Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 6: Moose / Tuttuvak

Publication Information

Cover photo: Bull moose near the Babbage River, Yukon North Slope, Jay Frandsen, © Parks Canada/Jay Frandsen, 2020

Citation: Wildlife Management Advisory Council (North Slope). (2021). *Yukon North Slope Wildlife Conservation and Management Plan – Companion Report*. Whitehorse, Yukon: Wildlife Management Advisory Council (North Slope).

Available from: Wildlife Management Advisory Council (North Slope)
P.O. Box 31539
Whitehorse, Yukon,
Y1A 6K8, Canada

Download link: https://wmacns.ca/what-we-do/conservation-plan/companion

Acknowledgements

Many individuals and organizations have contributed to the preparation of the *Yukon North Slope Wildlife Conservation and Management Plan – Companion Report*. Much of the western science and traditional knowledge research that is the evidentiary basis for this plan reaches back several decades.

Critical reviews by Environment Yukon, Parks Canada, the Canadian Wildlife Service, Fisheries and Oceans Canada have been helpful in addressing a wide-range of terrestrial, aquatic and marine conditions that inform the conservation requirements of the Yukon North Slope.

The principal writers of the Companion Report are Kim Heinemeyer and Joan Eamer. Kim is a conservation biologist with Round River Conservation Studies. She was ably supported by Julia O'Keefe, Maggie Triska, and Will Tyson. Joan is a former Council member, science writer, and environmental consultant. They were assisted with strong support from Mike Suitor - Environment Yukon biologist, Dave Tavares – Parks Canada science advisor, Craig Machtans – Environment and Climate Change Canada manager, and Tyler Kuhn – Environment Yukon biologist. Allison Thompson and Kaitlin Wilson – Council biologists, and Lindsay Staples – past chair – participated in all stages of report design, drafting and editing. Kirsten Madsen provided invaluable editing support.

The Aklavik Hunters and Trappers Committee assisted with and contributed to a substantial body of traditional knowledge of the wildlife and habitat, and traditional use mapping, of the Yukon North Slope that informs the report.

Jennifer Smith, Council chair, Council members and alternates, Tyler Kuhn, Matt Clarke, Craig Machtans, Billy Storr, Evelyn Storr, Colleen Arnison, and Michelle Gruben, and Council staff Allison Thompson and Kaitlin Wilson reviewed the final draft of the report.

Companion Report to the Yukon North Slope Wildlife Conservation and Management Plan Number 6: Moose / Tuttuvak

Table of Contents

Maps

Figures

Tables

About the Companion Report

This report is a companion document to the *Yukon North Slope Wildlife Conservation and Management Plan* (WMAC (NS), 2022). The *Yukon North Slope Wildlife Conservation and Management Plan* (the Plan) is grounded in traditional knowledge and Western science. It addresses traditional use and wildlife conservation and management issues affecting the Yukon North Slope. Strategies in the Plan align with actions underway or planned by a range of agencies and organizations with jurisdiction on the Yukon North Slope.

This companion report summarizes the information that was used to support the objectives and strategies in the Plan, and provides references for the studies used in its development. The companion report draws from authoritative works, reports that synthesize knowledge and issues, and presentations of recent research findings. Sources include traditional knowledge and traditional use, scientific reports and journal articles, and management and conservation reports.

Companion Report Table of Contents

Each chapter is available for download at https://wmacns.ca/what-we-do/conservation-plan/companion.

There are fourteen companion reports, addressing selected topics of key interest as well as ten wildlife species featured in the Plan. The featured species were selected by participants at a workshop held in Aklavik. The wildlife species in the companion reports:

- Have high cultural or economic value or are important as food for Inuvialuit;
- Have similar habitat needs to other wildlife species, so that conserving their habitat is key to conserving habitat for other species; and/or
- Are important for healthy ecosystems, including species that are main food items for top predators.

The Plan identifies key conservation requirements on the Yukon North Slope for each featured wildlife species. The Plan's objectives and strategies are designed to meet these conservation requirements. This companion report summarizes the information that guides the objectives, strategies and conservation requirements in the *Yukon North Slope Wildlife Conservation and Management Plan*.

Companion Report: Moose / Tuttuvak

This companion report provides information on the conservation requirements for moose as identified in the *Yukon North Slope Wildlife Conservation and Management Plan*. It summarizes the information that guides the objectives, strategies and conservation requirements in the Plan. It includes information on traditional use, population status and trends, important habitat types and locations, threats to moose, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for moose on the Yukon North Slope

1. Coastal wetlands, river valleys, riparian areas, and areas with high winter use conserved.
2. Ongoing monitoring of moose density and distribution and habitat in relation to climate change.
3. Identification of specific migration corridors and protection of these corridors to ensure moose can meet annual needs.

From the *Yukon North Slope Wildlife Conservation and Management Plan* (WMAC (NS), 2022)

Moose on the Yukon North Slope

Moose (Tuttuvak, *Alces alces*) are distributed along the Yukon North Slope, favouring the narrow strips of willows and trees along rivers and creeks. Suitable habitats are found across 25% of the Yukon North Slope (Round River Conservation Studies, 2019). Most moose are migratory, moving between summer and winter ranges.

Moose have lived in the Mackenzie Delta for a long time, but they have become more abundant in recent decades and more remain year-round. Moose are becoming more common in winter along the coastal plain.

Moose on the Yukon North Slope are of the subspecies *Alces alces gigas*, the largest North American moose. This subspecies' range is west of the Mackenzie Mountains, mainly in Yukon and Alaska (Hundertmark and Bowyer, 2004).

Traditional Use

Moose are identified in the *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016) as an important food source for the community and were also used in the past for tools and clothing.

> Moose hides are valuable because they are used to make the bottoms of makłak, and moccasins and jackets. Historically, they were also used to make gun cases, saigu (tepees), moccasins, bags, skin boats and toboggan wraps. While tanning a moose hide is a lot of work and can take about two weeks, their hide is very tough; it never tears. It was also mentioned during the verification sessions that the antlers could be used for a serving dish, the hair for handicrafts, the hide for a sled, the ears for mitts, and the sinew is very good for many purposes.
>
> Inuvialuit Settlement Region Traditional Knowledge Report (ICC et al., 2006, p. 11-66)

Aklavik Inuvialuit moose harvest levels have remained about the same since the 1980s. On average, 9 moose were harvested annually by Aklavik Inuvialuit from 1988 to 1997, as reported through the Inuvialuit Harvest Study (Inuvialuit Harvest Study, 2003, Table 21). Over the 10-year period, annual harvests ranged from 3 to 16 moose. From 2016 to 2018 the average harvest was 7 moose, ranging from 3 to 12 harvested moose per year (IRC, 2019). Note that response rates to harvest studies vary; more moose may have been harvested than indicated here.

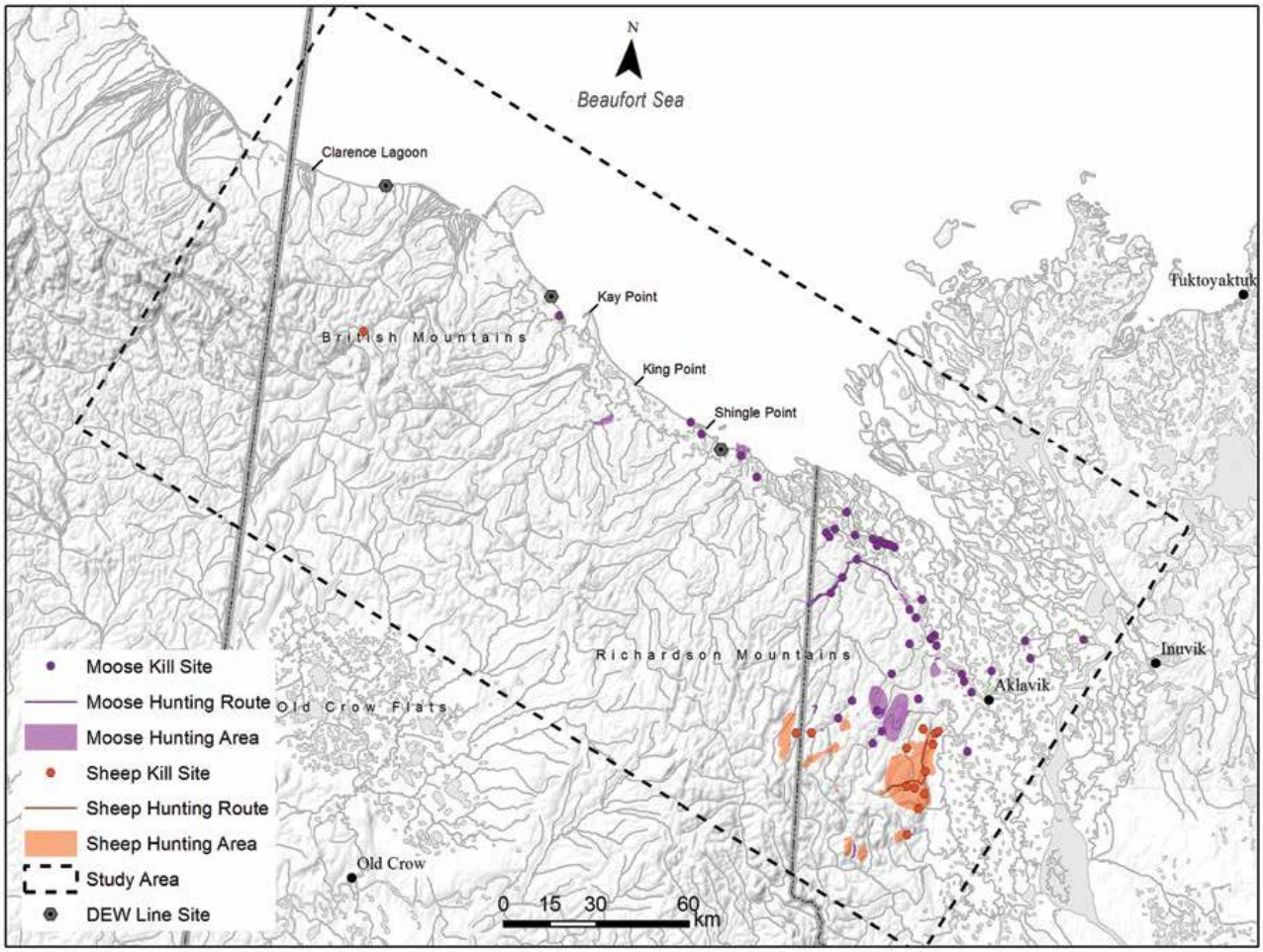
In a 1991 dietary survey of Aklavik Inuvialuit households, half of the 36 households surveyed reported eating moose at least once over the previous year (Wein and Freeman, 1992). Compared with caribou, moose was not frequently consumed. It was eaten on average 14 times a year, while caribou was on the menu an average of 145 times during the year.

Yukon North Slope moose have primarily been harvested from Aullaviat/Aunguniarvik (the Eastern YNS) (WMAC and AHTC, 2018b), along the coast as well as into the eastern slopes of the North Richardson Mountains (Map 6- 1). Yukon North Slope coastal moose were observed to eat more sedges and grasses. Some harvesters stated that coastal moose taste better and were preferred over moose in more inland and delta areas that eat primarily willow (WMAC (NS) & Aklavik HTC, 2003, 2018a). One moose hunter said that boiling removes this willow flavour. Harvesting in the winter and letting the carcass sit for a few hours before skinning also removes this flavour (WMAC (NS) and Aklavik HTC, 2003).

> Now, if they get moose from here [YNS] I'll take it, but not from the Delta….because the Delta has a strong taste like willow….[Moose on the YNS eat] the caribou moss or whatever. They eat something different here than compared to the Delta.
>
> *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b, p. 63)
>
> Out on the coast there's different habitat. They're [moose] feeding in lakes, grasses, whatnot… the meat is really different from the ones… up in the Mackenzie.
>
> *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) and Aklavik HTC, 2018a, p. 29)

The Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018b) provides documentation of past and current moose harvest locations on the Yukon North Slope (Map 6- 1).

Map 6- 1. Moose and Dall's sheep harvest locations identified in the Inuvialuit traditional use interviews



The interviewers asked Inuvialuit land users to identify hunting routes and areas used within living memory. Data from this map were used to develop the composite traditional use map in the Plan. Source: WMAC (NS) and Aklavik HTC (2018b), Map 8.

> Travelling throughout these areas here [pointing to the Yukon North Slope and mouth of the Delta], the moose population, you'd run across a small herd of eight, ten, fifteen animals in a group, throughout this whole travel [area]. By the end of your five, six days of travel, you come across seventy, eighty moose in different areas.
>
> Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018b, p. 61)

A moose hunt brings in meat when caribou are not available to a community (ICC et al., 2006). In a 2003 study (WMAC (NS) and Aklavik HTC, 2003), participants said that few Inuvialuit families

regularly harvest moose. When caribou are not around, moose spotted along the coast may be taken for meat.

> One spring we stayed at Firth River waiting for the ice to go away. With moose and caribou we made dry meat, that's how we eat.
>
> Sarah Meyook, in *Yukon North Slope Inuvialuit Oral History*, referring to the 1940s (Nagy, 1994, p. 66)

> When you got nothing to eat, that's a big animal, you could have it for months and months. Steady eating if you get moose.
>
> I get one per year. Moose is a good eating animal; if you get one it's worth five caribou. But some people don't eat moose meat.
>
> Inuvialuit Settlement Region Traditional Knowledge Report (ICC et al., 2006, p. 11-66)

Habitat for Moose

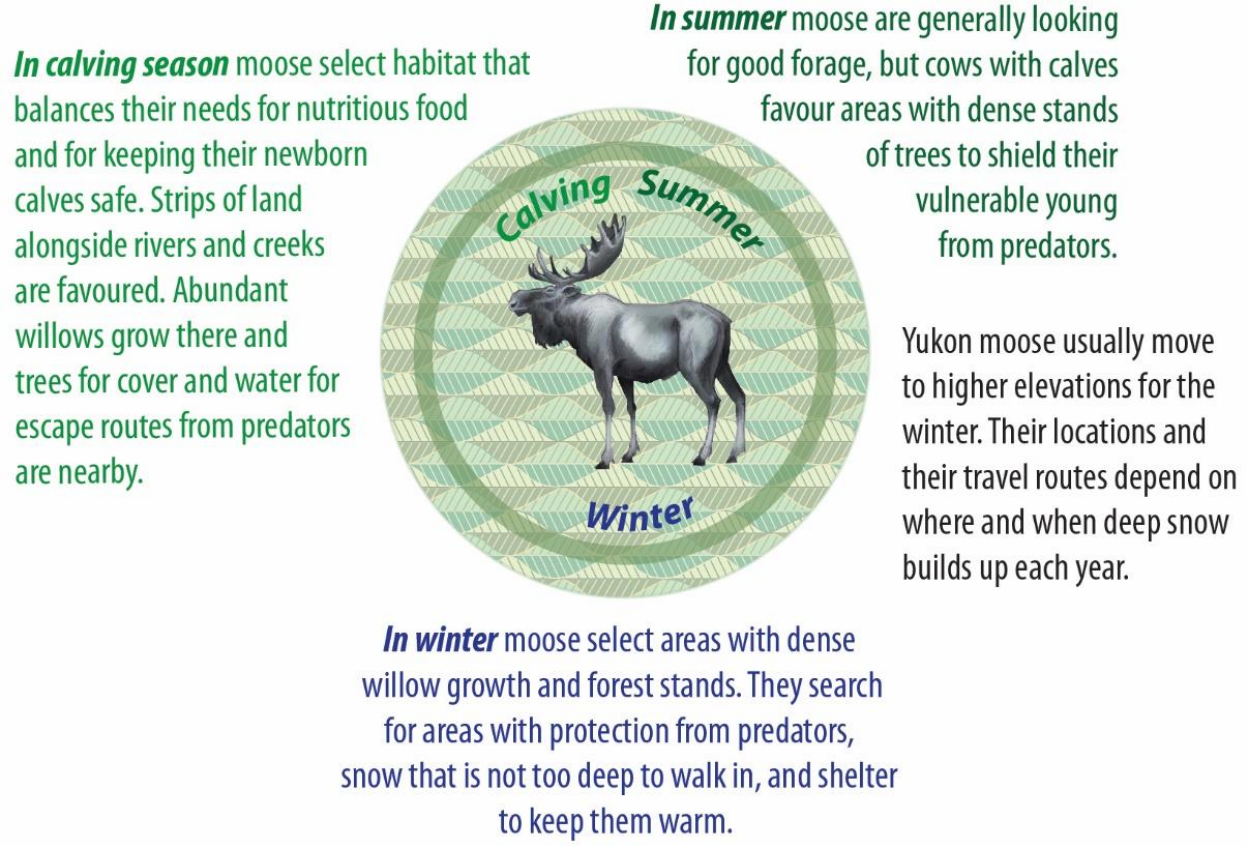
Introduction

Habitat requirements for moose centre on swamps, lakes, rivers, and streams, particularly those areas that have tall willow communities and conifer trees (WMAC (NS), 2012; Yukon Environment, 2018; WMAC (NS) and Aklavik HTC, 2018a). Habitat favoured by moose in the winter includes areas with mountainous terrain and steep-sided valleys in southwestern Ivvavik National Park (Cooley et al., 2019).

Data from collared moose show that moose migrate north from Old Crow Flats to mountainous terrain in southwest Ivvavik National Park for the rut period and winter (Cooley et al., 2019). Research in the late 1980s and early 1990s found a similar situation, with moose on the Eastern Yukon North Slope migrating to major south slope rivers like the Bell, Little Bell, and Fish Creek (Smits, 1991). Inuvialuit knowledge confirms that migrations continue in this area on an annual basis (WMAC (NS) and Aklavik HTC, 2018a).

Research and monitoring indicate that moose prefer a mosaic of habitat types that includes areas with abundant shrubs for food and stands of mature trees for cover from predators and harsh weather (Figure 6- 1). In common with other Yukon ungulates, moose search out mineral licks, especially in spring and summer. These natural deposits contain minerals and trace elements that moose need to supplement their diet and keep healthy. Moose habitat is limited on the YNS.

Figure 6- 1. Moose habitat use over the seasons



Based on *Science-Based Guidelines for Management of Moose in Yukon* (Yukon Environment, 2016).

Inuvialuit Traditional Knowledge About Moose Habitat on the Yukon North Slope

This section summarizes knowledge about moose habitat from the study *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) and Aklavik HTC, 2018a, pp. 27-30). During the traditional knowledge study, Inuvialuit land users marked on maps where they see moose.

Study participants described moose as always being in places with willows nearby and always in or close to water. Moose are usually spotted in low-lying or flat terrain. In the mountains, they are seen at the bottoms of hillsides or in river valleys.

> [Moose] always seem to be close to the water because they seem to be feeding in the lakes. I've seen them…feeding in the lakes all the time. …I think they're eating grass roots all the time. …Sometimes you see them eating tips of the willows.

Coastal habitat is flat, wet, and open and the moose eat grasses and sedges as well as willows. Inland areas are typically river valleys and creeks and the moose are eating willows. Several

people suggested a seasonal movement, with moose moving into the mountains and river valleys when snow covers the shorter coastal vegetation and then returning to the coast when the snow melts and new vegetation appears.

> In wintertime, they tend to go…farther inland. You see more draws and more willows growing. …They come inland a bit and are close to the rivers.
>
> I think they're [moose] just migrating back towards the Delta after a long winter… because I think they do move up to the mountains before freeze-up… I think they go up to the mountains for winter.

Study participants observed that moose seen inland are often in groups, or that there are many moose close together in areas with good willow habitat, especially in recent years.

> Most of the time when they're in the hills, they always bunch up together. …We never really saw that much long ago. …2006, I think, I started seeing those bunches.
>
> We went travelling up here [in the mountains] and usually this whole area [is] just covered in moose, right where all the willow habitat is… two or three years in a row we saw about 150.

Moose Habitat Suitability Model

A model of moose habitat was constructed as part of the development of the Wildlife Conservation and Management Plan (WMAC (NS), 2020). The moose habitat suitability model is based on traditional knowledge documented by 18 Aklavik Inuvialuit land users (summarized in WMAC and AHTC, 2018a), classification and mapping of the Yukon North Slope ecosystems (predictive ecosystem map or PEM), and analysis of terrain and water features. *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-Based Moose Habitat Model* (Round River Conservation Studies, 2019) provides detailed information on how the model was constructed and validated.

In interviews, Inuvialuit knowledge holders described important vegetation, water features, and topographic characteristics of moose habitat. They identified locations on a map and habitat types from a set of photos of ecosystems on the Yukon North Slope. The resulting moose habitat model predicts moose habitat across the Yukon North Slope regardless of season, while recognizing that moose may use habitat on a seasonal basis.

Predictive Ecosystem Mapping (PEM) uses knowledge about ecosystem patterns and relationships to predict locations of ecosystems on the landscape (Environment Yukon, 2016). The result is maps showing PEM classes. Each PEM class integrates many features, including vegetation, elevation, water, terrain, soils, and aspect.

These examples illustrate how traditional knowledge was combined with ecosystem mapping and water and terrain features to develop the moose habitat categories used in the model:

- Participants explained that they use the terms willow and willow-shrub to describe all deciduous woody shrubs above knee height. Therefore, when matching the participants' moose habitat descriptions with the ecosystem map to develop traditional knowledge habitat classes, other woody shrubs, such as alder, were included as "willow", while dwarf willow species were not included.
- Several participants described willow communities near swamps and near lakes as important for moose. The descriptions were mapped as tall willow PEM classes within 30m of swamps and 30m of lakes.
- Rivers were divided into three types to match descriptions by participants: 1) large rivers; 2) mountain creeks in valleys; 3) small creeks and channels that are low-lying compared to surrounding land and contain a thick growth of willows.

The result of this matching of traditional knowledge descriptions with ecosystem mapping and analysis of terrain and water features was the identification of 28 moose habitat characteristics (see Table 6- 1 for examples).

Table 6- 1. Examples of habitat categories developed for use in the model

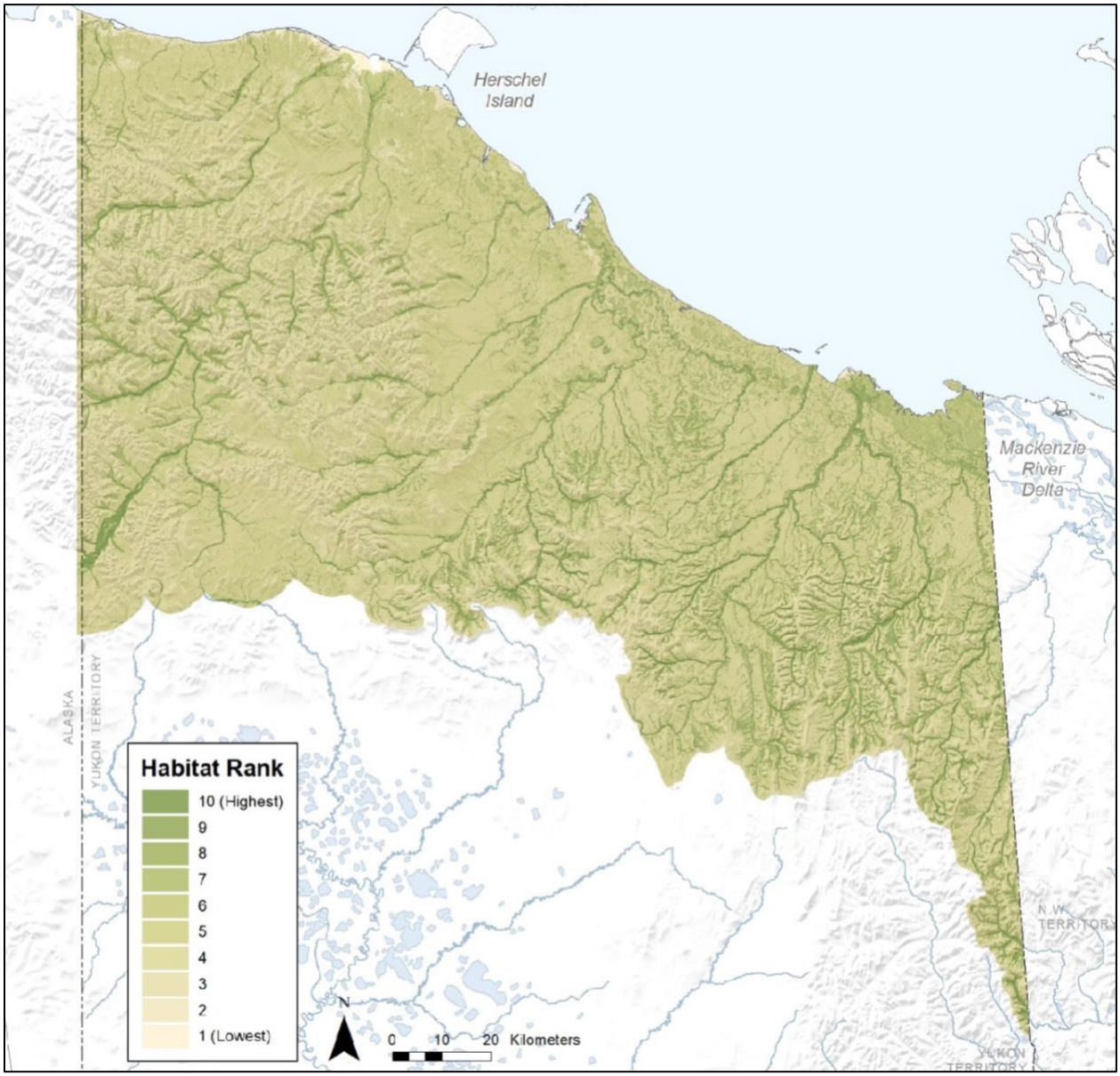
Habitat classification	Weight	GIS query (how the category was drawn on a map)
Willows in River Bed	9	Willows in "valley" landform (canyons, shallow valleys, U-shaped valleys), buffered 30m
Mountain Creeks	10	Streams in mountains with some presence of willow, occurring in and represented by any of three valley landforms: canyons, shallow valleys, U-shaped valleys
TK Habitat Class: Swamps	6	TK habitat class, buffered 30m
Willows Generally	5	Tall shrub classes in the PEM: willow floodplain, alder-heather seepage slope, willow-coltsfoot drainage channel, Alaska willow drainage channel, buffered 30m
TK Habitat Class: Low Flatlands	3	TK habitat class

TK (traditional knowledge) habitat classes were matched up with units on the ecosystem map. A buffer is a zone around a map feature. For example, the habitat class "Swamps" is buffered by 30m—it includes an area extending out 30m in all directions from each swamp to include areas nearby that are attractive to moose because they are close to a swamp, as indicated by participants in the traditional knowledge study. Habitat characteristics were weighted by how many of the 18 participants identified each one, e.g. the weight of 9 assigned to the "Willows in river beds" category means that 9 of the 18 participants identified this characteristic as being associated with moose. Source: Round River Conservation Studies (2019), Table 3

The identified habitat characteristics were used to produce a map which models the distribution of suitable moose habitat across the YNS; moose habitat is ranked on a scale from 1 (lowest quality) to 10 (highest quality) (Map 6- 2). The habitat quality rankings can be seen more clearly on the zoomed-in maps of portions of the Richardson Mountains, the Beaufort coast near the

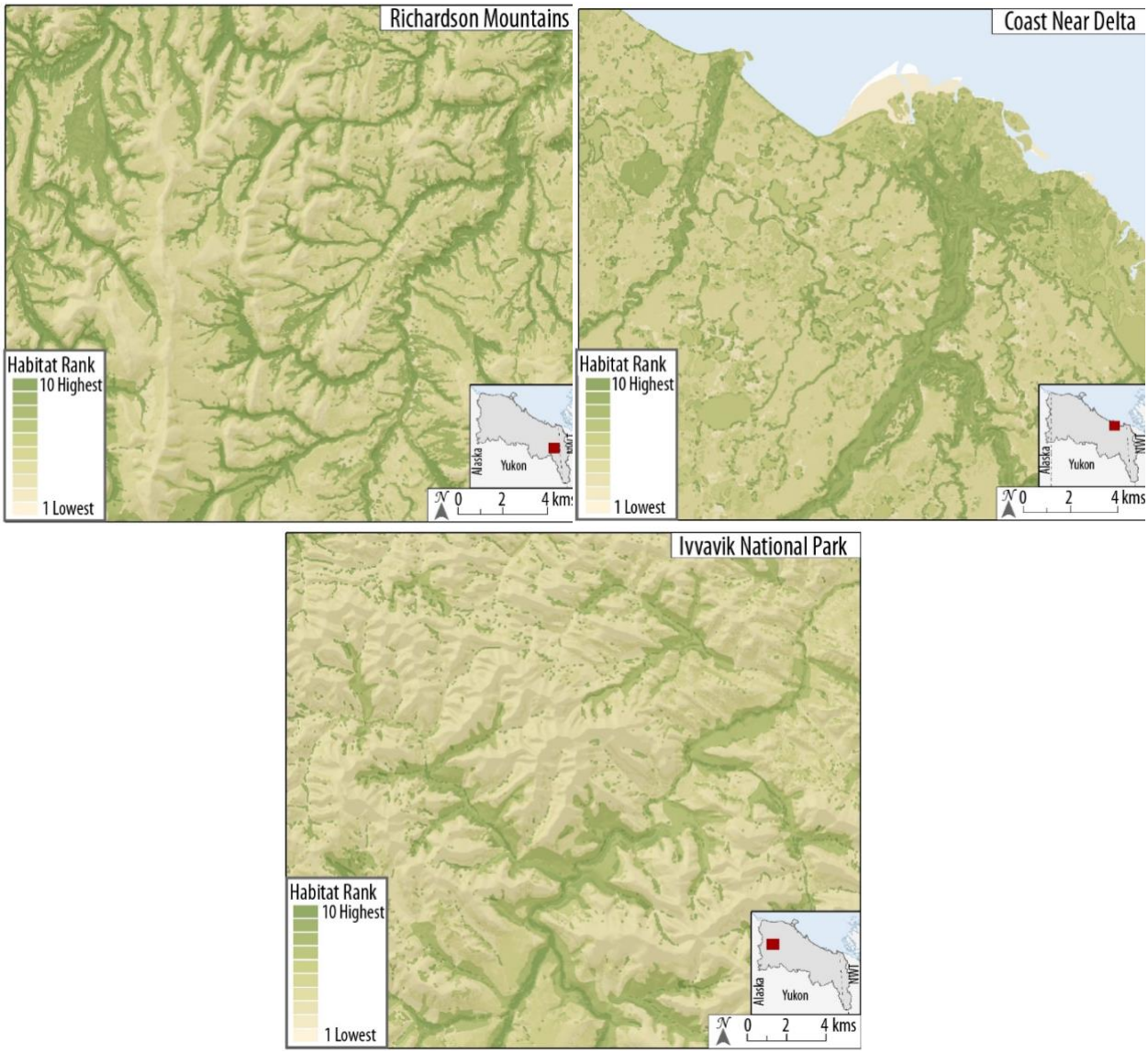
Mackenzie Delta, and western Ivvavik National Park (Map 6- 3). The TK-based habitat model shows that moose habitat is concentrated along rivers and in other areas where willow is found. The highest quality moose habitats cover 27% of the YNS. Overlaying the TK-based habitat model with moose locations from aerial surveys shows strong agreement between the two different sources of moose habitat information (83% of moose locations from aerial surveys fell within the top three habitat quality ranks), suggesting that the modeling methods used to map Inuvialuit TK of moose habitat were successful. The results of this work can contribute baseline information for monitoring changes to moose occupancy and space use with ongoing climate change, and identifying high quality habitats and corridors for conservation initiatives.

Map 6- 2. Traditional-knowledge-based moose habitat model: map of habitat ranks across the Yukon North Slope



Round River Conservation Studies (2019), Map 3. This map shows the distribution of suitable moose habitat as predicted through the TK-based moose habitat model, with summed habitat scores standardized to range in ranking from 1 (lowest quality) to 10 (highest quality). To produce this map, each habitat characteristic was mapped and given a score based on the number of interviewees that described the characteristic (e.g., Table 6-1). Then all the mapped characteristics were overlaid in a GIS system and overlapping scores were added together. All the layers were combined and added up to produce the habitat quality ratings.

Map 6- 3. Traditional-knowledge-based moose habitat model: zoomed-in view of habitat ranks in three areas of the Yukon North Slope

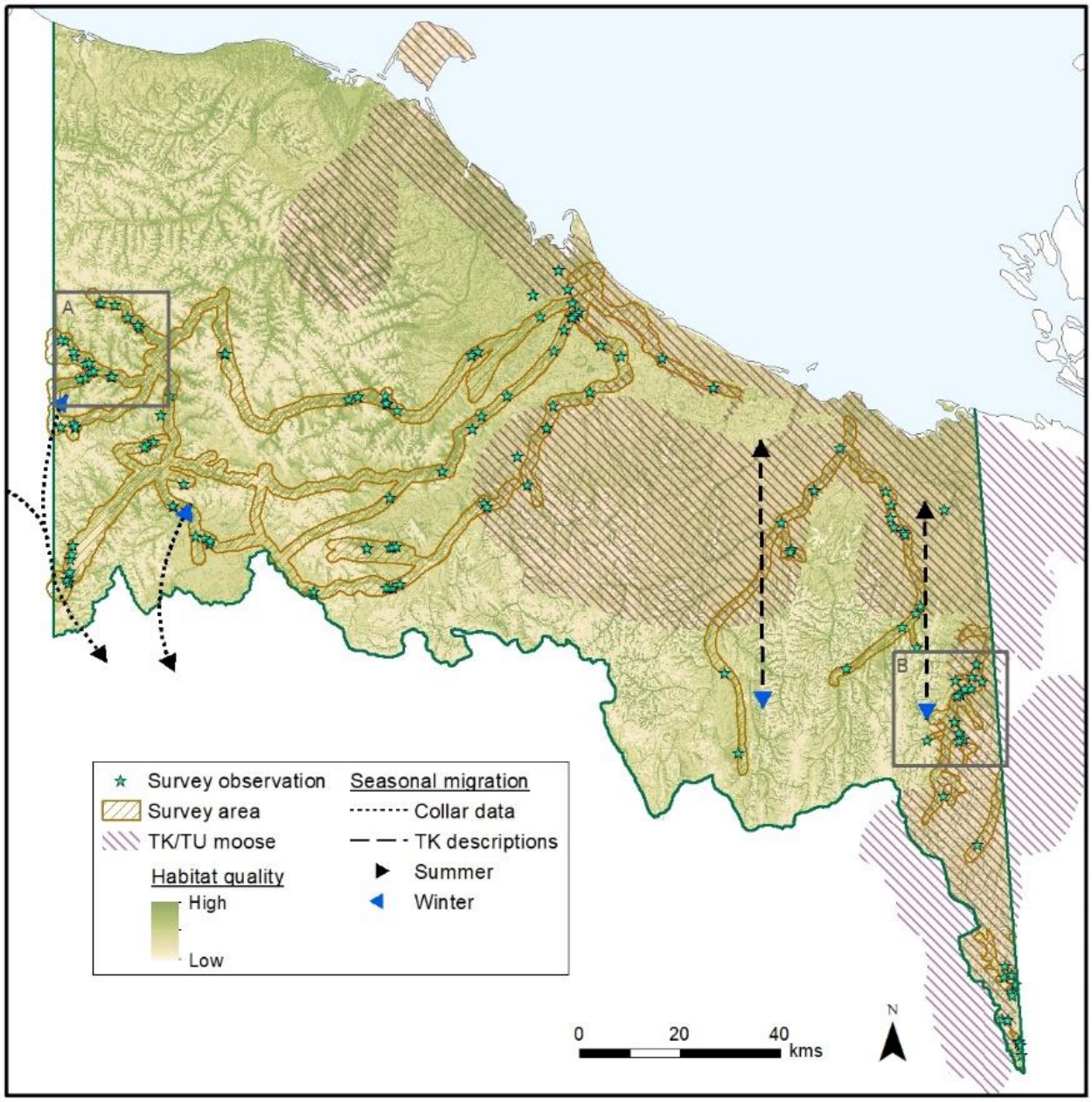


Round River Conservation Studies (2019), Maps 4, 5, and 6

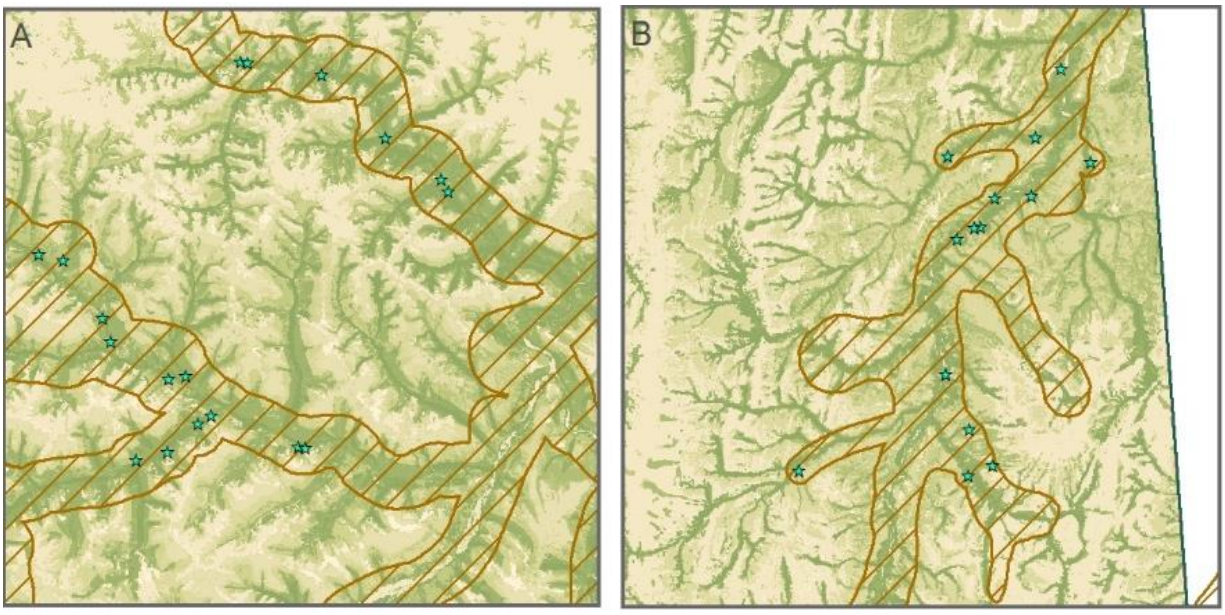
Moose Habitat Occupancy

While the habitat suitability model predicts where there are high and low quality habitats for moose, it does not identify where moose are actually found. There is evidence that moose may be more limited in distribution than predicted by the distribution of potential moose habitat. Map 6- 4 shows the habitat model as well as where moose have been observed. Observations represent the best information about where the moose actually are, but are limited to areas people frequent in their travels and hunting trips as well as what areas have been surveyed. Map 6- 4 also indicates general patterns of seasonal movement, based on tracking radio-collared moose and on traditional knowledge. More detail on seasonal movements of moose in the far west of the Yukon North Slope is in Cooley et al. (2019).

Map 6- 4. Moose habitat quality, mapped from a traditional-knowledge-based habitat model, and observations of moose locations from surveys and interviews with Inuvialuit experts



The map shows:
Distribution of suitable habitat over the whole Yukon North Slope, with darker green being higher quality moose habitat, based on a habitat model; Observations of moose from aerial surveys, and the areas that were surveyed;
General areas where Inuvialuit report seeing or harvesting moose; Seasonal migration patterns (shown by arrows) based on locations of collared moose (in the west) and on traditional knowledge and older collar data (in the east).
The square areas outlined and marked A and B on this map are magnified in the two maps on the next page.



The relationship between high quality moose habitat and survey areas can be seen in these magnified sections of the map. The main map and the two magnified area maps are from the Plan (WMAC (NS), 2022, Appendix 1). Habitat quality ratings are from a habitat model based on Inuvialuit traditional knowledge. Traditional Knowledge and Traditional Use information are from interviews with Inuvialuit experts (WMAC (NS) & Aklavik HTC, 2018a, 2018b); survey data are from Environment Yukon and Parks Canada.

Moose Populations

Species Conservation Status

Moose are not considered to be at risk in Yukon, Canada, or globally.

Table 6- 2. Moose conservation status

Status assigned by	Applies to	Status	References
Species at Risk Act (SARA)	Canada	Not listed	(Canada, n.d.)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Canada	No COSEWIC assessment; not a candidate species for assessment	(Canada, n.d.; COSEWIC, n.d.)
Canadian Endangered Species Conservation Council (General Status of Species in Canada)	Canada	N5: Secure*	(Canadian Endangered Species Conservation Council, 2016)
Yukon	Yukon	S5: Secure*	(Yukon, 2020)
NatureServe	Global	G5: Secure*; last reviewed 2016	(NatureServe, n.d.-b)

*Following the ranking system developed by NatureServe, an international network of conservation data centres (NatureServe, 2020a). G=Global; N=National; S=Subnational

Yukon North Slope Moose Populations

Survey Results

Aerial surveys of moose have been conducted in Ivvavik National Park, first in the Babbage River watershed, and later expanding to the west, and in the Richardson Mountains, including the Yukon North Slope mountainous areas. More recently, surveys have extended to the coastal plain. Surveys since the late 1980s are summarized in Table 6- 3.

Table 6- 3. Summary of moose surveys from late 1980s to present, Yukon North Slope

Area surveyed	When	Results and Notes	References
Ivvavik NP	2019 late winter	Survey area was extended to include areas in the southwest of Ivvavik because studies show moose migrate there in the winter from Old Crow Flats. 135 moose were observed.	(WMAC (NS), 2019)
Eastern Ivvavik (Babbage River area)	2009 late winter	52 moose were observed.	(WMAC (NS), 2012)
	2000 late winter	First survey of the area for moose; provides baseline information on population and habitat use. 51 moose were observed.	(Parks Canada, 2002)
Richardson Mountains and adjacent Yukon coastal plain	2013 late winter	Purpose: determine number of moose available for harvest; document late winter habitat use. Confirmed observation in 2000 of high densities of moose in some Northern Richardson Mountains valleys in winter. Population increased ~50% from 2000 to 700.	(WMAC (NS), 2013)
	2000 late winter	Population increased 67% from 1989. 445 moose were observed. Moose were at high densities in suitable habitat.	(WMAC (NS), 2013) (WMAC (NS), 2012)
	1987-1991; late winter survey in 1989	Studies included tracking of radio-collared moose, aerial searches, and surveys. Provided baseline population and habitat use information on moose in area. 266 moose were observed in the 1989 survey.	(WMAC (NS), 2005) (WMAC (NS), 2012)

Survey results indicate that moose numbers are increasing in the Northern Richardson Mountains. More moose may be leading to increases in predators (wolves and grizzly bears) (WMAC (NS), 2019). The 2012 late winter survey confirmed that moose are at high densities in some mountain valleys throughout the Northern Richardson Mountains and make use of limited

pockets of suitable habitat at lower elevations on the Yukon North Slope (WMAC (NS), 2014). The Bell River valley (directly south of the Yukon North Slope) and the passes leading to it are critical for Aullaviat/Aunguniarvik /Richardson Mountains moose—they are used consistently by moose to access seasonal ranges (WMAC (NS), 2014).

Ivvavik National Park's three winter moose surveys were conducted in 2000, 2009 and 2019. Due to survey infrequency their results were determined to be inadequate for estimating population trends. However, all three of these surveys shared similar routes and timing within the Eastern river/tributary valleys of Ivvavik, which consisted of the Babbage, Trail and Tulugaq rivers. From these aforementioned river valleys, the total moose observations per survey year were 34, 39 and 25, respectively.

When looking at total moose observations per survey year, regardless of survey effort and location, the totals were 51, 52 and 135, respectively. 2019's survey had a much higher count of moose due to its expansion of survey area and effort into South-Western areas of Ivvavik. Interestingly, 2019's winter survey suggests that Ivvavik's linear moose density was almost 6 times greater in its South-Western river/tributary valleys compared to its Eastern river/tributary valleys.

Moose composition surveys were successfully completed along with the population surveys in the years of 2000 and 2019. Of the three surveyed rivers in 2000 and 2019 (Babbage River, Trail River, Tulugaq River) the composition metrics were substantially different. In 2000's survey these three river systems had a calf/cow ratio of 27:100, while in 2019 the three rivers had a calf/cow ratio of 0:100. Cows were almost three times more prevalent in these three surveyed rivers during the 2000 survey.

When looking at the moose composition for 2019's complete survey area within Ivvavik, the calf/cow ratio was 18:100 while the bull/cow ratio was 106:100. Unsurprisingly, a higher proportion of calves were found in river/tributary valleys where cows were predominant over bulls. In 2019 the bull to cow ratio appears to be healthy, meaning that receptive cows would have a high potential of being bred, even if the relative moose densities are low, however, it is important to note that these composition metrics are representative of a winter survey and not during rut.

While survey routes do not include Qikiqtaruk (Herschel Island), records of wildlife observations are maintained by Herschel Island–Qikiqtaruk Territorial Park (Cooley et al., 2012). Moose were observed in only 3 of the 23 years from 1988 to 2010. Inuvialuit report that moose visit the island more frequently in recent years than in the past (WMAC (NS) and Aklavik HTC, 2003).

Longer-Term Trends

Moose were observed in the Mackenzie Delta during field studies prior to 1950 (Banfield, 1951). The Aklavik Inuvialuit Community Conservation Plan notes that moose were abundant in the northern part of the Mackenzie Delta around 1948 but are believed to have declined since then

(Aklavik HTC et al., 2016, p. 108). However, Aklavik Inuvialuit participants in a 2003 traditional knowledge study observed that delta moose were abundant and increasing, and that moose numbers had increased following a big forest fire in the Mackenzie Delta (WMAC (NS) and Aklavik HTC, 2003).

Recorded observations of moose along the Yukon coastal plain date back at least to the 1960s and 1970s (Kelsall, 1972; Ruttan, 1974 cited in Stern and Gaden, 2015). Surveys in the 1980s indicated that most of the moose that spent summers on the coastal plain migrated inland for the winter, mainly to areas south of the Yukon North Slope. More recent survey results (Table 6-3), as well as observations by Inuvialuit, indicate that increasing numbers remain on the coastal plain during winter (WMAC (NS), 2012; WMAC (NS) and Aklavik HTC, 2003).

> Moose have been on the North Slope as long as people remember but were found more in the far south in mountain valleys decades ago. Now they are regularly seen all year in tall willow areas in river valleys, all the way to the coast, but they are not abundant.
>
> Observations by Aklavik Inuvialuit Elders and harvesters (WMAC (NS) & Aklavik HTC, 2003, p. 29).

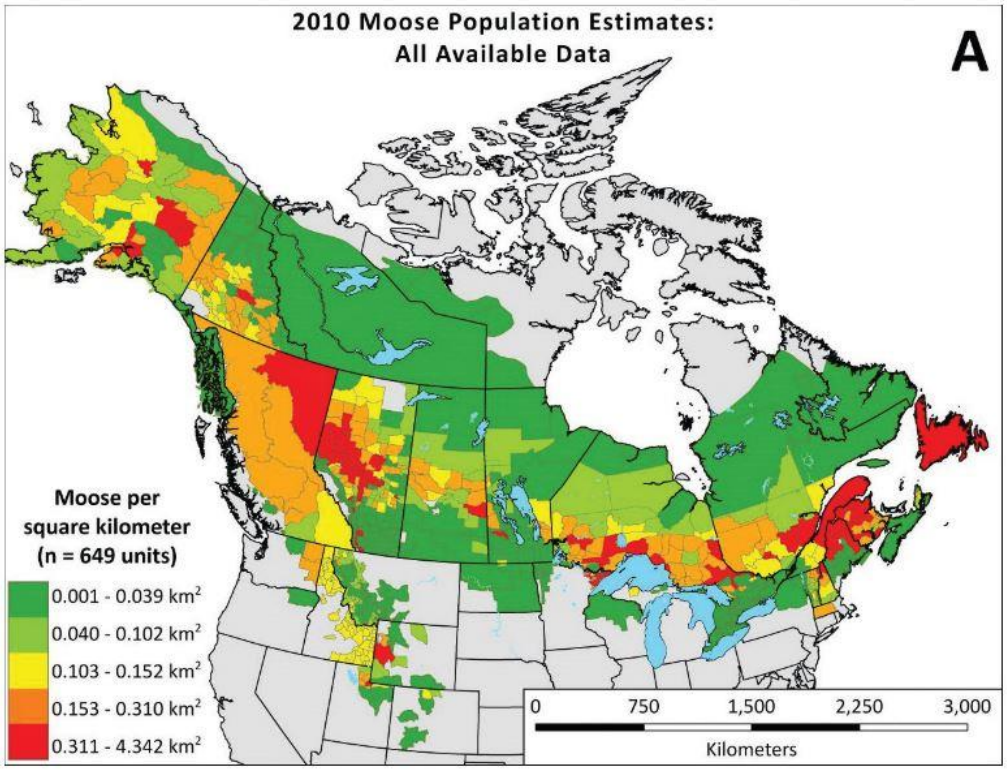
Harvest Management

There are no restrictions on Inuvialuit harvest of moose on the Yukon North slope. Non-Inuvialuit Yukon residents with a licence may harvest one male moose per year in Aullaviat/Aunguniarvik (the Eastern Yukon North Slope) (Yukon Government, 2019). Beneficiaries of adjacent land claim settlements may also harvest moose with Inuvialuit consent (WMAC (NS), 2012).

Transboundary Considerations

The estimated North American continental moose population is about one million (Timmermann and Rodgers, 2017), while the estimated number of moose in the Yukon is 70,000 (Yukon, 2020). Moose are more abundant in the boreal forest areas of the central and southern parts of their range than in the north (Map 6- 5). Studies in central Yukon found that moose were most frequently in areas with abundant shrubs close to forested areas that provide security and cover (McCulley et al., 2017a; McCulley et al., 2017b).

Map 6- 5. Moose distribution and estimated densities across North America, 2010



From Jensen *et al.* (2018), Figure A, based on population and harvest density estimates at the scale of management units for 2010.

Moose have been declining in some areas and increasing in others over the past decade, but the North American population is estimated to have remained stable from 2000 to 2015 (Timmermann & Rodgers, 2017). Moose on the Arctic coastal plain of Alaska are known to have expanded and contracted their range twice since about 1990 (Timmermann & Rodgers, 2017). Recent range expansion and increase in numbers of moose on the Alaskan coastal plain has been linked to climate warming and shrub expansion (see section on Impacts of Climate Change).

Moose move beyond the boundaries of the Yukon North Slope to the NWT, Alaska, and south within Yukon. There are science-based management guidelines in place for moose in the Yukon (Yukon Environment, 2016), though these were not designed for the Northern Yukon, and moose management plans in place for adjacent jurisdictions (Gwich'in Renewable Resource Board, 2000; Lenart, 2018) There are no transboundary plans or management plans for moose on the Yukon North Slope.

Observations, Concerns, and Threats

Impacts of Climate Change

In recent decades, the warming climate has increased plant productivity and expanded shrub cover on the Yukon North Slope and in neighbouring Alaska (Myers-Smith et al., 2019; Tape et al., 2016; Berner et al., 2018). More of the land is covered in willows and the average height of the bushes has increased, providing food for moose and allowing moose densities to increase (Tape et al., 2016). Research in northern Alaska, from the Brooks Range to the coast, indicates that moose select foraging habitat with tall shrubs—preferring average willow heights of at least 81 cm (Zhou et al., 2017; Zhou et al., 2020).

Some observations by Aklavik Inuvialuit about climate change and moose habitat

Aklavik Inuvialuit elders and harvesters observed in 2003 that, in the previous 20 years, tall willows in the Running River valley expanded 15 km northward, all the way to the coast (WMAC (NS) and Aklavik HTC, 2003).

Several of the 18 participants who contributed knowledge on moose as part of the Inuvialuit traditional knowledge study discussed impacts of climate change on moose. People observed that climate change is altering moose habitat—some said moose habitat is improving due to longer growing seasons and more willow growth. A few participants pointed out that climate change may have negative impacts on moose habitat, due to lakes drying up, more insect harassment, and more fires (WMAC (NS) and Aklavik HTC, 2018a).

Analysis of satellite images taken from 1985 to 2011 of the 15,000 km^2 Tuktoyaktuk coastal plain showed that plant growth increased over 85% of the land surface (Fraser et al., 2014). The biggest changes were an increase in land cover by shrubs and a decrease in ground lichens. Eighteen years of monitoring vegetation on Herschel Island shows a doubling every ten years of both the average height of tall plants and the abundance of shrubs (Figure 6- 2). The increased growth of shrubs is related to climate warming, especially the big increase in average winter temperatures in the region (4 degrees C increase over 30 years), leading to warmer soils, longer growing seasons, greater active layer depths, and more availability of nutrients (Myers-Smith et al., 2019; Fraser et al., 2014). Willows also flourish in areas cleared by people or burnt by wildfires. Aklavik Inuvialuit observed an increase in moose in the Mackenzie Delta following a big fire (Aklavik HTC et al., 2016).

Figure 6- 2. Shrubification on Qikiqtaruk, 1987-2019.

These repeat photos, from 1987 (left) and 2019 (right) show how shrubification has occurred over three decades on Qikiqtaruk Herschel Island. Photo credit belongs to Team Shrub and Isla Myers-Smith (www.teamshrub.com). More information can be found in Myers-Smith et al. (2011) and Myers-Smith et al. (2019).

The trends in shrub growth and moose densities on the Yukon North Slope may continue or there may be other changes in moose habitat. For example, more winter snow may cause moose to leave some areas, and hotter summers may dry up some swamps on the coastal plain.

Changes in moose density may cause major changes in food webs, such as an increase in wolves. Wolves are limited in their use of the Yukon North Slope in winter by the low densities of ungulates (Hayes et al., 2016). They have adapted to following the Porcupine caribou herd on its seasonal migrations. Increasing availability of moose in the mountains and tundra of the Yukon North Slope may alter the behaviour of wolves, allowing them to live year-round in higher density along the Yukon North Slope. Prey preference as described by Hayes et al., (2016) may also be changing due to the increasing prevalence of moose and cascade in ecology that may be occurring with wolves.

Increases in moose density could affect other herbivores if they compete for food or habitat areas. An Alaskan study examined the potential for competition among three common species that eat shrubs: moose, snowshoe hare, and ptarmigan (Zhou et al., 2017; Zhou et al., 2020). The study found that the three species prefer a similar range of willow species and that hares and moose prefer taller shrubs. The Arctic food web may also shift due to competition between beaver and moose for forage, and due to predators associated with each species. Beaver are a significant component of many predator diets, particularly during summer for wolves while moose is primary fair for wolves in winter. Bears on the other hand usually heavily prey on moose calves and beaver in spring and early summer.

As climates and ecosystems change, ungulate diseases and parasites can extend their ranges or become more prevalent in Arctic wildlife (Kutz et al., 2012; Verocai et al., 2012). An example is a nematode legworm (*Onchocerca cervipedis)* that infects moose and caribou and appears to have

recently extended its range northward to subarctic moose populations in northwestern North America (Verocai et al., 2012). Winter ticks (*Dermacentor albipictus*) are also believed to be extending their range northward as a result of warmer and shorter winters. Winter ticks are currently found as far north as Carmacks in the Yukon and Norman Wells in the NWT (Yukon Environment, 2016). Monitoring for winter ticks on Fortymile and Porcupine caribou have to date resulted in no cases (Yukon Environment, unpublished data).

Moose spending part of the year on the Yukon North Slope are exposed to effects of climate change in other parts of their ranges. Moose wintering in the British Mountains in the southwestern part of the Yukon North Slope spend the summer on Old Crow Flats (Cooley et al., 2019). This complex of shallow lakes and wetlands on permafrost is changing as the permafrost thaws and warmer temperatures lead to more evaporation. Studies indicate that moose currently benefit from the abundant growth of willows in drained lake basins (Cooley et al., 2019), but the long-term effects on moose of this drying trend are not known.

Impacts from Human Activities

Development activities altering vegetation near watercourses or affecting migration routes could have negative impacts on moose. Although moose are widespread on the Yukon North Slope, suitable habitat is limited (see section on the Moose Habitat Suitability Model). Moose habitat requirements centre on swamps and lakes that are located near the coast, and narrow riparian habitats adjacent to rivers and streams. Habitat favoured by moose in the winter includes areas in the southern Yukon North Slope with mountainous terrain and steep-sided valleys. Activities that occur within these specific habitats can have a disproportionate effect on moose on the YNS as adjacent habitats are limited.

Migration is critical to northern populations of moose. It is likely that several mountain passes allow moose to pass between critical winter range and summer range on and beyond the Yukon North Slope. Data from moose that migrate from the Old Crow Flats shows these moose exhibit high fidelity to their specific migration patterns and pathways. Ensuring that these migration corridors remain functional and that moose populations remain viable requires identifying the locations of the corridors and the timing and potential magnitude of their use, together with enacting policies for their protection as needed.

Links to Plans and Programs

This section lists plans and programs that link to the objectives and strategies of the *Yukon North Slope Wildlife Conservation and Management Plan*. These plans and programs informed the development of the Yukon North Slope Plan and are an integral part of its implementation.

Moose Conservation and Management

Moose management plans are in place for adjacent jurisdictions to the east and west, for the Gwich'in Settlement Area (Gwich'in Renewable Resource Board, 2000), and for Northeast Alaska (Game Management Units 26B and 26C: Lenart, 2018). The *North Yukon Regional Land Use Plan* includes a section on moose management for Vuntut Gwitchin First Nation traditional territory.

There are no international or interjurisdictional moose management plans that include the Yukon North Slope and there is no moose management plan for Yukon North Slope. However, several plans and guidelines include measures and guidance for conservation and management of Yukon North Slope moose:

- Aklavik Inuvialuit Community Conservation Plan (Aklavik HTC et al., 2016)
  The Aklavik conservation plan identifies the eastern Yukon North Slope as important for moose and includes moose conservation measures (p. 109):
  - Do not hunt more than is needed.
  - Harvest on sustainable basis.
  - Avoid shooting mature bulls during the rut.
  - Identify and protect important habitats from disruptive land uses.
- Science-based Guidelines for Management of Moose in Yukon (Yukon Environment, 2016)
  These guidelines are referred to throughout this chapter. Some key points from the guidelines:
  - Moose populations in Yukon are generally limited by predators, but when the density of moose is low, the additional mortality from harvest may cause the moose population to decline.
  - Harvest strategies should ensure moose populations do not decline below their natural range of variation. If they do, recovery may be difficult and lead to long periods with no surplus moose available for harvest.
- *Ivvavik National Park of Canada Management Plan* (Parks Canada, 2018)
  Conservation and management of moose is part of the plan's strategy "to protect and conserve natural ecosystems, habitat, wildlife, cultural resources and Inuvialuit practices, based on the best available scientific and traditional knowledge" (p. vii).

Research and Monitoring Programs

Moose are periodically surveyed in Ivvavik National Park, the Richardson Mountains and Eastern Yukon North Slope (Table 6- 3). Parks Canada and Herschel Island–Qikiqtaruk Territorial Park keep records of incidental observations (WMAC (NS), 2012; Cooley et al., 2012).

Selected Studies and Research Relevant to the Yukon North Slope

This section is an annotated listing of selected resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues that will be important to consider during its implementation. Knowledge about Yukon North Slope moose is augmented by research and monitoring in the region and in other parts of Yukon, NWT, and Alaska—for example, research on moose predators, seasonal movements of moose, and effects of changes in climate conditions and vegetation on moose.

Traditional Use and Traditional Knowledge Studies

- *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-Based Moose Habitat Model* (Round River Conservation Studies, 2019)
  A moose habitat suitability model was developed, based on traditional knowledge documented by 18 Aklavik Inuvialuit land users, classification and mapping of the Yukon North Slope ecosystems (predictive ecosystem map or PEM), and analysis of terrain and water features.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) and Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) and Aklavik HTC, 2018a)
  These two studies were undertaken by the WMAC (NS) and the Aklavik HTC to document traditional use patterns and knowledge about wildlife habitat on the Yukon North Slope. Both studies were based on interviews with Aklavik Inuvialuit land users. Maps were used in the interviews and all geographically referenced data were digitized and displayed on maps. The results were used in developing the Plan and are described and referenced throughout this chapter.

- *Aklavik Inuvialuit Describe the Status of Certain Birds and Animals on the Yukon North Slope* (WMAC (NS) and Aklavik HTC, 2003)
  This report, based on interviews and a public meeting, has a section on moose that includes Inuvialuit traditional knowledge and information on traditional use.

- *Inuvialuit Settlement Region Traditional Knowledge Report* (ICC et al., 2006)
  This study was undertaken as part of the Mackenzie Gas Project. The study area includes the Yukon North Slope as far west as Herschel Island. The report was written by the Inuvik, Tuktoyaqtuq, and Aklavik Community Corporations, based mainly on interviews with knowledgeable elders and harvesters.

Research

Habitat selection

- Central Yukon studies on moose habitat selection, range sizes and movement patterns (McCulley et al., 2017b; McCulley et al., 2017a)
  Results from this research indicated that, in central Yukon, winter movement of moose is constrained by snow depth—late winter is a critical period for moose as snow and weather conditions limit their access to food.

- *The Effects of Sex, Terrain, Wildfire, Winter Severity, and Maternal Status on Habitat Selection By Moose in North-Central Alaska* (Joly et al., 2017)
  In general, moose selected habitats with tall shrubs and/or areas with abundant forage, such as areas with luxuriant willow growth following wildfires. There were differences between bulls and cows in habitat preferences over the seasons and depending on the weather and snow depth. For example, all moose stayed close to rivers during moderate and severe winters but ranged more widely over the landscape during mild winters. Cows with calves showed a stronger preference for habitat that provided forested cover from predation.

Migration

Research that included tracking collared moose over the seasons shows that many of the moose that spend their summers on Old Crow Flats consistently migrate to mountainous areas in Alaska and Yukon for the winter (Clarke et al., 2017; Cooley et al., 2019). One of the wintering areas for these migratory moose is the British Mountains in southwest Ivvavik Park. During the winter, moose selected valleys with shrubs that cut through the alpine tundra. There was some indication that areas with thermal inversions were preferred, but avoiding cold areas was not a major driver for choice of habitat.

Predation

- *Ecology and management of wolves in the Porcupine Caribou Range, Canada 1987 to 1993* (Hayes et al., 2016)

Predation by wolves and grizzly bears is an important influence on moose habitat use and moose populations. Research on wolves within the range of the Porcupine caribou herd (including the Yukon North Slope in its entirety) provides information on predator-prey dynamics and evaluates management measures (wolf harvest management and wolf control) in relation to moose and caribou populations. The study found that tundra wolves follow the Porcupine caribou because there is not sufficient prey to support them in winter on the Yukon North Slope, a pattern that may change with increased moose densities.

Parasites and disease

- *Parasites in Ungulates of Arctic North America and Greenland: A view of contemporary diversity, ecology, and impact in a world under change* (Kutz et al., 2012)
  This review paper provides information on the distribution and effects of Arctic ungulate parasites and the relationship of these parasites with moose. It includes discussion of risks of parasite range shifts or expansions due to climate change, and the risks of transfer of parasites among ungulate species.

References

Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat. (2016). *Aklavik Inuvialuit Community Conservation Plan Akaqvikmiut Nunamikini Nunutailivikautinich*.

Banfield, A. W. F. (1951). Notes on the mammals of the Mackenzie District, Northwest Territories. *Arctic*, *4*(2). https://doi.org/10.14430/arctic3939

Berner, L. T., Jantz, P., Tape, K. D., & Goetz, S. J. (2018). Tundra plant above-ground biomass and shrub dominance mapped across the North Slope of Alaska. *Environmental Research Letters*, *13*(3). https://doi.org/10.1088/1748-9326/aaaa9a

Canada. (n.d.). Species at Risk Public Registry. Retrieved April 20, 2020, from https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Canadian Endangered Species Conservation Council. (2016). *Wild Species 2015: The General Status of Species in Canada*. Retrieved from National General Status Working Group. Electronic copy (http://www.wildspecies.ca); data summary, raw data, and downloadable report. website: https://www.wildspecies.ca/reports

Clarke, H., Cooley, D., Humphries, M. m., Landry-Cuerrier, M., & Lantz, T. C. (2017). *Summer Habitat Selection by Moose on the Old Crow Flats*. Yukon Environment.

Cooley, D., Clarke, H., Graupe, S., Landry-Cuerrier, M., Lantz, T. C., Milligan, H., … Humphries, M. M. (2019). The seasonality of a migratory moose population in northern Yukon. *Alces*, *55*, 105–130.

Cooley, D., Eckert, C. D., & Gordon, R. R. (2012). *Herschel Island—Qikiqtaruk Inventory, Monitoring, and Research Program - Key Findings and Recommendations*. Retrieved from Yukon Parks website: http://www.wmacns.ca/pdfs/369_Herschel-Qikiqtaruk-Ecological-Monitoring-YukonParks2012.pdf

COSEWIC. (n.d.). Committee on the Status of Endangered Wildlife in Canada. Retrieved April 20, 2020, from http://www.cosewic.ca/index.php/en-ca/

Environment Yukon. (2016). *Yukon Ecological and Landscape Classification and Mapping Guidelines. Version 1.0* (N. Flynn & S. Francis, Eds.). Whitehorse, Yukon: Department of Environment, Government of Yukon.

Fraser, R. H., Lantz, T. C., Olthof, I., Kokelj, S. V., & Sims, R. A. (2014). Warming-Induced Shrub Expansion and Lichen Decline in the Western Canadian Arctic. *Ecosystems*, *17*(7), 1151–1168. https://doi.org/10.1007/s10021-014-9783-3

Gwich'in Renewable Resource Board. (2000). *Moose Management Plan for the Gwich'in Settlement Area, Northwest Territories*.

Hayes, R. D., Baer, A. M., & Clarkson, P. (2016). *Ecology and management of wolves in the Porcupine Caribou Range, Canada 1987 to 1993*. https://doi.org/10.1080/13604813.2010.510666

Hundertmark, K. J., & Bowyer, R. T. (2004). Genetics, evolution, and phylogeography of moose. *Alces*, *40*(January 2004), 103–122.

ICC, TCC, & ACC. (2006). *Inuvialuit Settlement Region Traditional Knowledge Report*. Calgary, Alberta: Submitted by Inuuvik Community Corporation, Tuktuuyaqtuuq Community Corportaion, and Aklarvik Community Corporation to Mackenzie Project Environmental Group.

Inuvialuit Harvest Study. (2003). *Inuvialuit Harvest Study: Data and Methods Report 1988-1997*. Inuvik, Northwest Territories: The Joint Secretariat.

IRC. (2019). *Inuvialuit Harvest Study 2018 Partner Report*. Inuvialuit Regional Corporation.

Jensen, W. F., Smith, J. R., Carstensen, M., Penner, C. E., Hosek, B. M., & Maskey, J. J. (2018). Expanding Gis Analyses To Monitor and Assess North American Moose Distribution and Density. *Alces: A Journal Devoted to the Biology and Management of Moose*, *54*(0), 45–54.

Joly, K., Sorum, M. S., Craig, T., & Julianus, E. L. (2017). The Effects of Sex, Terrain, Wildfire, Winter Severity, and Maternal Status on Habitat Selection By Moose in North-Central Alaska. *The Effects of Sex, Terrain, Wildfire, Winter Severity, and Maternal Status on Habitat Selection By Moose in North-Central Alaska*, *52*, 101–115.

Kelsall, J. P. (1972). The northern limits of moose (Alces alces) in western Canada. *Journal of Mammalogy*, *53*(1), 129–138. https://doi.org/10.1644/870.1.Key

Kutz, S., Ducrocq, J., Verocai, G. G., Hoar, B. M., Colwell, D. D., Beckmen, K. B., … Hoberg, E. P. (2012). Parasites in Ungulates of Arctic North America and Greenland: A view of contemporary diversity, ecology, and impact in a world under change. *Advances in Parasitology*, *79*, 99–252. https://doi.org/10.1016/B978-0-12-398457-9.00002-0

Lenart, E. (2018). *Moose Management Report and Plan , Game Management Units 26B and 26C*. Alaska Department of Fish and Game.

Mcculley, A. M., Parker, K. L., & Gillingham, M. (2017a). Yukon Moose: I. Seasonal Resource Selection By Males and Females in a Multi-Predator Boreal Ecosystem. *Alces*, *53*, 113–136.

Mcculley, A. M., Parker, K. L., & Gillingham, M. (2017b). Yukon moose: II. Range sizes, movement rates, and use of elevation and land cover by males and females. *Alces*, *53*, 137–158.

Myers-Smith, I. H., Grabowski, M. M., Thomas, H. J. D., Angers-Blondin, S., Daskalova, G. N., Bjorkman, A. D., … Eckert, C. D. (2019). Eighteen years of ecological monitoring reveals multiple lines of evidence for tundra vegetation change. *Ecological Monographs*, *89*(2). https://doi.org/10.1002/ecm.1351

Myers-Smith, I. H., Hik, D. S., Kennedy, C., Cooley, D., Johnstone, J. F., Kenney, A. J., & Krebs, C. J. (2011). Expansion of canopy-forming willows over the twentieth century on Herschel Island, Yukon Territory, Canada. *Ambio*, *40*(6), 610–623. https://doi.org/10.1007/s13280-011-0168-y

Nagy, M. I. (1994). *Yukon North Slope Inuvialuit Oral History*. Government of the Yukon, Heritage Branch.

NatureServe. (n.d.-a). Conservation Status Assessment. Retrieved February 15, 2020, from https://www.natureserve.org/conservation-tools/conservation-status-assessment

NatureServe. (n.d.-b). NatureServe Explorer. Retrieved March 20, 2020, from https://explorer.natureserve.org/Search#q

Parks Canada. (2002). *Annual Report of Research and Monitoring in National Parks of the Western Arctic: 2002*.

Parks Canada. (2018). *Ivvavik National Park of Canada Management Plan*. Parks Canada.

Round River Conservation Studies. (2019). *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-Based Moose Habitat Model.* Prepared for Wildlife Management Advisory Council (North Slope).

Smits, C. M. M. (1991). *Status and seasonal distribution of moose in the northern Richardson mountains*. Yukon Fish and Wildlife Branch Report TR-91-2.

Stern, G. A., & Gaden, A. (2015). *From Science to Policy in the Western and Central Arctic: An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization*. Quebec City: ArcticNet.

Tape, K. D., Gustine, D. D., Ruess, R. W., Adams, L. G., & Clark, J. A. (2016). Range Expansion of Moose in Arctic Alaska Linked to Warming and Increased Shrub Habitat. *PLoS ONE*, *11*(4), e0152636. https://doi.org/10.1371/journal.pone.0152636

Timmermann, H. R., & Rodgers, A. R. (2017). The Status and Management of Moose in North America – Circa 2015. *Alces*, *53*, 1–22.

Verocai, G. G., Lejeune, M., Beckmen, K. B., Kashivakura, C. K., Veitch, A. M., Popko, R. A., … Kutz, S. (2012). Defining parasite biodiversity at high latitudes of North America: New host and geographic records for Onchocerca cervipedis (Nematoda: Onchocercidae) in moose and caribou. *Parasites and Vectors*, *5*(1), 1–8. https://doi.org/10.1186/1756-3305-5-242

Wein, E. E., & Freeman, M. M. R. (1992). Inuvialuit food use and food preferences in Aklavik, Northwest Territories, Canada. *Arctic Med Res*, *51*(4), 159–172. https://doi.org/10.1016/j.saa.2012.12.026

WMAC (NS). (2005). Research on the Yukon North Slope Funded Through the Inuvialuit Final Agreement (IFA) 1985-2005. Retrieved from http://www.wmacns.ca/

WMAC (NS). (2012). *Species Status Reports for the Yukon North Slope*. Retrieved from Wildlife Management Advisory Council (North Slope) website: http://www.wmacns.ca/

WMAC (NS). (2013). *Wildlife Management Advisory Council (North Slope) Annual Report April 1, 2012 to March 31, 2013*. Retrieved from http://www.wmacns.ca/

WMAC (NS). (2014). *Wildlife Management Advisory Council (North Slope) Term Report April 1, 2011–March 31, 2014*. Retrieved from http://www.wmacns.ca/

WMAC (NS). (2019). *Wildlife Management Advisory Council (North Slope) Annual Report April 1, 2018 to March 31, 2019*. Retrieved from http://www.wmacns.ca/

WMAC (NS). (2022). *Yukon North Slope Wildlife Conservation and Management Plan*.

WMAC (NS), & Aklavik HTC. (2003). *Aklavik Inuvialuit Describe the Status of Certain Birds and Animals on the Yukon North Slope*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS), & Aklavik HTC. (2018a). *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS), & Aklavik HTC. (2018b). *Yukon North Slope Inuvialuit Traditional Use Study*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

Yukon. (2020). Yukon Wildlife: Moose. Retrieved April 20, 2020, from https://yukon.ca/en/moose

Yukon Environment. (2016). *Science-Based Guidelines for Management of Moose in Yukon*. Yukon Department of Environment Fish and Wildlife Branch.

Yukon Environment. (2018). Moose. https://doi.org/10.2307/3503876

Yukon Government. (2019). *Yukon Hunting Regulations Summary 2019-2020*.

Zhou, J., Prugh, L., Tape, K. D., Kofinas, G., & Kielland, K. (2017). The Role of Vegetation Structure in Controlling Distributions of Vertebrate Herbivores in Arctic Alaska. *Arctic, Antarctic, and Alpine Research*, *49*(2), 291–304. https://doi.org/10.1657/AAAR0016-058

Zhou, J., Tape, K. D., Prugh, L., Kofinas, G., Carroll, G., & Kielland, K. (2020). Enhanced shrub growth in the Arctic increases habitat connectivity for browsing herbivores. *Global Change Biology*, *00*, 1–12. https://doi.org/https://doi.org/10.1111/gcb.15104