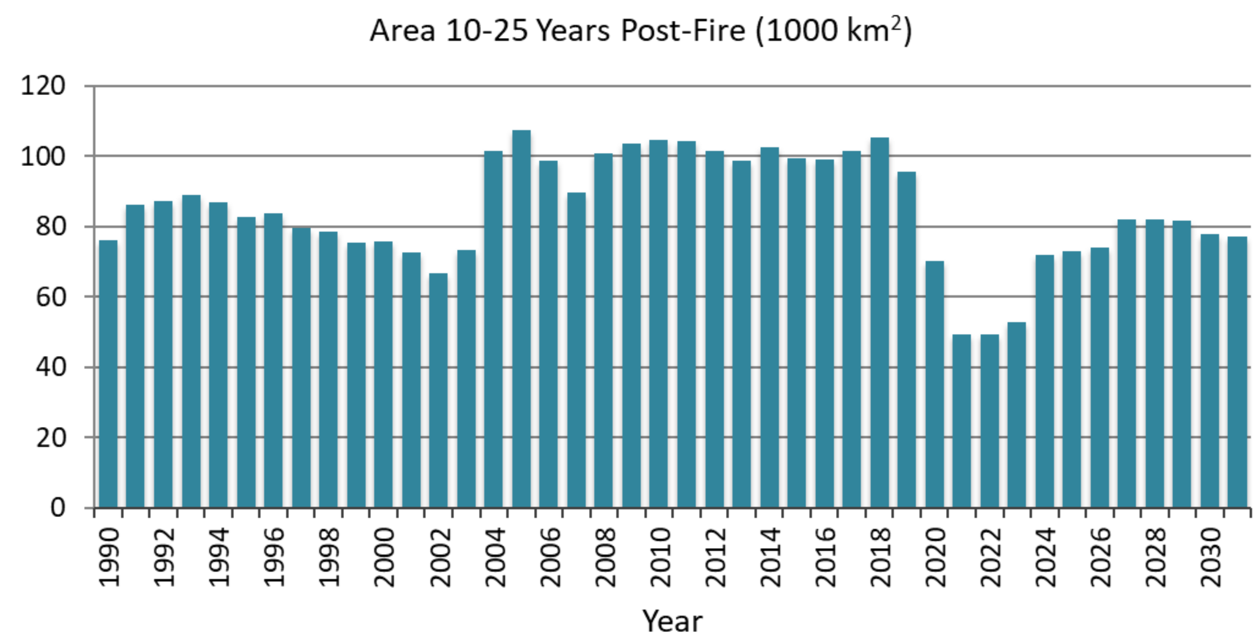

Figure 27. Area of NWT forest 10-25 years post fire, 1990-2030. Data Source: NWT Center for Geomatics.

Wildfire is a positive influence for moose habitat in the boreal forest under normal climatic conditions. However, climate change scenarios predict increased frequency and severity of fires, which may cause changes in boreal forest succession that in turn would influence the amount and quality of moose habitat (Lord and Kielland 2015).

Recently, both the height and geographical range of shrubs such as willow and alder have begun to increase in the Canadian Arctic (Lantz et al. 2010, Myers-Smith et al. 2011, Tape et al. 2016, Myers-Smith and Hik 2018). Increasing shrub height matters because the portion of shrubs covered by snow are not available as moose forage in winter. Winter range of moose on the tundra of Alaska's north slope is restricted to areas with shrub heights greater than 1 m (Tape et al. 2016). Currently, data are unavailable to quantify the expansion of moose habitat on the tundra in the NWT, however, with an environment similar to the Alaskan North Slope it is reasonable to anticipate shrubiness is likely to increase with a warming climate.

Proposed resource development projects could significantly alter moose habitat, in particular the development of a forestry industry in the Dehcho and South Slave Regions. The GNWT has entered into 25-year forest management agreements for operations near Fort Resolution, Pine Point, and near Fort Providence (ENR 2015a and 2015b). Under the Timberworks agreement the operator plans to harvest between 1300-1800 ha of forest per year from the Fort Resolution and Pine Point areas, whereas Digaa intends to harvest an average of 1,089 ha of forest annually from the Fort Providence area. Both projects require the construction of winter roads likely resulting in increased moose mortality from harvest and potentially from vehicle collisions as well.

Distribution Trends

The NWT moose range (Figure 2) is based upon the level IV ecosystem classification, which considers the vegetative cover of the region. Moose distribution is primarily limited by climate and available forage (Darimont et al. 2005) so a changing climate may result in changes in the distribution of moose. The species' distribution has expanded from boreal forest regions northward and eastward into the Southern Arctic Tundra of the NWT, Yukon and NU (Ecosystem Classification Group 2012, Environment Yukon 2016). In Alaska, moose were observed to colonize tundra habitats where shrub heights exceeded the depth of the winter snowpack, which occurred when shrubs reached heights of approximately 1 m (Tape et al. 2016). The height of shrubs on the Alaskan tundra began increasing around 1860, and moose subsequently colonized these areas (Tape et al. 2016). On the northern edge of the distribution, shrub height has increased and moose range has expanded continuously since the mid-1800s (e.g., Lantz et al. 2010). In Alaska, Yukon, and NWT, moose range would not have included the tundra regions above the treeline prior to the 1920s (Coady 1980; Tape et al. 2016).

Threats and Limiting Factors

Several threats and limiting factors exist for moose in the NWT. In order of importance, they are harvest, predation, parasites and disease, and anthropogenic disturbances. Invasive species have not been implicated in any decline or as a factor limiting density of moose in the NWT.

Harvest

Harvest occurs throughout moose range in the NWT, but hunting effort is greatest near communities and easily accessed areas. Harvest by humans can cause avoidance behaviour in moose, which is particularly pronounced around communities where moose are frequently targeted, creating what has been termed the vacuum effect (Johnson and Hayes 2003). Reports of moose moving away from areas of high hunting pressure have been recorded along human travel corridors, such as rivers and roads. Larter (pers. comm. 2018a) noted that moose were relatively scarce in areas adjacent to the Mackenzie and Liard Rivers following the fall hunt and speculated that moose avoided those areas at that time.

Total annual harvest of moose in the NWT is unknown. In the only published estimate, CIMP (2012) suggested annual harvest was between 1,000-2,000 animals, of which an estimated 80-90% is subsistence harvest, but this estimate should be viewed cautiously due to the limited availability of subsistence harvest data (Larter pers. comm. 2018b).

Data on harvest by NWT resident hunters (resident hunting licence holders) has been collected since the 1983/1984 hunting season (ECC unpublished data). Over this time their average annual harvest was 182 moose (range 123-306; SD=48). The harvest prior to 2000 may have been slightly higher than after 2000, but it has remained relatively stable for the past 20 years (Figure 28).

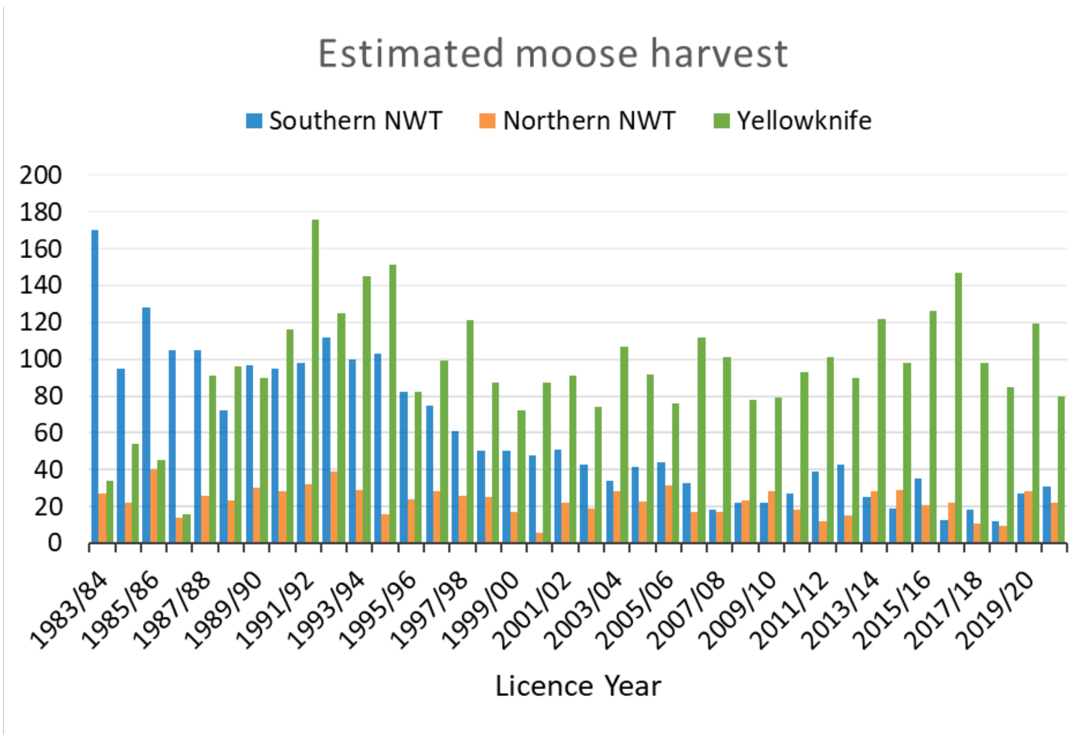

Figure 28. Estimated number of moose harvested by NWT resident hunters, 1983-2021. For the Resident Hunter Survey, the NWT is divided into three regions based on where the hunter resides. Southern NWT includes the Dehcho, South Slave and North Slave region except for

Yellowknife. Northern NWT includes Inuvialuit, Gwich'in, and Sahtú regions (ECC unpublished data 2022).

Of 1,020 moose harvested by resident hunters between 2000 and 2017 where sex and age were reported, 8% were juvenile animals, 21% were adult females and 71% were adult males (ECC unpublished data; Figure 31). Over this 17-year period the proportion of juvenile, female and male moose in the harvest was relatively constant (Figure 29).

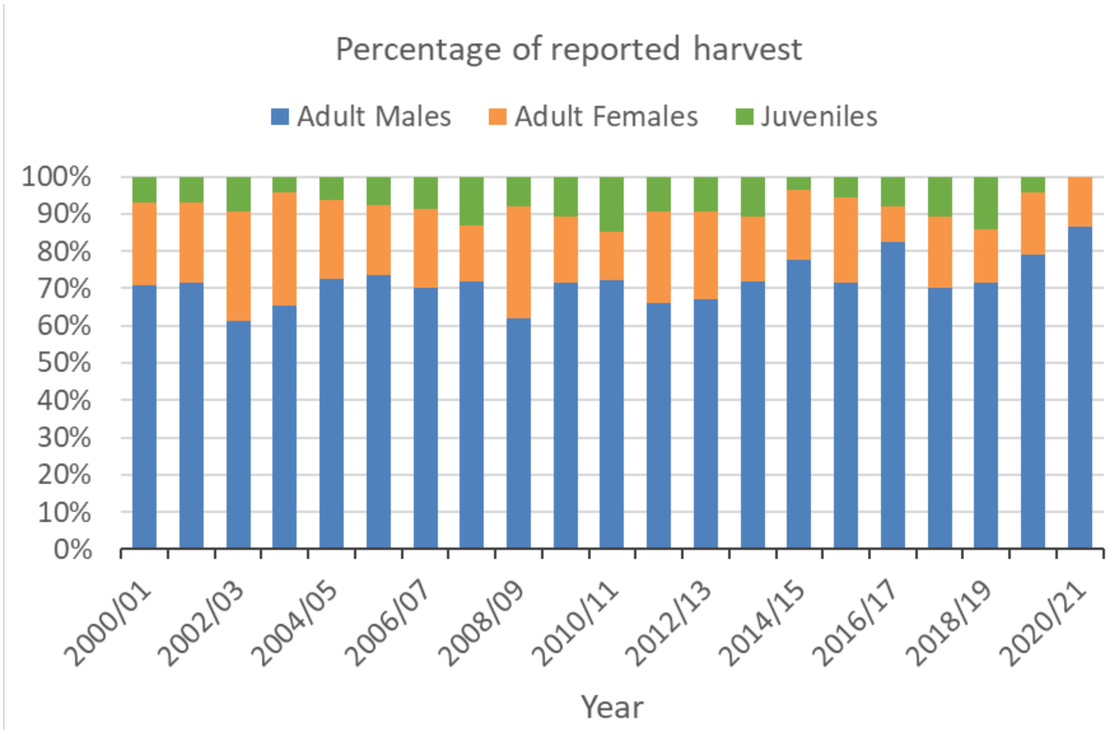

Figure 29. The percentage of adult males, adult females and juvenile moose in the harvest reported by NWT resident hunters, 2000-2017 (ECC unpublished data 2022).

Data on harvest by non-resident hunters in the Mackenzie Mountains has been reported since 1991 (Larter et al. 2018a; Figure 30). From 1991-2017 the average annual harvest was 59 moose (range 32-81; SD=16) from an area of approximately 140,000 km^2. Non-residents are only permitted to harvest male moose and take by non-resident hunters may have increased in recent years (Larter et al. 2018a). Non-resident hunter harvest in the Mackenzie Mountains peaked at 85 moose in 2012 compared to an average of 45 from 1991-2004 (Larter et al. 2018a). Larter et al. (2018a) noted that the increase of non-resident harvest of moose began after 2004 when the large outfitting zone of D/OT/01 was sold to a new owner who began to target moose. Since peaking in 2012, harvest has decreased averaging 75 annually since 2004. Based upon 139 incisor teeth turned in voluntarily from 2003-2017, the mean age of moose harvested from the Mackenzie Mountains was 7.7 years (range 3-15 years) (Larter et al. 2018a).

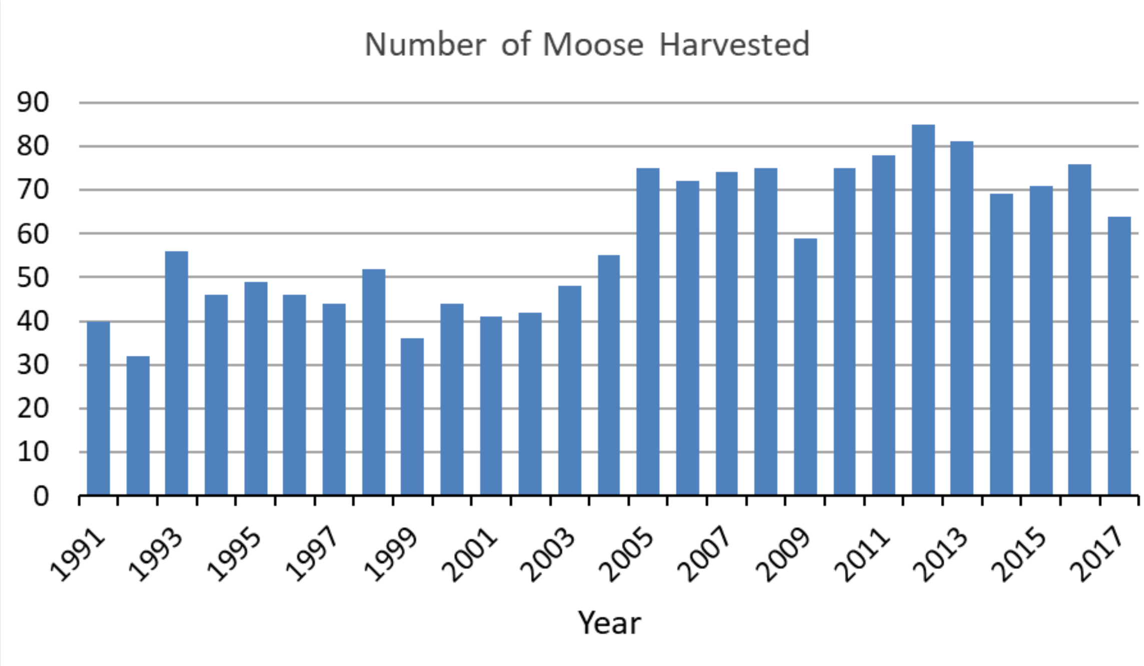

Figure 30. Number of moose harvested from the eight outfitting zones in the Mackenzie Mountains by non-resident hunters, 1991-2017 (Larter et al. 2018a).

Data on harvest by general hunting licence (GHL) holders were collected for the communities of Fort Simpson, Fort Liard and Nahanni Butte from 1936/1937 to 1983/1984 (ECC unpublished data, Figure 31). Even though information was not available from each of the three communities for every year, these data provide insight into the number of moose harvested locally for subsistence prior to the mid-1980s. They show an average harvest of 131 moose (range 23-324) for Fort Simpson, 83 (range 3-190) for Fort Liard, and 28 (range 1-55) for Nahanni Butte. In years with all three communities reporting (1963/1964 to 1977/1978) the average annual harvest for all three communities combined was 261 moose (range 125-378). Indigenous hunters from Fort Liard traditionally harvested moose in northeastern BC so the reported harvest includes moose from outside the NWT. From 1976-2006 the average annual moose harvest by resident and non-resident hunters in the two BC moose management units (*ca.* 28,000 km^2 area) adjacent to the Dehcho was 34, among the lowest of all 27 moose management units in the Peace Region and decreased over the past ten years (Baccante 2010). There are limited data on the sex composition of the harvest by Indigenous hunters. As part of a study of contaminants in moose, samples were collected from 43 moose harvested by Indigenous hunters from 2005-2007 and 36 harvested from 2011-2016 in the Dehcho. Males made up 68% (54 of 79) of the harvest sample during the two periods (Larter et al. 2018b).

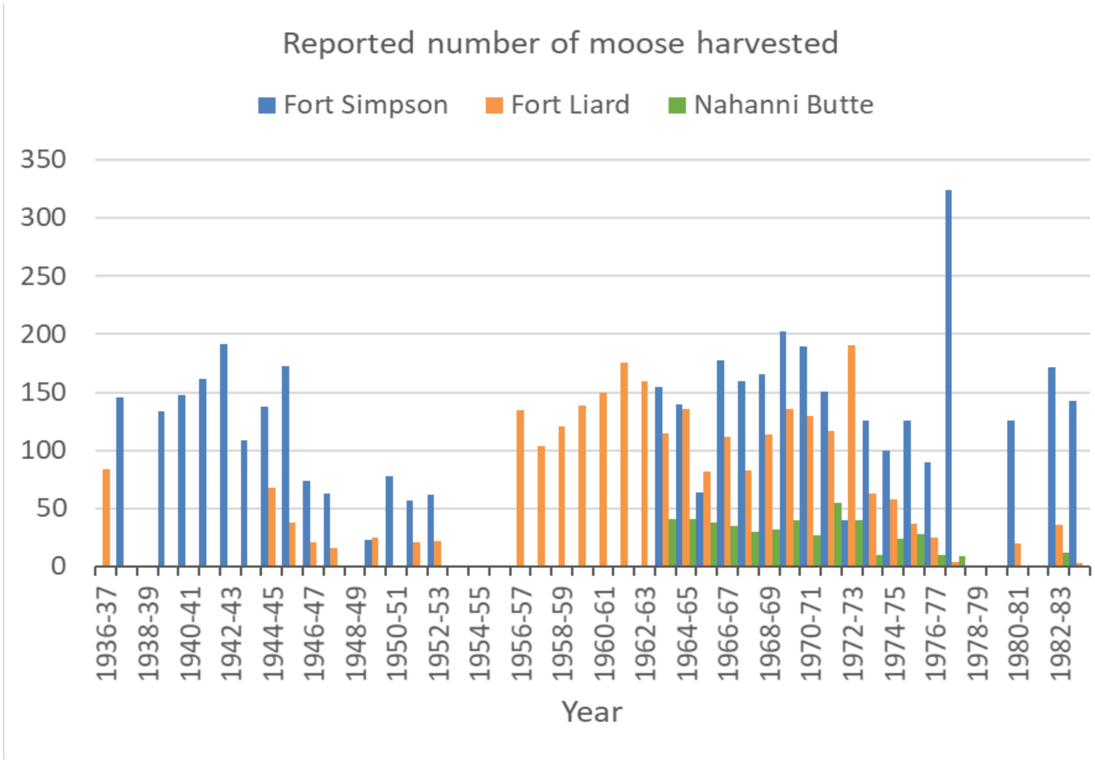

Figure 31. Reported harvest of moose by GHL holders of Fort Simpson, Fort Liard, and Nahanni Butte from 1936/1937 to 1983/1984. Data source: ECC Fort Simpson.

In the Sahtu, Stenhouse et al. (1995) estimated mean annual mortality rate of female moose to be 3%, based upon a study of 30 radio collared females. Veitch et al. (1995) compared the minimum moose harvest by resident hunters and Indigenous hunters combined to the results of an aerial survey of a 2,910 km^2 study area west of Norman Wells and reported annual harvest represented 6-7% of the estimated population. They noted that the population appeared to be remaining stable with continued high productivity. Over a two-year period, juveniles made up 14.0% and adults 86.0% of the annual moose harvest by Indigenous and resident hunters, with males and females making up 67.3% and 32.7% of the adults harvested, respectively (Veitch et al. 1995).

A study was conducted in the Inuvialuit Settlement Region from 1988-1997 to estimate harvest of many wildlife species including moose. Harvest information (Figure 32A) was collected from Inuvialuit beneficiaries in Aklavik, Holman (Ulukhaktok), Inuvik, Paulatuk, Sachs Harbour and Tuktoyaktuk (Joint Secretariat 2003). The total harvest reported over the ten years was 272 moose[3] with a mean annual harvest of 28. Not surprisingly, no moose were harvested on the Arctic islands i.e., communities of Ulukhaktok and Sachs Harbour (Figure 32A).

From 1995-2001, information about wildlife harvesting in the Gwich'in Settlement Area was collected from Gwich'in beneficiaries in Aklavik, Inuvik, Fort McPherson and Tsiigehtchic

[3] Total number and mean annual harvest calculated from data found in tables for each community for each year.

(GRRB 2009). A total harvest of 245 moose[4] was reported over the six years, and a mean annual harvest of 41. Most moose were harvested by the communities of Fort McPherson and Tsiigehtchic (Figure 32B).

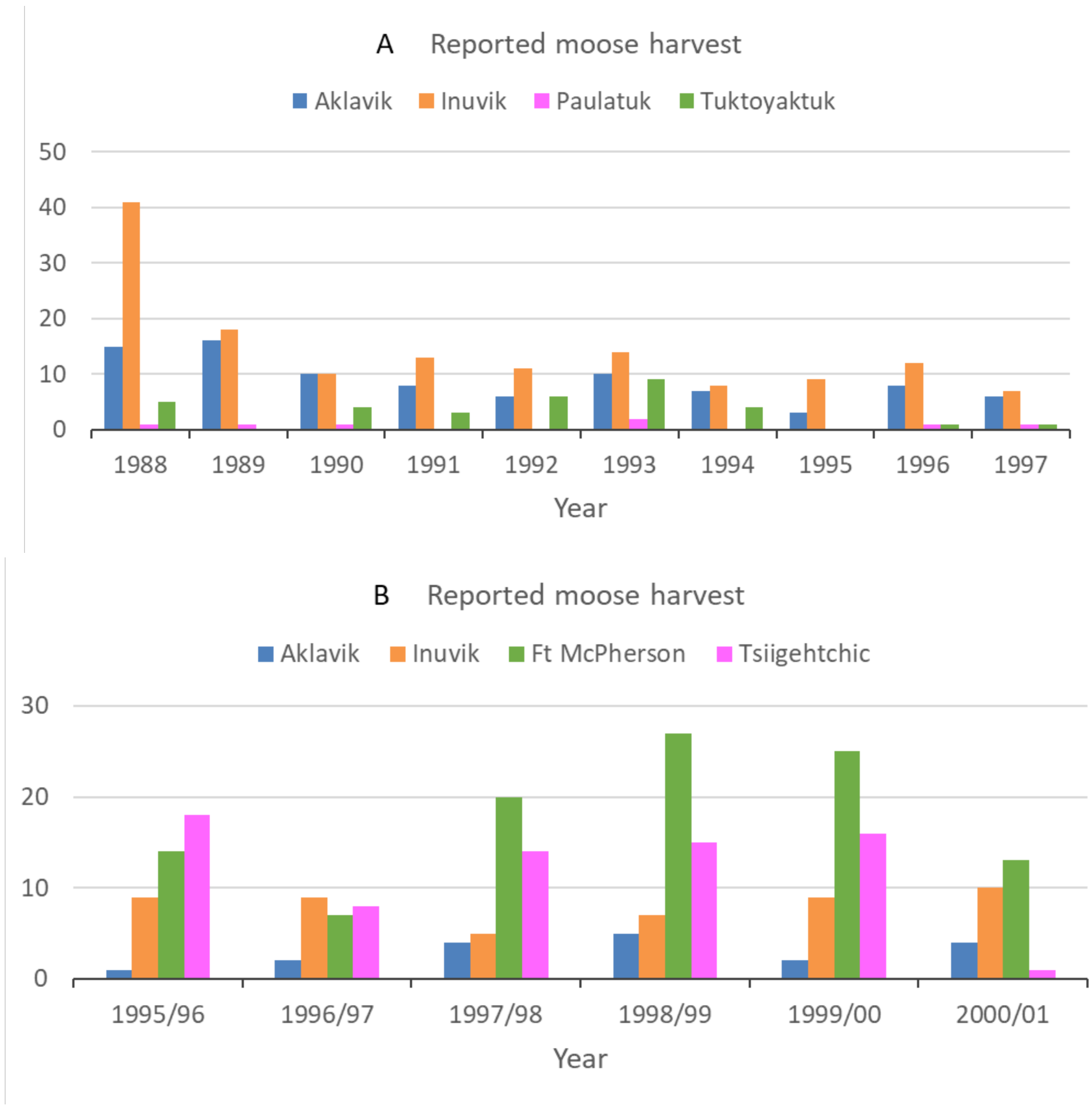

Figure 32. Moose harvests reported by Inuvialuit and Gwich'in beneficiaries. (A) Inuvialuit beneficiaries and (B) Gwich'in beneficiaries from communities in the Inuvialuit Settlement Region and Gwich'in Settlement Area. Figure adapted from Joint Secretariat (2003) and GRRB (2009).

[4] Total number and mean annual harvest calculated from data found in tables for each community for each year.

Based on the CIMP (2012) estimate of moose harvest across the NWT, the subsistence take would be between 800-1,800 moose annually, and resident and non-resident harvesters combined would take 100-400. Using 22,000, the lower bound of the estimated moose population of NWT (see *Population – Abundance*) and the higher estimated harvest (2,200), the total take would be 10% of the total population. If the total abundance was at the midpoint of the estimate, i.e., 36,500 moose, a harvest of 2,200 annually represents a 6% harvest rate. Veitch et al. (1995) reported a local population of moose with high productivity as being stable with a 6-7% annual harvest.

The impact of harvest will be minimized and moose production maximized if harvesters target males and juveniles (calves) and avoid harvesting females (Sæther et al. 2001; Xu and Boyce 2010). Although data are scant on age and sex composition of the harvest, females continue to make up as much as 30% of adult moose harvested in the NWT.

Harvest pressure in local areas, especially on female moose, has the potential to cause or exacerbate local declines in moose numbers. This situation has likely occurred historically in the NWT, and harvest should be considered a potential threat. However, given the current situation, harvest levels over the entire range of moose in the NWT appear to be sustainable. If hunting pressure was to increase, as may be the case with the dramatic decrease in availability of barren-ground caribou to be harvested, or with increased accessibility into the boreal forest, then harvest may become more of a threat.

Predation

Primary predators of moose are wolves and black bears in the Taiga Plains and Taiga Shield, wolves and grizzly bears on the tundra, and grizzly bears, black bears, and wolves in the cordillera (Veitch et al. 1995, Franzmann et al. 2007, McCulley et al. 2017b, Species at Risk Committee 2017).

The primary prey of wolves in the boreal forests of Canada is assumed to be the most locally abundant ungulate species, which is generally moose (Messier 1994). Other ungulate species such as elk (*Cervus canadensis*), boreal caribou, barren-ground caribou where their winter range overlaps with moose, mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and wood bison are alternate ungulate prey for wolves. Elk and deer are uncommon in the NWT, wood bison are common locally in parts of the Dehcho, North Slave and South Slave regions, and boreal caribou occur at low densities (estimated at 2-3/ 100 km^2; Larter et al. 2017a). Note that some surveys have reported moose densities of less than 2 per 100 km^2 (see Appendix A).

The impact of predation on moose in the NWT is unknown. There has been only one study in the NWT that collected data on predation on moose. In Stenhouse et al.*'s* (1995) study of 30 radio collared female moose in the Sahtú between 1985 and 1988, the mean annual mortality rate from all sources was 15.0%, of which 5 of 11 mortalities (45.5%) were likely due to wolf predation. This represents a wolf predation rate of approximately 6.8% annually. These data must be used with caution when assessing the impact of wolf predation on moose in the NWT because the results were from a small sample of adult female moose in a short-term study in small study area. Predation on calves is expected to be greater than and in addition to predation on adult females, therefore 6.8% would be an underestimate of predation rate at the population level. Elsewhere in North America, wolf predation has been shown to constrain moose populations at low densities (Gasaway et al. 1992, Messier 1994).

Studies on the diet of wolves have been used to investigate the prevalence of different prey species (Larter et al. 1994, Larter 2016, O'Donovan et al. 2018, ECC North Slave 2019). Using stable isotope and fatty acid analyses, O'Donovan et al. (2018), found bison were the predominant prey item in areas of the South Slave region where bison were present, but in areas where bison were absent, moose and boreal caribou made up substantial portions of the diet. Larter et al. (1994), using scat analysis, also found bison predominated the diet when the Mackenzie bison population was rapidly increasing. However, based upon available prey biomass, they determined that moose made up a significantly greater proportion of the wolf diet than expected and speculated that an apparent local decline in moose numbers may have been the result of wolf predation becoming destabilizing and exacerbating the decline (Larter et al. 1994). Larter (2016) reported the percent frequency occurrence of bison, moose, and caribou in wolf diets to be 7%, 14%, and 31% (n=72) respectively, from analyses of wolf scat and stomach contents in the Dehcho Region. Moose and caribou were distributed throughout the region while bison were found only in the southwestern portion. Stomach contents analysis did not find any evidence of moose in the diet of wolves from the tundra (n=59, ECC North Slave 2019).

There have been no studies of black bear or grizzly bear predation on moose in the NWT. Studies elsewhere in North America have reported that bear predation, specifically on moose calves, can be substantial and impact recruitment (Ballard 1992). Joly et al. (2015) reported black bears killed 40% of calves in their study in Alaska and Ballard et al. (1991) reported grizzly bears killed 73% of calves in a study in southcentral Alaska. Grizzly bear abundance in the NWT appears to be stable or increasing (Species at Risk Committee 2017), and recent increases in grizzly bear abundance in the Mackenzie Mountains (Larter et al. 2018a) could lead to increasing predation rates and lower recruitment on a local scale. There is no population information on black bears.

It is very difficult to assess how serious a threat predation is to moose in the NWT due to the lack of data on predator populations and predation rates. Increasing predation of moose calves by grizzly bears in the Mackenzie Mountains could impact future recruitment and depress moose numbers. Current resident and non-resident harvest on moose in the Mackenzie Mountains is low and does not include calves. Increasing numbers of alternate prey may sustain higher wolf numbers, which in turn may depress local populations of moose. However, over the past 15 years both the moose and wood bison populations have increased in the Liard Valley (Larter pers. comm. 2017 and 2018a).

Parasites and Disease

The impact of parasites and diseases as limiting factors in NWT moose populations is not known. Climate plays a role in prevalence and transmission of diseases and parasites, e.g. winter tick. Climate change could support longer periods during which parasites are active, and may also contribute to the expansion of their spatial distribution and increase the likelihood that new diseases and parasite will become established in NT (Kutz *et al.* 2009). Climate warming may also contribute to the expansion of range of other wildlife species like deer that could potentially transmit meningeal worm (*P. tenuis*) to moose or facilitate the transmission of chronic wasting disease to moose.

Contaminants

A research program was conducted from 2005 to 2016 to evaluate the levels of chemical elements in moose of the Mackenzie and Liard valleys and to address the public's concern about contaminants in an important traditional food source (Larter 2009; Larter *et al.* 2017b, 2018b, 2018c). Tissue samples from moose were provided by local harvesters and non-resident hunters from 2005-2009. Although the levels of most elements including arsenic, lead, mercury, selenium, and zinc were low and of little concern, the levels of cadmium in kidneys and livers resulted in a public health advisory (Larter and Kandola 2010). The levels of cadmium in the organs of moose harvested in the Mackenzie Mountains by non-resident hunters was almost 10 times higher than that of moose harvested in the valleys. This was attributed to bioaccumulation of cadmium by willows in an area of naturally high occurring geologic sources (Larter and Kandola 2010).

Some liver samples from this study and some samples from moose harvested by residents of the South Slave were tested for the presence of Persistent Organic Pollutants (POPs) including polychlorinated biphenyls, DDT related compounds, toxaphene, brominated diphenyl ethers (PBDEs) and perfluorinated alkyl substances. The overall concentrations of major groups of POPs were consistently low and comparable to limited data available from Scandinavia. Perfluorinated alkyl substances were the most prominent POP and Decabromodiphenyl ether (BDE-209) the most prominent PBDE, similar to that found in other arctic and subarctic herbivores. Both are generally particle-borne and relatively non-volatile. Interestingly, concentrations of POPs were higher in moose harvested in the Dehcho than in the South Slave (Larter et al. 2017b). The reasons for this difference are unknown. The minimal concentrations reported are of no threat to animal health or to those consuming moose meat.

Overall, the analysis of individual tissues showed that the levels of most elements were similar to those in moose from other regions of Canada and Alaska. Despite the higher cadmium levels reported in moose from the Mackenzie Mountains, there was no evidence of cadmium toxicity impairing renal function. There is little evidence to suggest health concerns for moose in the southern Mackenzie Mountains or the Mackenzie and Liard rivers valleys in the Dehcho region. Further, the results indicated that there were no concerns to human health associated with the consumption of moose. It is unlikely that normal kidney consumption would reach that of the public health advisory. Currently, except for cadmium in moose in the Mackenzie Mountains, contaminant levels are a negligible threat to moose and those who consume them.

Anthropogenic Habitat Disturbance

Anthropogenic disturbances such as roads, cutlines, communities, mines, and energy projects displace moose and alter their movements and distribution across the NWT. The frequency of the impact of such habitat changes is high because it is ongoing. The total area of these disturbances in the NWT is unknown and research to measure the extent of effective habitat loss for moose around each type of disturbance has not been conducted. For boreal caribou range these disturbances are being quantified and effective habitat loss is considered to be 500 m on either side of roads and cutlines (Environment Canada 2012). This information could be used as a surrogate for moose, at least for the area of boreal forest where moose and boreal caribou distribution overlap, until similar studies have been conducted on moose. It is likely that the amount of anthropogenic disturbance is less for moose in the Mackenzie Mountains than for those inhabiting the Taiga Plains and Taiga Shield and could be <1% of range.

Moose have much smaller home ranges than boreal caribou. Home range estimates for female moose in the Mackenzie Valley in the NWT as measured by their 100% minimum convex polygon was 174 km^2 for female moose (Stenhouse et al. 1995) compared to 1,243km^2 and 502km^2 for male and female moose, respectively, of the Mackenzie Mountains in the Yukon (McCulley et al. 2017a) versus 2,608km^2 for male and 3,119km^2 for female boreal caribou of NT Dehcho region (Larter et al. 2019). By having smaller individual home ranges the impact of linear development may be dramatically different between individuals, especially females.

Knowledge Gaps

Species Overview

Genetics

The genetic structure of moose in the NWT is unknown. Currently, we assume moose in the Mackenzie Mountains are of the subspecies *Alces alces gigas* and those east of the Mackenzie Mountains are *A. a. andersoni,* but this distinction has not been established by studies of moose genetics. There is a low genetic diversity among North American moose and the subspecific designation of *A. a. shirasi* has recently come into question (DeCesare et al. 2020). Investigating the genetic structure of moose in the NWT may determine that the species needs to be managed based on regional genetic differences.

State and Trends

Population

Large parts of the NWT have never been surveyed to estimate moose density and estimating territory-wide abundance or trend can only be done by extrapolating the results from surveys of small study areas to entire ecoregions. This knowledge gap could be closed by redesigning surveys to estimate moose density at the landscape or ecoregion level instead of focusing on small areas of local interest. There have been no surveys to estimate moose density or abundance in the NWT portion of the Mackenzie Mountains.

Two regions use distance sampling to estimate moose density while three use the geospatial method. There are also differences in the size and selection of study areas as well as timing of surveys: early winter versus late winter. Sex of adult moose can be determined during early winter surveys, but bulls have cast their antlers by the time late winter surveys take place, so sex ratio data is rarely collected then. Inconsistencies among regions make it impossible to compare results among regions and make combining data for territory-wide summaries questionable.

Information on productivity (calf production or birth rate) is lacking and better information on recruitment and harvest would permit a more complete picture of population dynamics. Currently, calf/cow ratio data, usually presented as calves/100 adult females, is the sole estimate of recruitment. Collecting harvest data is important to be able to accurately estimate total moose harvest and for those data to be available to all moose managers. The Resident Hunter Survey and Mackenzie Mountain Non-resident hunter harvest reporting provide good estimates of moose harvest by those hunters (Figures 30 and 32), but estimates of moose harvested by Indigenous hunters is lacking. The lack of adequate harvest data has been an ongoing issue since the 1980s (Treseder and Graf 1985; Graf 1992).

Habitat

Habitat Availability

More detailed and accurate landscape and vegetation data that would enable more precise mapping and calculation of areas of water, rock, and other uninhabitable terrain (e.g., permanent ice) would be useful in refining study areas, assessing the amount of available moose habitat, and enabling better estimation of moose abundance. It could also allow for a GIS-based assessment of carrying capacity for moose in the NWT.

Threats and Limiting Factors

The timing and synchrony of parturition in moose are believed to be adaptations to long-term patterns of climate that provide the most hospitable conditions for rearing young (Bowyer et al. 1998). Consequently, moose may be more susceptible to climatic change than other ungulates that are more adapted to climatic variability. However, there is almost no data on timing or synchrony of moose calving in the NWT.

The impact of wolf, grizzly bear, and black bear predation on moose populations in the NWT is unknown. Elsewhere, bear predation can dramatically reduce calf survival (Ballard et al. 1991, Joly et al. 2015) and impact adult survival (Ballard 1992). We have some knowledge of wolf abundance from surveys in limited areas in the North Slave, South Slave and Dehcho regions (Serrouya et al. 2016, ABMI 2018) and grizzly bear abundance in the Mackenzie Mountains may be increasing (Larter et al. 2018a), but we know nothing about black bear numbers.

Improved harvest information is essential to assessing factors that limit moose populations and drive population dynamics and could help in selection of survey areas.

The impacts of anthropogenic disturbances on moose movements and range use and whether those disturbances result in effective habitat loss as they do for boreal caribou (Environment Canada 2012) are unknown. Also unknown are the roles of parasites, diseases, and contaminants in limiting moose density in the NWT.

Climate change could affect moose in the NWT through altered effects parasites and pathogens, changes in the distribution and condition of preferred habitats, or other species that may directly or indirectly interact with moose. Changes could be negative in some respects and positive in others.

Positive Influences

Wildfire is the greatest disturbance in the boreal forest in the NWT and the most significant factor in re-establishing the early successional stage habitats where moose thrive. Recent improvements in mapping fires and assessing fire intensity should enable us to assess moose habitat on the landscape more accurately and improve our ability to plan and design moose surveys and dedicated moose research studies in future.

The vast number of studies conducted on moose elsewhere in North America over the last 3-4 decades provides an extensive knowledge base, which precludes the need for duplicate studies in the NWT and provides the opportunity to focus research where knowledge is indeed lacking and essential.

Protected areas have a positive influence on moose populations through the management and restriction of natural resource development projects and associated anthropogenic disturbances, as well as through the elimination of resident and non-resident harvest. As of 2022, 17.3% of the NWT was in protected areas (Gah pers. comm. 2022). Most was in areas protected by a federal (e.g., Nahanni, Nááts'įhch'oh) or territorial parks, or as Indigenous protected areas (e.g., Edéhzhíe, Ezǫdzìtì), or in areas conserved through conservation zoning (e.g., Thaidene Nëné Wildlife Conservation Area). Land use plans in the Dehcho and in the non-Tłįchǫ lands of Wek'èezhìı are being developed.

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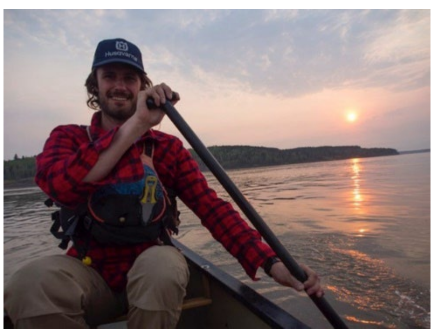
Chuck Blyth

Over his 30-year career with Parks Canada, Chuck had a wide variety of roles and responsibilities across the country. These included: Data manager for National Parks in the NWT, Resource Management Secretariat Manager for National Parks In the NWT, Resource Management Planner Western Regional Office Parks Canada, Superintendent and Chief of Resource Conservation for Nahanni National Park Reserve, National Warden Service Manger Parks Canada Ottawa, and Manager of University of Alberta – National Parks Research Center.

Chuck has published and written chapters in books in several wildlife topics including ungulate population dynamics, wildlife production systems in Western Canada, aspen parkland paleo ecology, vegetation and ungulate management reports for Elk Island National Park, and Resource Management Programs and Research for Nahanni National Park.

John Blyth



Growing up in national parks across the NWT started John off with a love of wild spaces and the people who live in them from an early age. Taking this passion, he went into the study of Archaeology and Anthropology, and has been living and working in the NWT as a multidisciplinary consultant in the fields of environmental science, anthropology, education, and wilderness safety for over a decade. Notable research projects John has been involved in include the TK and CK component of the NWT Species at Risk Committee Barren-ground Caribou Species Status Assessment, the 2014 GNWT Wildfire Report Card, the Enbridge TK Land Use Permit Renewal TK study for Łutsel K'e First Nation and several others.

Samantha Stokell

Samantha Stokell is a librarian with a background as a journalist in the North. She has a Bachelor of Fine Arts, a post-graduate Journalism certificate, and a Master of Library and Information Studies, with a concentration in First Nations studies. She lived in the NWT working as a reporter, and through her experiences with traditional and community knowledge holders decided to pursue her library degree. The specialization in First Nations studies allowed her to delve deeper into the issues facing First Nation communities in the documentation of TK and Indigenous information management. Samantha worked as a librarian at Xwi7xwa Library at the University of BC, the only Aboriginal-focused post-secondary library in Canada. During this time, she developed research techniques that allowed her to find TK documents and Indigenous information that was relevant to students, professors and community members looking for a First Nation, Métis or Inuit perspective in their field. Samantha currently lives in Fort Smith, NWT.

Nicholas (Nic) Larter

Nic recently retired from ENR (GNWT). During his 26+ years he spent nine years as the Muskox/Caribou Biologist in Inuvik and over 17 years as the Regional Biologist and Manager of Wildlife Research and Monitoring in Fort Simpson. Nic holds a PhD in Zoology from the University of BC and has extensive field experience with many northern wildlife populations including Peary and boreal caribou, muskoxen, moose and wood bison. Nic has published many scientific papers and government reports and has presented his research to local, national, and international audiences. He has been a member (or alternate member) for the NWT Species at Risk Committee since 2010; his current term expires in 2025. Nic is a member of the IUCN Bison Specialist Group, and a Research Associate of the Arctic Institute of North America. He was a member of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) representing the NWT from 2013-2020. His first summer wildlife job was working with moose in Denali National Park and the Kenai Moose Research Center in Alaska.

PERSONAL COMMUNICATIONS

TRADITIONAL and COMMUNITY KNOWLEDGE COMPONENT

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APPENDIX A

Estimates of moose calf/cow ratios, bull/cow ratios and twinning rates from surveys conducted in the NWT and adjacent areas in Alberta, British Columbia, and Wood Buffalo National Park, from 1980-2020.

Study Area	Year	Calves/100 cows	Bulls/100 cows	Cows with twins (%)
Beaufort Delta Region				
Arctic Red River (Benn 1999)	1998	67	172	9
Arctic Red River (Davison and Callaghan 2013)	2011	80	85	n/a
Fort McPherson (Benn and Firth 2001)	2000	45	205	0
Gwich'in Settlement Area (Lambert 2006)	2006	52	78	n/a
Inuvik – Tsiigehtchic (Chetkiewicz et al. 1998)	1996	58	96	13
Inuvik – Tsiigehtchic (Marshal 1999)	1997	54	146	38
Inuvik – Tsiigehtchic (Marshal 1999)	1998	69	175	13
Miner/Kugaluk River (Jingfors and Kutny 1989)	1988	25	69	0
North Richardson Mountains (Cooley 2000)	1989	41	110	16
North Richardson Mountains (Cooley 2000)	2000	40	99	19
Rengleng River (cited in Graf 1992)	1986	44	110	27
Sahtú Region				
Fort Good Hope (Jingfors et al. 1987a)	1984	61	79	18
Fort Good Hope (MacLean 1994b)	1992	53	94	31
Fort Good Hope (Veitch 1998)	1998	74	74	n/a
Norman Wells (Jingfors et al. 1987b)	1984	44	76	10
Norman Wells (Stenhouse et al. 1995)	1985-88	n/a	n/a	31[5]
Norman Wells (Latour 1992a)	1989	57	100	11
Norman Wells (Veitch et al. 1995)	1995	56	96	10
Tulita (MacLean 1994a)	1993	60	100	8
Tulita, Keele and Redstone Rivers (Swallow et al. 2003)	1999	44	151	3
Dehcho Region				
Liard Valley (Case 1992)	1985	75	77	37

[5] From observations of radio collared female moose rather than an aerial survey

Liard Valley (Case 1992)	1986	82[6]	100[7]	47
Liard Valley (Case 1992)	1987	46	62	20[8]
Liard Valley (Case 1992)	1988	19	131	0
Liard Valley (Larter pers. comm. 2018a)	2003	44.4	36.1	0
Liard Valley (Larter pers. comm. 2018a)	2011	See note[9]	26.4	0
Liard Valley (Larter pers. comm. 2018a)	2017/2018	53.7	62.6	11
Mackenzie Valley (Larter pers. comm. 2018a)	2003	32.5	55.3	0
Mackenzie Valley (Larter pers. comm. 2018a)	2011	54.4	41.7	2
Mackenzie Valley (Larter pers. comm. 2018a)	2017/2018	28.2	25.5	2
North Slave Region				
Taiga Plains (Cluff 2005)	2004	64	71	n/a
Taiga Plains (Cluff 2013)	2007	65	45	0
Taiga Plains (Cluff 2013)	2012	58	77	3
Taiga Shield (Case and Graf 1992)	1989	60	50	See note[10]
Taiga Shield (Cluff 2005)	2004	62	56	n/a
Taiga Shield (Cluff 2013)	2007	77	77	10
Taiga Shield (Cluff 2013)	2012	42	52	8
Taiga Shield (Cluff 2016)	2016	41	58	n/a
South Slave Region				
Buffalo Lake (Kelly and Cox 2017b)	2009	48	133	n/a
Buffalo Lake (Kelly and Cox 2017b)	2016	33	73	n/a
Kakisa (ECC unpublished data)	2012	44	92	11
Mills, Mink, and Falaise Lakes areas (Shank 1992)	1991	55	103	3
Mills Lake and Mink Lake area (Bradley et al. 1998)	1994	31	137	0
Mills Lake and Mink Lake area (Bradley and Johnson 1998)	1997	16	176	0
Slave River Lowlands - north (Graf and Case 1992)	1987/1988	69	96	34

[6] Calculated from data in Table 7 in Case (1992)
[7] Calculated from data in Table 7 in Case (1992)
[8] One of five cows observed with calves had twins
[9] Only a single cow with a calf was seen on the survey
[10] Very small sample size: 2/3 cows accompanied by calves had twins

Slave River Lowlands - north (Bradley et al. 1996)	1995	33	102	0
Slave River Lowlands - south (Graf and Case 1991)	1986	64	67	22
Slave River Lowlands - south (Bradley and Kearey 1998)	1996	37	121	3
Slave River Lowlands – north and south (ECC unpublished data)	2011	64	92	n/a
Wood Buffalo National Park Ft Smith (Irwin et al. 2005)	2000	45	42	1
Wood Buffalo National Park Ft Smith (Irwin et al. 2005)	2005	37	96	1

APPENDIX B

Estimates of moose density from surveys conducted in the NWT and adjacent areas in Alberta, British Columbia, and Wood Buffalo National Park, from 1980-2020.

Study Area	Year	Density (moose/100 km^2)
Beaufort Delta Region		
Arctic Red River (Lambert 2006)	2006	0[11]
Arctic Red River (Davison and Callaghan 2013)	2011	0.53
Arctic Red River (Davison and Callaghan 2019)	2017	3.23
Arctic Red River area (Chetkiewicz et al. 1998)	1996	2
Arctic Red River area (Benn 1999)	1999	5.5
Fort McPherson/Peel River (Lambert 2006)	2006	0.84
Fort McPherson/Peel River (Davison and Callaghan 2013)	2011	0.001
Fort McPherson/Peel River (Davison and Callaghan 2019)	2017	3.51
Inuvik 7(1)(a) (Davison and Callaghan 2013)	2011	9.66
Inuvik 7(1)(a) (Davison and Callaghan 2019)	2017	3.94
Inuvik -Tsiigehtchic (Lambert 2006)	2006	1.62
Inuvik -Tsiigehtchic (Davison and Callaghan 2013)	2011	0.85
Inuvik -Tsiigehtchic (Davison and Callaghan 2019)	2017	3.65
Mackenzie Delta (Brackett et al. 1985)	1980	1
Mackenzie Delta (Davison and Callaghan 2013)	2011	2.87
Mackenzie Delta (Davison and Callaghan 2019)	2017	5.57
Mackenzie Gas Pipeline Route (Lambert 2006)	2006	2.31
Mackenzie Gas Pipeline Route (Davison and Callaghan 2013)	2011	3.33
Mackenzie Gas Pipeline Route (Davison and Callaghan 2013)	2017	0.91
Mackenzie River Valley (Brackett et al. 1985)	1980	10
Miner/Kugaluk River (Jingfors and Kutny 1989)	1988	6
North Richardson Mountains (Cooley 2000)	2000	4.8
Peel River Valley (Lambert 2006)	2006	0.84
Rengleng River (cited in Graf 1992)	1986	5
Richardson Mountains (Lambert 2006)	2006	3.54
Richardson Mountains (Davison and Callaghan 2013)	2011	2.23
Richardson Mountains (Davison and Callaghan 2019)	2017	4.28
Sahtú Region		
Fort Good Hope (Jingfors et al. 1987a)	1984	13
Fort Good Hope (MacLean 1994b)	1992	17
Fort Good Hope (Veitch 1998)	1998	16

[11] Few to no animals observed in small survey areas can result in unreliable density estimates (see Figure 7).

Norman Wells (Jingfors et al. 1987b)	1984	15
Norman Wells (Latour 1992a)	1989	15
Norman Wells (Veitch et al. 1995)	1995	17
Sahtú – northern (GNWT 2021)	2021	3.0
Sahtú – southern (GNWT 2021)	2020	1.4
Tulita (MacLean 1994a)	1993	8
Tulita/Keele/Redstone (Brackett et al. 1985)	1980	11
Tulita/Keele/Redstone (Swallow et al. 2003)	1999	11
Dehcho Region		
Liard Valley (Case 1992)	1985	12
Liard Valley (Case 1992)	1986	7.4
Liard Valley (Larter pers. comm. 2018a)	2004	4.96
Liard Valley (Larter pers. comm. 2018a)	2011	1.22
Liard Valley (Larter pers. comm. 2018a)	2017/2018	7.16
Mackenzie Valley (Larter pers. comm. 2018a)	2003	4.22
Mackenzie Valley (Larter pers. comm. 2018a)	2011	5.29
Mackenzie Valley (Larter pers. comm. 2018a)	2017/2018	4.47
North Slave Region		
Taiga Plains (Cluff 2005)	2004	3.61
Taiga Plains (Cluff 2013)	2007	3.2
Taiga Plains (Cluff 2013)	2012	2.9
Taiga Shield (Case and Graf 1992)	1989	2
Taiga Shield (Cluff 2005)	2004	1.5
Taiga Shield (Cluff 2013)	2007	4.1
Taiga Shield (Cluff 2013)	2012	5.8
Taiga Shield (Cluff 2016)	2016	4.9
South Slave Region		
Buffalo Lake (Kelly and Parker pers. comm. 2020)	2009	5.0
Buffalo Lake (Kelly and Parker pers. comm. 2020)	2016	1.3
Buffalo Lake (Kelly and Parker pers. comm. 2020)	2019	1.8[12]
Fort Providence (Kelly and Cox 2017a)	2016	4.8
Fort Providence (Kelly pers. comm. 2019)	2019	6.3
Kakisa (ECC unpublished data)	2012	2.9
Mills, Mink, and Falaise Lakes areas (Shank 1992)	1991	17
Mills Lake and Mink Lake area (Bradley et al. 1998)	1994	7
Mills Lake and Mink Lake area (Bradley and Johnson 1998)	1997	3

[12] The same study area was used in 2009 and 2016, but the study area was larger for the 2019 survey. The estimated population density is for an area comparable to that surveyed 2009 and 2016. The estimated 2019 density for the enlarged Buffalo Lake study area which includes part of Wood Buffalo National Park was 3.5 moose/100 km^2.

Slave River Lowlands – north (Bradley et al. 1996)	1995	15
Slave River Lowlands – north (Graf and Case 1992)	1987-88	16
Slave River Lowlands – south (Bradley and Keary 1998)	1996	11
Slave River Lowlands – south (Graf and Case 1991)	1986	11
Slave River Lowlands (ECC unpublished data)	2011	3.6
Slave River Lowlands (ECC unpublished data)	2018	0.9
Adjacent Alberta, British Columbia, and Wood Buffalo National Park		
Alberta – WMU 531 northeast (Alberta Fish and Wildlife 2016)	2016	7
Alberta – WMU 536 northwest (Alberta Fish and Wildlife 2018a)	2018	15
Alberta – WMU 537 northwest (Alberta Fish and Wildlife 2018b)	2018	24
British Columbia – northeast (Backmeyer 2004)	1998	9
British Columbia – northeast (Rowe 2008)	2008	8.7
Wood Buffalo NP – Fort Chipewyan area (Anderson et al. 2010)	2002	8
Wood Buffalo NP – Fort Chipewyan area (Anderson et al. 2010)	2007	8
Wood Buffalo NP – Ft Smith area (Irwin et al. 2005)	2000	6.0
Wood Buffalo NP – Ft Smith area (Irwin et al. 2005)	2005	7.0
Wood Buffalo NP – Garden River area (Irwin et al. 2006)	2001	12
Wood Buffalo NP – Garden River area (Irwin et al. 2006)	2006	5