Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 1: Traditional Use

Publication Information

Cover photo: Fish drying at Tapqaq. ©Michelle Gruben, 2016.

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 1: Traditional Use

Table of Contents

Maps

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.

There are fourteen companion reports, addressing four selected topics of key interest as well as ten wildlife species featured in the Plan.

Companion Report Table of Contents

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

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: Traditional Use

This companion report is one of four reports on selected topics that cut across species divisions for the Plan. This report draws on traditional use studies that have been documented at a variety of levels over fifty years on the Yukon North Slope. In the 1970s, researchers mapped Inuvialuit traditional use and occupancy across the area. At that time during negotiation of the Inuvialuit Final Agreement and in the early 1990s, oral history projects documented the history of Inuvialuit cultural and subsistence use of the Yukon North Slope, and its changes from prior to European contact, through multiple cultural transitions. More recently, Inuvialuit use of this area, as well as changes or impediments to continued travel, harvesting, or cultural practices have been documented through a variety of projects.

The relationship between Inuvialuit and the Yukon North Slope is an inextricable one. Inuvialuit are part of this land and deeply connected with its wildlife and ecosystems. Maintaining and enhancing Inuvialuit traditional use is one of five objectives of the Plan. The Inuvialuit Final Agreement ensures legal protection for continued Inuvialuit use of the North Slope through preferential and exclusive harvesting rights and the right to participate in related management decisions.

The sustainability of traditional use is tied to a range of factors. These include the conservation of harvested wildlife, fish, and plants, their associated habitats, and the ability of community members to continue accessing and using harvesting areas. Continued traditional use on the Yukon North Slope requires the preservation of Inuvialuit traditional knowledge of harvesting areas, travel routes, processing techniques, environmental conditions, and culturally appropriate practices. It also requires the necessary economic and institutional support to undertake sometimes lengthy and expensive trips to traditional harvesting areas. All of these elements must be maintained in the broader context of ecological integrity. As our climate changes, there is both increased risk and uncertainty about Yukon North Slope systems, including the ways Inuvialuit interact with the land and sea. This chapter introduces the historical and current patterns of use, highlights important traditional resources, describes impacts that affect traditional use, and summarizes available research about Inuvialuit traditional use on the Yukon North Slope.

It is important to note that while the term 'use' is employed in this report, it does not limit interactions to only consumptive or extractive activities; 'use' can and does include reciprocal relationships, with Inuvialuit as part of the ecosystem.

Traditional Use on the Yukon North Slope

The history of Inuvialuit traditional use on the Yukon North Slope is long and complex and has been well-documented from the 1900s onwards. What has remained consistent over time is the importance of this place to Inuvialuit. Traditional use encompasses many activities and practices. Many of the more tangible uses are well-documented: food and medicinal plant harvest, hunting and trapping of furbearers, harvesting of major ungulate species, grizzly bear hunting, whaling, seal harvest, fishing, polar bear hunting, egg gathering, and bird and small mammal harvest (Usher, 2002; WMAC (NS) & Aklavik HTC, 2018b). Recent harvest studies have documented the continued reliance on traditional foods in the community of Aklavik (Inuvialuit Harvest Study, 2003; Joint Secretariat, 2018). Inuvialuit use of the Yukon North Slope is also represented in species-specific traditional knowledge reports on grizzly bear, caribou, and polar bear (Joint Secretariat, 2015; WMAC (NS) & Aklavik HTC, 2008, 2009) as well a report on Inuvialuit knowledge of wildlife habitat on the Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a). The Yukon North Slope is also significant for many other cultural uses, too. Numerous spiritual sites, burial grounds, travel routes, safe havens, and other cultural features across the landscape reflect its significance in Inuvialuit culture. Inuvialuit interact with this land and seascape in a plethora of ways that support wellbeing, such as family gatherings, personal enjoyment and spiritual connection. These can be more difficult to quantify, but are no less important to maintain and protect.

The continued ability of Inuvialuit to access and use the Yukon North Slope is a central goal of the Plan. Conserving habitat for harvested fish, wildlife, and plants, as well as supporting Inuvialuit land-users is critical for meeting this goal.

Sustaining Inuvialuit traditional use on the Yukon North Slope

The *Yukon North Slope Wildlife Conservation and Management Plan* identifies strategies to maintain and revitalize Inuvialuit traditional use on the Yukon North Slope. These strategies include the conservation of important wildlife, fish, plants, and their associated habitats. The Plan also identifies several priorities to directly support Inuvialuit traditional use of the Yukon North Slope:

1. Invest in Inuvialuit traditional use through sustainable funding that contributes to supporting and increasing the participation of Inuvialuit households in land-based activities.
2. Enhance the link between Inuvialuit traditional use of the Yukon North Slope and maintaining, transferring, and mobilizing Inuvialuit knowledge.
3. Strengthen Inuvialuit cultural attachments, especially those of young people, to the area through on-the-land activities, such as Elder host camps, and Indigenous cultural exchanges.
4. Monitor climate change impacts on traditional use using Inuvialuit knowledge, community-based monitoring and science.
5. Mobilize Inuvialuit and scientific knowledge of the climate change impacts on Yukon North Slope, along with culturally-informed adaptations, to ensure ongoing and adequate Inuvialuit traditional use.
6. Strengthen a proactive community-based role in the conservation and wildlife management of the Yukon North Slope including the co-production of knowledge

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

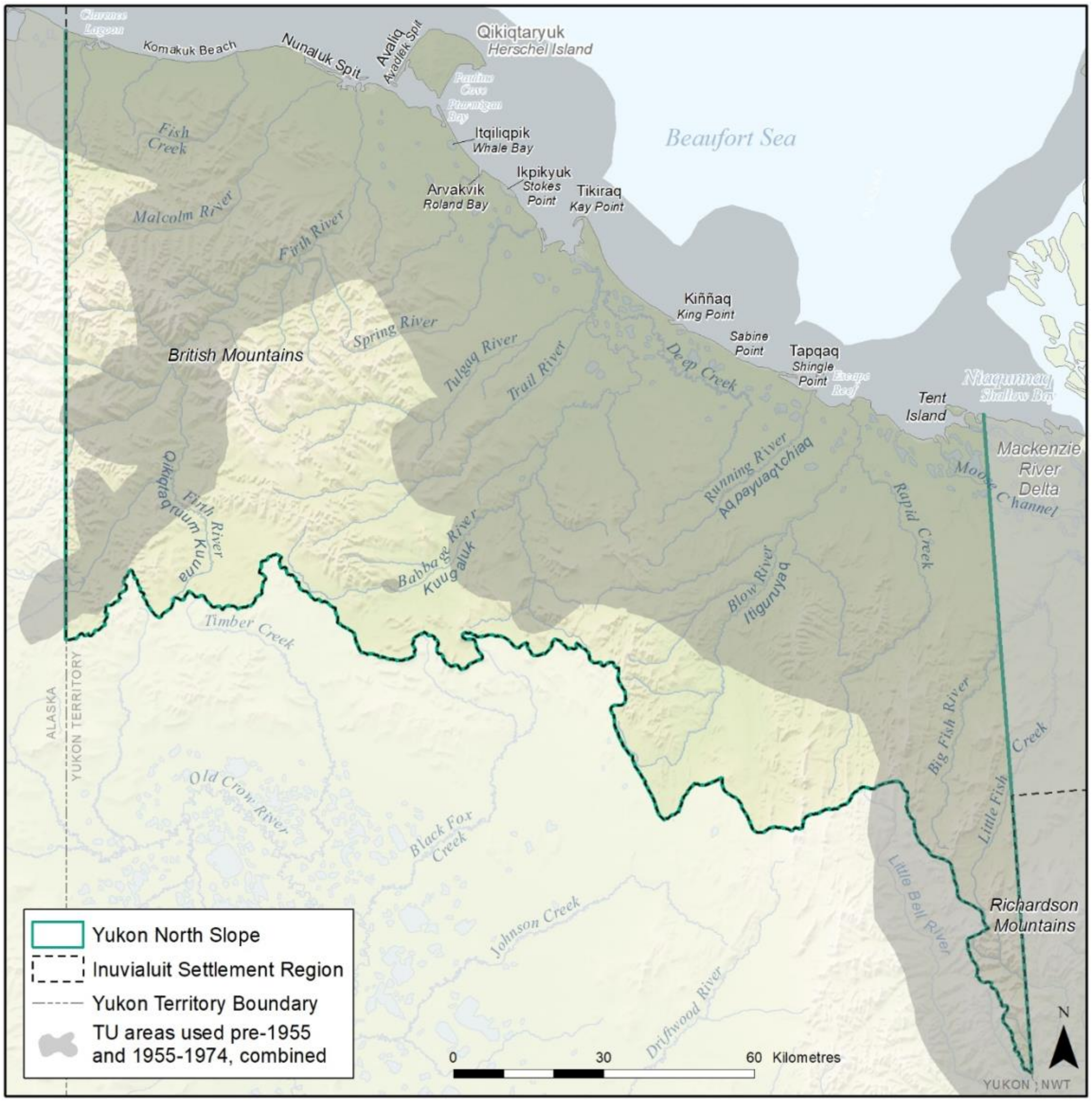
Traditional Use Through Time

The spatial and temporal patterns of traditional use have changed through history, as Inuvialuit culture has responded to social, economic, and environmental transitions. A major factor in these changes has been the dramatic and ongoing impact of government policies and laws and industrial development. It is important to recognize and understand various forms of past and current colonial behaviour in the context of traditional use. Colonial actions and their effects continue to have repercussions today on the extent of use, the legal context within which practices occur, and even the permanent settlement in Aklavik and other NWT communities. Maintaining and enhancing traditional use over the coming decades will need to include concerted efforts to respect, reconcile and accommodate different cultural values and management practices between Inuvialuit and federal and territorial government wildlife management models.

Archaeological evidence suggests that Inuvialuit are descendants of Thule people who migrated east from what is now Alaska over a thousand years ago. These ancestral Inuvialuit thrived on the North Slope landscape, relying heavily on the Beaufort Sea for food, heat, clothing, and travel.

At the time of European contact, Inuvialuit were divided into eight territorial groups, inhabiting the landscape from what is now known as Barter Island, Alaska, to Franklin Bay, NT (Betts, 2008; WMAC (NS) & Aklavik HTC, 2018b). Inuvialuit use occurred across the Yukon North Slope and several locations supported seasonal or year-round settlements, including Pauline Cove, Qaiñiuqvik (Clarence Lagoon), Komakuk, Nunaluk Spit, Avaliq (Avadlek Spit), Qargialuk (Ptarmigan Bay), Itqiliqpik (Whale Bay), Ikpikyuk (Stokes Point), Tikiraq (Kay Point), Kiññaq (King Point), Sabine Point, Tapqaq (Shingle Point), Aqpayuaqtchiaq (Running River), and Escape Reef (Map 1-1).

Map 1-1. Yukon North Slope showing historical use footprint and historically occupied coastal sites, identified by Inuvialuit land-users



Inuvialuit historical use and occupancy shown here have been documented through several studies (pre-1975 based on Freeman, 1976), summarized in WMAC (NS) & AHTC (2018b). The places named in the map represent a sample of the locations occupied by the Inuvialuit, as documented in these studies, and are not comprehensive. Some of these areas are no longer used due to changing environmental conditions, e.g., Nunaluk Spit was a permanent campsite but now the water is too shallow to access this by boat (Papik, Marschke and Ayles, 2003).

Inuvialuit quickly became integrated into commercial whaling and fur trading economies upon contact. The importance of these resources, along with growing trading activity with non-Indigenous people, influenced the development of more permanent settlements and trading posts along the coast (Freeman, 1976; Nagy, 1994; WMAC (NS) & Aklavik HTC, 2018b). This transition influenced patterns of use across the Yukon North Slope, which continued after the collapse of the whaling industry. The introduction of larger boats and a greater emphasis on whaling and fishing altered the extent of land-use compared to the 1800s, when Inuvialuit would travel further inland, following caribou on foot and with pack dogs. By the 1970s, summer caribou harvest primarily occurred in areas within walking distance of the coast (Freeman, 1976).

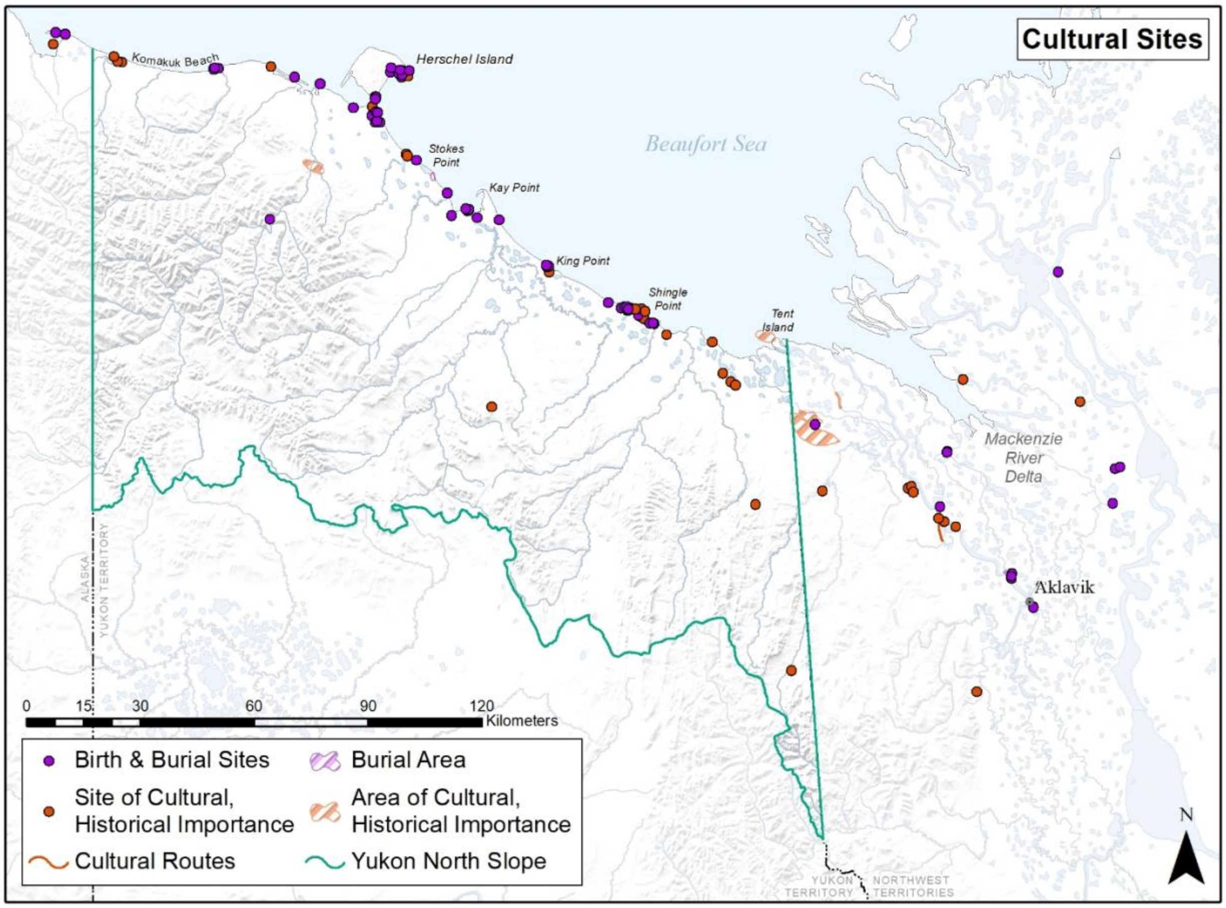
Increased Canadian Government and non-Indigenous presence in the arctic significantly impacted Inuvialuit use of the Yukon North Slope; many of these impacts were negative. Christian missions in Aklavik, residential schooling, government codification of trapping, and industrial activity associated with the construction of the Distant Early Warning Line (DEW Line) and the centre of Inuvik fundamentally altered the lifestyles and culture of Inuvialuit. They forced a greater reliance on wage labor and permanent settlement in Aklavik (Freeman, 1976; WMAC (NS) & Aklavik HTC, 2018b). These changes, coupled with the influence of oil exploration, which started in the Mackenzie Delta in 1958 and continued through the 1970s, and the construction of the Dempster Highway, further affected traditional use activities (WMAC (NS) & Aklavik HTC, 2018b).

Despite these monumental changes to the Inuvialuit way of life, a mixed economy persists in Aklavik. Hunting, trapping, whaling, fishing, and gathering of food and medicinal plants continue to play a major role in Inuvialuit economy and culture. A large percentage of Inuvialuit participate in harvesting of traditional foods, which make up a considerable portion of local diets. Traditional harvesting contributes to household incomes, nurtures social cohesion and individual wellness, and supports an informal trading of commodities (Inuvialuit Harvest Study, 2003; Joint Secretariat, 2018; Usher, 2002). The recent report on Inuvialuit traditional use of the Yukon North Slope also highlights the cultural importance of this place, extending beyond the measurable contributions to diets or economies. Many cultural sites, such as burial grounds, exist across the Yukon North Slope. Family histories and traditions are intimately tied to the landscape (WMAC (NS) & Aklavik HTC, 2018b) (Map 1-2).

Today, Inuvialuit traditional use faces many environmental and cultural challenges. The large socio-economic and cultural shifts that have occurred in recent generations have resulted in a reliance on wage labor and permanent settlement. This makes long distance travel and frequent seasonal use of the Yukon North Slope difficult (Freeman, 1976; WMAC (NS) & Aklavik HTC, 2018b). Increases in the price of fuel and supplies have outpaced wage growth, and the cost of trips to the Yukon North Slope have become a barrier to frequent use (Nickels, Furgal, Buell, & Moquin, 2005; Pearce et al., 2011; WMAC (NS) & Aklavik HTC, 2018b). Environmental change, particularly climate change, compounds these difficulties. Unpredictable weather, less predictable wildlife movement, altered snow and ice conditions, lower water levels, changing vegetation patterns, and stronger ocean wave action all impact traditional use. These changes, and the resulting changes in wildlife distribution, health, and abundance, make it more difficult to access, harvest, and consume traditional foods or maintain cultural infrastructure (Friendship & Community of Aklavik, 2011; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018b).

Programs, such as the Inuvialuit Harvesters Assistance Program (IRC, 2019) seek to address many of the economic or social barriers to continued traditional use. Community climate change adaptation plans identify new strategies that may be necessary to support continued traditional use (Friendship & Community of Aklavik, 2011). The continued ability of Inuvialuit to access and use the Yukon North Slope is a central goal of the Plan. Conservation of fish and wildlife habitat and support for Inuvialuit land-users is critical for meeting this goal.

Map 1-2. Inuvialuit cultural sites across the Yukon North Slope

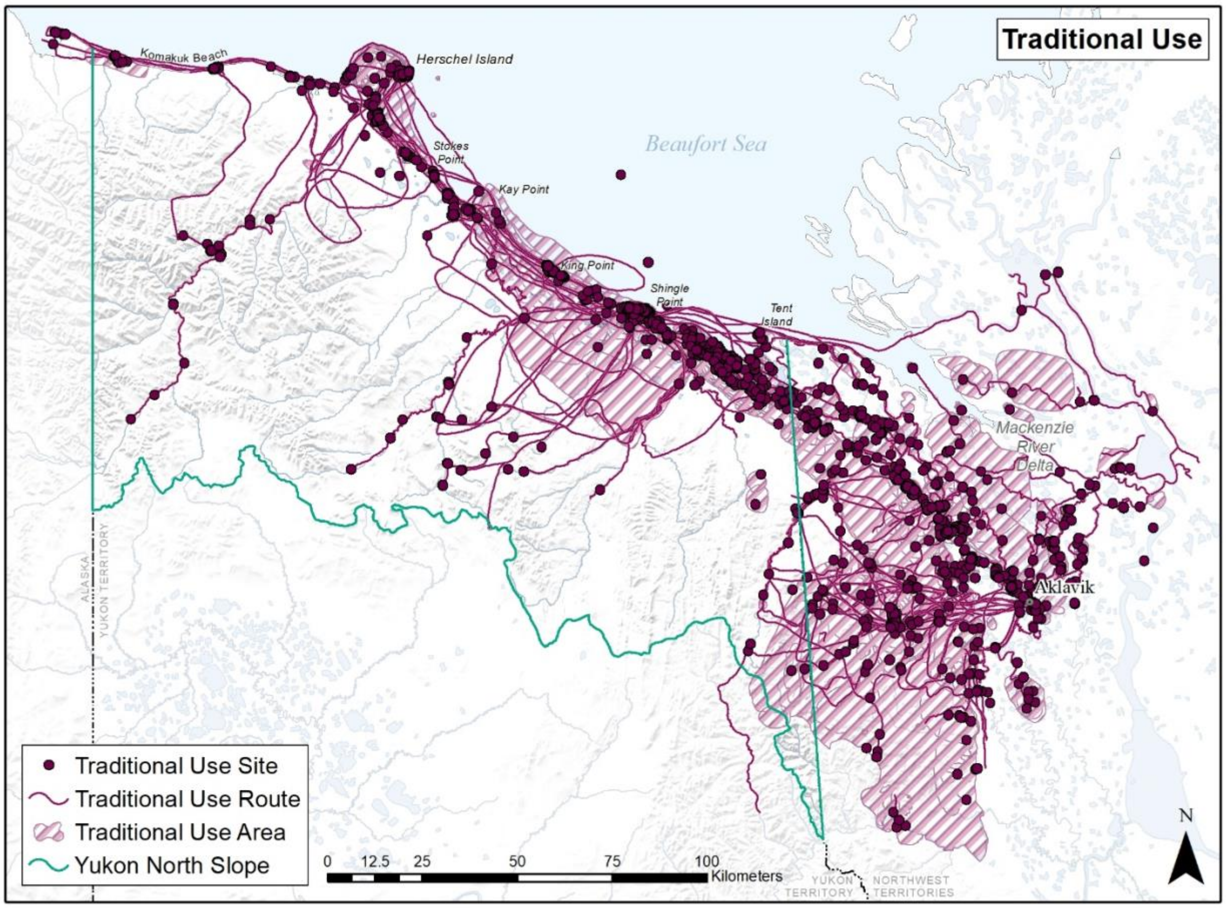


Adapted from the Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b). Interview participants mapped culturally or historically significant locations within their living memory. This does not include the numerous archaeological sites across the YNS that pre-date the memories of current land-users. Used with permission.

Current Patterns in Traditional Use

Current patterns of travel and land-use across the Yukon North Slope vary based on seasonal and environmental conditions, with the highest use in the eastern and coastal areas (Map 1-3). Historically, travel and land-use were more evenly spread across the Yukon North Slope, particularly with permanent and seasonal settlements across the landscape. The growing importance of wage labour, permanent settlement, and use of modern travel methods has led to a greater emphasis on harvesting in areas closer to Aklavik (WMAC (NS) & Aklavik HTC, 2009, 2018b). This shift results in a high reliance on coastal areas and Aullaviat/Aunguniarvik (the eastern Yukon North Slope) (WMAC (NS) & Aklavik HTC, 2018b).

Map 1-3. Spatial summary of Aklavik Inuvialuit traditional use on the Yukon North Slope



As part of the Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b), land-users were asked to identify traditional use areas, travel routes, and sites within their living memory. This mapping effort is the most recent depiction of the spatial footprint of Inuvialuit traditional use on the Yukon North Slope. Used with permission.

Current use of the Yukon North Slope is diverse and varies based on environmental conditions, seasonal species availability, community needs, and individual preference. The recent traditional use study identifies over 50 species of mammals, birds, fish, and plants harvested on the Yukon North Slope within the living memory of study participants (Table 1-1). Caribou are consistently identified as the most significant harvested species in the study area (Inuvialuit Harvest Study, 2003; Joint Secretariat, 2018; Usher, 2002; WMAC (NS) & Aklavik HTC, 2009, 2018b). However, summer whaling camps, spring grizzly bear and polar bear hunting, fishing, berry gathering, and many other harvesting activities shape Inuvialuit use of the Yukon North Slope. Harvesting on the Yukon North Slope is adaptive and responds to environmental conditions, species movements, and community needs.

Table 1-1. Terrestrial, aquatic, and marine animals, fish, and plant species harvested by Aklavik Inuvialuit

Common name	**Inuvialuktun name (Uummarmiutun dialect)**	**Binomial name**
Terrestrial, aquatic, and marine mammals		
Caribou	*Tuktu*	*Rangifer tarandus*
Moose	*Tuttuvak*	*Alces alces*
Dall's Sheep	*Imnaiq*	*Ovis dalli dalli*
Grizzly bear	*Aklaq*	*Ursus arctos*
Polar bear	*Nanuq*	*Ursus maritimus*
Wolf	*Amaruq*	*Canis lupus*
Wolverine	*Qavvik*	*Gulo gulo*
Lynx	*Niutuiyiq*	*Felix lynx*
Muskrat	*Kivigaluk*	*Ondatra zibethicus*
Beaver	*Kiqiaq, Paluqtaq*	*Castor canadensis*
Mink	*Itigiaqpak*	*Mustela vison*
Snowshoe hare (rabbit, hare)	*Ukalliq*	*Lepus americanus*
Arctic ground squirrel	*Sikrik*	*Spermophilus parryii*
Arctic fox (white fox)	*Tigiganniaq*	*Alopex lagopus*
Red fox (coloured fox)	*Kayuqtuq*	*Vulpes vulpes*
Beluga whale (white whale)	*Qilalugaq*	*Delphinapterus leucas*
Bowhead whale	*Arviq*	*Balaena mysticetus*
Ringed seal	*Natchiq*	*Phoca hispida*
Waterfowl and other birds		
American black duck		*Anas rubripes*
American wigeon	*Ugiuhiug*	*Anas americana*
Brant	*Nirglingaq*	*Branta bernicla*

Cackling goose		*Branta hutchinsii*
Canada goose	*Uluagullik*	*Branta canadensis*
Common eider	*Qauraviq*	*Somateria mollissima*
Common goldeneye		*Bucephala clangula*
Greater scaup		*Aythya marila*
Greater white-fronted goose (yellowlegs)		*Answer albifrons*
Green-winged teal		*Anas crecca*
Lesser scaup		*Aythya affinis*
Long-tailed duck (Old Squaw)	*Ahaliq*	*Clangula hyemalis*
Mallard duck		*Anas platyrhynchos*
Northern pintail	*Ku ugaq*	*Anas acuta*
Northern shoveler		*Anas clypeata*
Red-breasted merganser		*Mergus serrator*
Rock ptarmigan	*Niksaqtuniq*	*Lagopus mutus*
Spruce grouse (partridge)	*Ittuktuuq*	*Facipennis canadensis*
Surf scoter	*Aviluqtuq*	*Melanitta perspicillata*
White-winged scoter	*Aviluqtuq*	*Melanitta fusca*
Willow ptarmigan	*Qargiq, Nasaullik*	*Lagopus lagopus*
Fish		
Arctic char (Dolly Varden char, red char, char)	*Iqaluqpig*	*Salvelinus malma*
Arctic cisco (herring)	*Qaaqtaq*	*Coregonus autumnalis*

Arctic grayling (grayling)	*Suluqpauraaq*	*Thymallus arcticus*
Broad whitefish (whitefish)	*Aanaarlirq*	*Coregonus nasus*
Burbot (loche)	*Titaalirq*	*Lota lota*
Inconnu (coney)	*Siirgarq*	*Stenodus leucichthys*
Lake herring		*Coregonus artedi*
Lake trout		*Savelinus namaycush*
Lake whitefish (humpback, crooked back)	*Pikuktung*	*Coregonus clupeaformis*
Least cisco (herring, big-eye herring)	*Iriqpaligaurat*	*Coregonus sardinella*
Longnose sucker (sucker)		*Catostomus catostomus*
Northern pike (jackfish, pike)	*Siuliq*	*Esox lucius*
Pacific herring (blue herring, bluefish, herring)	*Qaluhaq*	*Clupea harengus*
Plants		
Blackberry	*Paunraq*	*Empetrum nigrum*
Blueberry	*Uquk, Asiaq, Asiavik*	*Vaccinium uliginosum spp. microphyllum*
Cranberry	*Kimmingnaq*	*Vaccinium vitis-idaea spp. minus*
Liquorice root (bear root, rat root)	*Masu*	*Hedysarum Americanum*
Wild rhubarb	*Qusimmait*	*Polygonum alaskanum*
Yellowberry (salmon berry)	*Aqpik*	*Rubus chamaemorus*

This table was adapted from the Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b). Used with permission.

Summer and Fall

During ice-free months, land-users primarily travel by boat and harvest along the coast. Major activities include seasonal whaling camps and fishing, but also the harvest of a wide range of terrestrial species, including caribou, berries, moose, small game, ducks, and geese (Harwood, Norton, Day, & Hall, 2002; Usher, 2002; WMAC (NS) & Aklavik HTC, 2018b). Travel and harvest occur along the length of the Yukon North Slope shoreline and include trips to Qikiqtaruk (Herschel Island).

> In the spring or summer we try to get all our caribou from along the shore. When it's a lot of mosquitoes they always go, you know, towards the wind, from the ocean. That's where they always go. When it's hot too they can't stay up on the mountains, they always go towards the sea.
>
> *Barbara Allen, reproduced from Aklavik Local and Traditional Knowledge About Porcupine Caribou (WMAC (NS) and Aklavik HTC, 2009, p. 29)*

A major site of importance during the ice-free months is Tapqaq (Shingle Point). Inuvialuit land-users maintain approximately 60 cabins at Tapqaq, which serves as a staging point for whaling, fishing, terrestrial harvesting, and other family activities (WMAC (NS) & Aklavik HTC, 2018b). Travel to and from Tapqaq occurs by boat, through the western edges of the Mackenzie Delta and along the coast. Every July, Inuvialuit participate in a beluga whale harvest at Tapqaq, lasting 4-6 weeks (Harwood et al., 2002), and the coastal waters are heavily used for fishing (Usher, 2002; WMAC (NS) & Aklavik HTC, 2018b).

The importance of Tapqaq is not limited to the marine. In the 2018 Yukon North Slope traditional use study, nearly every form of harvesting activity was mapped at or nearby Tapqaq, including harvest of caribou, moose, waterfowl, furbearers, grizzly bear, and berries or medicinal plants. Inuvialuit describe hunting caribou that come to the breezy shoreline for insect relief, and will often opportunistically combine harvesting activities based on species availability and seasonal conditions (WMAC (NS) & Aklavik HTC, 2009, 2018b). Tapqaq is also important for other traditional uses. It is the location of numerous cultural sites, a safe haven for travelers, and

> *Shingle Point is the best. You have a lot of access to a lot of things. You can pick berries, or you can make yourself dried fish, caribou meat, everything… That's my favourite place in Yukon, is Shingle Point, and that's where I brought up my little ones. I teach my oldest daughter how to make dry fish. Every year she would bring dry fish; and it's just the way it's been made…. You just can't start cutting for dry fish. You have to learn to clean the fish, and you've got to learn how to drain the blood out of the dried fish.*
>
> PIN 105, reproduced from *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) and Aklavik HTC, 2018, p. 100)

the site of cultural events, such as the Shingle Point Summer Games (WMAC (NS) & Aklavik HTC, 2018b). Understanding how climate change will continue to influence Inuvialuit use is critical to maintaining important cultural practices and connections.

> Shingle Point is the best. You have a lot of access to a lot of things. You can pick berries, or you can make yourself dried fish, caribou meat, everything... That's my favourite place in Yukon, is Shingle Point, and that's where I brought up my little ones. I teach my oldest daughter how to make dry fish. Every year she would bring dry fish; and it's just the way it's been made.... You just can't start cutting for dry fish. You have to learn to clean the fish, and you've got to learn how to drain the blood out of the dried fish.
>
> *PIN 105, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p. 100)*

Travel and use of the Yukon North Slope in the summer and fall extend far beyond Tapqaq, all the way to the Alaskan border (Map 1-3). Though recent use of the western portion of the Yukon North Slope has diminished due to the increased difficulties of making long trips due to the high cost of fuel and equipment and increasing extreme weather, this area is still highly significant to Inuvialuit land-users. A large concentration of cultural and archaeological sites represent this historic use and continued community importance (WMAC (NS) & Aklavik HTC, 2018b).

Winter and Spring

Travel by snowmobile has replaced the use of dog teams as the primary form of access to the Yukon North Slope during winter and spring. Winter conditions make inland travel easier, resulting in trips farther from the coast to access seasonally available resources (WMAC (NS) & Aklavik HTC, 2018a, 2018b). Inuvialuit winter harvest includes caribou, sheep, furbearers, arctic char, grizzly bears, and polar bears. Harvesting locations are often determined by proximity to Inuvialuit camps and cabins (WMAC (NS) & Aklavik HTC, 2008) or seasonally specific locations, such as char overwintering sites (WMAC (NS) & Aklavik HTC, 2018b). Frequently used areas include the Richardson Mountains or the mountains behind Tapqaq (WMAC (NS) & Aklavik HTC, 2008, 2018b); however, harvesting still occurs at the farthest reaches of the Yukon North Slope. For example, grizzly harvest in Ivvavik National Park (WMAC (NS) & Aklavik HTC, 2008) and caribou harvest on Qikiqtaruk (WMAC (NS) & Aklavik HTC, 2009).

> I've seen a number of them [graves] out on the land. Not much in the Mackenzie Delta; it's more out on the Yukon Coast. At Shingle Point, up on the hillside, there's a fair number of our ancestors there. At King Point on the west side of the big bay. Over at Niakolik [Point], another [one]. These are all campsites where Inuvialuit would have stayed. The majority of our older ancestors, our elders, were born along the coast, be it Shingle Point, Kay Point, Ptarmigan Bay, along the coast, Herschel Island, over right into Alaska. All throughout here in the early days there'd be camps,

> ten fifteen, twenty miles apart. And there'd be people being born here. I was born here November 1956 in the dead of winter [pointing to Komakuk Beach]. There's old gravesites here [pointing to the YNS on the map]….These ones are noticeable, with the fences here and here. But these other ones are just open with logs that are put a certain way….My granddad is here….my dad's dad….right on the west side of that little hill there [at Ptarmigan Point]…. My grandma is way over here….just before Demarcation Bay.
>
> *PIN 101, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC 2018, p. 47)*

The timing and route of the spring caribou migration determines spring land-use. Inuvialuit harvesters typically hunt caribou in areas south and west of Aklavik in the spring, when the herd passes on their migration (WMAC (NS) & Aklavik HTC, 2009). While migration patterns have always varied, migration routes and timing have become less predictable, resulting in changes to associated patterns of Inuvialuit land-use (WMAC (NS) & Aklavik HTC, 2009, 2018b, 2018a). Given this, it is difficult to attribute a specific location or time to winter or spring caribou harvest, as land-users react each year to opportunities as they arise.

> In the spring, for us it's easier, because you can cross all the valleys, and there's lots of snow. So, you're not really scared to go anywhere. Some creeks in the fall time, we won't even cross or we won't even go beside, because we know – if we see an animal, we know we get on that side of the creek, we know once we get into the creek, we can't come out of it.
>
> *Anonymous, reproduced from Aklavik Local and Traditional Knowledge about Grizzly Bears of the Yukon North Slope (WMAC (NS) and Aklavik HTC, 2008, p. 28)*

Grizzly bear and polar bear harvests are major focal points of land-use during the frozen months. Polar bear harvest occurs on near shore ice. Inuvialuit hunters follow pressure ridges to find places where polar bear hunt seal (Joint Secretariat, 2015). Grizzly bear harvest occurs primarily in the spring when bears emerge from their winter dens. Major areas of importance for grizzly bear harvesting are the Richardson Mountains and adjacent river valleys, which are accessible from Aklavik via snowmobile, though harvesting of grizzly bears occurs as far west as Ivvavik National Park (WMAC (NS) & Aklavik HTC, 2008, 2018b). It is also common practice to combine hunting trips for both polar bear and grizzlies, harvesting along snowmobile travel routes (Joint Secretariat, 2015; WMAC (NS) & Aklavik HTC, 2008, 2018b).

> In between Kay Point and King Point, my uncle used to always go in between there, and sometimes we'll see maybe three or four bears in one area in that place. And they used to be big bears, like eight-footers, nine-footers. And my uncle even told us to go there one time, and sure enough. He told us to go about five mile out, ten miles out, and as soon as we went that far out there, we started seeing polar bears all over – polar bear tracks all over the place there.

Pin 13, Aklavik, reproduced from *Inuvialuit and Nanuq A Polar Bear Traditional Knowledge Study* (Joint Secretariat, 2015, p. 86)

Climate Change and Traditional Use

Climate change is having a large impact on Inuvialuit traditional use. There are few studies that exclusively examine this impact on the Yukon North Slope, but the community of Aklavik and its reliance on the area has been incorporated into regional efforts to understand the impacts of environmental change on Inuvialuit communities. Due to their long and intimate relationship with the landscape, Inuvialuit are well-positioned to identify a range of environmental impacts associated with climate change (Table 1-2), many of which have a direct effect on traditional use. Across the ISR, community members have described a loss of cultural sites, increased difficulty of travel due to changing landscapes and weather, altered species migrations, and a change in the availability and quality of harvested resources (Bartzen, 2014; Friendship & Community of Aklavik, 2011; IRC, 2016; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2009). Climate change impacts may vary widely based on the specific resource, mode of access (e.g., travel by boat or snowmobile), or location.

Table 1- 2. Climate change impacts observed by Inuvialuit traditional knowledge holders, and selected references

Theme	Observation	Selected Sources
Climate Change Impacts to Wildlife and Habitat	Changing migration routes and timing	(Bartzen, 2014; Furgal & Seguin, 2006; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2009, 2018a)
	Changes in species abundance, range, or frequency of observation	(Bartzen, 2014; WMAC (NS) & Aklavik HTC, 2009, 2018a)
	Changes to denning timing or behavior	(WMAC (NS) & Aklavik HTC, 2018a; WMAC (NS), Yukon Environment, Aklavik HTC, & Parks Canada, 2008)
	Changing quality of harvested fish and wildlife	(IRC, 2016)
	Changes to wildlife habitat	(Joint Secretariat, 2015; WMAC (NS) & Aklavik HTC, 2009, 2018a)
	New or invasive species	(IRC, 2016)
Changes to weather and ice	Stronger storms	(IRC, 2016; Nickels et al., 2005)
	Greater frequency of freezing rain events	(Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2009, 2018a)
	Later freeze up, earlier breakup	(Nickels et al., 2005)

	Changing near shore ice conditions	(IRC, 2016; Joint Secretariat, 2015; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018b)
Landscape and Vegetation Changes	Lower water levels, less fresh drinking water	(Furgal & Seguin, 2006; Nickels et al., 2005)
	Increased sedimentation due to erosion or runoff	(Nickels et al., 2005; Papik, Marschke, & Ayles, 2003; WMAC (NS) & Aklavik HTC, 2018b)
	Permafrost thaw and ground subsidence	(Nickels et al., 2005)
	Increased shrub proliferation	(IRC, 2016)

Only research and observations that occurred in the community of Aklavik are referenced. This table originally appeared in *Arctic Climate Change Research and Monitoring A Review for Use on the Yukon North Slope* (WMAC (NS), 2020). Used with permission.

Inuvialuit have described how climate change alters the availability or quality of resources, including the following examples: changing environmental conditions have caused a decrease in berry production and an associated increase in harvesting difficulty; increased frequency of winter freeze/thaw events have impacted caribou foraging and health; warmer temperatures and lower water levels have changed the quality of harvested fish; and fresh drinking water is less available on the Yukon North Slope (IRC, 2016; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018a). Additionally, due to the cumulative impact of multiple stressors on certain species, harvesters are witnessing changes that may be difficult to exclusively link to climate. For example, when discussing changes in Porcupine caribou herd population size and migration patterns, Aklavik Inuvialuit offer a range of possible explanations that place climate change impacts alongside stressors such as harvesting pressure or harassment from radio collaring (WMAC (NS) & Aklavik HTC, 2009).

> The caribou are coming later. Sometimes they don't come, they go by a different route, way up… Old Crow Flats… sometimes they don't make it for the calving ground, they have calves in the mountains in spring time. So they die off – too much snow… deep snow in the valley they can't make it down. Lots of young ones die. They say it's overhunting, it's not that. It's the weather, climate change.
>
> *Anonymous, reproduced from Aklavik Local and Traditional Knowledge About Porcupine Caribou (WMAC (NS) and Aklavik HTC 2009, p. 23)*

Climate change effects on physical landscapes and weather patterns also impact Inuvialuit access to cultural sites and infrastructure on the Yukon North Slope. Receding sea ice leads to stronger wave action, as well as changing water levels and shoreline erosion, which make travel by boat more difficult and dangerous (Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018b). A later freeze up and earlier breakup shortens the snowmobile travel season (Nickels et al., 2005).

Climate change has also made weather less predictable and increased the frequency of strong storms, making travel more dangerous (IRC, 2016; Nickels et al., 2005). Inuvialuit infrastructure, such as cabins, are threatened by increasing coastal erosion, which has also impacted archaeological sites in the region (Irrgang, Lantuit, Gordon, Piskor, & Manson, 2019). These changes have made traveling on the Yukon North Slope more difficult. The knowledge and strategies developed through generations of traditional use may not apply to rapidly changing conditions.

> There's a whole bunch of them [burial places] right there, Ptarmigan Bay....within that island. That island is very small. It's eroding. In fact, my cabin, I had to move it three times because I'm losing ground....
>
> *PIN 121, reproduced from Yukon North Slope Inuvialuit Traditional Use study (WMAC (NS) and Aklavik HTC 2018b, p. 50)*

Taken as a whole, the wide-ranging climate change impacts across the Yukon North Slope create significant challenges to Inuvialuit traditional use. In isolation, it can be difficult to assess the magnitude of a single environmental change; however, when viewing the breadth of impacts facing Inuvialuit, the pace of change in the region, and the wide geographic and ecological extent of these changes, it is difficult to understate the significance of climate change in the region and its impact on traditional use of this land.

Loss of resources and harvesting opportunities, increased travel risks, the shifting ability to apply traditional teachings, the loss of traditional sites and connection to place: all of these outcomes of climate change have immediate effect on Inuvialuit traditional use. But more than that, these changes have a cost to the mental and physical wellbeing of individuals and communities (Middleton, Cunsolo, Jones-Bitton, Wright, & Harper, 2020). It is clear that maintaining and enhancing traditional use is an utmost priority for conservation of the Yukon North Slope.

> If it's good travelling, there's ice, it's safe to travel between the ice. But then one time we were stranded for a month because of the wind. We went down [to Kaktovik, Alaska] for a funeral and we ended up staying there for a month and coming back.... We had to wait for the weather because there was no ice. And it's not safe to travel without ice.... So we have to travel when it's nice.... because it took us about eight hours, I think, from Kaktovik to Shingle [Point]. We ended up camping at Shingle and coming back home.... A lot of it depends on the weather – if it's good.
>
> *PIN 108, reproduced from Yukon North Slope Inuvialuit Traditional Use study (WMAC (NS) and Aklavik HTC 2018, p. 32)*

Climate Change Adaptation

Aklavik land-users are participating in efforts to adapt to the challenges of climate change. At an individual level, many harvesters and travellers have already adopted new techniques or strategies for coping with a changing environment. Individual adaptations include measures such as traveling with more gas and emergency supplies, using new forms of emergency communication and navigation, and changing the harvesting areas for certain species (Friendship & Community of Aklavik, 2011; Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018b; Worden, 2018). At a community level, adaptation efforts may take the form of discussions about harvesting species whose populations are less threatened (e.g. muskox or moose) or purchasing infrastructure such as community freezers to support year-round availability of traditional food (Friendship & Community of Aklavik, 2011). At an institutional level, the Community of Aklavik participates in an ISR-wide climate change adaptation strategy, as well as the National Inuit Climate Strategy; both strategies prioritize supporting continued subsistence harvesting and traditional use (Friendship & Community of Aklavik, 2011; IRC, 2016; ITK, 2019).

Increased understanding of environmental changes on the Yukon North Slope, through both Indigenous monitoring and Western scientific research, is critical for adaptation efforts. Inuvialuit observations of species health and environmental conditions are incorporated into park management plans and monitoring programs (Cooley, Eckert, & Gordon, 2012; Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018; Parks Canada, 2018). The management of the Porcupine Caribou Herd is informed by land-user knowledge and observation (ABEKS, 2018; Russell, Svoboda, Arokium, & Cooley, 2013). Inuvialuit participate in joint harvest and sampling efforts of fish and marine mammals (DFO, 2010; Harwood et al., 2002). Increasingly, scientific research is guided by the priorities and concerns of local land-users. For example, extensive research on shoreline erosion has documented the threat to Inuvialuit cultural sites and infrastructure on the Yukon North Slope (Irrgang et al., 2019; Konopczak, Manson, & Lantuit, 2016).

More research is needed on the future of traditional use and the specific challenges facing the Yukon North Slope. Climate change impacts are likely to vary with local geographies, and may be experienced differently by land-users on the Yukon North Slope compared to other regions of the ISR. A recent summary of climate change research throughout the arctic recommends the development of place-based research and monitoring and increased ecological modeling to better understand potential future changes across the landscape (WMAC (NS), 2020). In some applications, such as assessing the threat to cultural sites due to shoreline erosion, predictive modeling has already helped to quantify threats to Inuvialuit traditional use (Irrgang et al., 2019). Efforts to extend this level of understanding across land-user values and climate change impacts will better support continued traditional use of the Yukon North Slope.

Because of the direct link between ecosystem health and Inuvialuit traditional use, the research described throughout the Plan is directly relevant to climate change adaptation efforts. Ensuring the availability and health of fish and wildlife resources, understanding threats to Indigenous wellbeing, infrastructure, cultural sites and practices, and planning for scenarios of ecological change are all essential for sustaining the continued use of the Yukon North Slope.

The effects pathways resulting from climate induced changes to the North Slope environment carry cascading impacts on wildlife, their habitat and the Inuvialuit who share it. These introduce special challenges for co-management and will require a heightened capacity and commitment by management partners to anticipate and respond to ecological uncertainty and wildlife and human population-level surprises that are difficult to predict at present. Future Inuvialuit traditional use of the North Slope will depend a great deal on these responses and associated management actions (Staples, 2013).

Selected Studies and Traditional Use Research Relevant to the Yukon North Slope

This section is an annotated listing of selected traditional use reports, papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research that will be important to consider during its implementation. The studies described below are the foundational publications that inform the understanding of traditional use in the Plan.

- Inuit Land Use and Occupancy Project (Freeman, 1976)
  As part of the Inuit Land Use and Occupancy Project report, traditional use of the Beaufort Sea and YNS was mapped across three time periods: the whaling and fur trade prior to 1930, the period between 1930 and 1955 when the fur trade became well-established in the Mackenzie Delta, and the period between 1955 and 1974, which was characterized by the development of the DEW Line and establishment of Inuvik. Traditional use was documented on 1:500,000 scale maps, and shows harvest areas for caribou, moose, sheep, muskox, grizzly bear, polar bear, beluga whale, seal, waterfowl, snowshoe hare, arctic hare, arctic ground squirrel, furbearer trapping, and fishing sites.

- Yukon North Slope Inuvialuit Oral History (Nagy, 1994)
  Researchers accompanied Inuvialuit land-users on field trips across the Yukon North Slope and Qikiqtaruk (Herschel Island) to describe the history of the landscape and Inuvialuit relationship with the land. The project discusses lifestyle changes that accompanied major social shifts in the region, such as the development of the DEW Line, and describes traditional reliance on the Yukon North Slope for sustenance and economic support. The project documented 120 place names in the study area and serves as an account of Inuvialuit historical presence on the landscape.

- Inuvialuit Food Use and Food Preferences in Aklavik, Northwest Territories, Canada (Wein & Freeman, 1992)
  This study examined the annual frequency of use of 32 species of mammals, fish, birds, and plants in Inuvialuit households in Aklavik and rated the degree of preference for each food

source. The most frequently consumed traditional foods were caribou, beluga, whitefish, and hare. Overall, traditional foods were widely preferred to store-bought foods.

- Inuvialuit Use of the Beaufort Sea and its Resources, 1960-2000 (Usher, 2002)
  Comprehensive surveys of Inuvialuit harvesters were conducted as part of three different studies: The Area Economic Surveys (1960s), Inuit Land Use and Occupancy Project (1970s) and the Inuvialuit Harvest Study (1990s). These studies show the impact of a move away from dog teams for transport and the adoption of snow machines, as the mean annual harvest of country foods declined with less of a need to feed dogs. The composition of yearly harvest also shifted during this period, with the balance between marine and terrestrial food sources changing from 75:25 in the 1960s to 45:55 in the 1990s. The overall importance of traditional foods, however, remained high, and the authors emphasize the importance of ongoing harvest studies for economic planning and fish and wildlife management.

- Unikkaaqatigiit Inuit Perspectives on Climate Change (Nickels et al., 2005)
  In response to rapid environmental change in the arctic, the Inuit Tapiriit Kanatami, the Nasivvik Centre for Inuit Health and Changing Environments at Laval University, and the Ajunnginiq Centre at the National Aboriginal Health Organization cooperated with regional Inuit communities to conduct a series of workshops discussing environmental change and its impacts on Inuit land-users. These workshops were held between 2002 and 2005, and included the ISR communities of Aklavik, Inuvik, Tuktoyaktuk, Paulatuk, and Ulukhaktok (known then as Holman Island). The workshops were community-focused, not landscape-specific, so it is not possible to identify which Akalvik responses were directed towards changes on the Yukon North Slope and which responses were made in relation to other parts of the ISR. However, Aklavik residents identified a range of environmental changes that impact traditional use. These include changes in ice conditions and resulting impacts to travel, changes in sea level, decreased health in fish and wildlife, and changing precipitation patterns, all of which impact traditional use of the land.

- Aklavik Local and Traditional Knowledge about Grizzly Bears of the Yukon North Slope (WMAC (NS) & Aklavik HTC, 2008)
  As part of a six-year grizzly bear research project on the YNS, Aklavik land-users contributed to an interview series that discussed grizzly bear habitat and natural history on the YNS, as well as Aklavik Inuvialuit relationships with and harvest of grizzly bears. With respect to traditional use on the YNS, this document is an important reference, as it details Inuvialuit harvesting practices and locations.

- Aklavik Local and Traditional Knowledge about Porcupine Caribou (WMAC (NS) & Aklavik HTC, 2009)
  The purpose of this study was to document Inuvialuit traditional knowledge of the Porcupine caribou herd. Specifically, Aklavik land-users were interviewed on herd movement patterns, population trends, range, habitat requirements, and overall heard health, as well as the

relationship between Aklavik Inuvialuit and caribou. Study results are important for informing conservation and management of the herd and contributing to harvest management. While this is not strictly a traditional use study, much of the knowledge reported in this document has been gained through generations of harvesting caribou, and a primary goal of caribou management bodies is to ensure continued sustainable harvest. The knowledge shared in this report provides a foundation for understanding Inuvialuit seasonal land-use, conservation concerns, and goals for the continued harvest of the Porcupine caribou herd.

- Inuvialuit and Nanuq A Polar Bear Traditional Knowledge Study (Joint Secretariat, 2015)
  This report is an effort to better represent aboriginal knowledge of polar bear in published literature. Researchers interviewed 72 traditional knowledge holders across the six ISR communities to discuss polar bear natural history and Inuvialuit relationships with polar bears, including the harvest of bears. Inuvialuit knowledge of a wide range of polar bear traits, including the sensory abilities of polar bears, interactions between bears and other species, their diet, behaviors, assessment of body condition, movement patterns, denning behaviors, and interactions with people, are included. With respect to traditional use, this study discusses Inuvialuit harvesting techniques in detail, as well as the necessary understanding of environmental conditions and travel practices – gained through generations of knowledge holders – that enables a successful hunt.

- Inuvialuit Harvest Study (Joint Secretariat, 2018)
  Regular surveys across the Inuvialuit Settlement Region measured the harvesting of birds, fish, and mammals in each Inuvialuit community. This allowed for a comparison of reported harvest across years and communities, and counted the number of community members that participated in harvesting. While these studies did not specifically identify harvest that occurred on the Yukon North Slope, they provided a quantitative measurement of species-specific harvesting trends and community participation in Aklavik.

- Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b)
  In 2015, 40 Inuvialuit community members were interviewed in the community of Aklavik to describe their traditional use of the Yukon North Slope. Interviewees were asked to map traditional use within their "living memory," including kill sites and harvesting areas for fish, wildlife, berries, and medicinal plants, as well as cultural sites, such as cabin and tent sites, birth sites, burial locations, and places of cultural, historical, or personal importance. Interviewees also documented travel routes and safe havens. In total, 2,091 features were mapped on 1:125,000-scale maps. Interviewees also described the shifts that have occurred in traditional use over their lifetimes, including adoption of new technologies, response to landscape and climate change, and the impacts of societal change. When compared to previous research, this mapping effort documents a change in the geographical extent of traditional use by Aklavik Inuvialuit over time. A contraction in the spatial footprint of traditional use is attributed to numerous factors, including the collapse of the fur trade, a shift to permanent year-round residency in Aklavik, the impacts of mandatory schooling and

reliance on wage labor, increasing costs of purchasing and maintaining harvesting equipment, and less predictable weather patterns due to climate change. However, the Yukon North Slope continues to make a significant contribution to Inuvialuit livelihoods, and the importance of the landscape cannot be quantified simply in economic or subsistence terms. Interviewees were clear to emphasize their personal connections to this land and the role that the landscape plays in their culture.

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.

- *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond* (BSP, 2009)
  The plan includes objectives, strategies, and actions for supporting the on-going traditional use of the Beaufort Sea and promoting a local subsistence economy.

- *Beaufort Sea Beluga Management Plan* (FJMC, 2013)
  The plan contains a mandate to promote continued traditional knowledge transmission, supporting opportunities for youth to gain the necessary skills for continued beluga harvest and processing.

- *Harvest Management Plan for Porcupine Caribou Herd in Canada and Implementation Plan* (PCMB, 2010, 2016)
  Harvest allocations are set for regions of overlap with Porcupine caribou herd. Inuvialuit Game Council has committed to providing harvest data, coordinating with governments, and implementing an annual allowable harvest, where necessary.

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016)
  Population trends, conservations status, and traditional use are described for a range of species that occur within the Aklavik planning area. This area includes, but is not limited to, the Yukon North Slope.

- *Inuvialuit on the Frontline of Climate Change: Development of a Regional Climate Change Adaptation Strategy* (IRC, 2016)
  Workshops and interviews were held in all six Inuvialuit Communities to discuss climate change impacts and adaptation strategies. Each community produced an adaptation plan. Subsistence hunting is one of five categories where adaptation efforts are described. The plan is not Yukon North Slope-specific but lists strategies to support continued traditional harvesting for the community of Aklavik.

- *Inuvialuit Settlement Region Polar Bear Joint Management Plan* (Joint Secretariat, 2017) and *Consensus Agreement Respecting the Implementation of the Inuvialuit Settlement Region Polar Bear Joint Management Plan and Framework for Action* (NWT Conference of Management Authorities, 2018)
  The plan recognizes the cultural importance of polar bear harvest and discusses strategies to support continued traditional harvest in the face of environmental change. Objective 2 of the plan is to adaptively co-manage the population, which requires more frequent and timely communication with harvesters to describe current conditions.

- *Integrated Fisheries Management Plan for Dolly Varden (Salvenlinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region Northwest Territories and Yukon North Slope* (DFO (Department of Fisheries and Oceans Canada), Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada, 2019)
  The management goal of the plan is to ensure long-term conservation, rebuilding, and sustainable use of Dolly Varden stocks. This plan includes descriptions of conservation strategies such as closing of fish holes to harvesting, reduced sport fishing pressure, and updated population assessments. It also ensures the harvest of at least 150 adult Dolly Varden for cultural and subsistence purposes.

- *Inuvialuit Harvesters Assistance Program* (IRC, 2019)
  Sustainable resource harvesting is a cornerstone of Inuvialuit culture but has become more difficult due to a combination of factors, including the anti-fur lobby, decreased fur prices, and an associated reduction in incomes. The harvesters assistance program was created by the IRC, Inuvialuit Game Council, and the Government of the Northwest Territories to "provide assistance to Inuvialuit individuals and groups to engage in traditional and emerging renewable resources activities." The program also encourages the re-establishment of traditional skills needed for harvesting, particularly in youth. Subsistence harvesters can apply for funding through the program to offset the costs associated with traditional harvesting, such as equipment purchasing.

References

ABEKS. (2018). *Arctic Borderlands Ecological Knowledge Society Strategic Plan – 2017-2020*.

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

Bartzen, B. (2014). *Local Ecological Knowledge of Staging Areas for Geese in the Western Canadian Arctic*. Environment Canada.

Betts, M. W. (2008). Subsistence and Culture in the Western Canadian Arctic: A Multicontextual Approach. *Canadian Museum of Civilization*, *Mercury Se*(Archaeology paper No. 169).

BSP. (2009). *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond*. Beaufort Sea Partnership.

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

DFO. (2010). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope, 2011-2015. Volume 2: Appendices*. Fisheries and Oceans Canada.

DFO (Department of Fisheries and Oceans Canada), Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada. (2019). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope. Volume 1: The Plan–2019 Update*. Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, and Parks Canada Agency.

FJMC. (2013). *Beaufort Sea Beluga Management Plan. 4th Amended Printing*. Inuvik, NT: Fisheries Joint Management Committee.

Freeman, M. M. R. (Ed.). (1976). *Inuit Land Use and Occupancy Project Report*. Retrieved from http://publications.gc.ca/site/eng/9.850125/publication.html

Friendship, K., & Community of Aklavik. (2011). *Climate Change Adaptation Plan: Community of Aklavik, Northwest Territories*. Retrieved from https://www.cakex.org/documents/climate-change-adaptation-action-plan-community-aklavik-northwest-territories

Furgal, C., & Seguin, J. (2006). Climate change, health, and vulnerability in Canadian northern Aboriginal communities. *Environmental Health Perspectives*, *114*(12), 1964–1970. https://doi.org/10.1289/ehp.8433

Harwood, L. A., Norton, P., Day, B., & Hall, P. A. (2002). The harvest of beluga whales in Canada's Western Arctic: Hunter-based monitoring of the size and composition of the catch. *Arctic*, *55*(1), 10–20. https://doi.org/10.14430/arctic687

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

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

IRC. (2016). *Inuvialuit on the Frontline of Climate Change: Development of a Regional Climate Change Adaptation Strategy*. Inuvik, NT: Inuvialuit Regional Corporation.

IRC. (2019). Inuvialuit Harvesters Assistance Program. Retrieved June 24, 2019, from Inuvialuit Regional Corporation website: https://www.irc.inuvialuit.com/program/inuvialuit-harvesters-assistance-program

Irrgang, A. M., Lantuit, H., Gordon, R. R., Piskor, A., & Manson, G. K. (2019). Impacts of past and future coastal changes on the Yukon coast — threats for cultural sites, infrastructure, and travel routes. *Arctic Science*, *5*(2), 107–126. https://doi.org/10.1139/as-2017-0041

ITK. (2019). *National Inuit Climate Change Strategy*. Retrieved from Inuit Tapariit Kanatami website: https://www.itk.ca/national-inuit-climate-change-strategy/resources/

Joint Secretariat. (2015). *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Joint Secretariat, Inuvialuit Settlement Region.

Joint Secretariat. (2017). *Inuvialuit Settlement Region Polar Bear Joint Management Plan*. Joint Secretariat, Inuvialuit Settlement Region.

Joint Secretariat. (2018). Inuvialuit Harvest Study. Retrieved November 25, 2018, from https://jointsecretariat.ca/isr-cbmp/inuvialuit-harvest-study/?fbclid=IwAR0kjt4Vqn7OFiTceSkdgy_Hdf_a-5e4qPNiPf1udEsfZTkX5oldThCDIkY

Konopczak, A. M., Manson, G. K., & Lantuit, H. (2016). Coastal erosion and resulting impacts along the ice-rich permafrost coast of the Yukon Territory, Canada. *EPIC3XI. International Conference on Permafrost, Potsdam, 2016-06-20-2016-06-24*. Retrieved from http://epic.awi.de/41521/

Middleton, J., Cunsolo, A., Jones-Bitton, A., Wright, C. J., & Harper, S. L. (2020). Indigenous mental health in a changing climate: A systematic scoping review of the global literature. *Environmental Research Letters*, *15*(5). https://doi.org/10.1088/1748-9326/ab68a9

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

Nickels, S., Furgal, C., Buell, M., & Moquin, H. (2005). *Unikkaaqatigiit-Putting the Human Face on Climate Change: Perspecitives from Inuit in Canada*. Ottawa, ON: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.

NWT Conference of Management Authorities. (2018). *Consensus Agreement Respecting Implementation of the Inuvialuit Settlement Region Polar Bear Joint Management Plan and Framework for Action*.

Papik, R., Marschke, M., & Ayles, B. (2003). *Inuvialuit Traditional Ecological Knowledge of Fisheries in Rivers West of the Mackenzie River in the Canadian Arctic*. Canada/Inuvialuit Fisheries Joint Management Committee Report 2003-4.

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

PCMB. (2010). *Harvest Management Plan for the Porcupine Caribou Herd in Canada*. Retrieved from Porcupine Caribou Management Board website: https://www.pcmb.ca/documents/Harvest Management Plan 2010.pdf

PCMB. (2016). *Implementation Plan, A Companion Document to the Harvest Management Plan for the*

Porcupine Caribou Herd in Canada.

Pearce, T., Ford, J. D., Duerden, F., Smit, B., Andrachuk, M., Berrang-Ford, L., & Smith, T. (2011). Advancing adaptation planning for climate change in the Inuvialuit Settlement Region (ISR): A review and critique. *Regional Environmental Change*, *11*(1), 1–17. https://doi.org/10.1007/s10113-010-0126-4

Russell, D. E., Svoboda, M. Y., Arokium, J., & Cooley, D. (2013). Arctic Borderlands Ecological Knowledge Cooperative: can local knowledge inform caribou management? *Rangifer*, *33*(2), 71. https://doi.org/10.7557/2.33.2.2530

Usher, P. J. (2002). Inuvialuit Use of the Beaufort Sea and its Resources, 1960-2000. *Arctic*, *55*(December 2001), 18–28.

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). (2020). *Arctic Climate Change Research and Monitoring A Review for Use on the Yukon North Slope*.

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

WMAC (NS), & Aklavik HTC. (2008). *Aklavik Local and Traditional Knowledge about Grizzly Bears of the Yukon North Slope: Final Report*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS), & Aklavik HTC. (2009). *Aklavik Local and Traditional Knowledge about Porcupine Caribou*. Retrieved from Wildlife Management Advisory Council (North Slope) website: http://www.wmacns.ca/pdfs/287_WMAC_rpt_pcbou_knwldg_web.pdf

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).

WMAC (NS), Yukon Environment, Aklavik HTC, & Parks Canada. (2008). *Yukon North Slope Grizzly Bear Population Study (Mid-Term Project Report)*.

Worden, E. (2018). *"Everything is changing so much": Community Perspectives on the Declining Beluga Whale Harvest in Aklavik, NT*. Univrsity of Manitoba.

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 2: Climate Change Effects / Hila aallanguqtuq

Publication Information

Cover photo: Herschel Island-Qikiqtaruk. © Cameron Eckert/Yukon Parks, 2017.

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 2: Climate Change Effects / Hila aallanguqtuq

Table of Contents

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 four selected topics of key interest as well as ten wildlife species featured in the Plan. 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: Climate Change Effects / Hila aallanguqtuq

This companion report is one of four reports on selected topics that cut across species divisions for the Plan. The phrase Hila aallanguqtuq is from the Inuvialuktun Uummarmiutun dialect, and can be translated as 'weather is changing' (IRC, 2020). Information presented in this chapter is drawn from research, monitoring, policy and planning initiatives at regional, national, and circumpolar scales. The climate change effects-related objectives and actions in Yukon North

Slope plans and programs are listed. The report also summarizes observations of climate change and projected effects related to wildlife and Inuvialuit traditional use on the Yukon North Slope.

Introduction to Climate Change Effects

Climate change is a central theme of the *Yukon North Slope Wildlife Conservation and Management Plan*. The plan is grounded in five principles, one of which states: "Climate change effects on the Yukon North Slope should be considered in all aspects of wildlife conservation, Inuvialuit traditional use, and management planning." Climate change is also directly addressed in two of the Plan's strategies.

Climate Change Strategies in the *Yukon North Slope Wildlife Conservation and Management Plan*

Strategy B3. Climate Change Effects: Monitor effects of climate change on Yukon North Slope ecosystems. Promote and engage in studies that contribute to understanding and forecasting the effects of climate change on wildlife and habitat. On an ongoing basis, assess options and implement measures for mitigation and adaptation to address climate change effects in the management of wildlife and wildlife habitats.

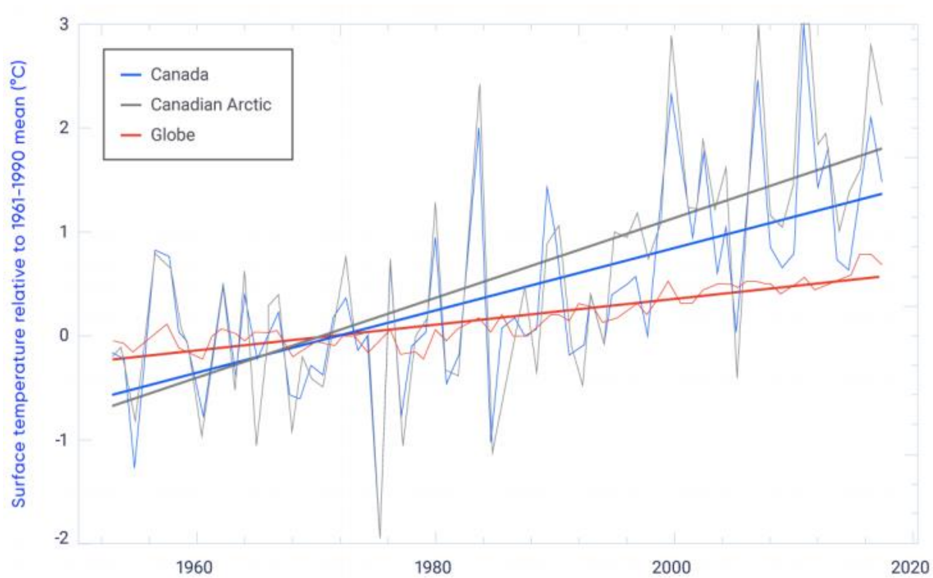
Strategy C2. Climate Change and Traditional Use: Employ monitoring and directed research to track and understand current and future effects of climate change on Inuvialuit traditional use of the Yukon North Slope. On an ongoing basis, assess options and implement measures for mitigation and adaptation, to enhance the resilience of traditional use to climate change.

Climate change is occurring most rapidly in northern latitudes. Temperatures north of 60° were the second highest on record (since 1900) during October 2019 to September 2020. This continues a trend of record-breaking climate-induced changes in the Arctic, including increasing temperatures, loss of sea ice, and greening of lower Arctic tundra ecosystems. Inuvialuit have observed climate change effects on the Yukon North Slope including changes in temperature, weather, precipitation, permafrost and ice conditions, especially since the 1980s (IRC, 2016; Joint Secretariat, 2015). Specifically, these changes include increases in surface air temperatures, which is more pronounced in Northern Canada (Figure 2-1, X. Zhang et al., 2019). Extreme weather events, such as thunderstorms, windstorms and forest fires, as well as precipitation have increased. The delayed winter season, due to warmer temperatures, has led to more precipitation falling as rain, rather than snow, during winter months (IRC, 2016; X. Zhang et al., 2019). Permafrost thawing has resulted in landscape slumping and the development of thermokarst landforms, irregular surfaces of marshy hollows and hummocks (Derksen et al., 2019). During the winter, ice on lakes is thinner and breaks up earlier than it did historically; a similar trend for sea ice occurs during summer months (Derksen et al., 2019).

Changes in climate influence wildlife, causing range shifts, increased or altered predation and competition, phenological mismatches, and altered biodiversity (Tape, Gustine, Ruess, Adams, & Clark, 2016; Tape, Jones, Arp, Nitze, & Grosse, 2018; Zhou et al., 2020). Changes in climate directly affect Inuvialuit traditional use by making reliable weather cues that have been passed down across generations no longer valid, resulting in altered or unsafe travel routes due to changes such as decreased ice thickness (IRC, 2016; Nickels, Furgal, Buell, & Moquin, 2005). As wildlife locations and behaviors shift, harvested animals may not occur in the same locations they have historically, thus hunting routes and camp locations may need to adapt (IRC, 2016; Nickels et al., 2005). The interconnectedness of people, landscape and wildlife illustrates how drastically the Inuvialuit way of life may be impacted by changes in climate, but also how their traditional knowledge will continue to be key to their survival (IRC, 2016; Nickels et al., 2005). The value of local knowledge as a way to understand environmental change is increasingly recognized, and confirms the need to involve local people in future research and monitoring processes (IRC, 2016; Nickels et al., 2005).

This chapter presents observed changes in climate (e.g., warming temperatures, decreased snowfall, diminishing sea ice) and future climate change projections for Canada produced under different emissions scenarios. Where possible, we ground climate model projections in examples of trends on the Yukon North Slope observed by Inuvialuit and through local research studies. The climate change projections considered in this report include Representative Concentration Pathways (RCP) 2.6 (lower projected emissions) and RCP 8.5 (high projected emissions, sometimes called "business as usual") (Bush & Lemmen, 2019).

Figure 2- 1. Rates of warming for Canada, the Canadian Arctic and globally



Historical observations of annual mean surface temperature for Canada (blue), the Canadian Arctic (grey) and the global average (red). The rate of surface warming in Canada is greater than twice the rate of surface warming for the globe, and the rate of surface warming in the Canadian Arctic is approximately three times the global rate. Source: Figure 3.3 (Flato, Gillett, Arora, Cannon, & Anstey, 2019), Canadian results use Adjusted and

Homogenized Canadian climate data (Vincent et al., 2015) and the global result use HadCRUT data set (Morice, Kennedy, Rayner, & Jones, 2012).

Climate Change Effects on the Yukon North Slope: Selected Studies and Syntheses of Research Results

This section summarizes information about key changes occurring in the north due to climate change, with an annotated listing of selected reports, community observations, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

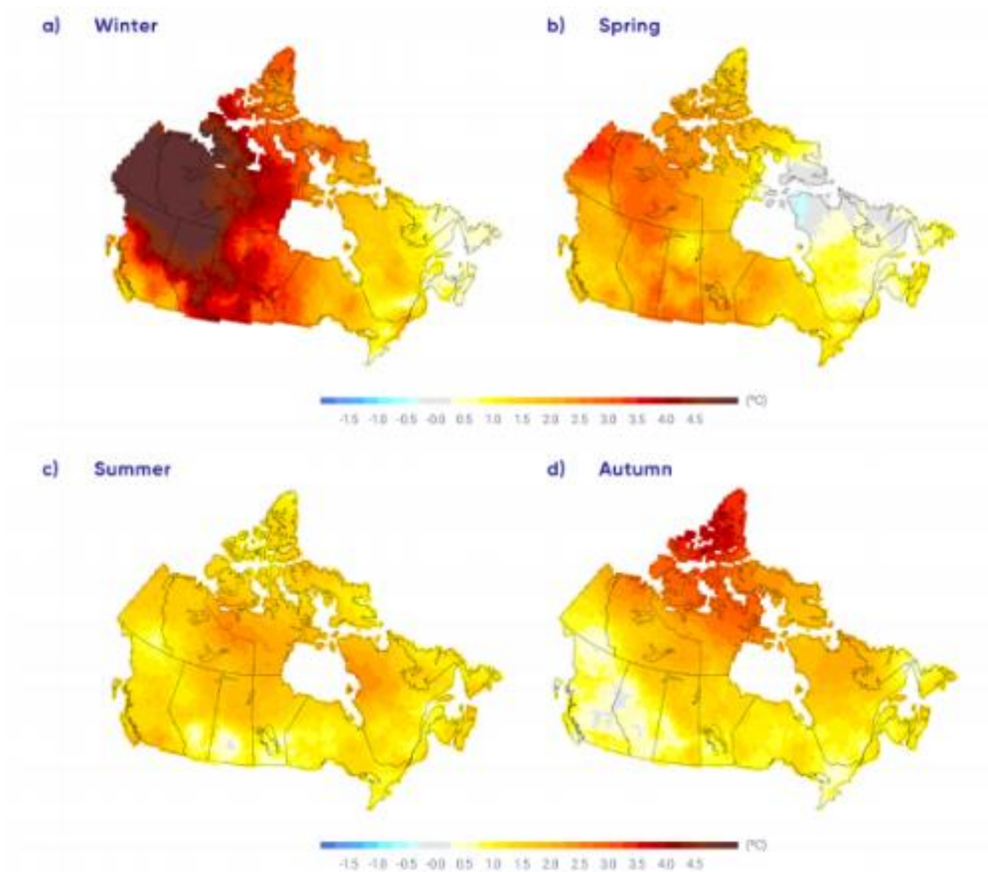
Temperature and Arctic Amplification

Over the last 50 years, annual air temperatures have increased globally, and these increases are most pronounced at northern latitudes (Figure 2- 2). The Arctic has warmed at more than twice the rate of global temperature increases, a phenomenon which is referred to as Arctic amplification. The annual mean Arctic temperatures over the period of 2014 to 2019 have exceeded all previous records.

Temperatures are projected to continue increasing during all seasons across Canada under both the low (RCP 2.6) and high (RCP 8.5) emissions scenarios (Zhang et al., 2019) and temperatures in Yukon have increased by 2°C over the last 50 years (Streicker, 2016).

- Historic and projected trends in temperature across Canada (X. Zhang et al., 2019)
  Historic and projected temperature increases are not uniform across Canada throughout the year. The largest observed temperature increases from 1948-2016 occurred in northern Canada, and they were greatest in the winter (4.3° C) followed by autumn (2.3° C), spring (2.0° C), and summer (1.6° C) (Map 2-1). Temperatures are projected to continue increasing during all seasons across Canada under both the low and high emissions scenarios. This has led to a decrease in the length of the winter season and increase in the length of the growing season.

Figure 2- 2. Observed changes (°C) in temperature across all seasons in Canada (1948-2016)



The observed changes (°C) in mean temperatures between 1948 and 2016 for the four seasons: winter (a), spring (b), summer (c) and autumn (d). Source: Figure 4.4 (X. Zhang et al., 2019) updated from Vincent et al. (2015)

- Observed temperature trends in the ISR (IRC, 2016; Nickels et al., 2005)
  General trends related to temperature observed in the ISR include increased average air temperature, particularly in the winter, increased ground and marine temperatures, warmer winter seasons, and increased seasonal variability in relation to temperature (day to day, hour to hour). The summer heat is more intense, and there are fewer extreme cold days in the winter.

- Processes and impacts of Arctic amplification: A research synthesis (Serreze & Barry, 2011)
  Trends and variability in surface air temperature tend to be larger in the Arctic region than for the Northern Hemisphere or globally. Arctic amplification is expected to become stronger in coming decades, invoking changes in atmospheric circulation, vegetation, and the carbon cycle, with impacts both within and beyond the Arctic.

Sea Ice

Climate change is impacting sea ice extent, thickness, and age. In the Beaufort Sea, summer sea ice extent has significantly declined. In 2018, a 68% decline in sea ice extent was observed, compared to baseline estimates (1979-1989) (J. Stroeve & Notz, 2018). The extent of Arctic sea ice is expected to continue to decline under all emissions scenarios with the likelihood of Arctic ice-free periods in summer and fall increasing under higher emissions scenarios (Figure 2-4; Stroeve and Notz, 2018).

Increased summer melt results in younger sea ice (Figure 2- 3), which is saltier, thinner, weaker, and therefore more likely to melt during summer. Between 1985 and 2019, the amount of very old (over 4 years) ice in the Arctic Ocean's ice pack declined from 33% to 1.2% (Lindsay & Schweiger, 2015).

The loss of summer sea ice has significant implications for marine fish and wildlife species, as well as for the traditional use and travel for Inuvialuit. These implications are discussed later in this report.

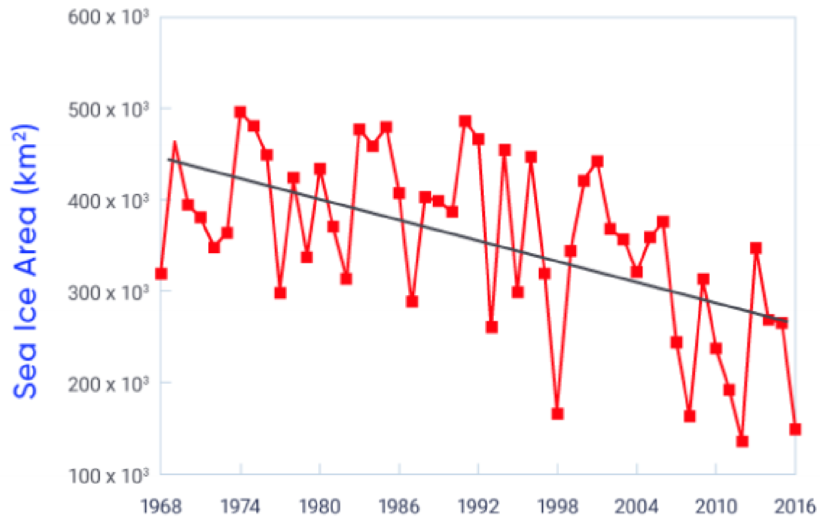
- Observed changes in ice conditions across the ISR (IRC, 2016; Nickels et al., 2005)
  Changes in ice conditions decrease safety and increase difficulties of winter travel. Specifically, the ice is thinner, ice near the shorelines is rougher, and ice freezes later in the fall and breaks up earlier in the spring than it did historically. In some years up to a month difference was reported.

- Reduced sea ice thickness (Hynes, Wesche, & Aklavik HTC, 2017).
  Community-based monitoring at Tapqaq (Shingle Point) indicates that reduced ice thickness has made travel less safe over the past 5 to 10 years. This is a concern for Inuvialuit who use boats to access the Yukon North Slope: for example, summer sea ice is further off the coast, which allows large waves to form between the ice and shore, creating dangerous boating conditions.

- The Arctic's rapidly shrinking sea ice cover: a research synthesis (J. C. Stroeve et al., 2012)
  The sequence of extreme September sea ice extent minima over the past decade suggests acceleration in the response of the Arctic sea ice cover to external forcing, hastening the ongoing transition towards a seasonally open Arctic Ocean.

- Observed and projected trends in glaciers, and sea, river and lake ice across Canada (Derksen et al., 2019)
  The Beaufort Sea has lost summer sea ice at a rate of 8.3% per decade (Figure 2-5). Increased temperatures, under all emissions scenarios, will likely result in continued reduction of sea ice in the summer and potentially the winter.

Figure 2- 3. Beaufort Sea ice loss from 1968-2016



Time series of summer sea ice for the Beaufort Sea (-8.3% per decade). Source: Figure 5.8 (Derksen et al., 2019) adapted from Mudryk et al. (2018)

Precipitation

The average total precipitation across the Arctic has increased and is projected to continue to increase, including on the Yukon North Slope. This is a result of warmer and moister air, linked to jet stream patterns and sea ice retreat (Bintanja, 2018). Although precipitation has increased during all seasons, the most notable increases have been observed during the winter months (Map 2-2, Zhang et al., 2019).

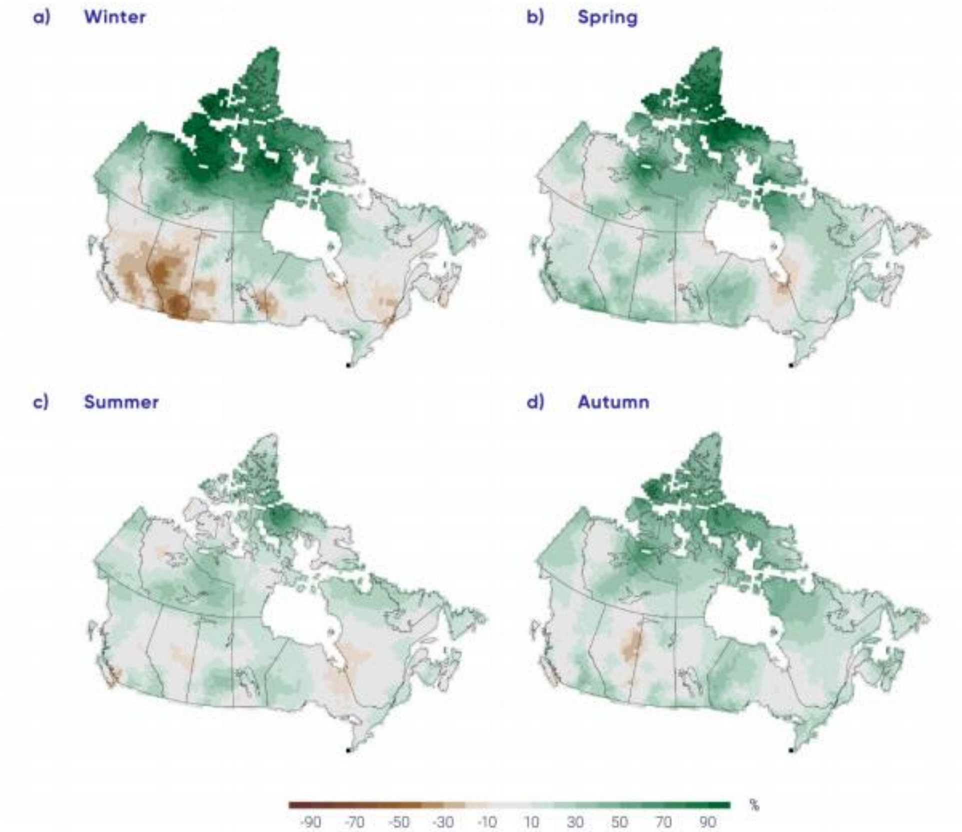
Arctic precipitation is expected to increasingly fall as rain, although changes in the expected proportion of snow versus rain vary dramatically based on season and region, and are difficult to predict at the regional scale (Bintanja & Andry, 2017). This has profound hydrological and ecological consequences in the Arctic, such as increased permafrost thaw (Douglas, Turetsky, & Koven, 2020), run-off and flooding (Bintanja & Andry, 2017; Il Jeong & Sushama, 2018) and impacts on wildlife species (Boelman et al., 2019; Rennert, Roe, Putkonen, & Bitz, 2009).

- Observed precipitation and weather trends in the ISR (IRC, 2016; Nickels et al., 2005)
  Overall observed weather conditions identify weather as being more variable and less predictable. For the ISR as a whole, conditions are drier; however, wetter and colder summers have been observed in certain areas of the ISR. Reports of more variable weather included an increase in thunderstorms (including more forceful rain), windstorms, funnel winds, and freezing rain events.

- Historic and projected trends in precipitation across Canada (X. Zhang et al., 2019)
  General trends indicate that precipitation has increased during all seasons on the Yukon North Slope with the greatest increases predicted in winter (Figure 2- 4). Data for extreme precipitation events (i.e., those occurring over a day or less) are lacking; however, in the high

emissions scenario these extreme events are expected to increase. Additionally, both emissions scenarios have high confidence in the likelihood of precipitation falling as rain versus snow during winter months.

Figure 2- 4. Observed changes (%) in precipitation across all seasons in Canada (1948-2012)



Observed changes in normalized seasonal precipitation (%) between 1948 and 2012 for the four seasons. Source: Figure 4.16 (X. Zhang et al., 2019) updated from Vincent et al. (2015)

- Rain-on-snow events in North America (Il Jeong & Sushama, 2018)
  Warmer air temperatures are predicted to increase the occurrence of rain-on-snow events from November through March in the high latitude and mountainous regions of North America, including the Yukon North Slope. Rain-on-snow events result in increased runoff and subsequent flooding. They may also increase 'icing' events, where a crust of ice forms after rain in freezing temperatures.

Snow Cover

Snow cover is an essential part of the Arctic, where snow typically covers the landscape for 8-10 months of the year. Therefore, observed reductions in snow cover and the predicted continuation of snow cover loss (Derksen et al., 2019) are of high concern. Snow cover reduction has been found to explain ~70% of the reduced surface albedo (the fraction of sunlight reflected by the Earth's surface) in the Arctic (R. Zhang, Wang, Fu, Rasch, & Wang, 2019).

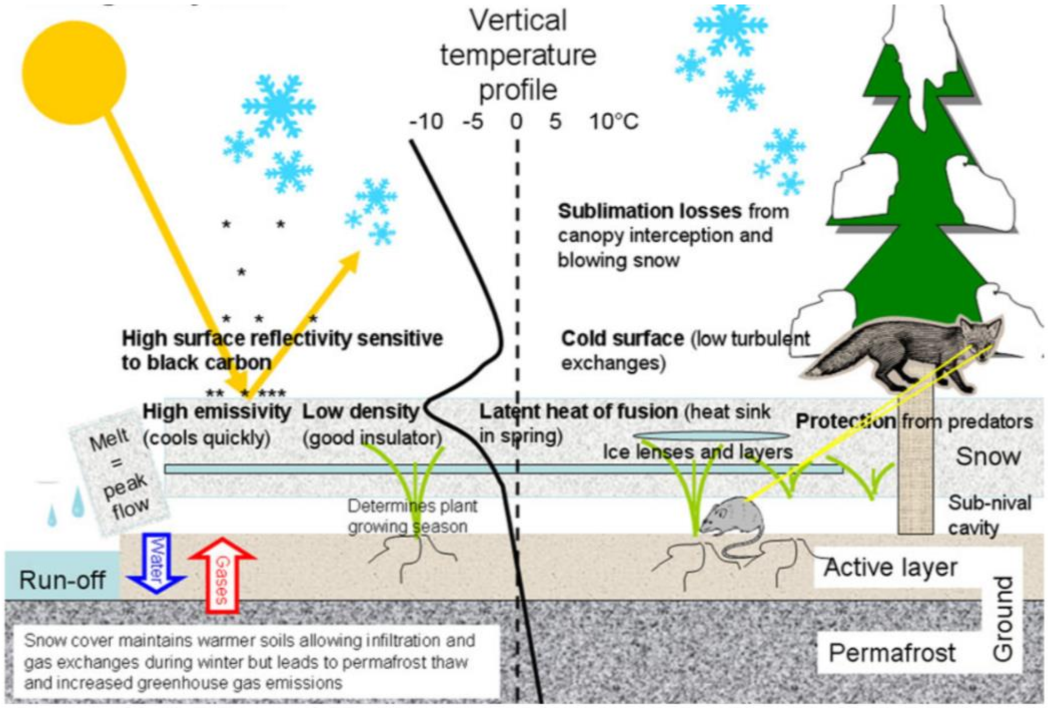
Reductions in snow cover and variations in seasonal timing and duration as well as altered physical properties of the snow pack are linked to warmer temperatures and precipitation falling as rain (Kim, Kimball, Du, Schaaf, & Kirchner, 2018; R. Zhang et al., 2019).

Snow cover provides thermal insulation, which influences ice thickness as well as permafrost (Callaghan et al., 2011). For example, the air temperature above snow cover may be -20°C, but the soil temperature will remain around 0°C if covered by 50cm of snow (Pomeroy & Brun, 2001). As the near-ground surface is typically protected from freezing, the soil layer and wildlife in the subnivean zone (area between the ground surface and the bottom of the snow cover) are shielded from extreme weather conditions (Figure 2– 5) (Callaghan et al., 2011). Snow cover loss also results in a longer growing season, reduced spring floods, and decreased permafrost, which accelerates freshwater release (Kim et al., 2018).

Wet snow typically falls in the spring, when temperatures are warmer, but it is now falling in autumn and winter, when the dry snow associated with colder temperatures historically fell (Kim et al., 2018). Thawing and refreezing associated with spring wet snow conditions in Alaska and western Canada during 2015 and 2016 were determined to contribute to an ~25% decrease in snow cover albedo compared to dry snow conditions (Kim et al., 2018).

People and wildlife that live in the Arctic are well-adapted to snow. A decrease in snow alters not only climate, hydrological and ecological systems, but also impacts social and traditional use, including travel routes, animal harvest, and traditional food webs (Callaghan et al., 2011). Unfortunately, due to challenges in monitoring and collecting data on snow cover, snow melt, and energy dynamics at higher latitudes and elevations within the Arctic, including the Yukon North Slope, there is a lack of information on rates of loss or change (Kim et al., 2018).

Figure 2- 5. Snow cover is an important component of climate, hydrological and ecological systems in the Arctic



Overview of the interactions of snow cover with multiple features – the black line indicates an idealized ground-snow-atmosphere temperature profile. This aims to highlight the strong temperature gradients occurring near the snow surface (snow is represented by the off white/gray rectangle). Source: (Callaghan et al., 2011)

- Observed and projected trends in snow cover and sea ice across Canada (Derksen et al., 2019)

  Across most of Canada, seasonal snow cover has decreased since the 1980s, and to a lesser degree snow accumulation has also decreased. Warmer temperatures result in more precipitation falling as rain, and snow arriving later and melting earlier. Low and high emissions scenarios project that snow cover duration will continue to decline as the surface air temperature increases.

- Observed snow trends in the ISR (IRC, 2016; Nickels et al., 2005)

  A decrease in snowfall has been observed in the ISR.

Permafrost

Permafrost is highly sensitive to increasing air temperatures and changes in snow cover (Chadburn et al., 2017; Crites, Kokelj, & Lacelle, 2020; Derksen et al., 2019). The temperature of permafrost in the North Slope of Alaska has increased by ~3°C over the last 40 years (Zhang et al., 2003). This has led to rapid thawing of permafrost, resulting in freshwater release and ground instability as well as additional GHG release and landscape changes including slumping, formation of thermokarsts, and the expansion (or occasional draining) of lakes (Derksen et al., 2019; Nickels et al., 2005). Permafrost melt also increases erosion, mudslides, and landslides (IRC, 2016; Nickels et al., 2005). Coastal erosion, which has been observed at Qikiqtaruk (Herschel Island) and Tapqaq (Shingle Point), on the Yukon North Slope, is of particular concern due to the potential loss of cultural features near the coast (Cunliffe et al., 2019; Irrgang, Lantuit, Gordon, Piskor, & Manson, 2019; Radosavljevic et al., 2016).

- Observed and projected trends in permafrost across Canada (Derksen et al., 2019)
  Permafrost temperature has increased at an estimated rate of ≤0.5°C per decade across Canada. As mean air temperature is projected to increase under all emissions scenarios, large areas of permafrost warming and thawing are expected by mid-century. In the MacKenzie Valley, the thickness of the permafrost active layer (i.e., the soil layer above the permafrost that thaws and freezes annually) has increased by ~10% since 2000. The thawing of ice-rich permafrost results in ground instability and additional GHG release, likely accelerating climate change impacts. Also, northern soils in Canada efficiently store mercury which becomes vulnerable to release as permafrost thaws.

- Observed changes in permafrost across the ISR (IRC, 2016; Nickels et al., 2005)
  The permafrost melting has caused slumping to occur, as well as rising in areas where it is forced up from underneath, creating larger and new islands. Specifically, Tapqaq (Shingle Point) is said to be dropping, decreasing in terms of relief, but also growing at a rate of ~4 feet per year (since 1990) due to siltation and deposition. This sediment flush from permafrost melt is filling in small bays and safe harbors along the Yukon North Slope, which affects safety and access for Inuvialuit boaters.

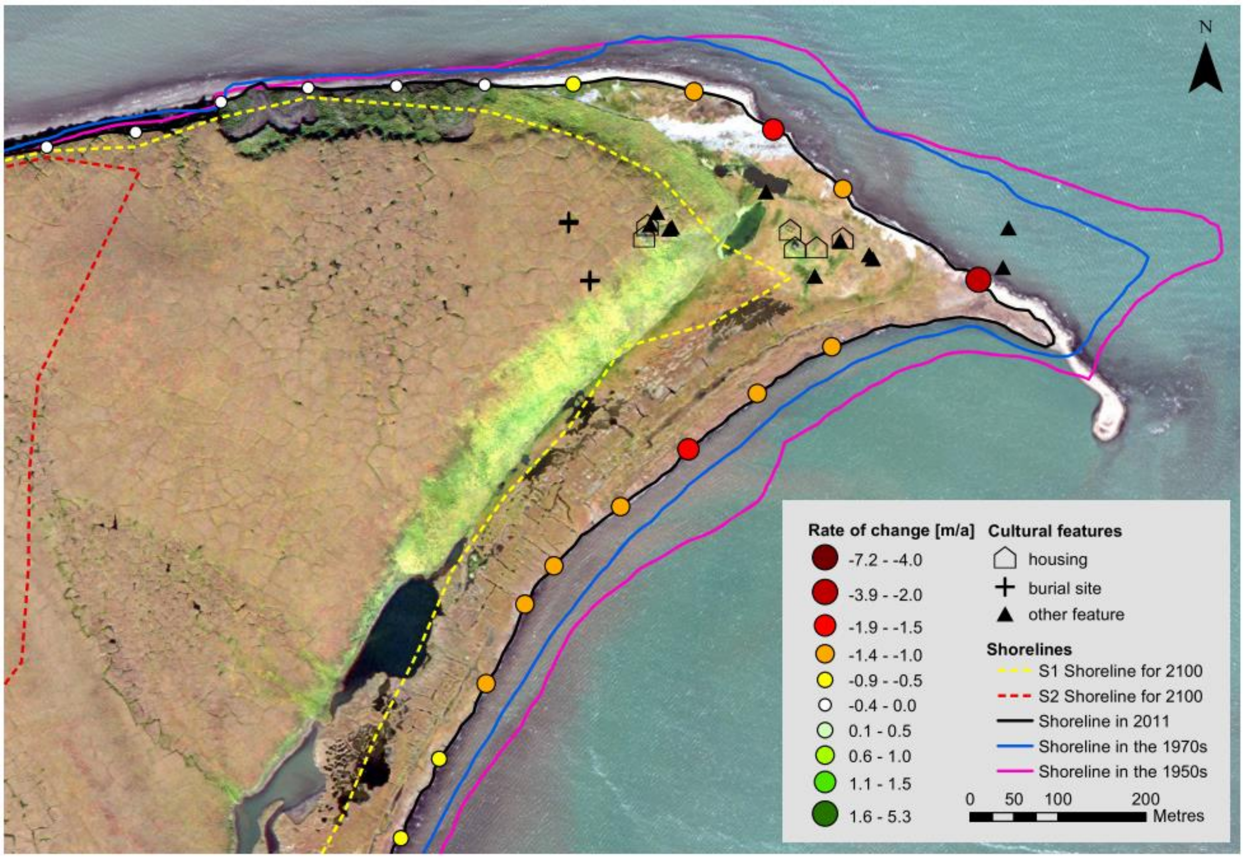
- Landscape slumping and downslope influences (Kokelj, Tunnicliffe, Lacelle, Lantz, & Fraser, 2015)
  Large slumps (>20 ha) were observed in the Peel Plateau. These slumps displace previously frozen materials (including cultural features), impact drainage networks and increase stream sediment loads downslope. Increases in rainfall have likely accelerated their presence and impact.

- Erosion and slumping (Friendship & Community of Aklavik, 2011; IRC, 2016)
  Changes result in modifications to the water course of rivers; this affects fish health and increases safety risks for Inuvialuit travel.

- Erosion and flooding (Radosavljevic et al., 2016)
  Coastal erosion has increased, particularly in areas where temperature increases exceed the global mean (such as on the Yukon North Slope). This has been observed in Alaska and along Qikiqtaruk (Herschel Island) at Simpson Point. Increases in erosion and flooding due to warming temperatures, sea level rise, longer open water periods and increased extreme weather events make infrastructure and cultural and ecological sites along coastlines increasingly vulnerable.

- Reduction in shorelines (Cunliffe et al., 2019; Irrgang et al., 2019)
  Shoreline loss was observed on Qikiqtaruk (Herschel Island) (Cunliffe et al., 2019) and predicted over ~210 km of Yukon shoreline from the Alaska border to Tapqaq (Shingle Point), including the 10-40 km wide coastal plain in the eastern Yukon North Slope (Irrgang et al., 2019). Predicted shoreline loss on the Yukon North Slope (not including Herschel Island/ Qikiqtaruk) is expected to result in the loss of 45-60% of cultural features, including burial sites, cabins, camps, and travel routes) by 2100 (Figure 2- 6). Erosion and sedimentation are predicted to continue to threaten cultural features, travel routes and coastal life along the Yukon coast.

Figure 2- 6. Observed and predicted changes in shoreline and the location of cultural features at Qargialuck, Catton Point, Yukon North Slope



Historic shoreline data from the 1950s (pink line) and 1970s (blue line) show that significant land loss has already occurred at Qargialuck, and may be representative of shoreline losses in other areas of the Yukon North Slope. Two scenarios of potential future shoreline loss display the vulnerability of cultural features and infrastructure along the coastline. S1 is conservative (yellow dashed line) and S2 represents dynamic, increased change (red dashed line). The rate of change [m/a] was estimated from historic shoreline levels. Source: (Irrgang et al., 2019, Figure 2)

Inland Water and Ice

Permafrost and hydrology are linked in Arctic systems, and increased temperatures not only reduce permafrost but influence basewater (streamflow sustained between precipitation events) and groundwater flows. To date, small changes in total annual discharge in northwestern Canada have been observed, but as temperatures continue to rise, so will increases in winter groundwater and baseflow (Crites et al., 2020). Permafrost type (discontinuous or continuous) as well as reductions in permafrost thickness will influence inland water and ice formation on lakes, rivers and streams (Crites et al., 2020; Nitze et al., 2017).

As permafrost continues to melt on the Yukon North Slope, the increasing thickness of the active layer may result in increased connectivity of ground water, as well as evapotranspiration (evaporation and transpiration of water from the surface to the atmosphere). These may result in hydrological changes such as dynamic lake responses and increased thermokarst formations (Nitze et al., 2017; Stern & Gaden, 2015). Wetlands may be affected, though changes to wetlands are difficult to predict (Callaghan et al., 2011).

Overall, inland ice on lakes and rivers is expected to decrease in thickness, form later in the fall and break up earlier in the spring (Derksen et al., 2019). Inland ice is important not only during the winter, but also in the summer, as it melts slower than snowpack and thus helps to recharge rivers and streams later in the season (Crites et al., 2020).

Glaciers are expected to decrease across the Canadian Arctic, resulting in increased groundwater (Derksen et al., 2019). Although glaciers are absent on the Yukon North Slope, their loss in the surrounding landscape may influence the local hydrology due to increases in groundwater.

- Observed and projected trends in glaciers, and sea, river and lake ice across Canada (Derksen et al., 2019)
  Spring lake and river ice breakup is expected to occur earlier (10-25 days) and fall freeze up later (5-15 days), by mid-century. Seasonal ice thickness is expected to decrease (10-50 cm) and mid-winter breakup and ice jam events are expected to increase.

- Observed changes in water across the ISR (IRC, 2016)
  Increased flooding, erosion or disappearance of islands and sandbars, rising waterline and higher/more frequent waves.

- Freshwater climate related effects identified (Nickels et al., 2005)
  Freshwater levels are lower and sedimentation in water bodies has increased. In some areas, sandbars are larger and/or higher.

- Climate change issues identified by the community of Aklavik, Northwest Territories (Friendship & Community of Aklavik, 2011; IRC, 2016)
  More open water, overflow, and shallow waters make travel more difficult; shallow waters also affect the ability of barges to deliver supplies to Aklavik.

Shifting Ecosystems and Vegetation

Arctic ecosystems are experiencing landscape and vegetation shifts due to warming temperatures. These climate change effects include permafrost thaw, a longer growing season, shrub expansion and enhanced vegetation productivity, or 'Arctic greening' (Myers-Smith et al., 2011, 2019; Nickels et al., 2005; Prowse, Terry, Fred, & James, 2009; Rowland, Fresco, Reid, & Cooke, 2016). These changes influence rates of carbon cycling. Ecosystems shifts have caused the expansion of vegetation and animal species into the region that were historically uncommon or absent in the Arctic (IRC, 2016; Nickels et al., 2005). Changes due to shifting ecosystems such as expanding shrubs indirectly impact the subnivean zone (area between the ground surface and the bottom of the snowpack). Shrubs limit snow compaction, creating a thick, low-density snow layer, which can more than double the insulating property of the snowpack (Berteaux et al., 2017).

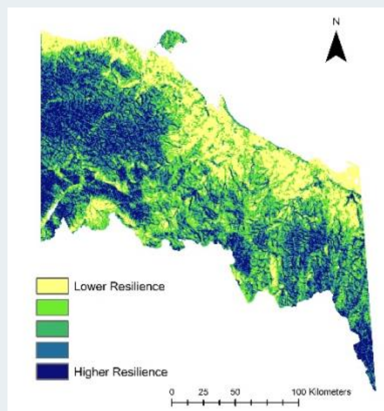
Climate change emissions scenarios predict that 'cliome' shifts (climatic patterns, vegetation communities, and soil characteristics) will occur across the Yukon North Slope; however, the number of cliome shifts increases over time and in higher emissions scenarios (Rowland et al., 2016; SNAP, 2012). In general, it is expected that more cliome shifts indicates greater ecological stress and change across the Yukon North Slope (Rowland et al., 2016; SNAP, 2012).

- Observed changes in vegetation across the ISR (IRC, 2016; Nickels et al., 2005)
  The land is greening, plants are increasing in size and abundance. New species of vegetation have been observed moving into local areas (e.g., willow, spruce, and grasses). Changes in rainfall, intense heat, colder summer conditions and increased erosion have negatively impacted berry production.

- Increased shrubification in the arctic, high-latitude, tundra ecosystems (Myers-Smith et al., 2011, 2019)
  Shrubification, meaning an increase in shrub abundance, cover and biomass, is expanding over tundra environments in the circumpolar Arctic, including the Yukon. This change is driven by warmer temperatures, shifts in snow cover and herbivory intensity, increased permafrost thaw and tundra fires. Shrubification has the potential to further alter regional climate, soil temperatures, nutrient cycling, biodiversity, and ecosystem services.

Terrestrial Resilience

Certain Landscapes may be resilient to ecosystem and vegetation shifts – that is, they may have the ability to maintain biological diversity and ecological function, despite the effects of climate change (Buttrick et al., 2015; Gunderson, 2000). In general, it is expected that mountainous areas of the Yukon North Slope will have higher resiliency due to their topographic complexity, whereas the coastal plains will have lower resilience primarily because they lack topographic diversity. However, this result is influenced by local variations in the landscape and the species that are adapted to them.



The map above estimates potential terrestrial resilience across the Yukon North Slope. Source: analysis completed by RRCS based on procedures described by Buttrick et al. (2015); map produced by

- Vegetation shifts and terrestrial resiliency (Prowse et al., 2009)
  Grasses, sedges, flowering species, and moss (*Tomentypnum nitens*) have increased in productivity and abundance. Other species occurring in high northern latitudes are expected to decrease. Cumulative impacts of climate change will result in altered plant community structure and composition.

- Cliome shifts (Rowland et al., 2016; SNAP, 2012)
  One predicted response of ecosystem change for the Yukon was produced by the Scenarios Network for Arctic Planning (SNAP). This analysis predicts potential climate-biomes 'cliomes' likely to exist within the Yukon under various emissions scenarios and time spans. These

cliomes characterize climatic patterns and vegetation communities to best predict changes. They account for time lags associated with vegetation change as well as soil influences. They are intended to identify dynamic areas within the landscape, as well as potential refugia and resilient areas, to guide management.

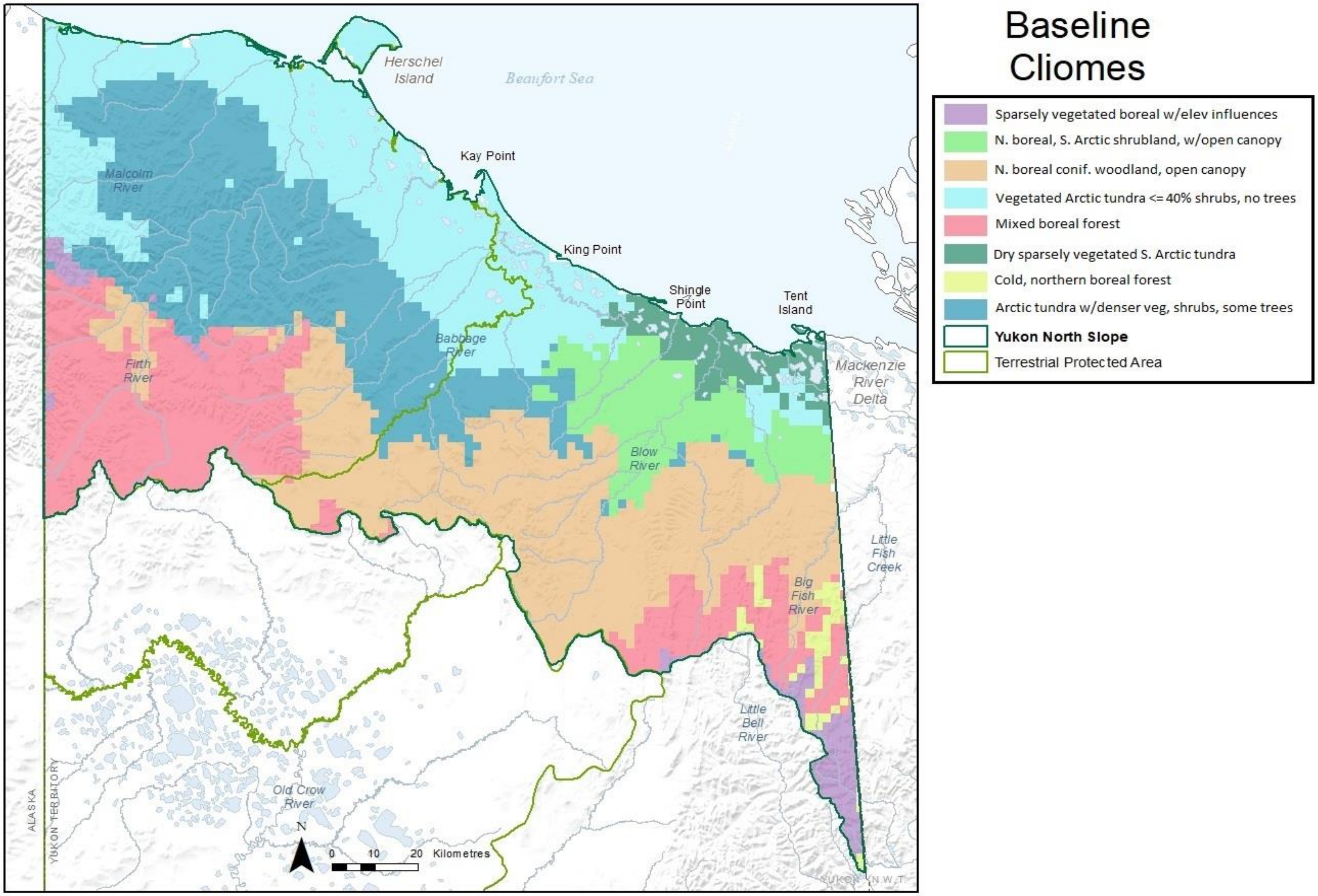
Multiple transitions between cliomes may occur. But not all shifts are equal, although all shifts likely indicate ecological stress on the environment. For example, throughout much of the Arctic, cliomes that are dominated by shrubby grass/moss/lichen/tundra are predicted to shift to forest cliomes, which is a profound change. However, shifts between shrubby grass, moss, lichen, and tundra environments are likely to be more minor in their overall influence on wildlife. By the 2070s and 2090s the cliomes that are expected to dominate the Yukon North Slope include new types such as boreal forest with coastal influence and intermixed grass and tundra, dry boreal wooded grasslands, and densely forested southern boreal forests.

Table 2- 1. Predicted cliome shift trends (compared to the baseline in 1961-1990) in the Yukon at the end of the century (2060s-2090s)

Cliome – Land cover description	Predicted trend
(1) Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice, with an extremely short growing season	Decline
(3) Densely vegetated arctic tundra with up to 40% shrubs	Absent
(4) Arctic tundra with denser vegetation and more shrub cover including some small trees	Absent
(5) Dry sparsely vegetated southern arctic tundra	Absent
(6) Northern boreal/southern artic shrubland, with an open canopy	Absent
(7) Northern boreal coniferous woodland, open canopy	Absent
(8) Dry boreal wooded grasslands – mixed coniferous forests and grasses	Decline
(9) Mixed boreal forest	Absent
(10) Boreal forest with coastal influence and intermixed grass and tundra	Increase
(11) Cold northern boreal forest	Absent
(12) More densely forested closed-canopy boreal forest	Decline
(13) Sparsely vegetated boreal forest with elevation influences	Decline
(14) Densely forested southern boreal	Increase
(15) Southern boreal/aspen parkland	Increase
(16) Southern boreal, mixed forest	Increase
(17) Coastal rainforest, wet, more temperate	Increase
(18) Prairie and grasslands	Emerge (currently not present)

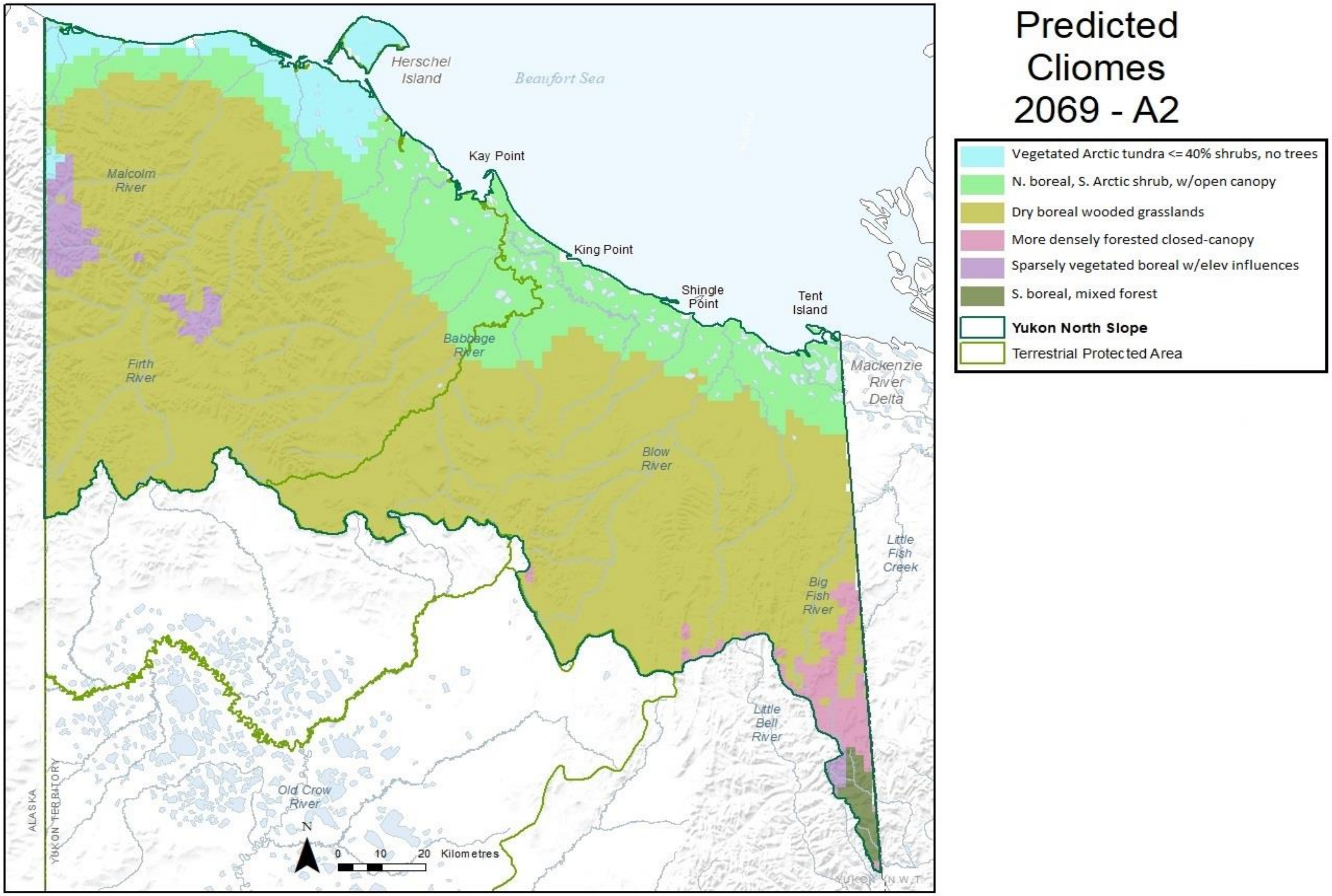
Note cliome (2) is not found in the Yukon under present or future climate conditions. Source: (Rowland et al., 2016).

Map 2- 1. Yukon North Slope baseline cliomes



Baseline cliomes predicted across the Yukon North Slope. Source data (SNAP, 2012), map produced by RRCS 2019

Map 2- 2. Yukon North Slope predicted cliomes



Predicted cliomes under a high emissions scenario (A2) across the Yukon North Slope. Note that most areas are expected to undergo cliome changes in the next 50 years. Source data (SNAP, 2012), map produced by RRCS 2019

- **Changes in disturbance regimes (X. Zhang et al., 2019)**
  Weather extremes, caused by changes in the frequency of precipitation and temperature, have increased the likelihood of drought, wildfire, and flood events in Western Canada.

- **Observed changes in wildlife across the ISR (IRC, 2016; Nickels et al., 2005)**
  People have observed changes in the health, behaviour, and distribution of arctic wildlife species, including marine and terrestrial species, birds, fish, and insects. General observations include: decreased health of marine and terrestrial wildlife and fish; changes in migration and distribution patterns; and the appearance of new species of marine and terrestrial mammals, birds, fish, and insects. Additionally, unfamiliar animals have appeared on the Yukon North Slope (e.g., grasshoppers at Tapqaq).

Potential Impacts on Wildlife and Habitat

The cascading effects of a changing climate have year-round implications for wildlife and habitat within the Yukon North Slope. Potential wildlife implications include: increases or decreases in competition for habitat and resources; shifting plant and animal ranges; alteration in prey sources and diets; changes in reproduction and survival rate; and expanding boreal species, parasites, diseases, and invasive species. Many of these potential responses have been observed and reported by Inuvialuit (Nickels et al., 2005; WMAC (NS) & Aklavik HTC, 2018b). These responses may be positive or negative. Whether the potential benefits, such as increased habitat availability, will outweigh potential negatives such as emerging diseases is yet to be seen. Observed responses to climate change effects are summarized below. See the dedicated companion reports for focal species, which describe climate change effects on wildlife in more detail.

> **Climate Change effects on Wildlife and Habitat in the Yukon North Slope Wildlife and Conservation Management Plan**
>
> Strategy B3. Monitor effects of climate change on Yukon North Slope ecosystems. Promote and engage in studies that contribute to understanding and forecasting the effects of climate change on wildlife and habitat. On an ongoing basis, assess options and implement measures for mitigation and adaptation to address climate change effects in the management of wildlife and wildlife habitats.
>
> Priorities:
>
> – Monitor climate change and its effects and improve understanding of linkages between changes in climate and effects on ecosystems and wildlife, and on the interactions between climate change and other stressors, such as contaminants, through collection of scientific data and Inuvialuit traditional knowledge.
> – Adjust actions, where possible, to adapt to effects of climate change on wildlife and wildlife habitat.
> – Take steps to reduce greenhouse gas emissions.

Throughout the northern landscape, changes in climate and precipitation patterns have led to phenological (seasonal timing) shifts. For example, on Qikiqtaruk, spring occurs ~9 days earlier each decade (Myers-Smith et al., 2019). This can result in phenological mismatches for species that migrate to forage for resources that are now peaking in quality or abundance earlier due to earlier spring conditions (Choi et al., 2019). Climate-driven species expansions, particularly to northern regions, may add the challenge of differentiating between what is an invasive species and what is natural range expansion (SNAP, 2012).

> "Well, when I was a little girl I never used to… see hardly any moose. And today, it's totally different. It's because… we're having earlier [growing] seasons."
>
> Source: PIN 1, Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a) p. 30

Wildlife Range/Distribution Shifts

Terrestrial

Moose (*Alces alces*) have been observed to be locallly more abundant than they were historically on the Yukon North Slope, and this may be due to changes in vegetation associated with climate change (WMAC (NS) & Aklavik HTC, 2018a). Beaver (*Castor canadensis*) is another species with a northern expansion (potentially) promoted by increased temperatures (IRC, 2016; Tape et al., 2018). Beaver distribution was previously thought to be limited to the treeline end; however, beavers and their dams have been observed on and near the Babbage River since 2008 (Jung, Frandsen, Gordon, & Mossop, 2017; Tape et al., 2018). Beaver dams create ponds that subsequently raise water temperatures downstream. This can influence permafrost stream ice regimes, freshwater, and riparian habitat (Tape et al., 2018).

Increased Temperature – A Potential Catch 22

Increased temperatures may promote the expansion of plant species that moose like to forage; however, moose are highly sensitive to thermoregulatory (heat) stress, and hence increased temperatures may cause population declines in moose.

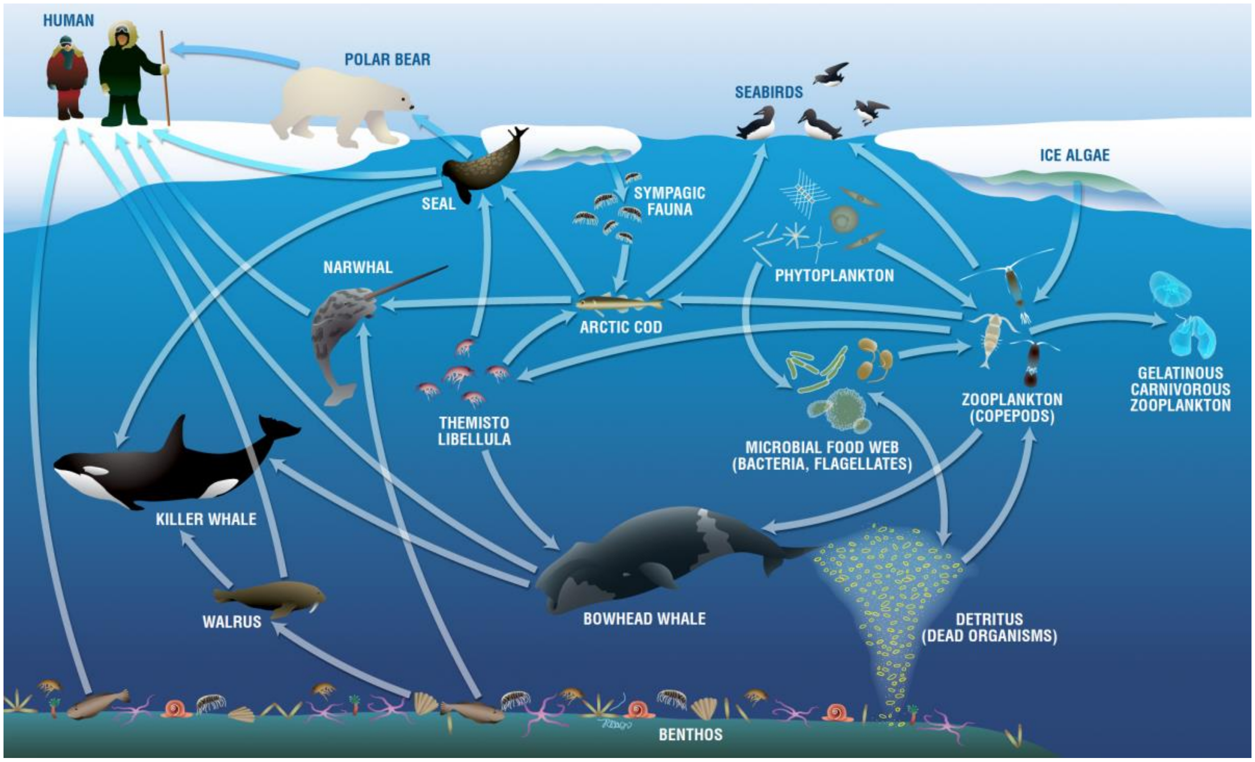
These warm ponds and downstream waters may provide new spawning habitat for fish species such as Dolly Varden (locally known as 'char') (*Salvelinus malma*) and salmon species. The warmer waters may also promote the spread of fish species currently limited in arctic lakes (such as walleye), further altering competition and predation pressure (Dunmall, Mochnacz, Zimmerman, Lean, & Reist, 2016; Poesch, Chavarie, Chu, Pandit, & Tonn, 2016). However, beaver dams could also block passage or generate siltation of spawning beds and restrict fish spawning and species expansions (Tape et al., 2018). Dolly Varden habitat is being affected by the erosion of riverbanks, limiting their ability to access parts of their range. Broad Whitefish range is changing, in part due to salinity changes in coastal waters.

> …you know, we've never had salmon in the area before, and now they're starting to… pop up in places where we're getting the Arctic char. - PIN 101, p. 42
>
> …the erosion on the hills…make the creek shallow… Probably harder [for Dolly Varden char] to get up to where they're supposed to spawn. - PIN 111, p. 42
>
> Well, whitefish never used to be at Shingle Point long ago, when I was a little girl… Now the fish from the Delta are starting to come into that area… Because our water is not as salty as before. - PIN 1, p. 43
>
> *Source: Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a)*

Marine

The marine food web is complex. Climate change has an impact on the entire food web, through a number of different pathways (Figure 2-7). Climate change effects, including warming and sea ice reduction, are of high concern for marine mammals such as polar bears (*Ursus maritimus*) and ringed seals (*Pusa hispida*), occurring in the Southern Beaufort Sea (Joint Secretariat, 2017; WMAC (NS), 2012). Loss of sea ice may result in polar bears seasonally shifting their distribution inland. This would alter prey sources and den locations, and increase competition for habitat and resources, potentially having negative consequences on population stability and productivity (Fischbach, Amstrup, & Douglas, 2007; Mckinney, Atwood, Iverson, & Peacock, 2017). Ringed seals are the primary prey of polar bears; stable sea ice in areas with high quantity prey is critical to ringed seal survival (WMAC (NS), 2012). Over the past few decades, ringed seal populations in the Beaufort Sea have exhibited declines in body condition (Harwood et al., 2015). These declines, which include lower reproductive and survival rates, are linked to decreases in their preferred winter food source, Arctic cod (*Boreogadus saida*), and declines in summer sea ice (Harwood et al., 2015; Spear et al., 2019).

Figure 2- 7. Simplified marine food-web of feeding relationships among species in the Canadian Arctic



This marine food-web shows how disruptions to one species or component (such as sea ice) will influence the other organisms in the marine environment. Note that some species have multiple prey options that may shift as the food web is disrupted. Source: (Darnis et al., 2012)

During summer months, ringed seals and bowhead whales (*Balaena mysticetus*) feed on zooplankton, which are present in the nutrient rich waters of the Beaufort Sea (Harwood et al., 2015; WMAC (NS), 2012). Zooplankton diversity and production are linked to upwellings in nutrient rich waters and sea ice algae production. Losses in sea ice, and its associate algae, have led to smaller, less nutritious zooplankton off the western coast of Alaska (Spear et al., 2019). However, some zooplankton species (euphausiids; krill) have been linked to warmer conditions and increased upwellings and may provide supplementary prey sources for marine mammals (Spear et al., 2019). The body condition of bowhead whales in the Beaufort Sea has increased over the past 40 years (Harwood et al., 2015). This has been linked to upwelling, longer periods of open water, potentially increased zooplankton productivity, and less competition from fish for the zooplankton (Harwood et al., 2015). The marine mammal food-web is intricately linked, however, and the same decreases in summer sea ice that promote improved body condition in bowhead whales may also lead to an increase in killer whales (*Orcinus orca)*, which would negatively impact marine mammals, including the bowhead (Darnis et al., 2012).

Changing weather and disturbance regimes

Increases in extreme weather events, rain, and changes in snow density on the Yukon North Slope (IRC, 2016; Kim et al., 2018; Nickels et al., 2005) are likely to put wildlife populations such as caribou (*Rangifer tarandus*), muskox (*Ovibos moschatus*), and Dall's sheep (*Ovis dalli dalli*) at increased risk of population decline. These species are vulnerable to icing events during winter months, as the ice crust restricts their access to food and negatively impacts their reproductive success and survival (Berteaux et al., 2017; WMAC (NS), 2012). For example, increased freeze-thaw frequency is linked to reduced adult survival in sheep (Van de Kerk et al., 2020; Van De Kerk, Verbyla, Nolin, Sivy, & Prugh, 2018). Adult caribou, which are also vulnerable to freeze-thaw frequency, showed health declines following increased spring temperatures. This may have been caused by decreased access to ground lichens due to ice cover (Gagnon et al., 2020).

Snow cover and condition also impact wildlife movement, predator-prey dynamics, and thermal insulation. Deep, soft, and wet snow may impede animal movement, particularly of ungulates, and increase predation risks (Duquette, 1988; Nicholson, Arthur, Horne, Garton, & Del Vecchio, 2016). The subnivean zone allows small mammal species such as lemmings (Lemmus spp.), shrews (Sorex spp.) and mustelids (Mustela spp.) to move and forage under the snow, while being protected from predators (Berteaux et al., 2017). Therefore, variability in snow cover and duration may negatively influence small mammal survival. In some cases it may expose them to phenology mismatches, where their white winter coats remain in snow-free landscapes (Berteaux et al., 2017; Boelman et al., 2019).

> I remember a few years back… we had a really warm spell and we had some rain [in January], and you notice a lot of dead caribou… it got cold and the caribou couldn't break through the crust on the snow.
>
> *Source: PIN 302, Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a), p. 25*

Wildfires, which are increasing in a warming Arctic (X. Zhang et al., 2019), decrease the quality of caribou winter habitat by destroying lichens, which take over 50 years to recover. However, moose habitat is likely to increase post wildfire, and therefore caribou may experience both habitat loss and increased competition (Joly, Duffy, & Rupp, 2012).

Vegetation Shifts

Plant canopy height, as well as shrub and graminoid (grass and grass-like plants) abundance has been increasing by two-fold per decade, while bare ground cover is being reduced by half per decade (Myers-Smith et al., 2019). Shrubification benefits some species, including moose (*Alces alces*), snowshoe hares (*Lepus americanus*) and shrub-nesting birds (Stern & Gaden, 2015; Tape et al., 2016). However, shrubification may negatively impact upland bird species. Increased competition from species that forage on willows may negatively influence some species, such as the ptarmigan (*Lagopus* spp.) (Stern & Gaden, 2015; Tape et al., 2016). Expanding shrubs may negatively impact caribou populations, as the expanding shrubs are unlikely to contain high-quality forage and more likely to contain species with anti-browsing toxins (Fauchald, Park, Tømmervik, Myneni, & Hausner, 2017). Shrubification also reduces lichen cover, which caribou depend on in the winter (Fraser, Lantz, Olthof, Kokelj, & Sims, 2014).

Vegetation shifts can also have secondary effects, shaping trophic levels. For example, with shrubification creating a more abundant food source for moose, the moose population may then be able to support a larger predator population. While the Porcupine Caribou Herd is not a predator-limited population, increased predation in addition to other stressors (climate-induced or otherwise) could be a notable concern in the future.

Parasites and Disease

Parasites are essential to ecosystem function. However, high levels of parasites or expanding diversity of parasites may have a negative influence on wildlife populations by lowering reproduction rates or increasing mortality rates (Kutz et al., 2012). There have been cases of parasite range expansion and transmission between species observed on or expanding towards the Yukon North Slope. These include lungworm (*Protostrongylus stilesi and Parelaphostrongylus odecoilei*) incursions in Dall's sheep in regions of the NWT, including the Mackenzie and Northern Richardson mountains (Hoberg et al., 2002). *P. stilesi* was also detected in muskox on the Arctic Coastal Plain in the Yukon North Slope; this specific lungworm can pass between muskox and Dall's sheep (Hoberg et al., 2002). However, Dall's sheep are believed to be the original carrier of the lungworm, *P. stilesi* (Hoberg et al., 2002). *M. ovi* was documented in Alaska within caribou in the Forty mile and Nelchina herds and Dall's sheep in the eastern Alaska Range, Talkeetna Mountains, and Wrangell Mountains (ADF&G, n.d.). It is unknown how Dall's sheep will respond to *M. ovi,* and this bacteria along with those in the family Pasteurellaceae (which are likely to spread north) cause respiratory diseases like pneumonia that have devastated bighorn sheep populations elsewhere (Jex et al., 2016).

Other parasites expected to expand their ranges north as the climate warms include winter ticks (*Dermacentor albipictus*) and legworm (*Onchocerca cervipedis*). Winter ticks have been documented in Carmacks, YT, and Normal Wells, NWT, and they are of high concern for moose (Yukon Environment, 2016). The nematode, legworm, is of highest concern to moose and caribou (Verocai et al., 2012).

Biting Insects

An observed increase in mosquitoes has been attributed to rising temperatures, melting permafrost, increased groundwater, and extreme rain and flood events that produce ideal breeding conditions for these insects (WMAC (NS) & Aklavik HTC, 2009). Insect harassment is greatest during summer months and may influence fall health for wildlife such as caribou (Gagnon et al., 2020).

…it gets pretty hot some summers…and we'll have a lot of bugs… we know we're not going to have good shape [healthy] caribou because… they're mostly running all the time.

Source: PIN 6, Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a), p. 25

Potential Impacts on Traditional Knowledge and Use

The environment influences every aspect of Inuvialuit life. The impacts of climate change affect traditional use as a foundation of Inuvialuit culture and knowledge (Figure 2- 8). The effects of climate change on wildlife, habitat, and geophysical and weather conditions as described in this report have carry-through effects on traditional use. These impacts are interrelated and complex. Inuvialuit have experienced and adapted to climatic and ecological change in the past, over many hundreds of years. However, the change that is now occurring is at a pace and scale that will test the limits of adaptability.

Climate change may impact traditional knowledge and use both directly and indirectly. Cultural and ecological sites along coastlines are highly vulnerable as erosion increases and sea levels rise (Radosavljevic et al., 2016). Additionally, reduced ice thickness has made travel less safe over the past 5 to 10 years, and access to traditional fishing areas has changed (Hynes et al., 2017). Inuvialuit have expressed concerns about decreasing water levels and the effect of increased water temperatures on fish and harvest (Hynes et al., 2017).

Climate Change and Traditional Use in the Yukon North Slope Wildlife and Conservation Management Plan

Strategy C2. Employ monitoring and directed research to track and understand current and future effects of climate change on Inuvialuit traditional use of the Yukon North Slope. On an ongoing basis, assess options and implement measures for mitigation and adaptation, to enhance the resilience of traditional use to climate change

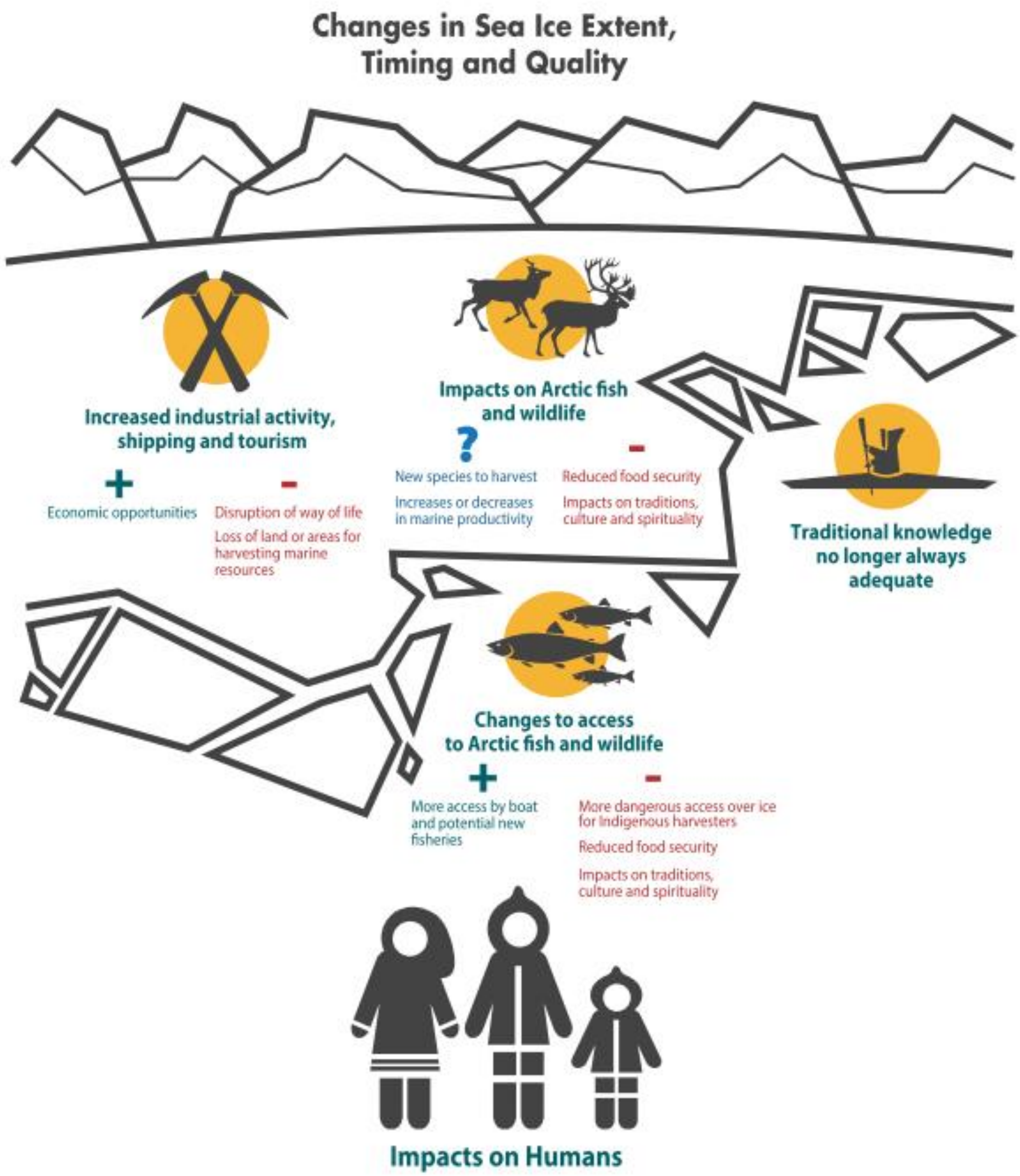
Priorities:

– Monitor climate change impacts on traditional use using Inuvialuit knowledge, community-based monitoring and Western science
– Mobilize Inuvialuit and scientific knowledge of the climate change impacts on Yukon North Slope, along with culturally-informed adaptations, to ensure ongoing and adequate Inuvialuit traditional use
– Work to develop infrastructure support associated with investments in Inuvialuit traditional use

The increased risks caused by changing and unpredictable weather and landscape conditions may keep some Inuvialuit from participating in traditional activities (Friendship & Community of Aklavik, 2011). This may negatively influence other aspects of traditional life including language, oral history, and cultural values (Friendship & Community of Aklavik, 2011). It also highlights a potential need to diversify hunting/fishing approaches as historic areas or methods may not be as successful or viable (Friendship & Community of Aklavik, 2011).

"Inuvialuit notice the effects of climate change on a daily basis. In the past, they relied on their TK when they went out on the ice, but changing ice conditions have thrown some uncertainty into the reliability of this knowledge and made harvesting increasingly dangerous and difficult." Source: Inuvialuit and Nanuq (Joint Secretariat, 2015, p. 196)

Figure 2- 8. Impacts to Sea Ice and cascading effects on humans



(Adapted from: Eamer et al. 2013. Life Linked to Ice: A guide to sea-ice-associated biodiversity in this time of rapid change. CAFF Assessment Series No. 10, p.64)

This diagram shows the pathways in which changes to sea ice extent, timing, and quality can impact traditional use, traditional knowledge, and cause other human impacts (ITK, 2019 adapted from Eamer *et al.* 2013).

Travel

> All the land where we travel long ago, easy to travel, it's not like that anymore. It's too much changes now, the creeks are drying out, the lakes is getting shallow. You'd be lucky to get into some places where we used to just go with boats. It's not like that anymore.
>
> *Source: Annie B. Gordon, (WMAC (NS) & Aklavik HTC, 2009) p. 63*

Climate change has been affecting travel routes on the Yukon North Slope and routes used to access the Yukon North Slope. Creeks that were used in past are dried out now (WMAC (NS) & Aklavik HTC, 2018b). In the past, sea ice conditions created favourable corridors for safe travel along the coast but that does not happen anymore. In particular, the Mackenzie Delta is "… a huge interconnected network of travel routes. It is easy to get lost in this labyrinth, and even the most experienced land users have been temporarily disoriented on occasion, particularly since Delta topography is in constant flux as a result of geological and climate change processes" (WMAC (NS) & Aklavik HTC, 2018b). Furthermore, unpredictable ice and weather patterns make travel riskier (WMAC (NS) & Aklavik HTC, 2018b). Safe havens become even more important when the weather is unpredictable, but safe havens are changing too.

> When we were kids, waiting for this wind to calm down…because we can't take chances. Even our relatives from Alaska was with us. They told us, we can't ever take chances because sometimes the wind blows this way [gestures] and it's rough. We can't go until the wind change. Like, it blows that way [gestures]; then it's calm, you can go. Same thing with over here at Shingle. Say you want to go to Herschel Island and the wind is blowing from the ocean in [toward land], it's rough. You can't go. But when the wind blows from the mountains, this way [gestures], we can go. It's calm. It's rough out here, but it's calm in here. That's what we learned from our elders. They always say wait until the wind blows from this side [gestures] or wait until it's calm. Growing up, there used to be ice out here; used to be so good. We used to travel through icebergs all the way nonstop to Barter Island, Alaska. It used to take us 16 hours with speedboats, right through the ice- bergs and everything. But nowadays, it's so dangerous. There's no ice, nothing, it's always rough.
>
> *Source: PIN 109, Yukon North Slope Inuvialuit Traditional Use Study, (WMAC (NS) & Aklavik HTC, 2018), p. 31-32.*

Food security

Climate change may negatively impact Inuvialuit food security, as access to wildlife may decrease and below-ground freezer capability may be lost (ITK, 2019). This may result in an increased reliance on expensive outside food sources (Friendship & Community of Aklavik, 2011). Additionally, as climate change alters animal behaviour, and as some species decline and others increase, the animals that make up the traditional food basket may shift (Friendship & Community of Aklavik, 2011).

Disease

Increased exposure to vector-borne and zoonotic diseases and contaminants may increase health concerns not previously observed in the region (ITK, 2019).

Harvest

Increased travel risks and the safety of hunters may be directly affected by climate change impacts such as changing and unpredictable ice conditions. Travel routes may be adapted to align with changing wildlife movements and distributions (ITK, 2019), as new areas for harvesting may need to be considered for species that are no longer as plentiful or accessible (e.g., caribou) (IRC, 2016). Proactive measures have been taken to potentially circumvent climate change effects on specific species. For example, Aklavik Inuvialuit have adjusted Dolly Varden char harvest by holding an Aboriginal communal fishing license allocation for the Big Fish River (Danny C. Gordon, personal communication, April, 2019; Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016; DFO, 2018).

Cultural Sites

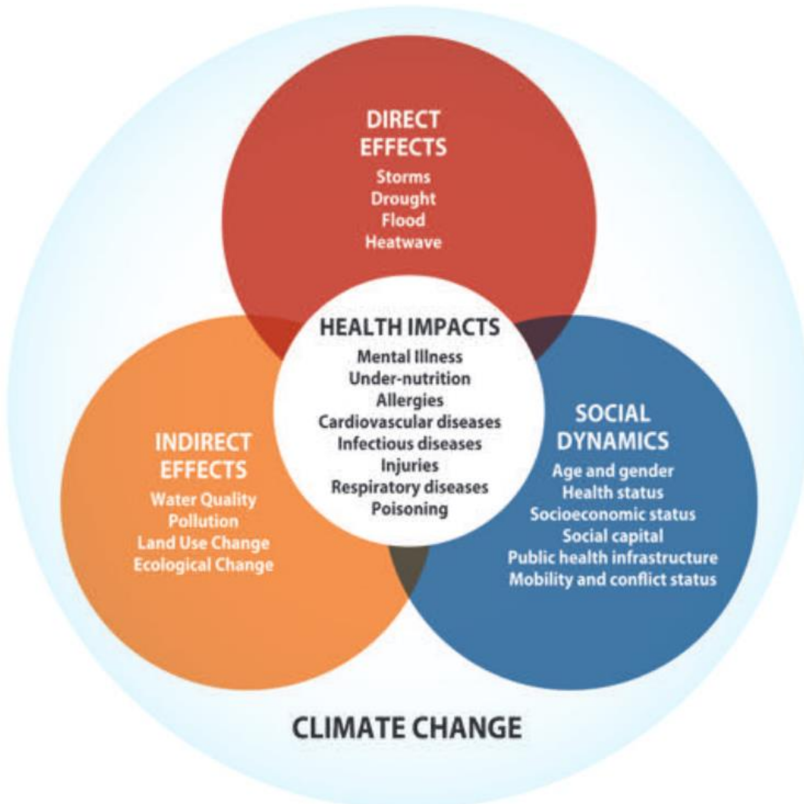
Cultural sites, such as cabins and camps, are being affected by climate change impacts to the landscape. Some cabins and camps are being lost to erosion and some are no longer accessible due to landscape changes. Some cabins have been moved multiple times in response to cultural erosion (WMAC (NS) & Aklavik HTC, 2018b) Cabins and camps provide a place to shelter from the elements and are typically located near a water source. A real or functional loss of these important sites can negatively impact the ability to harvest and conduct other traditional use activities on the Yukon North Slope. The loss of other cultural and spiritual sites to erosion or a changing landscape may contribute to an overall loss of culture as well as mental health impacts.

Socioeconomic Impacts

Climate change may cause socioeconomic impacts to Inuvialuit who use the Yukon North Slope. This may further affect their ability to access the Yukon North Slope. Changes to sea ice may result in an increase in Arctic-based resource extraction, which could increase participation in the wage economy. Access to wages could increase the ability to purchase and maintain equipment to access the Yukon North Slope, and yet could also restrict the ability of Inuvialuit to partake in traditional use activities. Working a set schedule and having limited opportunities to leave town could lead to land users traveling in inclement weather, because they feel they have no other choice.

Climate change will impact also impact human health, which is directly related to environmental change and will affect the future ability of Inuvialuit to use the Yukon North Slope and pass on traditional knowledge about the land (ITK, 2019).

Figure 2- 9. Climate change and the link to health impacts.



(Adapted fromWatts et al. 2015. Health and climate change: policy responses to protect public health. The Lancet 386(10006): 1861-1914, https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60854-6/fulltext)

Source: National Inuit Climate Change Strategy (ITK, 2019).

Cumulative Effects

Climate change will result in cumulative impacts to traditional use; that is, impacts that occur as a result of multiple climate change effects. Already, climate change is causing interrelated and complex impacts to the Yukon North Slope. The following story reveals how climate change impacts interact to create cumulative effects to Inuvialuit traditional use:

> I travelled with my father-in-law first time in '92 or '93. He's passed now. He was the one that was telling me stories all the way from Shingle Point…to Kaktovik; where people had camps, like at King Point, or Kay Point…and people that travelled along the coastline, where his father had a store, and where my grandfather's buried. It was really interesting. We travel there when we can, but now it's too dangerous because there's no safe havens any more. All those creeks that were actually there when we were travelling are all dried out, and you can't go out to the creeks anymore….On our way, where [someone's] dad showed us [where] his brother had a cabin, they went up a hill and they built a cabin. Then, when we were going down…when we went to check the cabin where it was, all the ground is flat; no more hills. They're all

> flat. When you look on the ground, there's openings, and you look under, and there's ice and water running. You can see that the land is collapsing. So it's really dangerous to travel now….That's along the coastline going to Kaktovik….on the Alaskan side….When we used to travel [to] Herschel, we used to go all along the waterline, where it's open now. [But] now, this part around here [pointing towards the area between Herschel Island and Ptarmigan Bay]…is all drying out. We used to go here. Now we have to really watch where we go because there's so much sand bar [pointing to the eastern entrance to Workboat Passage]."
>
> *Source: PIN 108 in Yukon North Slope Inuvialuit Traditional Use Study, (WMAC (NS) & Aklavik HTC, 2018), p. 32*

Cumulative effects of climate change will also impact Inuvialuit traditional knowledge. The relevance of existing knowledge during a time of rapid environmental change, the ability to gain new knowledge out on the land, and the opportunity to transmit knowledge to future generations will all be impacted by the interacting, cumulative effects of climate change.

Selected Studies and Traditional Use Research Relevant to the Yukon North Slope

This section is an annotated listing of selected traditional use reports, papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

There has been extensive documentation of traditional use of the Yukon North Slope including traditional use studies as well as traditional use information incorporated into research on specific species, climate change impacts, or oral history. The studies described below are the foundational publications that inform the understanding of traditional use in the Plan.

- Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b)
  In 2015, 40 Inuvialuit community members were interviewed in the community of Aklavik to describe their traditional use of the Yukon North Slope. Interviewees were asked to map traditional use within their "living memory," including kill sites and harvesting areas for fish, wildlife, berries, and medicinal plants, as well as cultural sites, such as cabin and tent sites, birth sites, burial locations, and places of cultural, historical, or personal importance. Interviewees also documented travel routes and safe havens. In total, 2,091 features were mapped on 1:125,000-scale maps. Interviewees also described the shifts that have occurred in traditional use over their lifetimes, including adoption of new technologies, response to landscape and climate change, and the impacts of societal change. This mapping effort

documents a change in the geographical extent of traditional use by the Aklavik Inuvialuit over time. A contraction in the spatial footprint of traditional use is attributed to numerous factors, including the collapse of the fur trade, a shift to permanent year-round residency in Aklavik, the impacts of mandatory schooling and reliance on wage labor, increasing costs of purchasing and maintaining harvesting equipment, and less predictable weather patterns due to climate change. However, the Yukon North Slope continues to make a significant contribution to Inuvialuit livelihoods, and the importance of the landscape cannot be quantified simply in economic or subsistence terms. Interviewees were clear to emphasize their personal connections to the Yukon North Slope and the role that the landscape plays in their culture.

- Unikkaaqatigiit Inuit Perspectives on Climate Change (Nickels et al. 2005)
  In response to rapid environmental change in the Arctic, the Inuit Tapiriit Kanatami, the Nasivvik Centre for Inuit Health and Changing Environments at Laval University, and the Ajunnginiq Centre at the National Aboriginal Health Organization cooperated with regional Inuit communities to conduct a series of workshops discussing environmental change and its impacts on Inuit land-users. These workshops were held between 2002 and 2005, and included the ISR communities of Aklavik, Inuvik, Tuktoyaktuk, Paulatuk, and Ulukhaktok (known then as Holman). The workshops were community-focused, not landscape-specific, so it is not possible to identify which Akalvik responses were directed towards changes on the North Slope and which responses were made in relation to other parts of the ISR. However, Aklavik residents identified a range of environmental changes that impact traditional use. These include changes in ice conditions and resulting impacts to travel, changes in sea level, decreased health in fish and wildlife, and changing precipitation patterns, all of which impact traditional use of the land.

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.

- *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond* (BSP, 2009)
  Recognizes the impact of climate change on the region, including impacts to wildlife and traditional use, and speaks to assessing and developing an adaptive management response to climate change. Specific concerns are activities made possible by reduced of sea ice, including increased shipping, tourism, commercial fishing, and mining.

- *Tarium Niryutait Marine Protected Areas Monitoring Plan* (DFO & FJMC, 2013)
  Establishes ecological indicators for monitoring within the marine protected area that include stressors related to climate-change.

- *Inuvialuit on the Frontline of Climate Change: Development of a Regional Climate Change Adaptation Strategy* (IRC, 2016)
  Workshops and interviews were held from 2015-2016 in all six Inuvialuit communities to discuss climate change impacts and adaptation strategies. This document highlights observed climate changes and an adaptation plan for the ISR. Subsistence hunting and fishing is one of five categories where adaptation efforts are described. The plan is not Yukon North Slope-specific but lists strategies to support continued traditional harvesting for the community of Aklavik.

- *Inuvialuit Settlement Region Polar Bear Joint Management Plan* (Joint Secretariat, 2017)
  Effects of climate change are incorporated throughout, including monitoring of polar bear populations and their habitat and prey to inform management. The plan states that "actions will be taken to ensure that the impact of climate change on polar bears is highlighted through the appropriate regional, national and international fora, and that effects of climate change on polar bears are monitored and mitigation actions taken where possible." (p. 1)

- *Herschel Island-Qikiqtaruk Territorial Park Management Plan* (Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018)
  Recognizes significant climate-change-induced stressors and changes to natural systems, including wildlife population shifts occurring in and around the Park. Maintains long-term monitoring datasets that track change across decades and systems (species and ecological integrity), particularly through the Herschel Island–Qikiqtaruk Inventory, Monitoring, and Research Program.

- Ivvavik National Park of Canada Management Plan (Parks Canada, 2018)
  Recognizes the significant changes to the natural systems within the Park. Acknowledges the Park's role in establishing benchmarks for measuring changes in ecosystem integrity and communicating those changes local and nationally.

- Canada's Changing Climate Report (Bush & Lemmen, 2019)
  Contains multiple chapters (individually cited throughout) that describe observed climate trends as well as emission scenarios projected trends. Temperature, precipitation, permafrost, sea ice, etc. are all evaluated.

- Our Clean Future: A Yukon strategy for climate change, energy and a green economy (Yukon Government, 2020)
  Provides territory-wide policy guidance on reducing emissions, renewable energy, climate change adaptations, and a green economy.

- Yukon Government, Government of Canada, and universities, and non-government-led climate, ecological, and wildlife research and monitoring programs
  In addition to the two park plans listed above, ongoing monitoring and research projects track changes and examine underlying ecological relationships on the Yukon North Slope. Ongoing work includes climate and hydrology monitoring and studies on ocean and sea-ice

conditions, snowpack, permafrost, erosion and slumping, vegetation, and habitats and population characteristics of wildlife species. All these current programs aid in tracking change.

- Arctic Report Cards (Arctic Program, n.d.)
  Issued annually since 2006, the Arctic Report Card is a timely and peer-reviewed source for clear, reliable, and concise environmental information on the current state of different components of the Arctic environmental system relative to historical records. The Report Card is intended for a wide audience, including scientists, teachers, students, decision-makers, and the general public interested in the Arctic environment and science. It is produced through the Arctic Program of the US National Oceanic and Atmospheric Administration (NOAA).

Knowledge Strengths and Gaps

Recent reports identify projected climate trends and also set out guidelines for adaptation (Bush & Lemmen, 2019; Yukon Government, 2020). However, knowledge gaps persist in most areas about climate change effects in the Arctic and specifically on the Yukon North Slope, including environmental information such as snow cover, wildlife responses, and the potential emergence/expansion of diseases, parasites, or invasive species. Changes in the ecosystem due to climate change may also increase exposure to contaminants; however, the potential interactions of climate change and contaminants are mostly unknown (Braune, 2011, also see companion report on contaminants; McKinney et al., 2015). The WCMP (Objective E) provides guidance for new research on the Yukon North Slope.

Ultimately, all climate change and response predictions contained in this chapter provide guidance at the landscape scale, but they cannot provide the exact fate of any specific species (SNAP, 2012). However, the predictions can help to inform community and regional planning (SNAP, 2012).

Inuvialuit, particularly Aklavik residents and those that regularly spend time on the Yukon North Slope, are well-positioned to lead the monitoring of climate change effects. The combination of local and traditional knowledge with regular visits to the Yukon North Slope form a foundation for understanding change. Most importantly, Inuvialuit are and will continue to be most affected by climate change in this place. As such, it is imperative that Inuvialuit are leaders in both monitoring and adaption, with meaningful support from partners like governments and co-management organizations.

Adaptation to Climate Change

The capability of species to disperse increases their ability to adapt to climate change through movement (SNAP, 2012). However, less mobile species may be greatly influenced by landscape connectivity and permeability. On the Yukon North Slope, the northern limit of the landscape abutting the ocean also creates unique restrictions to potential movement. Therefore, different wildlife management strategies may be required to promote species adaptation, maximize resiliency, protect movement corridors, stepping stones, or refugia, and increase landscape permeability to conserve biodiversity (Mawdsley, Malley, & Ojima, 2009).

Potential Changes in Commercial Access

Reductions in sea ice and longer periods of open water may lead to increased shipping and tourism (via cruise ships) in the Beaufort Sea (BSP, 2009) (See also: Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018). Additionally, there may be increased pressure to expand commercial fishing and mining in the Arctic region as seasonal access increases (BSP, 2009).

Climate Change Effects Monitoring and Research of Yukon North Slope Wildlife

Plans and research papers relevant to the Yukon North Slope (summarized above) recommend continued monitoring of climate change and its potential effects on species, particularly for species at high risk from the predicted changes. Periodic repeated sampling of wildlife populations is important as it establishes a record for evaluating population status and trends and potential links to the effects of climate change. Specific monitoring and/or research may be required to gather information on how climate change may be influencing these species.

Traditional Use and Traditional Knowledge

Inuvialuit traditional use and traditional knowledge of wildlife and habitats on the Yukon North Slope was documented in 2018 and highlight Inuvialuit observations of climate change. In 2019, Inuit Tapiriit Kanatami released the National Inuit Climate Change Strategy (ITK, 2019). The Inuvialuit Regional Corporation released *Inuvialuit on the Frontline of Climate Change* in 2016, which presents regional climate change adaptation plans for each Inuvialuit Community (IRC, 2016). The Inuvialuit Regional Corporation is currently producing an Inuvialuit climate change strategy. Inuvialuit-informed climate change adaptation strategies are therefore a knowledge strength. However, there is a knowledge gap in documenting ongoing traditional knowledge of how Inuvialuit and wildlife are adapting to climate change, and documenting ongoing changes to traditional use as a result of climate change.

References

ADF&G, A. D. of F. and G. (n.d.). Mycoplasma ovipneumoniae (M. ovi) in Alaska Wildlife: Answers to Frequently Asked Questions. Retrieved from https://www.adfg.alaska.gov/index.cfm?adfg=hottopics.movi

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

Arctic Program. (n.d.). Arctic Report Card: Tracking recent environmental changes relative to historical records. Retrieved from https://www.arctic.noaa.gov/Report-Card

Berteaux, D., Gauthier, G., Domine, F., Ims, R. A., Lamoureux, S. F., Lévesque, E., & Yoccoz, N. (2017). Effects of changing permafrost and snow conditions on tundra wildlife: critical places and times. *Arctic Science*, *3*(2), 65–90. https://doi.org/10.1139/as-2016-0023

Bintanja, R. (2018). The impact of Arctic warming on increased rainfall. *Scientific Reports*, *8*(1), 6–11. https://doi.org/10.1038/s41598-018-34450-3

Bintanja, R., & Andry, O. (2017). Towards a rain-dominated Arctic. *Nature Climate Change*, *7*(4), 263–267. https://doi.org/10.1038/nclimate3240

Boelman, N. T., Liston, G. E., Gurarie, E., Meddens, A. J. H., Mahoney, P. J., Kirchner, P. B., … Vierling, L. A. (2019). Integrating snow science and wildlife ecology in Arctic-boreal North America. *Environmental Research Letters*, *14*(1). https://doi.org/10.1088/1748-9326/aaeec1

Braune, B. (2011). Chemical contaminants in the Arctic environment – Are they a concern for wildlife? In R. T. Watson, T. J. Cade, M. Fuller, G. Hunt, & E. Potapov (Eds.), *Gyrfalcons and Ptarmigan in a Changing World, Volume 1* (pp. 133–146). https://doi.org/10.4080/ gpcw.2011.0114

BSP. (2009). *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond*. Beaufort Sea Partnership.

Bush, E., & Lemmen, D. S. (2019). *Canada's Changing Climate Report*. Ottawa, ON.

Buttrick, S., Popper, K., Schindel, M., McRae, B., Unnash, B., Jones, A., & Platt, J. (2015). *Conserving Nature's Stage: Identifying Resilient Terrestrial Landscapes in the Pacific Northwest*. Retrieved from http://nature.ly/resilienceNW

Callaghan, T. V., Johansson, M., Brown, R. D., Groisman, P. Y., Labba, N., Radionov, V., … Wood, E. F. (2011). Multiple effects of changes in arctic snow cover. *Ambio*, *40*(SUPPL. 1), 32–45. https://doi.org/10.1007/s13280-011-0213-x

Chadburn, S. E., Burke, E. J., Cox, P. M., Friedlingstein, P., Hugelius, G., & Westermann, S. (2017). An observation-based constraint on permafrost loss as a function of global warming. *Nature Climate Change*, *7*(5), 340–344. https://doi.org/10.1038/nclimate3262

Choi, R. T., Beard, K. H., Leffler, A. J., Kelsey, K. C., Schmutz, J. A., & Welker, J. M. (2019). Phenological mismatch between season advancement and migration timing alters Arctic plant traits. *Journal of Ecology*, *107*(5), 2503–2518. https://doi.org/10.1111/1365-2745.13191

Crites, H., Kokelj, S. V., & Lacelle, D. (2020). Icings and groundwater conditions in permafrost catchments of northwestern Canada. *Scientific Reports*, *10*(1), 1–11. https://doi.org/10.1038/s41598-020-60322-w

Cunliffe, A. M., Tanski, G., Radosavljevic, B., Palmer, W., Sachs, T., Lantuit, H., … Myers-Smith, I. H. (2019). Rapid retreat of permafrost coastline observed with aerial drone photogrammetry. *Cryosphere*, *13*(5), 1513–1528. https://doi.org/10.5194/tc-13-1513-2019

Darnis, G., Robert, D., Pomerleau, C., Link, H., Archambault, P., Nelson, R. J., … Fortier, L. (2012). Current state and trends in Canadian Arctic marine ecosystems: II. Heterotrophic food web, pelagic-benthic coupling, and biodiversity. *Climatic Change*, *115*(1), 179–205. https://doi.org/10.1007/s10584-012-0483-8

Derksen, C., Burgess, D., Duguay, C., Howell, S., Mudryk, L., Smith, S., … Kirchmeier-Young, M. (2019). Changes in snow, ice, and permafrost across Canada. In E. Bush & D. S. Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 194–260). Ottawa, ON: Government of Canada.

DFO. (2018). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region Northwest Territories and Yukon North Slope 2018–2022. Feb. 8 2018 Draft*.

DFO, & FJMC. (2013). *Tarium Niryutait Marine Protected Areas Monitoring Plan*. Fisheries and Oceans Canada and Fisheries Joint Management Committee.

Douglas, T. A., Turetsky, M. R., & Koven, C. D. (2020). Increased rainfall stimulates permafrost thaw across a variety of Interior Alaskan boreal ecosystems. *Climate and Atmospheric Science*, *3*(1). https://doi.org/10.1038/s41612-020-0130-4

Dunmall, K., Mochnacz, N. J., Zimmerman, C., Lean, C., & Reist, J. D. (2016). Using thermal limits to assess establishment of fish dispersing to high latitude and high elevation watersheds. *Canadian Journal of Fisheries and Aquatic Sciences*, *73*(12), 1750–1758.

Duquette, L. S. (1988). Snow Characteristics along Caribou Trails and within Feeding Areas during Spring Migration. *Arctic*, *41*(2), 143–144. https://doi.org/10.1097/00019616-199903000-00002

Fauchald, P., Park, T., Tømmervik, H., Myneni, R., & Hausner, V. H. (2017). Arctic greening from warming promotes declines in caribou populations. *Science Advances*, *3*(4). https://doi.org/10.1126/sciadv.1601365

Fischbach, A. S., Amstrup, S. C., & Douglas, D. C. (2007). Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. *Polar Biology*, *30*(11), 1395–1405. https://doi.org/10.1007/s00300-007-0300-4

Flato, G., Gillett, N., Arora, V., Cannon, A., & Anstey, J. (2019). Modelling future climate chnage. In E. Bush & D. S. Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 74–111). Ottawa, ON: Government of Canada.

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

Friendship, K., & Community of Aklavik. (2011). *Climate Change Adaptation Plan: Community of Aklavik, Northwest Territories*. Retrieved from https://www.cakex.org/documents/climate-change-adaptation-action-plan-community-aklavik-northwest-territories

Gagnon, C. A., Hamel, S., Russell, D. E., Powell, T., Andre, J., Svoboda, M. Y., & Berteaux, D. (2020). Merging indigenous and scientific knowledge links climate with the growth of a large migratory caribou population. *Journal of Applied Ecology*, (April 2019), 1–12. https://doi.org/10.1111/1365-2664.13558

Gunderson, L. H. (2000). Ecological REsilience - In Theory and Application. *Annual Review of Ecology and Systematics*, *31*, 425–439.

Harwood, L. A., Smith, T. G., George, J. C., Sandstrom, S. J., Walkusz, W., & Divoky, G. J. (2015). Change in the Beaufort Sea ecosystem: Diverging trends in body condition and/or production in five marine vertebrate species. *Progress in Oceanography*, *136*, 263–273. https://doi.org/10.1016/j.pocean.2015.05.003

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

Hoberg, E. P., Kutz, S. J., Nagy, J., Jenkins, E., Elkin, B., Branigan, M., & Cooley, D. (2002). Protostrongylus stilesi (Nematoda: Protostrongylidae): Ecological isolation and putative host-switching between Dall's sheep and muskoxen in a contact zone. *Comparative Parasitology*, *69*(1), 1–9. https://doi.org/10.1654/1525-2647(2002)069[0001:psnpei]2.0.co;2

Hynes, K., Wesche, S. D., & Aklavik HTC. (2017). Inuvialuit Knowledge and Use of Fisheries in the Mackenzie Delta. In B. Parlee & E. Maloney (Eds.), *Tracking change: Local and Traditional Knowledge in Watershed Governance. Report of the 2016 Community-Based Research Projects in the Mackenzie River Basin* (pp. 18–21). Retrieved from www.trackingchange.ca

Il Jeong, D., & Sushama, L. (2018). Rain-on-snow events over North America based on two Canadian regional climate models. *Climate Dynamics*, *50*(1–2), 303–316. https://doi.org/10.1007/s00382-017-3609-x

IRC. (2016). *Inuvialuit on the Frontline of Climate Change: Development of a Regional Climate Change Adaptation Strategy*. Inuvik, NT: Inuvialuit Regional Corporation.

Irrgang, A. M., Lantuit, H., Gordon, R. R., Piskor, A., & Manson, G. K. (2019). Impacts of past and future coastal changes on the Yukon coast — threats for cultural sites, infrastructure, and travel routes. *Arctic Science*, *5*(2), 107–126. https://doi.org/10.1139/as-2017-0041

ITK. (2019). *National Inuit Climate Change Strategy*. Retrieved from Inuit Tapariit Kanatami website: https://www.itk.ca/national-inuit-climate-change-strategy/resources/

Jex, B. A., Ayotte, J. B., Bleich, V. C., Brewer, C. E., Bruning, D. L., Hegel, T. M., … Wagner, M. W. (2016). *Thinhorn Sheep: Conservation Challenges and Management Strategies for the 21st Century*. Boise, Idaho: Wild Sheep Working Group, Western Association of Fish and Wildlife Agencies.

Joint Secretariat. (2015). *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Joint Secretariat, Inuvialuit Settlement Region.

Joint Secretariat. (2017). *Inuvialuit Settlement Region Polar Bear Joint Management Plan*. Joint Secretariat, Inuvialuit Settlement Region.

Joly, K., Duffy, P. A., & Rupp, T. S. (2012). Simulating the effects of climate change on fire regimes in Arctic biomes : implications for caribou and moose habitat Simulating the effects of climate change on fire regimes in Arctic biomes : implications for caribou and moose habitat. *Ecosphere*, *3*(5), 1-. https://doi.org/10.1890/ES12-00012.1

Jung, T. S., Frandsen, J., Gordon, D. C., & Mossop, D. (2017). Colonization of the Beaufort Coastal Plain by Beaver (*Castor canadensis*): A Response to Shrubification of the Tundra? *The Canadian Field-Naturalist*, *130*(4), 332. https://doi.org/10.22621/cfn.v130i4.1927

Kim, Y., Kimball, J. S., Du, J., Schaaf, C. L. B., & Kirchner, P. B. (2018). Quantifying the effects of freeze-thaw transitions and snowpack melt on land surface albedo and energy exchange over Alaska and Western Canada. *Environmental Research Letters*, *13*(7). https://doi.org/10.1088/1748-9326/aacf72

Kokelj, S. V., Tunnicliffe, J., Lacelle, D., Lantz, T. C., & Fraser, R. H. (2015). Retrogressive thaw slumps: From slope process to the landscape sensitivity of northwestern Canada. *68e Conférence Canadienne de Géotechnique et 7e Conférence Canadienne Sur Le Pergélisol, 20 Au 23 Septembre 2015, Québec, Québec.*, (October).

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

Lindsay, R., & Schweiger, A. (2015). Arctic sea ice thickness loss determined using subsurface, aircraft, and satellite observations. *Cryosphere*, *9*(1), 269–283. https://doi.org/10.5194/tc-9-269-2015

Mawdsley, J. R., Malley, R. O., & Ojima, D. S. (2009). *A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation*. *23*(5), 1080–1089. https://doi.org/10.1111/j.1523-1739.2009.01264.x

Mckinney, M. A., Atwood, T. C., Iverson, S. J., & Peacock, E. (2017). Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use. *Ecosphere*, *8*(1). https://doi.org/10.1002/ecs2.1633

McKinney, M. A., Edro, S. P., Ietz, R. D., Onne, C. S., Isk, A. T. F., Oy, D. R., … Etcher, R. J. L. (2015). A review of ecological impacts of global climate change on persistent organic pollutant and mercury pathways and exposures in arctic marine ecosystems. *Current Zoology*, *61*(4), 617–628. https://doi.org/10.1093/czoolo/61.4.617

Morice, C. P., Kennedy, J. J., Rayner, N. A., & Jones, P. D. (2012). Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 dataset. *Journal of Geophysical Research Atmospheres*, *117*.

Mudryk, L., Derksen, C., Howell, S., Laliberte, F., Thackeray, C., Sospedra-Alfonso, R., … Brown, R. (2018). Canadian snow and sea ice: historical trends and projections. *Cryosphere*, *12*, 1157–1176.

Myers-Smith, I. H., Forbes, B. C., Wilmking, M., Hallinger, M., Lantz, T., Blok, D., … Hik, D. S. (2011). Shrub expansion in tundra ecosystems: Dynamics, impacts and research priorities. *Environmental Research Letters*, *6*(4). https://doi.org/10.1088/1748-9326/6/4/045509

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

Nicholson, K. L., Arthur, S. M., Horne, J. S., Garton, E. O., & Del Vecchio, P. A. (2016). Modeling caribou movements: Seasonal ranges and migration routes of the central arctic herd. *PLoS ONE*, *11*(4), 1–20. https://doi.org/10.1371/journal.pone.0150333

Nickels, S., Furgal, C., Buell, M., & Moquin, H. (2005). *Unikkaaqatigiit-Putting the Human Face on Climate Change: Perspecitives from Inuit in Canada*. Ottawa, ON: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.

Nitze, I., Grosse, G., Jones, B. M., Arp, C. D., Ulrich, M., Fedorov, A., & Veremeeva, A. (2017). Landsat-based trend analysis of lake dynamics across Northern Permafrost Regions. *Remote Sensing*, *9*(7), 1–28. https://doi.org/10.3390/rs9070640

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

Poesch, M. S., Chavarie, L., Chu, C., Pandit, S. N., & Tonn, W. (2016). Climate change impacts on freshwater fishes: a Canadian perspective. *Fisheries*, *41*(7), 385–391. https://doi.org/10.1007/s10750-017-3310-4

Pomeroy, J., & Brun, E. (2001). Physical Properties of Snow Introduction: Snow Physics and Ecology. *Snow Ecology*, 45–126. Retrieved from http://www.inscc.utah.edu/~campbell/snowdynamics/reading/Pomeroy.pdf

Prowse, A., Terry, D., Fred, J., & James, D. (2009). *Implications of Climate Change for Northern Canada : Freshwater , Marine , and Terrestrial Ecosystems*. *38*(5), 282–289.

Radosavljevic, B., Lantuit, H., Pollard, W. H., Overduin, P. P., Couture, N., Sachs, T., … Fritz, M. (2016). Erosion and Flooding—Threats to Coastal Infrastructure in the Arctic: A Case Study from Herschel Island, Yukon Territory, Canada. *Estuaries and Coasts*, *39*(4), 900–915. https://doi.org/10.1007/s12237-015-0046-0

Rennert, K. J., Roe, G., Putkonen, J., & Bitz, C. M. (2009). Soil thermal and ecological impacts of rain on snow events in the circumpolar arctic. *Journal of Climate*, *22*(9), 2302–2315. https://doi.org/10.1175/2008JCLI2117.1

Rowland, E. L., Fresco, N., Reid, D. G., & Cooke, H. A. (2016). Examining climate-biome (“cliome”) shifts for Yukon and its protected areas. *Global Ecology and Conservation*, *8*, 1–17. https://doi.org/10.1016/j.gecco.2016.07.006

Serreze, M. C., & Barry, R. G. (2011). Processes and impacts of Arctic amplification: A research synthesis. *Global and Planetary Change*, *77*(1–2), 85–96. https://doi.org/10.1016/j.gloplacha.2011.03.004

SNAP. (2012). *Predicting Future Potential Climate-Biomes for the Yukon, Northwest Territories, and Alaska*. https://doi.org/10.1097/00019052-200008000-00006

Spear, A., Duffy-Anderson, J., Kimmel, D., Napp, J., Randall, J., & Stabeno, P. (2019). Physical and biological drivers of zooplankton communities in the Chukchi Sea. *Polar Biology*, *42*(6), 1107–1124. https://doi.org/10.1007/s00300-019-02498-0

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.

Streicker, J. (2016). *Yukon Climate Change Indicators and Key Findings 2015*. 84 p.

Stroeve, J. C., Serreze, M. C., Holland, M. M., Kay, J. E., Malanik, J., & Barrett, A. P. (2012). *The Arctic ' s rapidly shrinking sea ice cover : a research synthesis*. 1005–1027. https://doi.org/10.1007/s10584-011-0101-1

Stroeve, J., & Notz, D. (2018). Changing state of Arctic sea ice across all seasons. *Environmental Research Letters*, *13*(10). https://doi.org/10.1088/1748-9326/aade56

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

Tape, K. D., Jones, B. M., Arp, C. D., Nitze, I., & Grosse, G. (2018). Tundra be dammed: Beaver colonization of the Arctic. *Global Change Biology*, *24*(10), 4478–4488. https://doi.org/10.1111/gcb.14332

Van de Kerk, M., Arthur, S., Bertram, M., Borg, B., Herriges, J., Lawler, J., … Prugh, L. (2020). Environmental Influences on Dall’s Sheep Survival. *Journal of Wildlife Management*, *84*(6), 1127–1138. https://doi.org/10.1002/jwmg.21873

Van De Kerk, M., Verbyla, D., Nolin, A. W., Sivy, K. J., & Prugh, L. (2018). Range-wide variation in the effect of spring snow phenology on Dall sheep population dynamics. *Environmental Research Letters*, *13*(7).

https://doi.org/10.1088/1748-9326/aace64

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

Vincent, L. A., Zhang, X., Brown, R. D., Feng, Y., Mekis, E., Milewska, E. J., … Wang, X. L. (2015). Observed trends in Canada's climate and influence of low-frequency variability models. *Journal of Climate*, *28*, 4545–4560.

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

WMAC (NS), & Aklavik HTC. (2009). *Aklavik Local and Traditional Knowledge about Porcupine Caribou*. Retrieved from Wildlife Management Advisory Council (North Slope) website: http://www.wmacns.ca/pdfs/287_WMAC_rpt_pcbou_knwldg_web.pdf

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

Yukon Government. (2020). *Our Clean Future: A Yukon strategy for climate change, energy and a green economy*. Whitehorse, Yukon, Canada.

Zhang, R., Wang, H., Fu, Q., Rasch, P. J., & Wang, X. (2019). Unraveling driving forces explaining significant reduction in satellite-inferred Arctic surface albedo since the 1980s. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(48), 23947–23953. https://doi.org/10.1073/pnas.1915258116

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., … Kharin, V. V. (2019). Changes in Temperature and Precipitation Across Canada. In E. Bush & D. S. Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 112–193). Ottawa, ON: Government of Canada.

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

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 3: Contaminants / Halumailiȓuq

Publication Information

Cover photo: Debris at a remote camp, Yukon North Slope. © Parks Canada, 2006

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 3: Contaminants / Halumailiȓuq

Table of Contents

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.

There are fourteen companion reports, addressing four selected topics of key interest as well as ten wildlife species featured in the Plan.

Companion Report Table of Contents

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

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: Contaminants / Halumailiȓuq

This companion report is one of four reports on selected topics that cut across species divisions for the Plan. The phrase Halumailiȓuq is from the Inuvialuktun Uummarmiutun dialect, and can be translated as 'it is not clean anymore / get dirty' (IRC, 2020). Contaminant-related objectives and actions in Yukon North Slope plans and programs are listed, and strength and gaps in knowledge about contaminants related to wildlife on the Yukon North Slope are summarized.

This report draws on Northern Contaminants Program research and monitoring since the early 1990s, including studies on the Yukon North Slope, in the Mackenzie River and Delta, and in other parts of the Canadian Arctic. Additional information sources relevant to the Yukon North Slope are included, such as circumpolar contaminants studies and research undertaken to address specific contaminants issues, including how climate change affects contaminant levels in wildlife.

Introduction to Contaminants

Contaminants can be released through industrial or agricultural activities, and from products in common use, such as chemicals used in electrical equipment or in flame retardants.

Many contaminants in the environment are human-made chemicals known as persistent organic pollutants (POPs). These include many pesticides and PCBs[1]. "Legacy" POPs are those that were used historically but are now banned or restricted.

Another category of contaminants is heavy metals, including mercury and cadmium. These toxic metals occur naturally in rocks and soils, and are widespread at low levels. However, they can become contaminants of concern when they are processed or released to the environment as part of human activities, or as a result of climate change effects, including permafrost thaw and slumping.

Radioactivity is also considered a contaminant. Some radioactive substances are from natural sources. Sources of human-caused radioactivity include nuclear weapons, such as those tested during the 1950s and 1960s, or from accidents at nuclear power generating plants.

Almost all contaminants that are detected in the Yukon North Slope were transported by air or ocean currents from the more populated, agricultural, and industrial regions of the world. The exception is historical localized contamination from the former Distant Early Warning (DEW) line sites (such as Komakuk Beach). Clean-up at these sites was completed in 2014.

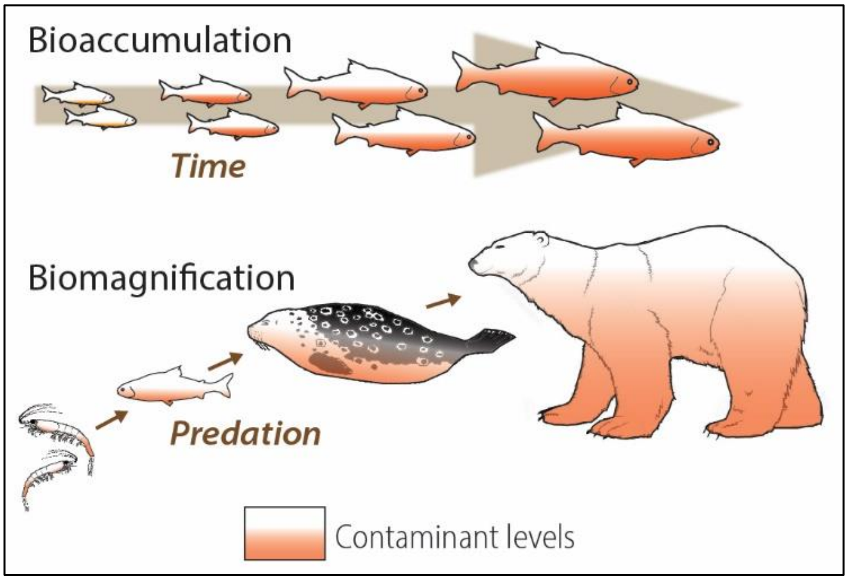
Another potential route for contaminants to enter the Yukon North Slope is via rivers. Pollutants discharged to the Mackenzie River have the potential to reach Yukon North Slope marine waters, though greatly diluted along the river's pathway.

As contaminants arrive in the Yukon North Slope, they may be taken up by algae and plants and enter the food chain. Many of the POPs are stored in fats and build up in fatty tissues like blubber or fish livers. Plants, land animals, and many fish usually have only low levels of contaminants, while some predatory fish may have higher levels. Marine mammals generally

[1] Polychlorinated biphenyls, chemical compounds with chlorine once widely used, for example as a coolant in electrical equipment.

have the highest contaminant levels, because they are long-lived top predators. Figure 3– 1 shows how these contaminants build up in wildlife.

Figure 3– 1. How contaminants build up in wildlife



The longer an animal lives the more contaminants build up in its body. This is called bioaccumulation. For some contaminants, biomagnification also occurs. This is when contaminant levels rise through the food chain when one animal eats another animal that has accumulated contaminants.
Source: adapted from www.blue-growth.org

Because the presence of contaminants in the environment is a global problem, it can only be fixed with global solutions. Results of studies in northern Canada have been important in making the case for global regulation of many contaminants (Government of Canada, 2018). International agreements include the 2004 Stockholm Convention on POPs, which was expanded to regulate additional contaminants in 2017 (United Nations, 2018), and the 2017 Minamata Convention on mercury (United Nations, 2019).

Selected Studies and Research Results Relevant to the Yukon North Slope

Persistent Organic Pollutants

These agricultural and industrial chemicals are widespread in the Arctic environment and can accumulate to high levels in marine predators, especially in some marine mammals and birds. POPs are either not detectable or at very low levels in terrestrial wildlife but sometimes build up to high levels in fatty tissues of freshwater predator fish, such as in the livers of loche (burbot, *Lota lota*).

- Review of trends in POPs in the circumpolar Arctic (Rigét et al., 2019)
  Levels of legacy POPs have declined in most Arctic animals, with some exceptions, including beluga whales. Chemicals that were used more recently or are still in use, such as brominated flame retardants[1] and perfluorinated compounds[2], show a mixed pattern of trends.

- Legacy POPs in Beaufort Sea beluga (Noël et al., 2018)
  Beluga and other marine top predators are particularly vulnerable to contaminant-associated health risks because they have long lives, limited ability to excrete contaminants, and low reproductive rates. Samples of beluga blubber obtained from Inuvialuit harvesters in the Mackenzie estuary area from 1989 to 2015 were analyzed for legacy contaminants. In beluga, most POPs showed no change or little change over the period, despite declines in other Arctic wildlife. Although the release of POPs has declined greatly due to regulation, climate change and melting sea ice are affecting how the chemicals move through the Arctic marine environment. The authors conclude that continued monitoring is needed to understand these mechanisms and to be informed about current levels of contaminants in beluga.

- Contaminants of emerging concern in Beaufort Sea beluga (Smythe et al., 2018)
  Samples of beluga blubber were obtained from harvesters in the Inuvialuit Settlement Region and the eastern Arctic over the period 1982 to 2013. The samples were analyzed for contaminants of emerging concern. The Beaufort Sea samples showed the strongest trends: increases in two types of chemicals used as flame retardants[3] and decreases in another group of chemicals used in manufacturing.[4] The authors concluded that it is important to continue monitoring for contaminants of emerging concern, especially as it is not always known if these contaminants will build up in food chains and whether they affect the health of animals or are a danger to people eating harvested foods. The authors also concluded that further monitoring is needed because the effects of climate-change-driven processes on contaminants in the environment are not well understood.

Mercury

Mercury is found naturally in rocks and it is released to the air by volcanoes. Human-caused sources of mercury are outcomes of industrial processes and the burning of fossil fuels.

[1] A group of chemicals used to reduce flammability of materials, especially plastics and textiles.
[2] A group of chemicals used in making stick- or stain-resistant products.
[3] Polybrominated diphenyl ether (PBDEs) and hexabromocyclododecane (HBCDs). These compounds have been phased out of use but are still present in the environment
[4] Perfluoroalkylcarboxylic acids

- Review of mercury in the Canadian Arctic marine environment (Braune et al., 2015)

  Recent past: Over the past several decades mercury levels have increased in some marine animals and remained unchanged in others. Ringed seals, beluga and polar bears from the Beaufort Sea region have higher concentrations of mercury than those in other parts of the Canadian Arctic.

  Long-term trends: Teeth from marine mammals can be analyzed to look at long-term trends of mercury. Teeth from Beaufort Sea beluga have more mercury in recent decades than before the rise of industry in the late 19th century. The biggest increase in mercury was in the mid-20th century. The recent trend in mercury in Beaufort Sea beluga is a decline since the 1990s. Mercury in Beaufort Sea ringed seals has remained about the same since the 1990s.

- Review of mercury in the Canadian Arctic terrestrial environment (Gamberg et al., 2015)

  Arctic terrestrial mammals and birds typically have low levels of mercury, though caribou can have higher levels because they eat lichen. Lichens have more mercury than other types of vegetation because they have no roots and absorb mercury and other contaminants directly from the air.

- Porcupine caribou

  Porcupine caribou samples have been analyzed for mercury most years since 1999. A report to the Porcupine Caribou Management Board in 2017 advised that caribou are largely free from contamination and healthy to eat (Gamberg Consulting, 2017). Some Porcupine caribou, however, can accumulate relatively high levels of cadmium and mercury in their organs (mainly in their kidneys and liver), partly from natural sources and partly from industry in other parts of the world. Mercury levels measured in Porcupine caribou vary with the seasons but have not increased or decreased over the past 20 years (Gamberg et al., 2015).

- Dolly Varden

  Sea-run (anadromous) Dolly Varden are very low in mercury, based on a review of mercury levels in Arctic char from the Canadian central and eastern Arctic, Dolly Varden from the Rat and Vittrekwa rivers (Evans et al., 2015), and Babbage River Dolly Varden (Tran et al., 2016). Summer ranges of Rat River and Vittrekwa River sea-run Dolly Varden extend along the Yukon North Slope coast (DFO et al., 2019). In contrast to land-locked Arctic char in high Arctic lakes, which accumulate high levels of mercury (AMAP, 2018a), the freshwater Dolly Varden in the Babbage River had lower mercury levels on average than the sea-run char from the same river. These differences in mercury levels were attributed to differences in growth patterns (Tran et al., 2016).

  Another study compared mercury in Dolly Varden that were collected from the Rat River and Firth River in the 1980s with Dolly Varden that were collected from the same rivers in the 2010s. This comparison concluded that mercury levels have increased slightly in Rat River Dolly Varden, but not in Firth River Dolly Varden (Tran et al., 2019). The study also found that there are local variations in how mercury is accumulated by Dolly Varden and concluded that it is important to continue to monitor mercury levels and to gain a better understanding of mercury uptake.

Radioactivity

The largest human-activity-related source of radioactivity in Arctic environments has been radiocesium[1] in fallout from nuclear weapons testing, starting in the 1950s. After the Nuclear Test Ban Treaty was signed in 1963, there were few atmospheric nuclear explosions, and levels of radiocesium in the Arctic declined. The greatest risk now is from accidents at nuclear power plants (Strand et al., 2002). Radioactivity has largely been a concern for consumers of caribou and reindeer because lichens take up radioactive fallout from the air.

- Caribou (Macdonald et al., 2007)
  Radioactivity has been monitored in caribou, including Porcupine caribou, since the 1960s. Human-caused radioactivity from weapons testing in the 1950s and 1960s was found in caribou but it has declined over the decades. Radioactivity is lower in Porcupine caribou than in caribou herds in eastern Canada. While the Chernobyl nuclear reactor accident in 1986 caused large increases in radioactivity in reindeer in Europe, the effect was small for the Porcupine herd. An increase in radioactivity of less than 10% in Porcupine caribou was measured in the late 1980s.

- Fukushima nuclear accident (Stocki et al., 2016)
  This study addressed concerns from northern communities about whether radioactivity from Japan's Fukushima Daiichi nuclear accident in 2011 was contaminating harvested animals. The study looked at radiocesium in Porcupine caribou and Beaufort Sea beluga whales as well as radiocesium in the food sources of these two species. This included lichens and mushrooms from the Old Crow area and fish caught at Shingle Point. Samples from before the accident and from after the accident showed that there was no increase in radioactivity in either caribou or beluga or in any of their food sources.

Risk to Wildlife

Research in recent years has applied information about toxicity of contaminants and assessed their effects on Arctic wildlife. Researchers have identified the effects of mixtures of contaminants (Villa et al., 2017; Desforges et al., 2017) and looked at effects that may be hard to detect in individuals, but show up at the population level. For example, studies show that there

[1] Radiocesium, also called caesium-137, is a common product of nuclear fission in nuclear reactors and nuclear weapons. Because it forms compounds that dissolve in water, it spreads through the environment.

is a link between elevated contaminant levels and changes in polar bear endocrine, immune, and reproductive systems (Joint Secretariat, 2017).

The Arctic Monitoring and Assessment Programme periodically reviews knowledge on biological effects of contaminants on Arctic fish and wildlife, including Canadian research and monitoring results (Fisk et al., 2005; Letcher et al., 2010; AMAP, 2018a; Dietz et al., 2019). The most recent review (AMAP, 2018b) found that:

- Legacy chemicals and mercury continue to pose a significant concern for Arctic biota.
- The suite of environmental contaminants found in many Arctic top predators is expanding and may require new investigation of potential biological effects.
- The mixtures of chemicals Arctic wildlife are exposed to needs to be taken into account to improve risk prediction.

The impact of contaminants on wildlife needs to be considered in combination with other threats to wildlife.

Risk to Human Health

Indigenous people in northern Canada have experienced higher levels of exposure to contaminants because of the high proportion of harvested food in their diets. The people most at risk from contaminants are Inuit of the eastern Arctic who harvest a lot of marine mammals. Because Inuvialuit diets are more varied, the risk of exposure to contaminants is lower.

A synthesis of initiatives on food security in the ISR (Kenny et al., 2018) highlights the importance of work on contaminants for ensuring food safety. Country foods are nutritious and preferred but are also the main source of exposure to persistent contaminants.

The fourth Northern Contaminants Program human health assessment (Curren, 2017) concluded that the nutritional benefits of traditional foods in general outweigh the risks from contaminants. A health survey conducted in the Inuvialuit Settlement Region (ISR) from 2007 to 2008 by the Centre for Indigenous Peoples' Nutrition and Environment contributed to the assessment (Egeland, 2010).

Contaminant levels and risks have declined since the 1990s. Many of the worst contaminants have been banned or reduced in use. This has improved the safety of harvested foods. Human blood samples in the eastern Arctic show that POPs have declined by up to 80% and mercury and lead have declined by about 60% since the early 1990s (Curren, 2017). Still, concerns remain about health effects of some contaminants, including mercury and new types of chemicals that have been found in samples of traditional foods and human blood.

Links to Plans and Programs

The following plans and programs informed the development of the *Yukon North Slope Wildlife Conservation and Management Plan* and are an integral part of its implementation.

- The Northern Contaminants Program (Government of Canada, 2018; Curren, 2017)
  The Northern Contaminants Program (NCP) is a national program that has been running since 1991. It is a partnership among governments, community organizations and researchers. Its goal is to reduce and, where possible, eliminate contaminants in harvested food in northern Canada, while providing information to help people make decisions about food use.

  The NCP funds and coordinates research and monitoring on contaminants in Arctic environments and on the human health effects of contaminants in harvested foods. NCP studies have also focused on the nutritional role and economic importance of traditional (country) foods. The program is guided by committees in the Yukon and NWT. The NCP places a strong focus on Arctic indigenous peoples' participation in research and monitoring and in communication of results.

  The NCP is Canada's partner in the Arctic Monitoring and Assessment Programme (AMAP, 2019), the Arctic-wide network that coordinates contaminants research, monitoring, and action to reduce contaminants at the international level.

- *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond* (BSP, 2009)
  The plan includes objectives, strategies, and actions on providing information on contaminants in country foods to communities (objective 2.9) and on contaminants research and monitoring (objective 4.3).

- *Tarium Niryutait Marine Protected Areas Monitoring Plan* (DFO & FJMC, 2013)
  The monitoring plan supports continued monitoring of health effects of contaminants on beluga through collaborative efforts of Fisheries and Oceans Canada, the Fisheries Joint Management Committee, and the Northern Contaminants Program.

- Fish and Marine Mammal Community Monitoring Program (FJMC, 2013)
  This program was built on a beluga monitoring program that was started by Fisheries and Oceans Canada in the mid-1980s and has been administered by the Fisheries Joint Management Committee since 1987. In 2010 the program was expanded to include more species and to integrate community-based monitoring. The program includes collection of samples at Shingle Point.

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016)
  Monitoring health and the presence of contaminants in seals was identified as a moderate research priority in the Aklavik Inuvialuit Community Conservation Plan.

- *Inuvialuit Settlement Region Polar Bear Joint Management Plan* (Joint Secretariat, 2017)
  The plan identifies contaminants as a threat to polar bears. The concern is that POPs, heavy metals and other contaminants of emerging concern may be harming the health of polar bears. The plan notes the potential for increased exposure to contaminants from an increase in shipping and from oil and gas activities. Knowledge gaps include understanding how climate change impacts might lead to changes in contaminant levels; baseline contaminant levels related to the oil and gas development; and understanding sub-lethal impacts of contaminants and pollution on individual bears and on populations. The plan lays out approaches for monitoring contaminants in polar bears and for filling the identified knowledge gaps.
- *Management Plan for the Peregrine Falcon anatum/tundrius* (Falco peregrinus anatum/tundrius) *in Canada* (ECCC, 2017)
  Contaminants are a threat to some birds of prey, as identified in this species at risk management plan. DDT (a pesticide) caused egg-shell thinning in peregrine falcons prior to the 1970s, leading to a severe population decline. Global control of DDT use in the 1970s led to population recovery, almost to historical numbers by 2017. Brominated flame retardants (PBDEs) were detected in significant quantities peregrine falcons in the 2000s and it is not yet known if regulatory measures have lowered these levels. The plan includes high priority conservation measures to ban or control contaminants and to research their effects on falcon health.

Knowledge Strengths and Gaps

Contaminants of Emerging Concern

New chemicals are still being developed and brought into use. Contaminants vary greatly in toxicity and in how fast they degrade and how much they build up in different animal tissues. Although many contaminants of emerging concern are being monitored, the effects of mixtures of low levels of many contaminants on wildlife and human consumers of country foods are not well understood. New analytical techniques mean that researchers continue to find additional chemicals in wildlife. For example, analysis of archived polar bear samples, including from Beaufort Sea bears, identified many previously unknown contaminants in polar bears (Liu et al., 2018). This may indicate that exposure and toxic risk in polar bears has been underestimated. An additional emerging issue is the spread of plastic waste, especially very small particles of plastics (microplastics) throughout the world's oceans, including to Arctic waters.

Contaminants and Climate Change

Climate change and the related loss of sea ice are driving change in Arctic ecosystems. Changes in food webs due to climate change are linked to changes in pathways of contaminants through ecosystems and to levels of contaminants in some animals (Braune, 2011; McKinney et al., 2015). This is not an easy puzzle to solve and often the relationships between contaminants and climate change are not understood. McKinney et al. (2015) reviewed research in this field and developed recommendations for monitoring and targeted research to improve understanding of how climate change and exposure to contaminants in the Arctic interact.

Climate change, contaminants, and polar bears

Loss of sea ice can lead to long periods without food for polar bears. Prolonged fasting increases concentrations of contaminants in their tissues. This could lead to health effects, and impact reproduction and survival.

Contaminants Monitoring of Yukon North Slope Wildlife

Plans and research papers relevant to the Yukon North Slope (summarized above) recommend continued monitoring of contaminants in species with a history of high contaminant levels and/or high risks of accumulating contaminants, especially species that are regularly harvested for food or species that may be at particular risk of health effects from contaminants. Multi-year sampling records are available for several wildlife populations that frequent the Yukon North Slope are summarized in Table 3– 1:

Table 3– 1. Main multi-year sampling data sets for wildlife populations frequenting the Yukon North Slope

Wildlife population	Contaminants studied	Selected references
Dolly Varden	mercury	Babbage River (Tran et al., 2016); other stocks that frequent the Yukon North Slope coast (Evans et al., 2015)
Porcupine caribou	mercury, cadmium and radioactivity	Mercury and cadmium since late 1990s (Gamberg Consulting, 2017; Gamberg et al., 2015); radioactivity since 1960s (Macdonald et al., 2007; Stocki et al., 2016)
Ringed seals	mercury, legacy POPs, contaminants of emerging concern	Hunter samples from Sachs Harbour since late 1990s (Houde et al., 2017; Brown et al., 2016)
Beluga	mercury, legacy POPs, contaminants of emerging concern	Hunter samples from Tuktoyaktuk since the 1980s (Smythe et al., 2018; Noël et al., 2018; Stocki et al., 2016)

Polar bears	mercury, legacy POPs, contaminants of emerging concern, macro plastics in stomach contents	Southern Beaufort Sea subpopulation, various studies (e.g. Liu et al., 2018; McKinney et al., 2017), GNWT harvest sample collection

References

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

AMAP. (2018a). *AMAP Assessment 2018: Biological Effects of Contaminant Exposure in Arctic Wildlife and Fish*. https://doi.org/10.13140/RG.2.1.4083.2488

AMAP. (2018b). *AMAP Assessment 2018: Biological Effects of Contaminants on Arctic Wildlife and Fish - Key Messages*. Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP).

AMAP. (2019). Arctic Monitoring and Assessment Programme | AMAP. Retrieved January 28, 2019, from https://www.amap.no/

Braune, B. (2011). Chemical contaminants in the Arctic environment – Are they a concern for wildlife? In R. T. Watson, T. J. Cade, M. Fuller, G. Hunt, & E. Potapov (Eds.), *Gyrfalcons and Ptarmigan in a Changing World, Volume 1* (pp. 133–146). https://doi.org/10.4080/ gpcw.2011.0114

Braune, B., Chételat, J., Amyot, M., Brown, T. M., Clayden, M., Evans, M. S., … Stern, G. A. (2015). Mercury in the marine environment of the Canadian Arctic: Review of recent findings. *Science of the Total Environment*, *509–510*, 67–90. https://doi.org/10.1016/j.scitotenv.2014.05.133

Brown, T. M., Fisk, A. T., Wang, X., Ferguson, S. H., Young, B. G., Reimer, K. J., & Muir, D. C. G. (2016). Mercury and cadmium in ringed seals in the Canadian Arctic: Influence of location and diet. *Science of The Total Environment*, *545–546*, 503–511. https://doi.org/10.1016/J.SCITOTENV.2015.12.030

BSP. (2009). *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond*. Beaufort Sea Partnership.

Curren, M. S. (Ed.). (2017). *Canadian Arctic Contaminants Assessment Report: Human Health Assessment 2017*. Government of Canada.

Desforges, J.-P., Levin, M., Jasperse, L., De Guise, S., Eulaers, I., Letcher, R. J., … Dietz, R. (2017). Effects of Polar Bear and Killer Whale Derived Contaminant Cocktails on Marine Mammal Immunity. *Environmental Science and Technology*, *51*(19), 11431–11439. https://doi.org/10.1021/acs.est.7b03532

DFO (Department of Fisheries and Oceans Canada), Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada. (2019). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope. Volume 1: The Plan–2019 Update*. Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, and Parks Canada Agency.

DFO, & FJMC. (2013). *Tarium Niryutait Marine Protected Areas Monitoring Plan*. Fisheries and Oceans Canada and Fisheries Joint Management Committee.

Dietz, R., Letcher, R. J., Desforges, J. P., Eulaers, I., Sonne, C., Wilson, S., … Víkingsson, G. (2019). Current state of knowledge on biological effects from contaminants on arctic wildlife and fish. *Science of the Total Environment*, *696*, 133792. https://doi.org/10.1016/j.scitotenv.2019.133792

ECCC. (2017). *Management Plan for the Peregrine Falcon anatum/tundrius* (Falco peregrinus anatum/tundrius) *in Canada*. Environment and Climate Change Canada.

Evans, M. S., Muir, D. C. G., Keating, J., & Wang, X. (2015). Anadromous char as an alternate food choice to marine animals: A synthesis of Hg concentrations, population features and other influencing factors. *Science of the Total Environment*, *509–510*, 175–194. https://doi.org/10.1016/j.scitotenv.2014.10.074

Fisk, A. T., De Wit, C. A., Wayland, M., Kuzyk, Z. Z., Burgess, N., Letcher, R. J., … Muir, D. C. G. (2005). An assessment of the toxicological significance of anthropogenic contaminants in Canadian arctic wildlife. *Science of the Total Environment*, *351–352*, 57–93. https://doi.org/10.1016/j.scitotenv.2005.01.051

FJMC. (2013). *Beaufort Sea Beluga Management Plan. 4th Amended Printing*. Inuvik, NT: Fisheries Joint Management Committee.

Gamberg Consulting. (2017). *Report to the hunters of the Porcupine caribou - July, 2017*. Information sheet distributed at the Northern Contaminants Program 25th Anniversary Results Workshop, September 26-28, 2017, Yellowknife, NWT.

Gamberg, M., Poulain, A. J., Zdanowicz, C., & Zheng, J. (2015). Mercury in the Canadian Arctic Terrestrial Environment: An Update. *Science of The Total Environment*, *509–510*, 28–40. https://doi.org/10.1016/J.SCITOTENV.2014.04.070

Government of Canada. (2018). Northern Contaminants Program - Background. Retrieved January 18, 2019, from http://www.science.gc.ca/eic/site/063.nsf/eng/h_67223C7F.html

Houde, M., Wang, X., Ferguson, S. H., Gagnon, P., Brown, T. M., Tanabe, S., … Muir, D. C. G. (2017). Spatial and temporal trends of alternative flame retardants and polybrominated diphenyl ethers in ringed seals (Phoca hispida) across the Canadian Arctic. *Environmental Pollution*, *223*, 266–276. https://doi.org/10.1016/j.envpol.2017.01.023

Jenssen, B. M., Villanger, G. D., Gabrielsen, K. M., Bytingsvik, J., Bechshoft, T., Ciesielski, T. M., … Dietz, R. (2015). Anthropogenic flank attack on polar bears: interacting consequences of climate warming and pollutant exposure. *Frontiers in Ecology and Evolution*, *3*(February), 1–7. https://doi.org/10.3389/fevo.2015.00016

Joint Secretariat. (2017). *Inuvialuit Settlement Region Polar Bear Joint Management Plan*. Joint Secretariat, Inuvialuit Settlement Region.

Kenny, T. A., Wesche, S. D., Fillion, M., MacLean, J., & Chan, H. M. (2018). Supporting Inuit food security: A synthesis of initiatives in the Inuvialuit Settlement Region, Northwest Territories. *Canadian Food Studies / La Revue Canadienne Des Études Sur l'alimentation*, *5*(2), 73–110. https://doi.org/10.15353/cfs-rcea.v5i2.213

Letcher, R. J., Bustnes, J. O., Dietz, R., Jenssen, B. M., Jørgensen, E. H., Sonne, C., … Gabrielsen, G. W. (2010). Exposure and effects assessment of persistent organohalogen contaminants in arctic wildlife and fish. *Science of the Total Environment*, *408*(15), 2995–3043. https://doi.org/10.1016/j.scitotenv.2009.10.038

Liu, Y., Richardson, E. S., Derocher, A. E., Lunn, N. J., Lehmler, H. J., Li, X., … Martin, J. W. (2018). Hundreds of Unrecognized Halogenated Contaminants Discovered in Polar Bear Serum. *Angewandte Chemie - International Edition*, (2). https://doi.org/10.1002/anie.201809906

Macdonald, C. R., Elkin, B. T., & Tracy, B. L. (2007). Radiocesium in caribou and reindeer in northern Canada, Alaska and Greenland from 1958 to 2000. *Journal of Environmental Radioactivity*, *93*(1), 1–25. https://doi.org/10.1016/j.jenvrad.2006.11.003

McKinney, M. A., Atwood, T. C., Pedro, S., & Peacock, E. (2017). Ecological Change Drives a Decline in Mercury Concentrations in Southern Beaufort Sea Polar Bears. *Environmental Science and*

Technology, *51*(14), 7814–7822. https://doi.org/10.1021/acs.est.7b00812

McKinney, M. A., Edro, S. P., Ietz, R. D., Onne, C. S., Isk, A. T. F., Oy, D. R., … Etcher, R. J. L. (2015). A review of ecological impacts of global climate change on persistent organic pollutant and mercury pathways and exposures in arctic marine ecosystems. *Current Zoology*, *61*(4), 617–628. https://doi.org/10.1093/czoolo/61.4.617

Noël, M., Loseto, L. L., & Stern, G. A. (2018). Legacy contaminants in the Eastern Beaufort Sea beluga whales (Delphinapterus leucas): are temporal trends reflecting regulations? *Arctic Science*, *14*(September), 373–387.

Rigét, F., Bignert, A., Braune, B., Dam, M., Dietz, R., Evans, M. S., … Wilson, S. (2019). Temporal trends of persistent organic pollutants in Arctic marine and freshwater biota. *Science of the Total Environment*, *649*(August 2018), 99–110. https://doi.org/10.1016/j.scitotenv.2018.08.268

Smythe, T. A., Loseto, L. L., Bignert, A., Rosenberg, B., Budakowski, W., Halldorson, T., … Tomy, G. T. (2018). Temporal Trends of Brominated and Fluorinated Contaminants in Canadian Arctic Beluga Delphinapterus leucas. *Arctic Science*, *404*(September), AS-2017-0044. https://doi.org/10.1139/AS-2017-0044

Stocki, T. J., Gamberg, M., Loseto, L. L., Pellerin, E., Bergman, L., Mercier, J. F., … Wang, X. (2016). Measurements of cesium in Arctic beluga and caribou before and after the Fukushima accident of 2011. *Journal of Environmental Radioactivity*, *162–163*, 379–387. https://doi.org/10.1016/j.jenvrad.2016.05.023

Strand, P., Howard, B. J., Aarkrog, A., Balonov, M., Tsaturov, Y., Bewers, J. M., … Rissanen, K. (2002). Radioactive contamination in the Arctic - Sources, dose assessment and potential risks. *Journal of Environmental Radioactivity*, *60*(1–2), 5–21. https://doi.org/10.1016/S0265-931X(01)00093-5

Tran, L., Reist, J. D., Gallagher, C. P., & Power, M. (2019). Comparing total mercury concentrations of northern Dolly Varden, Salvelinus malma malma, in two Canadian Arctic rivers 1986–1988 and 2011–2013. *Polar Biology*, (0123456789). https://doi.org/10.1007/s00300-019-02476-6

Tran, L., Reist, J. D., & Power, M. (2016). Northern Dolly Varden charr total mercury concentrations: variation by life-history type. *Hydrobiologia*, *783*(1), 159–175. https://doi.org/10.1007/s10750-016-2666-1

United Nations. (2018). Stockholm Convention: Protecting human health and the environment from persistent organic pollutants. Retrieved January 18, 2019, from http://chm.pops.int/

United Nations. (2019). Minamata Convention on Mercury. Retrieved January 18, 2019, from http://www.mercuryconvention.org/

Villa, S., Migliorati, S., Monti, G. S., Holoubek, I., & Vighi, M. (2017). Risk of POP mixtures on the Arctic food chain. *Environmental Toxicology and Chemistry*, *36*(5), 1181–1192. https://doi.org/10.1002/etc.3671

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

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 4: Aullaviat/Aunguniarvik: Conservation Values Summary

Publication Information

Cover photo: Annie B. Gordon's Camps at Tapqaq. © Michelle Gruben, 2016.

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 4: Aullaviat/Aunguniarvik Conservation Values

Table of Contents

Figures

Maps

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.

There are fourteen companion reports, addressing four selected topics of key interest as well as ten wildlife species featured in the Plan.

Companion Report Table of Contents

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

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: Aullaviat/Aunguniarvik

This chapter is one of four chapters on selected topics that cut across species divisions for the Plan. Information presented in this chapter is drawn from research, monitoring, and policy and planning initiatives at regional, national, and circumpolar scales. This chapter specifically summarizes the diversity of information that has been gathered on the values of the eastern portion of the Yukon North Slope, an area named by the Inuvialuit as Aullaviat/Aunguniarvik.

The body of information that it provides informs the Plan's recommendation for enhancements to the IFA-based conservation regime that applies to this area.

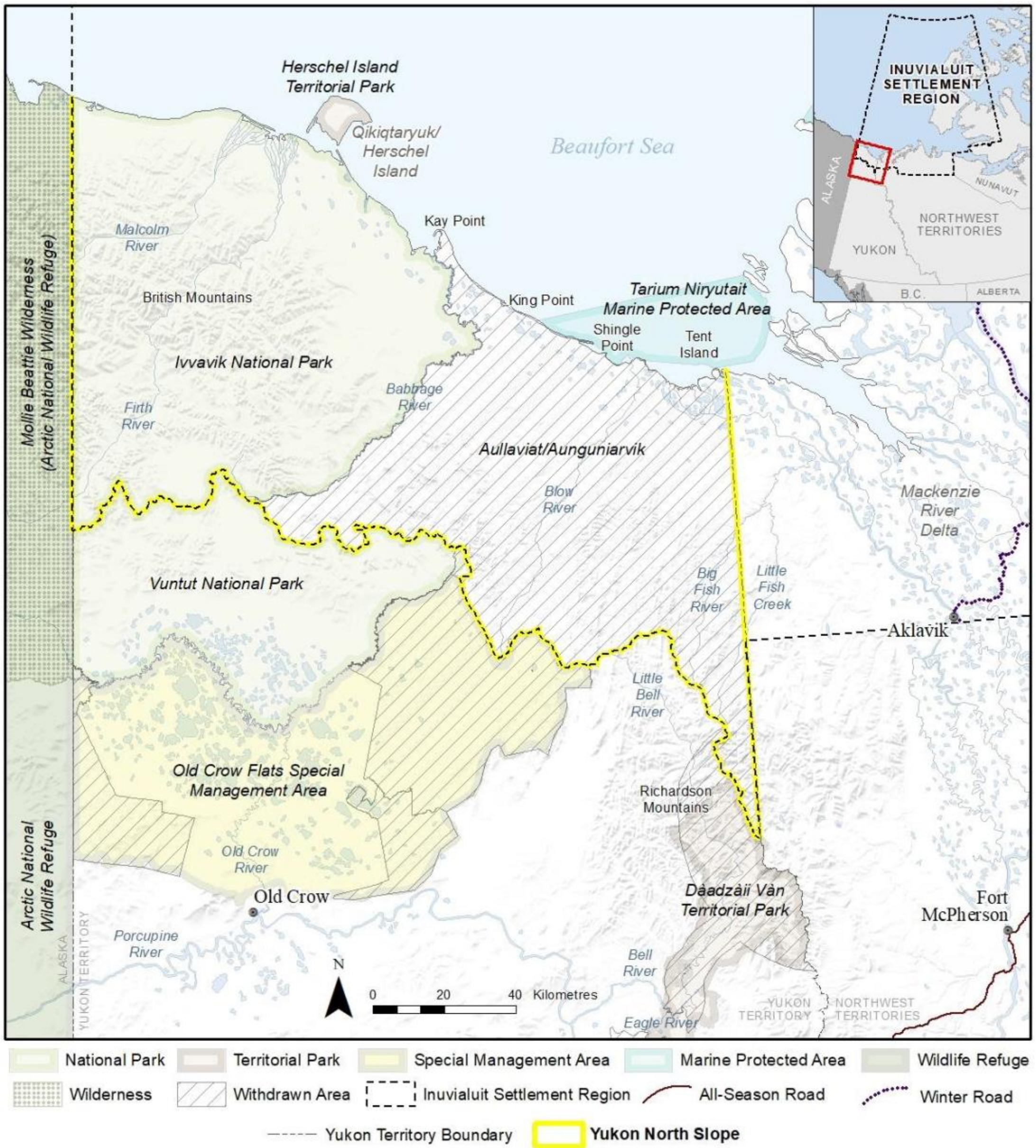
Introduction to Aullaviat/Aunguniarvik

Aullaviat/Aunguniarvik is the Inuvialuktun (Uummarmiutun dialect) name for the 840,000 ha region of the Yukon North Slope (YNS) east of Ivvavik National Park (Ivvavik NP), extending to the MacKenzie Delta and border of the Northwest Territories (Map 4- 1). Aullaviat/Aunguniarvik translates in English to 'where people and animals travel' and 'where people harvest', which succinctly summarizes some of the most important values of these landscapes. The area is also known as the 'Eastern Yukon North Slope'.

Located approximately 60 km to the east of Aullaviat/Aunguniarvik, Aklavik is the most western village in the Inuvialuit Settlement Region. The Inuvialuit of Aklavik have used coastline and inland landscapes of Aullaviat/Aunguniarvik for harvesting, traveling and cultural activities for many generations, as reflected in the Inuvialuit name for this region. The contemporary importance of Aullaviat/Aunguniarvik to the Inuvialuit in Aklavik as well as in Inuvik remains high. As the eastern portion of the Yukon North Slope is closer to these communities, it is the most easily accessed for traditional harvesting and other cultural activities. Inuvialuit primarily access the Yukon North Slope using boats to travel down the Mackenzie Delta, then along the coastline of Aullaviat/Aunguniarvik, a trip exceeding 100 km. Access in winter also occurs through snow travel, historically by dog sled, but more commonly now by snowmobile.

The *Yukon North Slope Wildlife Conservation and Management Plan* identifies a number of priorities and conservation requirements for the conservation and management of wildlife, habitat and traditional use in Aullaviat/Aunguniarvik. These include but are not limited to the conservation requirements identified for Featured Species (see Appendix 1 of WMAC NS (2021) for additional information). The Plan's priorities to support and conserve traditional use rely heavily upon the conservation of Aullaviat/Aunguniarvik.

Map 4- 1. Regional map showing the Yukon North Slope, Aullaviat/Aunguniarvik, and adjacent conservation lands.

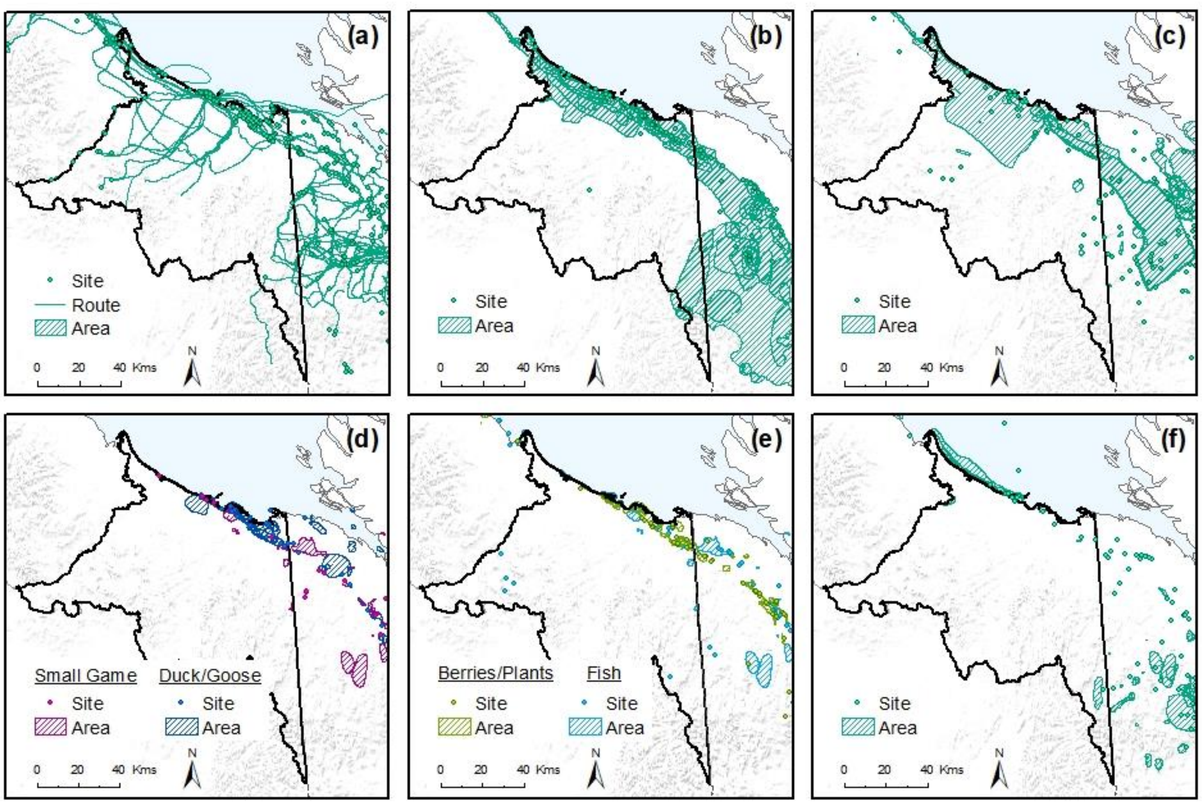


Traditional Use

The connection between Aullaviat/Aunguniarvik and Inuvialuit goes back many generations. Today, Aullaviat/Aunguniarvik provides Inuvialuit with a place to travel, connect, conduct cultural activities, pass on knowledge, and harvest, among other activities. This report focuses on harvesting activities, although it is recognized that harvest is interconnected with the above-listed traditional use activities. The harvesting opportunities provided by Aullaviat/Aunguniarvik are summarized here primarily based upon interviews and traditional use mapping with Aklavik and Inuvik Inuvialuit land users that occurred in 2015 (WMAC (NS) & Aklavik HTC, 2018b). It is important to understand that this work is a snapshot in time, as Inuvialuit continue to adapt traditional use to changing environmental conditions and community needs. Use has shifted considerably over generations and will continue to evolve. This adaptability is supported by the diversity and health of the Aullaviat/Aunguniarvik landscape.

The prominent role of Aullaviat/Aunguniarvik in contemporary traditional use is due to multiple factors (for historical context, see the WCMP and Companion Report 1: Traditional Use). It is located in relatively close proximity to Aklavik, compared to more western Yukon North Slope landscapes. The coastal region is of particular importance as it is most readily accessed; Inuvialuit use boats to travel from the Delta and along the near-shore waters of Aullaviat/Aunguniarvik to important safe harbors, camps, and the seasonal village of Tapqaq (Shingle Point) (Map 4- 2).

Map 4- 2. Traditional use mapping with the Aklavik Inuvialuit



The traditional use research provides mapped information on important traditional and cultural activities occurring within Aullaviat/Aunguniarvik: (a) camps (tent sites), cabins, safe harbors, burial sites and travel routes; (b) caribou harvesting sites and areas; (c) furbearer harvesting sites and other wildlife harvesting areas, including grizzly bear, wolverine and wolf; (d) small game harvesting areas, including hares and ptarmigan, ducks and geese; (e) harvesting areas for berries, medicinal plants and fish; (f) harvesting areas for Dall's sheep, moose and seal. Aullaviat/Aunguniarvik boundary is shown in black.

The seasonal village of Tapqaq and main YNS traditional camps for Inuvialuit are located along the Aullaviat/Aunguniarvik coast. Tapqaq (labelled on Map 4- 9 with English name Shingle Point) is where Inuvialuit gather during summer for several weeks of harvesting and other cultural activities. There are numerous family cabins along the point as well as up and down the coast. Multiple burial sites and other special cultural features and values are located in and around Taqpaq. Kiññaq (King Point) is another important camp and cabin area. Both of these areas have multiple cabins and camp sites (e.g., for tents) along the shoreline as well as inland next to the matrix of small lakes and rivers that form this most western terminus of Delta wetlands. Across Aullaviat/Aunguniarvik, 72 cabins, 88 tent sites, 25 burial sites and 17 other special cultural and historic sites were mapped in the 2018 Inuvialuit traditional use study (WMAC (NS) & Aklavik HTC, 2018b). These represent 57% of cabins, 69% of camps/tent sites, and 58% of special cultural and historic sites that were mapped across the Yukon North Slope for the recent traditional use study (WMAC (NS) & Aklavik HTC, 2018b). While most of these sites are found near coastal areas, important sites can be found throughout Aullaviat/Aunguniarvik.

Camps, cabins and gathering areas provide a base for multi-day seasonal harvesting efforts. Traditional use mapping demonstrates the link between key sites and access to the important resources of the Yukon North Slope. In addition to the major travel routes offshore used to access the Yukon North Slope from the Delta, some major travel routes follow the shoreline both on land as well as along the coastline (Map 4- 2a). Some major travel routes into the interior of the YNS follow major river systems including the Blow River and Running River from the coast, as well as Big Fish River from the NWT, but travel is not limited to these river systems. Mapping suggests much of Aullaviat/Aunguniarvik is accessed for harvesting.

Aullaviat/Aunguniarvik is where Inuvialuit and caribou meet. Caribou are one of the key species harvested on the Yukon North Slope and over 80% of the harvest sites and harvesting areas mapped in the 2018 study are located in Aullaviat/Aunguniarvik. Nearly all harvesting occurs near the coast and on the coastal plain (Map 4- 2b) with occasional harvesting further south. Harvesting is influenced by access to the Yukon North Slope, which is connected to climatic changes, local-scale weather changes, transmission of traditional knowledge, and socioeconomic factors. Harvesting occurs primarily in summer and fall and access is mainly by boat along the coast during these seasons (WMAC (NS) & Aklavik HTC, 2009, 2018b). Nearly four decades of GPS collar monitoring indicates that only a small proportion of the Porcupine caribou herd travels along the coast, with animals most frequently using the northwestern portion of Aullaviat/Aunguniarvik. This is where the majority of caribou harvesting was mapped during the study. Thus, most harvesting occurs at the edge of the primary seasonal distribution of the herd. This indicates the importance of maintaining healthy and abundant caribou, such that the seasonal range of the herd does not constrict away from these important harvesting areas.

Aullaviat/Aunguniarvik supports the majority (78%) of furbearer and grizzly bear harvesting mapped on the Yukon North Slope for the 2018 traditional use study (Map 4- 2c). Much of the furbearer harvest documented (WMAC (NS) & Aklavik HTC, 2018b) occurs along the coastline, particularly the central coastline near Tapqaq, but grizzly bear and wolverine in particular are also harvested more broadly, including well inland into the foothills and mountains of the Richardson Mountains. Polar bear is another important harvested species, but this harvest primarily occurs on the sea ice (Joint Secretariat, 2015) and is not included here.

The harvest of waterfowl is an important component of the land-based economy for Inuvialuit, who harvest a diversity of ducks and geese. Not surprisingly, the majority of this harvest on the Yukon North Slope occurs within the Mackenzie Delta wetlands that consistute the northeast corner of Aullaviat/Aunguniarvik (Map 4- 2d). Additionally, geese are harvested in upland areas where snow geese, in particular, congregate in large number for staging and foraging; key upland geese harvesting areas were identified south of Tapqaq.

Small game, including hare and ptarmigan, are harvested in areas local to camps or along travel routes, including opportunistically (Map 4- 2d).

Berries and medicinal plants are harvested broadly along the coast (Map 4- 2e). Families spend considerable time and effort collecting berries, either as the primary activity or coincident with other traditional use activities (WMAC (NS) & Aklavik HTC, 2018b). Over 90% of the berry harvesting areas identified on the Yukon North Slope occur in Aullaviat/Aunguniarvik. The Delta wetlands were identified as important for the collection of medicinal plants, which are also collected in other locations along the coast; again, over 90% of the medicinal plant harvesting areas were identified in Aullaviat/Aunguniarvik.

> Shingle Point is one of the best places to go because you can fish there, and hunt around from there, and if the berries grow early, then you got good places to go berry picking.
>
> PIN 123, p. 99, (WMAC (NS) & Aklavik HTC, 2018b)

Fishing is a key traditional use of the Yukon North Slope, and 78% of the Yukon North Slope fishing sites identified during the 2018 traditional use study are in Aullaviat/Aunguniarvik. Fishing occurs all along the coast, where nets are set for a mixed fishery of species foraging and migrating along the brackish nearshore waters over summer (Map 4- 2e) (WMAC (NS) & Aklavik HTC, 2018b). Tapqaq is a central area for fishing, as well as Kiññaq (King Point), other bays and inlets along the coastline, and the lakes and streams within the Delta wetlands of northeastern Aullaviat/Aunguniarvik are also used. Additionally, rivers and creeks inland were identified, including Big Fish River and multiple sites along Fish Hole River and its tributaries.

> Shingle Point is the best. You have a lot of access to a lot of things. You can pick berries, or you can make yourself dried fish, caribou meat, everything…That's my favourite place in Yukon, is Shingle Point, and that's where I brought up my little ones. I teach my oldest daughter how to make dry fish.
>
> PIN 105, p. 100, (WMAC (NS) & Aklavik HTC, 2018b)

Multiple other species are harvested on the Yukon North Slope, including moose, Dall's sheep and seal, though the number of Inuvialuit study participants mapping the harvesting sites and areas for these were fewer than some of the species discussed above (Map 4- 2f). Still, these add to the diversity of Yukon North Slope traditional uses. Again, most harvesting of these species occurs primarily in Aullaviat/Aunguniarvik.

Featured Fish and Wildlife Species

Porcupine Caribou Herd (Tuktu)

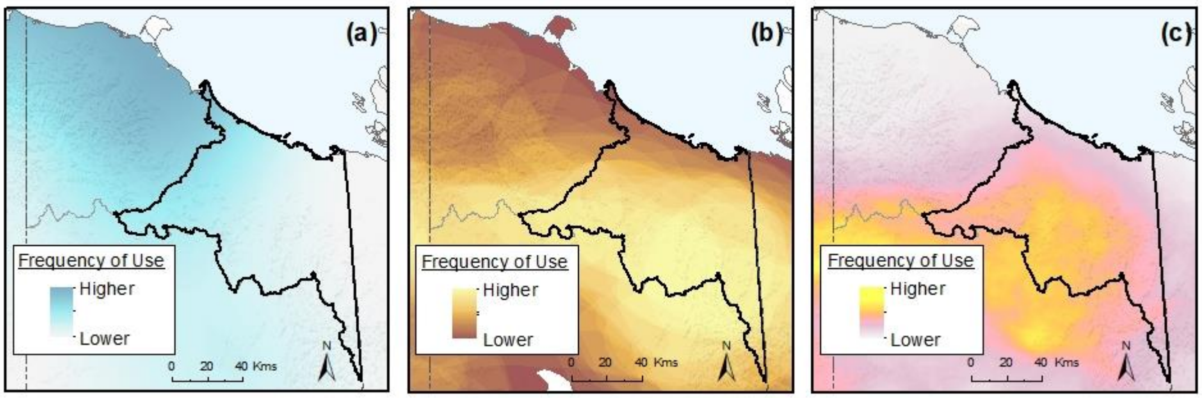
A cultural keystone species of the Yukon North Slope, the Porcupine caribou herd relies upon Aullaviat/Aunguniarvik for critical seasonal habitats including calving and late summer as well as for migrating, particularly post-calving. Calving habitat is located along the western portion of Aullaviat/Aunguniarvik (Map 4- 3a), contiguous with the calving habitats found in Ivvavik National Park, which themselves are contiguous with core calving grounds in adjacent Alaska in the Arctic National Wildlife Refuge. While not used heavily every year, the calving habitats in Aullaviat/Aunguniarvik are used more heavily in some years, and this has been associated with years when phenological events (e.g., onset of spring green up) occur later (Severson et al., 2021). Climate change is predicted to push calving and post-calving further west as spring phenology and snow melt occur earlier. Still, it remains important to maintain calving habitats across the calving distribution in an increasingly uncertain future that includes both climate change and a risk of development in calving habitats within Alaska.

The majority of the Porcupine herd uses the southeastern portion of Aullaviat/Aunguniarvik for mid-summer foraging grounds (Map 4- 3b). This seasonal use is likely critical for weight gain prior to winter, and the highly concentrated and consistent use of this region of Aullaviat/Aunguniarvik strongly indicates that these landscapes are critical to the health and conservation of the Porcupine caribou herd (Barboza, Van Someren, Gustine, & Syndonia Bret-Harte, 2018).

Aullaviat/Aunguniarvik also provides contiguous and intact landscapes that support the annual migrations of the caribou between their wintering habitats and their calving grounds. Annual migration routes are highly variable, but compiling nearly 20 years of collar data provides insights into the landscapes used most frequently over multiple years, for spring as well as fall migration. These data show the importance of Aullaviat/Aunguniarvik in supporting caribou migration in both the spring and fall, but with particularly intensive use of the area during the fall migration (Map 4- 3c), likely linked to the importance of the southern Aullaviat/Aunguniarvik in the mid-summer.

Conservation and management of Aullaviat/Aunguniarvik to maintain the integrity of calving, late summer and migration habitats is critical to meeting the WMCP's conservation requirements for the Porcupine caribou herd.

Map 4- 3. Selected Porcupine Caribou Herd seasonal use patterns on the Yukon North Slope



Based upon GPS collar data collected over 37 years spanning 1972 to 2016, these maps show how frequently caribou use areas of the Yukon North Slope during different seasons including: (a) calving; (b) mid-summer; and (c) fall migration. Aullaviat/Aunguniarvik boundary is shown in black.

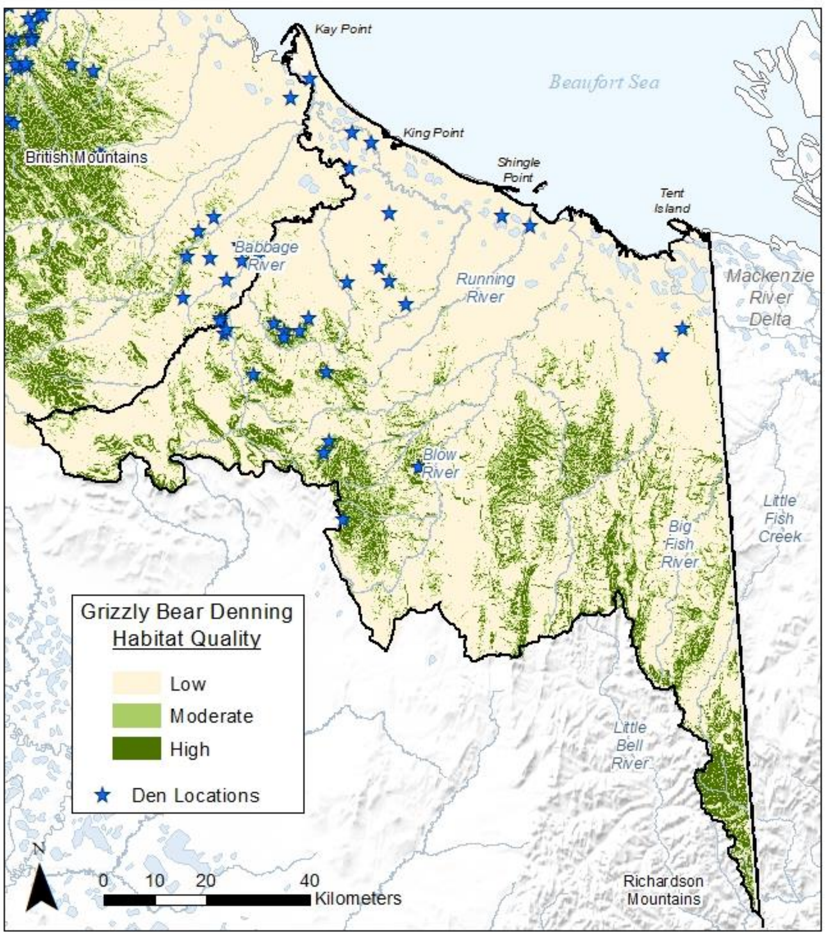
Grizzly Bear/Akłaq

Grizzly bear is an important species when planning for large-scale conservation, because they require a diversity of ecosystems widely distributed across healthy landscapes. This becomes even more important in low-productivity northern landscapes such as the Yukon North Slope. Home ranges of northern bears, including those on the Yukon North Slope, have been shown to be larger than home ranges in southern regions (Triska & Heinemeyer, 2020).

Seasonal habitat models based on traditional knowledge and GPS collar data from bears monitored on the Yukon North Slope show that Aullaviat/Aunguniarvik supports a diversity of seasonal habitats used by grizzly bears (Triska & Heinemeyer, 2020; WMAC (NS) & Aklavik HTC, 2018a). The Richardson Mountains provide high quality denning habitat, but this critical habitat is quite limited across the larger landscape of Aullaviat/Aunguniarvik, with several documented denning areas located in very small patches of predicted habitat (Map 4- 4). Note that some dens near the coast occur in areas outside predicted habitat, suggesting bears are selecting fine scale features not captured by the regional scale modeling effort. Other seasonal habitats are widespread within Aullaviat/Aunguniarvik, across both the mountains and the coastal plains with a consistent pattern of the highest quality habitats associated with creeks, rivers, and other mesic areas. The broad river valleys including the Blow River, Running River and Rapid Creek support important and rich summer and fall habitats.

The collar data, along with other research, shows the landscapes of Aullaviat/Aunguniarvik support multiple home ranges of grizzly bears, including reproductive female grizzly bears. They are important in contributing to the maintenance of a robust population of bears on the Yukon North Slope. Conservation of suitable denning habitats across Aullaviat/Aunguniarvik is important, as these habitats are generally limited in the region, and bears require suitable denning sites within their home ranges.

Map 4- 4. Predicted grizzly bear denning habitats based on models



The grizzly bear denning habitat model was developed from traditional knowledge. Denning sites were compiled from a diversity of sources including GPS collared bears, aerial surveys, traditional knowledge, and incidental sightings during the course of other research efforts. The map shows known denning sites compiled by the Yukon Government. Aullaviat/Aunguniarvik boundary shown in black.

Dolly Varden/Iqaluqpig

Within Aullaviat/Aunguniarvik, Dolly Varden (known locally as char) are found in the Babbage River and its tributary Fish Hole Creek, the Big Fish River and its tributary Little Fish Creek, in Fish Creek, and within the Mackenzie Delta system. Dolly Varden summer all along the coast of the Yukon North Slope, returning to rivers and creeks to winter where groundwater keeps the water from freezing. These same areas are often used for spawning and are critical for the species (Morrison, 2017). Some Dolly Varden remain in freshwater year around; this includes isolated populations that exist above barriers on the Babbage River and Little Fish Creek. Along the coast, a corridor of brackish water is used by Dolly Varden, as well as numerous other fish species, for seasonal movement and summer foraging habitats.

The western Arctic Dolly Varden population is listed as a species of special concern under the federal *Species at Risk Act*. Assessments of the populations in the Babbage River and Big Fish River systems indicate that Dolly Varden char are stable in these systems (Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada, 2019), though the species is not as abundant in the Big Fish River as it was in the 1970s (Stephenson, 2003). The Aklavik Community Conservation Plan designates the Big Fish River riparian zone in the highest conservation status (Category E) and the entire watershed as Category D (of particular importance and sensitivity), primarily because of the historic and current importance of these Dolly Varden for Inuvialuit (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016).

Conservation of quality winter, spawning and summer habitats for Dolly Varden within Aullaviat/Aunguniarvik will contribute significantly to the overall status and resilience of this important northern fish species. The limited sites of suitable wintering habitat are critical to the maintenance of Dolly Varden within Aullaviat/Aunguniarvik river systems. Climate change can be expected to influence the hydrology of the Yukon North Slope, due to changing precipitation and temperature regimes and melting permafrost. This may affect wintering and spawning habitats that are dependent upon ground water. The near-shore Beaufort Sea ecosystems are complex. Marine ice, water currents and water mixing regimes, biotic conditions, and seasonal timing of key events all may be affected by climate change and have significant effects on Dolly Varden and other fish (Carmack & Macdonald, 2002). Monitoring of Dolly Varden abundance, condition and winter habitat may become increasingly important, to identify important changes that affect how the harvest of the fish is managed and ensure sustainability.

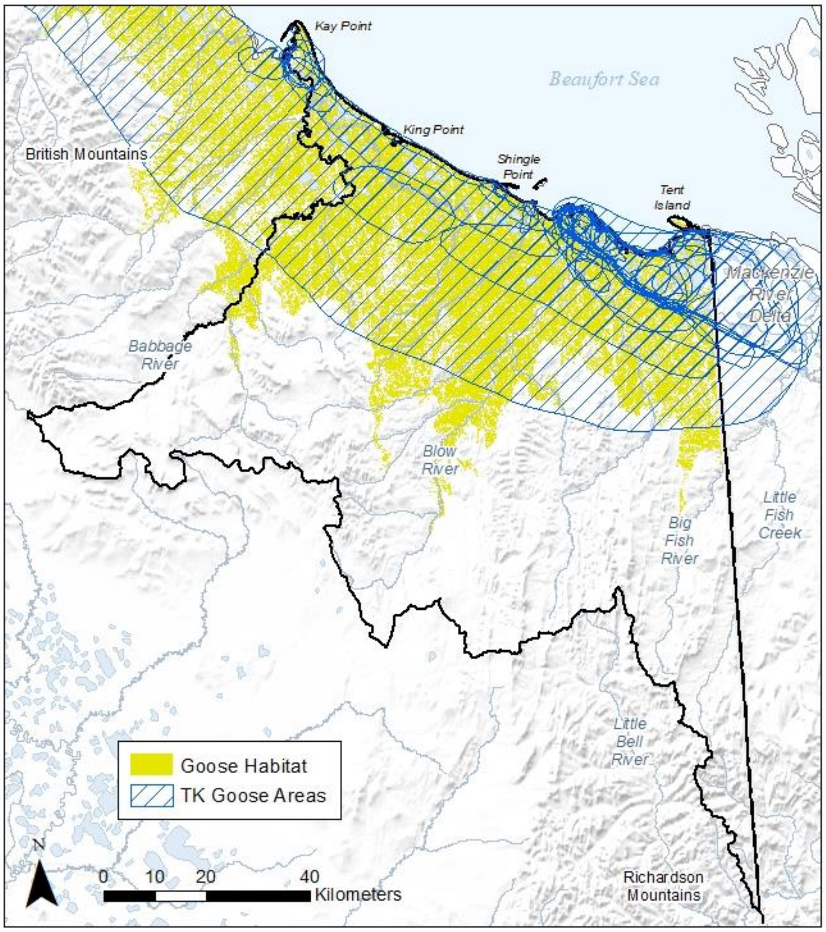
Geese

The Yukon North Slope provides important staging and stopover habitats for geese, particularly yellowlegs (greater white-fronted geese) and snow geese. Some areas are used by yellowlegs for nesting. The Delta wetlands and northern coastal plains of Aullaviat/Aunguniarvik are particularly important for geese. The Delta wetlands provide high quality foraging and nesting habitats, and the northern coastal plains support a mosaic of wetlands, small lakes and higher ground with excellent foraging opportunities. In particular, coastal and coastal plain habitats from Kay Point east were identified as important goose foraging and staging habitat by Inuvialuit land users. The most commonly identified areas were east of Tapqaq, and yellowlegs nesting habitats were predominately in the Delta habitats of Aullaviat/Aunguniarvik (WMAC (NS) & Aklavik HTC, 2018a).

Traditional knowledge-based habitat suitability models were developed to predict the distribution of nesting, foraging and staging habitats for geese (Round River Conservation Studies, 2018). The models predict between 66 and 82% of Yukon North Slope high quality goose habitats are found in Aullaviat/Aunguniarvik. These three seasonal models were combined to estimate the distribution of moderate and high-quality habitats for multiple goose life requisites. The resulting composite map (Map 4-8) shows 67% of the highest value habitats for goose are found in Aullaviat/Aunguniarvik. These same areas were mapped by Inuvialuit land users during traditional knowledge interviews, with the Delta wetlands identified repeatedly for their importance for geese (Map 4-8).

The Aklavik Community Conservation Plan (2016) identifies the Mackenzie Delta, including the portion falling within Aullaviat/Aunguniarvik, as significant migratory bird habitat, with a management designation of Category C (Box 1). Additional recognition of the importance of Aullaviat/Aunguniarvik for geese and other waterfowl is provided by the designation of coastal habitats from Kay Point to the eastern boundary of Aullaviat/Aunguniarvik as part of the Canada's Important Bird Areas (Birds Canada, n.d.).

Map 4- 5. Goose habitat areas predicted from traditional knowledge-based habitat models and identified during traditional knowledge interviews



Three habitat suitability index models were developed based on verbal descriptions provided by Aklavik Inuvialuit land users, predicting foraging, staging and nesting habitats. The yellow on the map shows the combined high and moderate habitats from these three habitat models. Polygons (blue lines) were drawn by the Inuvialuit land users to show important goose habitat areas. This map shows the importance of the coastal plains and the particularly high importance of the Delta wetlands as identified by multiple experts. Aullaviat/Aunguniarvik boundary shown in black.

Dall's sheep/Imnaiq

The northern Richardson Mountains supports an isolated population of Dall's sheep that are separate from other sheep populations and found at the northern limit of Dall's sheep range. The northern extent of this herd occupies southeastern portion of Aullaviat/Aunguniarvik and is the only known population on the Yukon North Slope outside Ivvavik National Park. Surveys and population estimates conducted since the mid-1980s indicate that the Dall's sheep population increased through the late 1990s, then experienced a decline and partial recovery. The most recent population survey in 2017 suggested a population size near 700 animals (Davison, Russell, & Belanger, 2018), which is close to historic population estimates (Yukon Environment, 2011). The northern Richardson sheep population is isolated, with the Ivvavik National Park sheep population over 200 km away and the southern Richardson Mountain population approximately 75km away (Yukon Environment, 2011). Thus, the opportunity for immigration and genetic mixing is slim or non-existent, but the isolation also may help protect the sheep population from respiratory illnesses or other significant diseases.

Dall’s sheep may be affected by climate change, including changing alpine vegetation, snow conditions and predator dynamics. In the face of climate change, northern populations of Dall’s sheep may become increasingly important for the viability of the species. The Northern Richardson Dall’s sheep population may be buffered from some of the climate impacts that more southern populations are likely to face, and its isolation may protect it from potential new disease or parasite threats.

Polar Bear/Nanuq

Polar bears require vast landscapes, though much of their life requisites are met on sea ice. Aullaviat/Aunguniarvik is part of the South Beaufort Sea (SB) subpopulation. Polar bears are a very important species to Inuvialuit for both traditional use and cultural reasons. Polar bear are listed federally as a species of special concern (COSEWIC, 2018).

Polar bears make extensive use of the near shore ice floes off the Yukon North Slope coast including off the Aullaviat/Aunguniarvik coast (Joint Secretariat, 2015; WMAC (NS) & Aklavik HTC, 2018a). Polar bears historically could meet most or all of their life requisites on the sea ice, including denning, though they also establish land-based dens along the coast (Joint Secretariat, 2015; WMAC (NS) & Aklavik HTC, 2018a) including known denning along the coast of Aullaviat/Aunguniarvik. Polar bears also travel overland, particularly along the coast. The Aullaviat/Aunguniarvik coastal area including the northern coastal plains is identified in the Aklavik Community Conservation Plan as mainland coastal polar bear denning area, designated as a Category C (defined in Box 1).

The SB polar bear subpopulation faces an uncertain future, with climate change causing profound changes in the extent of seasonal ice floes, which is their primary habitat. Climate change may also contribute to declines in ringed seals, the primary prey of polar bears (Harwood et al., 2015; Spear et al., 2019). Polar bears may shift their distribution to find alternative prey and den locations, potentially spending more time on land. This could increase competition for habitat and resources, impacting population stability and productivity (Fischbach, Amstrup, & Douglas, 2007; Mckinney, Atwood, Iverson, & Peacock, 2017).

Thus, conservation of polar bears under rapidly changing conditions caused by climate change may increasingly depend upon secure and intact coastal and near-coast inland habitats as well as near-shore marine systems, including within Aullaviat/Aunguniarvik. Likely, bears will be required to travel further to meet life requisites. Monitoring polar bear terrestrial use and movements is needed to understand how polar bear conservation requirements may also change.

Moose/Tuttuvak

Moose are relatively new to the Yukon North Slope, having expanded into the area from the Mackenzie Delta within the last 100 years (see Moose Companion Report). Moose are increasing in abundance in northern latitudes, as climate changes to vegetation increase the high quality browse they require, such as willow (Tape, Gustine, Ruess, Adams, & Clark, 2016). Traditional knowledge identifies that moose move seasonally in Aullaviat/Aunguniarvik: coastal areas are used primarily in the summer, with many of these animals migrating south into the Richardson Mountains and mountainous river valleys when snow has covered up shorter vegetation (WMAC (NS) & Aklavik HTC, 2018a).

Government of Yukon's Wildlife Key Areas (2014) identifies the Blow River, Rapid Creek, and the Big Fish River of Aullaviat/Aunguniarvik as important for moose, along with portions of the Babbage River on the boundary with Ivvavik National Park. The TK-based moose habitat model concurs and adds other rivers, creeks and willow-dominated habitats as important for moose across Aullaviat/Aunguniarvik. The major drainages and river valleys may also be important for seasonal migrations. There has been limited or no scientific research on the movements and habitat use patterns of moose in Aullaviat/Aunguniarvik but collar data from Ivvavik National Park suggests the importance of seasonal migration for northern moose populations.

Monitoring and research focused on moose within Aullaviat/Aunguniarvik would help fill significant information gaps about a species whose population appears to be changing relatively quickly in response to climate change. Moose may themselves subsequently drive changes, such as in predator-prey dynamics or vegetation effects, due to the ecological effect of the new and increasing numbers of these large-bodied ungulates on the landscape.

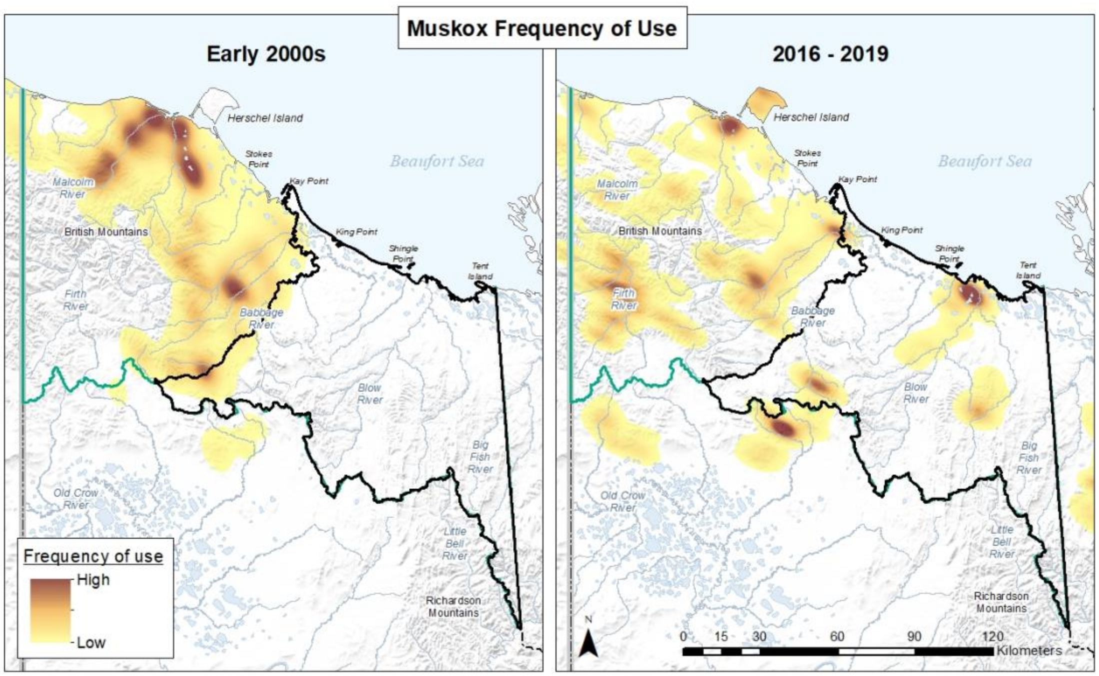
Muskox

Muskox disappeared from Alaska and Yukon in the mid 1800s and were successfully reintroduced to Alaska's Arctic National Wildlife Refuge in 1969-1970 (WMAC (NS), 2017, 2020). The population has grown to a current estimate of about 700 animals, with approximately half of these animals residing east of Alaska in the Yukon and NWT (Cuyler et al., 2019). It is estimated that approximately 400 muskoxen occur on the Yukon North Slope and in the Richardson Mountains (M. Suitor, personal communication, August 11, 2021). Muskox have been classified as Critically Imperilled/Imperilled (S1S2), following NatureServe criteria (Yukon Government, n.d.). Satellite collar monitoring suggests that muskox may be increasing their distribution in Aullaviat/Aunguniarvik (Map 4- 6), though this may be an artifact of collar bias. Regardless, muskox have been found in the area consistently, from the coastal plains to within the Richardson Mountains (Environment Yukon, unpublished data). Muskox distribution is scattered, and significant amounts of predicted high quality habitat appear to be currently unoccupied

(Carter, 2020) (Map 4- 7). Given that muskox have vulnerable status in Yukon, Aullaviat/Aunguniarvik is important as an area that offers secure and suitable landscapes to support their conservation.

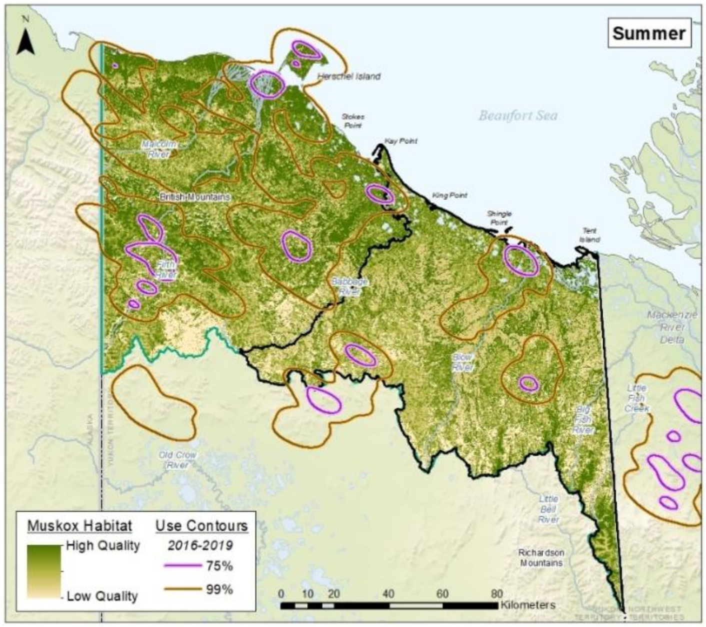
Currently, muskox in Aullaviat/Aunguniarvik are only occasionally harvested by Inuvialuit. Regional ties to this species were effectively severed by the 100 years of muskox absence. Still, Inuvialuit have expressed a consistent and keen interest in understanding muskox status and ecology on the Yukon North Slope, and a research plan has been developed to guide future research (WMAC (NS), 2019).

Map 4- 6. Frequency of use distributions of muskoxen in the early 2000s and between 2016-2019



The frequency of use by muskoxen are based on the locations of collared animals: 14 animals in early 2000s and 24 animals in late 2000s (2016-2019). The darker (brown) areas indicate the highest density of locations and therefore the most intensely used areas. Lighter areas show less intensely used areas. Aullaviat/Aunguniarvik boundary is shown in black.

Map 4- 7. Predicted habitat for muskoxen and distribution of muskoxen across the Yukon North Slope, based on GPS collared animals

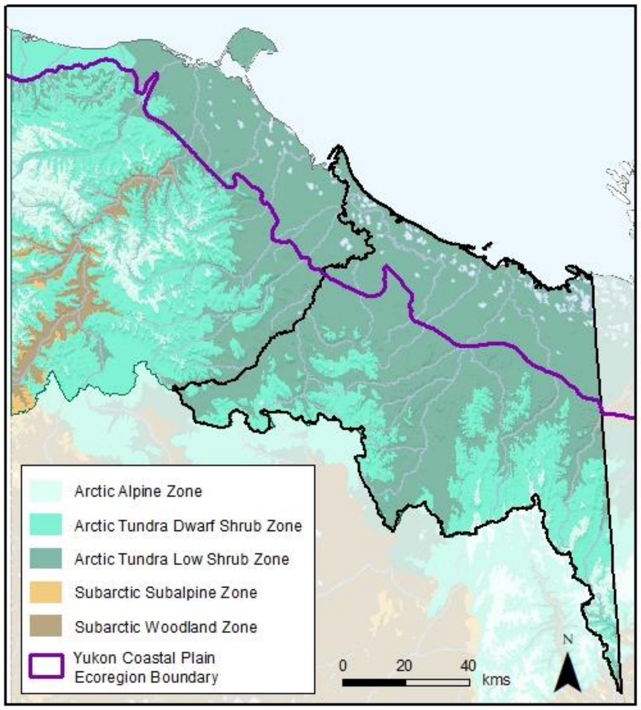


Muskox habitat model shown above was developed from data on 24 GPS collared muskox collected between 2016-2019, with the distribution of muskox also shown. The 75% distribution indicates the area in which 75% of muskox locations were found, and the 99% shows where 99% of the locations were found. Most muskox groups included a GPS collared individual, suggesting these areas are representative of recent muskox distribution. Aullaviat/Aunguniarvik boundary is shown in black.

Ecological Communities of Aullaviat/Aunguniarvik

The Yukon North Slope and Aullaviat/Aunguniarvik are predominately classified into two major ecological regions, identified as the Yukon Coastal Plains and the British-Richardson Mountains by the Ecological Land Classification (ELC) system (Statistics Canada, 2018). The Yukon Ecological Land Classification (YELC) broadly identifies similar ecological associations, but refines the classification of ecosystems that dominate the coastal plains to cover a much more extensive area of the Yukon North Slope than the Canadian system identifies (Map 4- 8). It identifies a single YELC zone for the coastal plains called 'Arctic tundra low shrub'. It breaks the mountain region into two ecological classes: 'Arctic tundra dwarf shrub' and 'Arctic alpine' zones. It shows the coastal plains ecosystems extending south within major river valleys that bisect the southern mountains (Environment Yukon, 2016). Ivvavik National Park has an additional YELC class along the Firth River called the 'Subarctic woodland zone,' which is not present in any significant amount in Aullaviat/Aunguniarvik.

Map 4- 8. Major Ecological Land Classifications within the Yukon North Slope



Major ecosystems have been defined across Canada, and identify two dominant ecoregions in Aullaviat/Aunguniarvik: Yukon coastal plains and the British-Richardson Mountains; the purple line shows the boundary between the two ecoregions. The Yukon Biogeoclimatic Ecosystem Classification (see legend) identifies a broader swath of tundra low-shrub ecosystems across the coastal plains, extending south along the major river valleys, transitioning to dwarf shrub ecosystems and eventually to alpine ecosystems. The Aullaviat/Aunguniarvik boundary is shown in black.

In the north, marine and estuary systems of the Beaufort Sea include wetland complexes of the Mackenzie Delta (the Delta) on the east side of Aullaviat/Aunguniarvik (Map 4- 9), and the shoreline complex of inlets, bays, spits, cliffs and beaches including significant coastal features such as Shingle Point, Trent Bay and Kay Point. These rich nearshore marine ecosystems support the cultural and ecological systems of the coastal regions of Aullaviat/Aunguniarvik. Moving south from the coast, a broad swath of lowland coastal plains is dominated by a mosaic of tussock tundra wetland ecosystems and numerous lakes, interspersed with streams, rivers and associated riparian habitats. Further inland, the coastal plains gradually rise. Lakes and standing water are not so abundant, and the plains eventually transition into the foothills and the mountainous terrain of the Richardson Mountains. Two major river valleys bisect the mountain range.

The coastal plains, which are dominated by cottongrass tundra ecosystems, have a short but highly productive summer (Map 4- 10), and the highest peak greenness index measured on the Yukon North Slope, even though the delayed onset and early senescence of vegetation on the coastal plains suggests a shorter growing season as compared to more mountains portions of the Yukon North Slope (Berner, L.T., P. Jantz, K.D. Tape, 2018; Berner, Jantz, Tape, & Goetz, 2018). The high productivity of the coastal plains undoubtedly contributes to the high cultural and ecological values of Aullaviat/Aunguniarvik.

Figure 4- 1. An example of coastal habitat in Aullaviat/Aunguniarvik

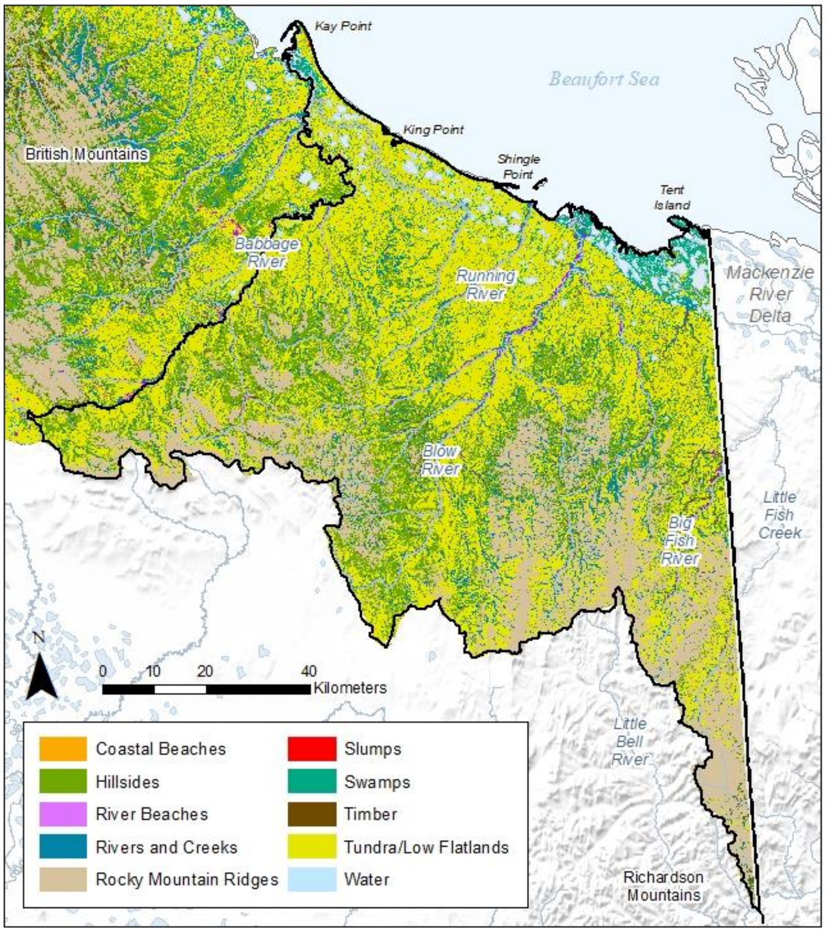
©Michelle Gruben, 2016.

The Richardson Mountains form the southern portion of Aullaviat/Aunguniarvik, with the southern boundary defined by the east-west trending divide of this mountain range. The Richardson Mountains support dwarf shrub complexes on the lower and mid-slopes, and lichen and herbaceous communities at their highest elevations (Map 4- 9). Occasional stands of conifer are found primarily along the river corridors as well as south-facing slopes of tributaries in the Richardson Mountains.

Figure 4- 2. Admiring the view near the Blow River Pass in Aullaviat/Aunguniarvik

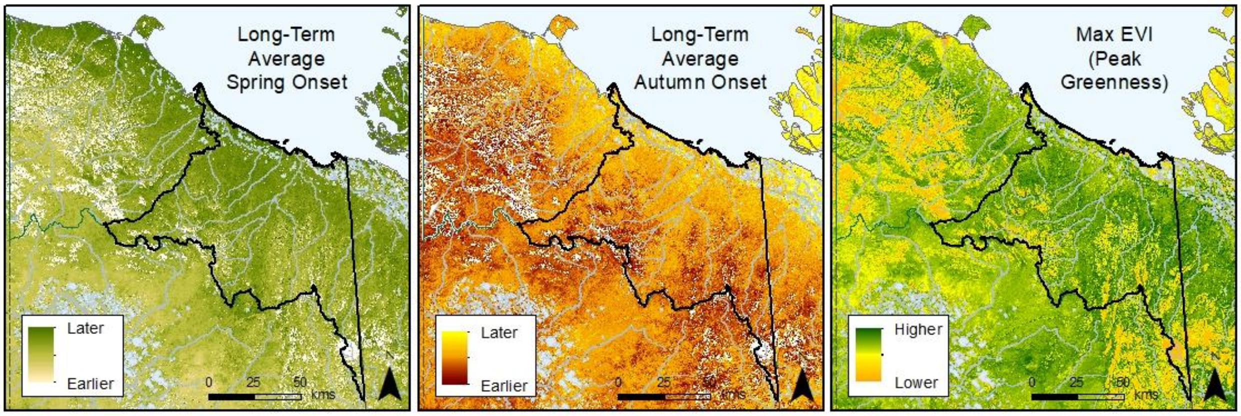
©Parks Canada/Jay Frandsen, 2020.

Map 4- 9. Major ecosystems of the Yukon North Slope, classified by Inuvialuit



The Inuvialuit used the Predictive Ecosystem Classification that identified 27 fine-scale ecosystems across the Yukon North Slope to identify 10 traditional knowledge-based ecosystems that succinctly capture the major ecological diversity of the area. Aullaviat/Aunguniarvik boundary is shown in black. Source: (WMAC (NS) & Aklavik HTC, 2018a)

Map 4- 10. Seasonal greenness indexes for the Yukon North Slope, capturing patterns of vegetation productivity



The above maps show spring onset (green-up), autumn onset (senescence), and peak greenness (EVI) (Berner, L.T., P. Jantz, K.D. Tape, 2018; Berner et al., 2018). These show that the coastal plains and river valleys dominated by arctic tundra ecosystems have a short growing season but still are highly productive, with high EVI values. Aullaviat/Aunguniarvik boundary is shown in black.

There are two major valleys that dissect the Richardson Mountains within Aullaviat/Aunguniarvik: the Babbage River that forms the eastern boundary with Ivvavik National Park; and the Blow River, with a broad river valley that divides the Richardson Mountains. These river systems and the passes they have formed through the Richardson Mountains connect the coast and coastal plains to the Old Crow basin to the south. They are almost certainly important wildlife movement corridors. These two rivers receive a significant portion of the freshwater flowing from Aullaviat/Aunguniarvik. Other major rivers of Aullaviat/Aunguniarvik include the Running River, which terminates at the Beaufort Sea along the coast, and the Big Fish River, with headwaters in the eastern Richardson Mountains of Aullaviat/Aunguniarvik, draining east from the Yukon North Slope to terminate in the Mackenzie Delta.

Figure 4- 3. Running River, one of the major rivers in Aullaviat/Aunguniarvik

©Cameron Eckert, 2014.

Regional Connectivity and Conservation

Aullaviat/Aunguniarvik provides critical ecological connectivity and core habitats within a larger matrix of conserved landscapes of the western Arctic region of North America (Map 4- 1). To the west lies Ivvavik National Park and Herschel Island-Qiqiktaruk Territorial Park and beyond that, Alaska's Arctic National Wildlife Refuge. To the south, Aullaviat/Aunguniarvik is adjacent to Vuntut National Park, Daadzaii Van Territorial Park and the Old Crow Flats Special Management Area. To the north lies the Beaufort Sea, with the Tarium Niryutait Marine Protected Area abutting the shores of Aullaviat/Aunguniarvik. This estuary area of the Mackenzie Delta provides important calving habitat for beluga whales. The Mackenzie Delta, which is primarily within Northwest Territories, is North America's largest arctic delta and the terminus of Canada's largest river, the Mackenzie River, as well as the Peel River. The Mackenzie Delta is a vast and largely intact complex of wetlands, rivers, lakes and low-lying uplands that support high arctic biodiversity.

Aullaviat/Aunguniarvik is also a corridor for Inuvialuit. Historically, and still today, Inuvialuit move through this landscape to connect with people and places on the Yukon North Slope and beyond. This includes travelling to gathering spaces, like Tapqaq, and visiting relatives in Alaska. Traditional use across this landscape is described above.

With Aullaviat/Aunguniarvik located centrally amongst a regional complex of important and protected landscapes, multiple other wide-ranging species (e.g., grizzly bear) not only rely upon

Aullaviat/Aunguniarvik for quality habitat, but also for connectivity to adjacent secure or otherwise vital ecosystems.

Additional Conservation Values

Listed Species Found in Aullaviat/Aunguniarvik

In addition to the species featured in this chapter and in the *Yukon North Slope Wildlife Conservation and Management Plan*, there are a number of plant and animal species that occur in Aullaviat/Aunguniarvik that are designated as federal Species at Risk. Addressing all species is not within the scope of the Plan and Companion Reports; however, it is expected that the conservation requirements identified for featured species in Aullaviat/Aunguniarvik will contribute to conservation of species at risk in the region.

Table 4- 1. Species on the Yukon North Slope that have been assessed and/or listed under the federal *Species at Risk Act*, as of spring 2021

Species (SARA designatable unit)	COSEWIC / SARA Schedule 1 (listing) Status	Recovery Document (if available)
Caribou (Barren ground populations)	Assessed by COSEWIC as Threatened (2016); under consideration for listing	n/a – species is not legally listed
Grizzly Bear (Western population)	Assessed by COSEWIC as Special Concern (2012); listed as Special Concern (2018)	SARA Management Plan under Development
Polar Bear	Assessed by COSEWIC as Special Concern (2008, 2018); listed as Special Concern (2011)	SARA Management Plan under development
Dolly Varden (Western Arctic populations)	Assessed by COSEWIC as Special Concern (2010); listed as Special Concern (2017)	SARA Management Plan under development
Beluga (Eastern Beaufort population)	Assessed by COSEWIC as Not at risk (2004)	n/a – species is not legally listed
Peregrine falcon (*Anatum tundrius* population)	Assessed by COSEWIC as Not at risk (2017); listed as Special Concern (2012)	Management Plan for the Peregrine Falcon anatum/tundrius (*Falco peregrinus anatum/tundrius*) in Canada (2017)
Buff-breasted sandpiper	Assessed by COSEWIC as Special Concern (2012); listed as Special Concern (2017)	SARA Management Plan under Development
Wolverine	Assessed by COSEWIC as Special Concern (2014); listed as Special Concern (2018)	SARA Management Plan under Development
Collared Pika	Assessed by COSEWIC as Special Concern (2011); listed as Special Concern (2017)	SARA Management Plan under Development
Red-necked Phalarope	Assessed by COSEWIC as Special Concern (2014); listed as Special Concern (2019)	SARA Management Plan under Development

Hudsonian Godwit	Assessed by COSEWIC as Threatened (2019); under consideration for listing	n/a – species is not legally listed
Lesser Yellowlegs	Assessed by COSEWIC as Threatened (2020)	n/a – species is not legally listed
Horned Grebe	Assessed by COSEWIC as Special Concern (2009); listed as Special Concern (2017)	SARA Management Plan under Development
Bank Swallow	Assessed by COSEWIC as Threatened (2013); listed as Threatened (2017)	SARA Recovery Strategy under Development
Short-eared Owl	Assessed by COSEWIC as Threatened (2021); listed as Special Concern (2012)	Management Plan for the Short-eared Owl (Asio flammeus) in Canada (2018)
Transverse Lady Beetle	Assessed by COSEWIC as Special Concern (2016); under consideration for listing	n/a – species is not legally listed
Gypsy Cuckoo Bumble Bee	Assessed by COSEWIC as Endangered (2014); listed as Endangered (2018)	SARA Recovery Strategy under Development
Grey Whale	Assessed by COSEWIC as Special Concern (2017); under consideration for listing	n/a – species is not legally listed
Ringed Seal	Assessed by COSEWIC as Special Concern (2019); under consideration for listing	n/a – species is not legally listed

Uncommon Ecosystems of the Yukon North Slope

Predictive Ecosystem Mapping (PEM) identified 27 ecosystems within Aullaviat/Aunguniarvik, with many of these ecosystems being common across the Yukon North Slope. There are three notable ecosystems that occur in relatively limited distributions across the Yukon North Slope (covering less than 5% of the area) with the majority (61-93%) of that distribution within Aullaviat/Aunguniarvik (Aullaviat/Aunguniarvik covers 43% of the YNS area). Below, these relatively rare ecosystems are shown (Figure 4-1) and briefly described (Ivvavik PEM fact sheets, unpubl. data).

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.

Figure 4- 4. Photos of Predictive Ecosystem Model ecosystem classes that are relatively rare on the YNS and predominately found within Aullaviat/Aunguniarvik

PEM predicts the distribution of 28 ecosystems across the YNS, with 27 of these classes found within Aullaviat/Aunguniarvik. Three of these classes are relatively rare ecosystems with a significant proportion of their Yukon North Slope distribution found within Aullaviat/Aunguniarvik: a) herb-willow riparian; b) alder-cottongrass tussock bog; and c) heather nivation slope.

Herb-willow riparian: This is a willow floodplain habitat that is not very common. It grows along streams and is usually flooded each year. This association is found on gradual receiving slopes at a range of elevations, from sea level to 600m. This ecosystem covers an estimated 0.7% of the Yukon North Slope, and 93% of its occurrence is within Aullaviat/Aunguniarvik.

Alder-cottongrass tussock bog: These areas of shallow peat moss (20-30 cm) are found from the coast to elevations of 600 m. This ecosystem has dwarf birch, cranberries, tussock cottongrass and alder. This association is found on gradual receiving slopes at a range of elevations, from sea level to 600m. This ecosystem covers 1.7% of the YNS, with 85% of its distribution in the Yukon North Slope occurring in Aullaviat/Aunguniarvik.

Heather nivation slope: This habitat may be called Arctic or Alpine heather snowbeds. Heather snowbeds are found in areas where snow accumulates and takes a long time to melt. This ecosystem type can be identified because the snow that accumulates over winter doesn't melt until July or August. It is often at higher elevation and/or in shady areas (cool and east facing aspects). This ecosystem type tends to be small and patchy and is too cold for tree or tall shrub growth. Mountain-heather plants are always found in these ecosystems. Small willows often grow under the snowbeds but there is a lot of bare ground as well. Due to the late snow melt, these sites remain wet for much of the year. This PEM class covers an estimated 3.6% of the Yukon North Slope, with 61% of this distribution within Aullaviat/Aunguniarvik.

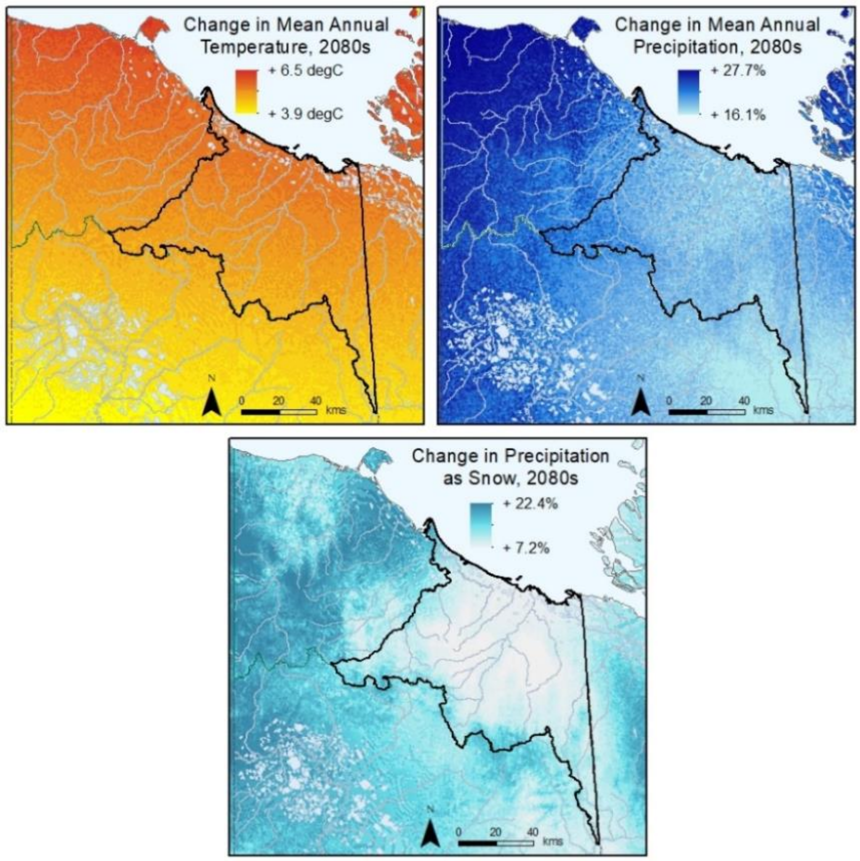
Climate Change Impacts to Aullaviat/Aunguniarvik

Climate change is a significant and challenging impact facing Aullaviat/Aunguniarvik and all of the Arctic. Current and predicted climate change effects to the Yukon North Slope are summarized in Companion Report 3. Predicting the impacts ahead is a difficult task, as climate change is a global process and impacts occur at different scales, from the local up to the global. Still, we can cautiously predict some impacts to Aullaviat/Aunguniarvik and interpret those predictions to understand what challenges lay ahead for conservation of wildlife, habitat and traditional use of the area.

Global circulation models are used to predict patterns in temperature and precipitation under varying climate change models; these global models can be downscaled to predict changing conditions at regional levels (Wang, Hamann, Spittlehouse, & Carroll, 2016; Wang, Hamann, Spittlehouse, & Murdock, 2012). Temperature increases are expected to occur more rapidly at higher latitudes. This predicted pattern holds true at the regional scale for the Yukon North Slope (Map 4- 11, upper left). When it comes to predicted changes in precipitation patterns, Aullaviat/Aunguniarvik is expected to experience fewer changes to precipitation (including snowfall) than neighbouring regions, such as Ivvavik National Park (Map 4- 11, upper right and lower respectively).

Modeling has been completed to provide insights into the vulnerability of Yukon North Slope ecosystems and wildlife to climate changes. Terrestrial resilience models predict the potential availability of climate refuges, which provide local refuge and favourable conditions for plants and animals even as the larger landscape changes (Buttrick et al., 2015). Climate refuges may be found in topographically diverse ecosystems because aspect, slope and other diversity provide microclimates that can serve as refuges for plants and animals as climate conditions change. These models predict that the coastal plain is particularly vulnerable to climate change. This is partly due to a lack of substantive climate refugia within this ecosystem (see Box on this in climate chapter). The relatively flat topography of the coastal plains limits the likelihood of diverse microclimates that may act as ecological refuges in a changing climate.

Map 4- 11. Predicted mean annual temperature, precipitation, and precipitation falling as snow in the Yukon North Slope in the 2080s



Downscaled global climate predictions provide regional patterns of predicted change in temperature and precipitation, as well as derived variables including the percent of precipitation falling as snow. These are predicted based on the A2 emissions scenario and a 23 global circulation model ensemble (Hamann, n.d.). Aullaviat/Aunguniarvik boundary is shown in black.

In another analysis, shifts in broad 'cliomes' were modeled (Rowland, Fresco, Reid, & Cooke, 2016; SNAP, 2012), providing additional insight into the types of changes that may be expected for the Yukon North Slope and Aullaviat/Aunguniarvik. Cliomes were identified as areas of broadly similar climate and vegetation patterns. Eight different cliomes were mapped in Aullaviat/Aunguniarvik. Future scenarios suggest that Aullaviat/Aunguniarvik will be largely dominated by two cliomes, indicating a simplification of the diversity currently found in Aullaviat/Aunguniarvik. These two dominant cliomes indicate that the coastal plains may become dominated by open shrub habitats, while the mountainous southern region transitions to a boreal forest cliome. Increasing cliome shifts suggest higher ecological stress (Map 2-4, climate change chapter). The modeling suggests that changes in the coastal plains, while pronounced, represent only one shift in cliome, and this shift is primarily an expansion of shrubby ecosystems already present in the area. The foothills are predicted to experience the greatest absolute change, with three shifts in cliomes, including some conifer-dominated ecosystems. The southern mountains are predicted to experience two shifts in cliomes, towards a boreal forest dominated landscape.

These varying approaches to understanding the effects of climate change provide different insights into future potential changes in Aullaviat/Aunguniarvik. The coastal plains may experience relatively less 'ecological stress', as indicated by shifting cliomes, but for species specialized and strictly dependent on the current coastal plains ecosystems, there will be few ecological refuges to support them. With the Beaufort Sea as a northern border, there may be few places for them to migrate seeking ecological niches. Alternatively, the more topographically complex foothills and mountains in the southern region may experience greater change, but will also provide greater diversity of local climate refuges for plants and animals.

The most powerful mitigation to the impacts of climate change is the maintenance of healthy, resilient and connected landscapes. The intact nature of the Yukon North Slope and Aullaviat/Aunguniarvik provides the opportunity for plants and animals to shift in distribution as ecological conditions change.

Conservation Designations of Aullaviat/Aunguniarvik

There are a number of existing conservation designations that support the maintenance of Aullaviat/Aunguniarvik ecological and cultural values, with variable leverage to secure these values. A number of policy and management tools also contribute to the maintenance of Aullaviat/Aunguniarvik, as outlined in Table 12 of the *Yukon North Slope Wildlife Conservation and Management Plan*.

Inuvialuit Final Agreement Withdrawal Order

The strongest current conservation status for Aullaviat/Aunguniarvik is through the Inuvialuit Final Agreement (IFA), which established a 'withdrawal order' that removes the area from surface or subsurface development, including mineral disposition, by Order-in-Council, subject to provisions that allow consideration of developments compatible with the conservation of wildlife, habitat and Inuvialuit use. These Orders-in-Council have been in place since 1980; the IFA states that they shall be maintained.

Aklavik Community Conservation Plan designations

The most recent Aklavik Community Conservation Plan (CCP) was completed in 2016 (Aklavik HTC et al., 2016), and identified special area designations based on important wildlife habitat and harvesting areas. There are five categories of designation, with three being of highest conservation significance: Categories C and D indicate areas of particular significance and sensitivity, and Category E identifies areas of extreme significance (Box 1).

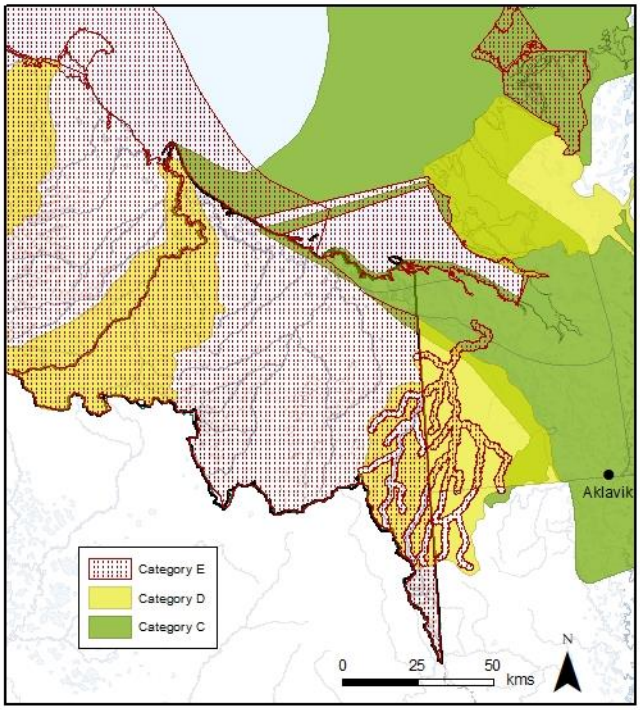
The CCP identifies Aullaviat/Aunguniarvik as Category E, along with the nearshore waters and Ivvavik National Park, the riparian zone of the Big Fish River, and the nearshore and marine area of Tarium Niryutait Marine Protection Area (Map 4- 12).

The CCP also identifies a number of areas in Aullaviat/Aunguniarvik as Categories C and D. These include the Babbage River watershed in the west, the Fish Hole and Big Fish River watersheds in the southeast region. The northern portion of the coastal plains and the coastline across the extent of Aullaviat/Aunguniarvik are identified for polar bear denning, and the Delta wetlands for migratory bird habitat, grizzly bear and polar bear denning, and subsistence harvest.

Box 1: Conservation designations of the Aklavik Community Conservation Plan

Category A: Lands and waters where there are no known significant and sensitive cultural or renewable resources. Lands and waters shall be managed according to current regulatory practices.
Category B: Lands and waters where there are cultural or renewable resources of some significance and sensitivity but where terms and conditions associated with permits and leases shall assure the conservation of these resources.
Category C: Lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year. These lands and waters shall be managed so as to eliminate, to the greatest extent possible, potential damage and disruption.
Category D: Lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year. As with Category C, these areas shall be managed so as to eliminate, to the greatest extent possible, potential damage and disruption.
Category E: Lands and waters where cultural or renewable resources are of extreme significance and sensitivity. There shall be no development on these areas. These lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption. This category recommends the highest degree of protection in this document.

Map 4- 12. Aklavik Community Conservation Plan conservation areas within Aullaviat/Aunguniarvik



The 2016 Aklavik Community Conservation Plan identifies areas of conservation priority including Category C, D, and E classifications that identify areas important for sensitive values. Category E is the highest conservation category. The Plan identifies the entirety of Aullaviat/Aunguniarvik as Category E, as well as the riparian zone of the Big Fish Watershed. Other regions within Aullaviat/Aunguniarvik are also identified as C or D category land. Aullaviat/Aunguniarvik boundary is shown in black.

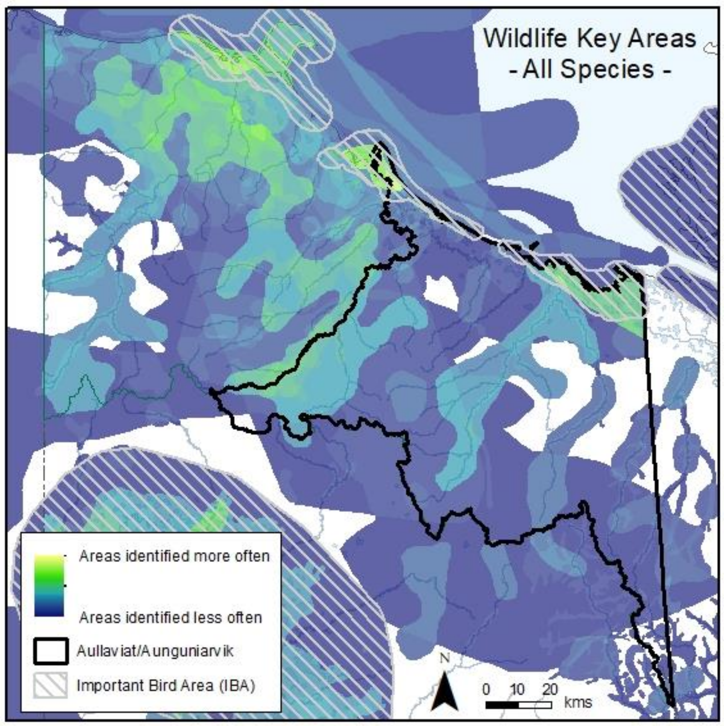
Wildlife Key Areas

The Yukon Government has developed a spatial database of areas or locations “used by wildlife for critical, seasonal life functions” (Government of Yukon, 2014, p.3). These spatial data are based on surveys as well as local knowledge. Areas are identified in Aullaviat/Aunguniarvik for a wide diversity of species, ranging from whales off-shore to Dall’s sheep in the Richardson Mountains (Map 4- 13). The Delta wetlands in the northeast portion of Aullaviat/Aunguniarvik, as well as some coastal and coastal plains areas are identified for nesting, staging, foraging and/or moulting for a diversity of birds including ducks, geese, gulls, swans, and shorebirds. Raptor, polar bear, wolf and fox denning areas are noted, and seasonal or annually important areas for muskox, moose, Dall’s sheep, and seals are mapped. This database provides an additional source of information to understand the biodiversity and wildlife values of Aullaviat/Aunguniarvik, and provides further evidence of the conservation importance of Aullaviat/Aunguniarvik.

Important Bird Areas

Important Bird Areas (IBA) is an international initiative that uses standardized criteria to identify areas of international significance for the conservation of birds and biodiversity, and provides information and tools for conservation. In Canada, IBAs are identified through a collaboration of multiple non-governmental organizations (www.ibacanada.org). There are two IBAs along the Aullaviat/Aunguniarvik coast, which cover nearly the entire length of the coastline (Map 4- 13).

Map 4- 13. Important Bird Areas and Yukon Wildlife Key Areas identified across the Yukon North Slope



Yukon Wildlife Key Areas (WKAs) are identified for multiple species and species groups. This map shows the spatial extent of all the combined WKAs with lighter shades of color showing where multiple WKAs overlap. Also shown are the Important Bird Areas along the coast. Aullaviat/Aunguniarvik boundary is shown in black.

Conclusions

This companion report presents information from Western science, traditional use and traditional knowledge studies on a suite of ecological and cultural values found in Aullaviat/Aunguniarvik. The information presented is in support of the *Yukon North Slope Wildlife Conservation and Management Plan*, which recognizes the importance of

Aullaviat/Aunguniarvik for all these values. The Plan focuses in particular on the importance of the region for: Inuvialuit traditional use, Porcupine Caribou herd calving and mid-summer habitats, Dolly Varden, and geese. The *Yukon North Slope Wildlife Conservation and Management Plan* also recognizes the regional importance of the area in light of the conservation status of neighbouring regions and their importance for featured species and Inuvialuit traditional use.

In particular, it is clear that Aullaviat/Aunguniarvik is vital to the maintenance of Inuvialuit traditional use, for providing critical habitats for the Porcupine Caribou Herd, and as a key landscape within the northern conservation complex of existing conservation areas. These values span the extent of Aullaviat/Aunguniarvik. Inuvialuit traditional use is concentrated near the coast, although use does occur throughout the region. The Porcupine Caribou herd relies on mid-summer habitat and migration corridors across the central and southern part of Aullaviat/Aunguniarvik. Inuvialuit traditional use of the Yukon North Slope is deeply intertwined with the health and annual movements of the Porcupine Caribou herd. The conservation of Aullaviat/Aunguniarvik also ensures caribou calving habitats are maintained to their fullest extent, providing the Porcupine Caribou Herd the flexibility required in an uncertain future. Considering these and other key values such as the critical habitats provided for grizzly bear, geese, and Dolly Varden, provides a compelling case for conservation.

Equally important is the contribution that Aullaviat/Aunguniarvik provides to the regional conservation system. Aullaviat/Aunguniarvik is surrounded by a matrix of territorial and national parks and marine conservation areas.

The regional values that would be at risk if Aullaviat/Aunguniarvik were functionally degraded are harder to map and identify: the free movement of plants and animals, including iconic species like caribou and grizzly bear, as well as innumerable lesser-studied and unmapped species of plants and animals that form Arctic ecological communities. The ecological integrity of Aullaviat/Aunguniarvik provides both high quality habitats for a multitude of species, as well as the opportunity for these species to move if their life requisites shift due to climate change. Indeed, the maintenance of large, connected, healthy landscapes is the best strategy for supporting ecological resilience.

Aullaviat/Aunguniarvik has already been designated under the highest conservation classification within the Aklavik Community Conservation Plan (2016), a clear indication of the interests and intent of Inuvialuit. Through the IFA, a withdrawal order is in place that protects Aullaviat/Aunguniarvik from industrial activities that would be incompatible with the IFA's stated conservation goals for the Yukon North Slope. Policies and statutes from multiple organizations and governments support the conservation vision for Aullaviat/Aunguniarvik, although these are piecemeal.

Formalizing the conservation intent of the Inuvialuit for Aullaviat/Aunguniarvik has been recommended by the WCMP, potentially through the development of an Indigenous Protected and Conserved Area or similar. Such a designation would also provide the foundation for greater Inuvialuit governance of Aullaviat/Aunguniarvik, and advance territorial and federal recognition of the special status of Aullaviat/Aunguniarvik. A formalized designation would contribute towards Canada's goal and commitments to conserve nature, part of Canada's international commitments to the United Nations *Convention on Biological Diversity* (1992), and commitments to reconciliation with Indigenous Peoples pursuant to Canada's *United Nations Declaration on the Rights of Indigenous Peoples Act* (2021).

References

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

Barboza, P. S., Van Someren, L. L., Gustine, D. D., & Syndonia Bret-Harte, M. (2018). The nitrogen window for arctic herbivores: Plant phenology and protein gain of migratory caribou (Rangifer tarandus). *Ecosphere*, *9*(1). https://doi.org/10.1002/ecs2.2073

Berner, L.T., P. Jantz, K.D. Tape, S. J. G. (2018). *ABoVE: Gridded 30-m Aboveground Biomass, Shrub Dominance, North Slope, AK, 2007-2016*. Oak Ridge, Tennessee, USA.: ORNL DAAC.

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

Birds Canada. (n.d.). IBA Canada: Important Bird Areas. Retrieved from https://www.ibacanada.ca/mapviewer.jsp?lang=EN

Buttrick, S., Popper, K., Schindel, M., McRae, B., Unnash, B., Jones, A., & Platt, J. (2015). *Conserving Nature's Stage: Identifying Resilient Terrestrial Landscapes in the Pacific Northwest*. Retrieved from http://nature.ly/resilienceNW

Carmack, E. C., & Macdonald, R. W. (2002). Oceanography of the Canadian shelf of the Beaufort Sea: A setting for marine life. *Arctic*, *55*(SUPPL. 1), 29–45.

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

COSEWIC. (2018). *Assessment and Status Report on the Polar Bear Ursus maritimus in Canada*. Committee on the Status of Endangered Wildlife in Canada.

Cuyler, C., Rowell, J., Adamczewski, J., Anderson, M., Blake, J., Bretten, T., … Ytrehus, B. (2019). Muskox status, recent variation, and uncertain future: Electronic supplementary material. *Ambio*, 1–30.

Davison, T., Russell, K., & Belanger, E. (2018). *Survey of Dall's Sheep in the Northern Richardson Mountains: June, 2017*. Retrieved from Government of the Northwest Territories website: https://www.enr.gov.nt.ca/sites/enr/files/resources/274_manuscript_survey_of_dalls_sheep_in_the_northern_richardson_mountains_june_2017.pdf

DFO (Department of Fisheries and Oceans Canada), Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada. (2019). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope. Volume 1: The Plan–2019 Update*. Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, and Parks Canada Agency.

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.

Fischbach, A. S., Amstrup, S. C., & Douglas, D. C. (2007). Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. *Polar Biology*, *30*(11), 1395–1405. https://doi.org/10.1007/s00300-007-0300-4

Government of Yukon. (2014). *Yukon Wildlife Key Area Inventory User's Manual*. Retrieved from http://www.environmentyukon.ca/maps/view/type/2/

Hamann, A. (n.d.). Current and projected climate data for western North America (ClimateWNA). Retrieved from https://sites.ualberta.ca/~ahamann/data/climatewna.html

Harwood, L. A., Smith, T. G., George, J. C., Sandstrom, S. J., Walkusz, W., & Divoky, G. J. (2015). Change in the Beaufort Sea ecosystem: Diverging trends in body condition and/or production in five marine vertebrate species. *Progress in Oceanography*, *136*, 263–273. https://doi.org/10.1016/j.pocean.2015.05.003

Joint Secretariat. (2015). *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Joint Secretariat, Inuvialuit Settlement Region.

Mckinney, M. A., Atwood, T. C., Iverson, S. J., & Peacock, E. (2017). Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use. *Ecosphere*, *8*(1). https://doi.org/10.1002/ecs2.1633

Morrison, C. M. (2017). *Life history strategies of northern form Dolly Varden (Salvelinus malma malma) in the western Canadian Arctic*. 1–114.

Round River Conservation Studies. (2018). *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-based Goose Habitat Model (Draft report for review)*.

Rowland, E. L., Fresco, N., Reid, D. G., & Cooke, H. A. (2016). Examining climate-biome ("cliome") shifts for Yukon and its protected areas. *Global Ecology and Conservation*, *8*, 1–17. https://doi.org/10.1016/j.gecco.2016.07.006

Severson, J. P., Johnson, H. E., Arthur, S. M., Caikoski, J., Leacock, W. B., & Suitor, M. J. (2021). Spring Phenology Drives Range Shifts in a Migratory Arctic Ungulate with Key Implications for the Future. *Global Change Biology*, *00*, 1–18.

SNAP. (2012). *Predicting Future Potential Climate-Biomes for the Yukon, Northwest Territories, and Alaska*. https://doi.org/10.1097/00019052-200008000-00006

Spear, A., Duffy-Anderson, J., Kimmel, D., Napp, J., Randall, J., & Stabeno, P. (2019). Physical and biological drivers of zooplankton communities in the Chukchi Sea. *Polar Biology*, *42*(6), 1107–1124. https://doi.org/10.1007/s00300-019-02498-0

Statistics Canada. (2018). *Ecological Land Classification, 2017.* Retrieved from https://www.statcan.gc.ca/eng/subjects/standard/environment/elc/12-607-x2018001-eng.pdf

Stephenson, S. A. (2003). *Local and Scientific Observations of Dolly Varden (Salvelinus malma) (W.) in the Big Fish River, Northwest Territories, Canada: 1995-2002*. Canadian Manuscript Report of Fishieries and Aquatic Sciences 2644.

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

Triska, M., & Heinemeyer, K. (2020). *Yukon North Slope Grizzly Bear Seasonal Habitat Models*. Round River Conservation Studies.

Wang, T., Hamann, A., Spittlehouse, D., & Carroll, C. (2016). Locally downscaled and spatially customizable climate data for historical and future periods for North America. *PLoS ONE*, *11*(6), 1–17. https://doi.org/10.1371/journal.pone.0156720

Wang, T., Hamann, A., Spittlehouse, D. L., & Murdock, T. Q. (2012). ClimateWNA-high-resolution spatial climate data for western North America. *Journal of Applied Meteorology and Climatology*, *51*(1), 16–29. https://doi.org/10.1175/JAMC-D-11-043.1

WMAC (NS). (2017). *Framework for the Management of Yukon North Slope Muskox*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS). (2019). *Yukon North Slope and Richardson Mountains Muskox Research Plan*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS). (2020). *Muskox Fact Sheets*. Retrieved from https://wmacns.ca/resources/muskox-fact-sheets/

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

WMAC (NS), & Aklavik HTC. (2009). *Aklavik Local and Traditional Knowledge about Porcupine Caribou*. Retrieved from Wildlife Management Advisory Council (North Slope) website: http://www.wmacns.ca/pdfs/287_WMAC_rpt_pcbou_knwldg_web.pdf

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 Environment. (2011). *Dall's Sheep in the Northern Richardson Mountains (supplement to status report)*.

Yukon Government. (n.d.). Yukon Wildlife: Muskox. Retrieved January 15, 2020, from https://yukon.ca/en/muskox

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 5:
Caribou / Tuktu

Publication Information

Cover photo:	Bull Caribou at the Firth River, Jay Frandsen. © Parks Canada/Jay Frandsen, 2020
Copyright:	2021 Wildlife Management Advisory Council (North Slope)
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 5: Caribou / Tuktu

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 four 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: Caribou / Tuktu

This companion report provides information on the conservation requirements for caribou 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 caribou, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for caribou on the Yukon North Slope

1. Protection of the entire caribou calving and post-calving grounds and summer habitat on the Yukon North Slope.
2. Protection of core summer habitats and migratory routes frequently used by the herd and conservation of those which are currently used less frequently but may become important in the future.
3. Conservation of caribou habitats across the Porcupine caribou herd's range, especially of calving grounds in the Alaska National Wildlife Refuge, through collaboration among jurisdictions and parties, and by actively supporting research, monitoring, management, and mitigation of development impacts to meet the ecological requirements of the herd.
4. Research and monitoring of habitat condition and quality with an emphasis on the calving and mid- to late-summer periods.

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

Caribou on the Yukon North Slope

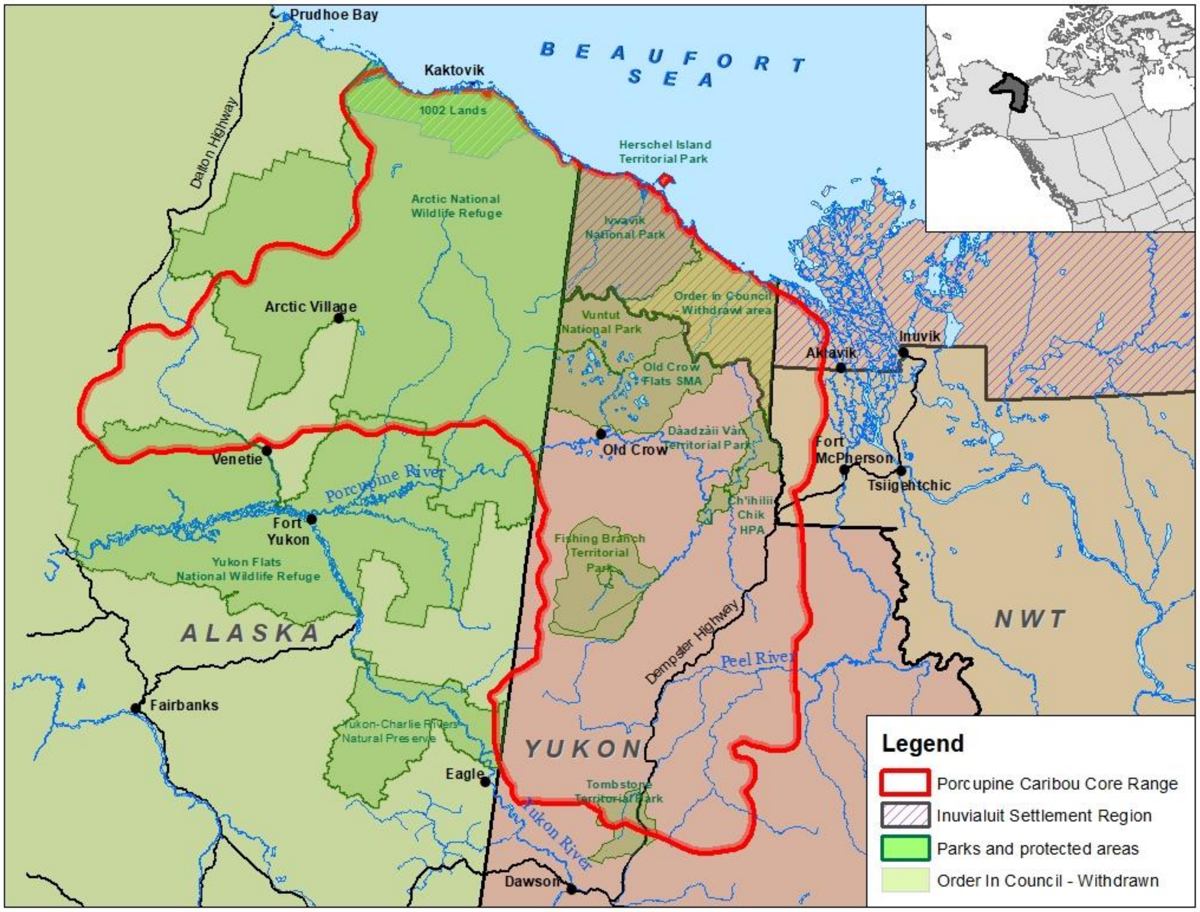
"…If you treat them good, they'll last you a lifetime. You look after the caribou. "

Jerry Arey, *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 71)

The Yukon North Slope is the northeast sector of the core range of the Porcupine caribou herd (Map 5- 1), a population of barren-ground caribou (Tuktu, *Rangifer tarandus granti*). Caribou migrate through and occupy diverse Yukon North Slope landscapes, from the coastal plain to mountain slopes. Large areas of the Yukon North Slope are especially important for caribou as late spring to mid-summer habitat for calving, nutrient acquisition, and insect relief.

The Porcupine caribou herd is separated from other barren-ground caribou herds to the east by the barrier of the Mackenzie River and Delta. The Porcupine herd's range overlaps at its western edge with the Alaskan Central Arctic herd. Caribou from these two herds may mix in areas of overlap in July and again during fall and winter (McFarland, Caikoski, Lenart, & Taras, 2017).

Map 5- 1. Porcupine caribou herd core range and protected areas



Map produced by Government of Yukon, 2021.

Much of the herd's range along the coastal plain, where the caribou congregate annually for calving, is protected as part of Ivvavik National Park or the Arctic National Wildlife Refuge, as shown on Map 5-1. However, critical areas of the coastal plains are vulnerable to potential human industrial impacts. The eastern portion of the Yukon coastal plain—Aullaviat/Aunguniarvik—is withdrawn from development by an Order in Council, and the Plan features a strategy to enhance this conservation framework (WMAC (NS), 2021, Strategy A1). The United States Congress 2017 decision to grant oil and gas leases in the 1002 Lands, the main calving location for the herd, weakens protection for Porcupine caribou and highlights the vulnerability of these critical calving, post-calving and early summer habitats (IGC, WMAC (NS), WMAC (NWT), & FJMC, 2018; PCMB, 2020b; D. E. Russell & Gunn, 2019). The 1002 Lands are approximately 600,000 hectares within Alaska's Arctic National Wildlife Refuge that are excluded from the Wilderness designation that applies to the rest of the refuge (USGS & USFWS, 2015).

The Porcupine caribou herd, at last estimate (2017), was made up of about 218,000 caribou (Porcupine Caribou Technical Committee, 2019a). Herd characteristics, such as birth rate and calf survival, indicate that the Porcupine herd is doing well, unlike other barren-ground caribou herds across North America, many of which are declining. The Porcupine herd, like other caribou herds, is vulnerable to impacts from climate change and industrial development (D. E. Russell & Gunn, 2019; D. Russell & Gunn, 2017).

Due to their abundance, caribou are the key ecosystem driver of the Yukon North Slope. They modify and shape landforms and vegetation and are an important source of nourishment to a wide variety of terrestrial and aquatic life, and, through their droppings, to vegetation (COSEWIC, 2016; Gunn, Russell, & Eamer, 2011). Caribou support Yukon North Slope populations of wolves and grizzly bears and provide food for other predators and scavengers, including wolverine and golden eagles (Hayes, Baer, & Clarkson, 2016; WMAC (NS) & Aklavik HTC, 2009).

Caribou are the most important of the Yukon North Slope's wildlife species for Inuvialuit harvest. They have a central place in Inuvialuit culture, traditions, and way of life (Inuvialuit Harvest Study, 2003; WMAC (NS) & Aklavik HTC, 2009, 2018b).

> Protection of our caribou; that's one thing that really stands out to me, because that's their main route, for their migration [across the Yukon North Slope]….We've been depending on the caribou herd ever since I was a boy.
>
> *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b, p. 100-107)

The Porcupine caribou herd is central to the economies and cultures of other Indigenous peoples in its range. It is highly valued by other northern residents for recreational hunting, wildlife viewing and tourism.

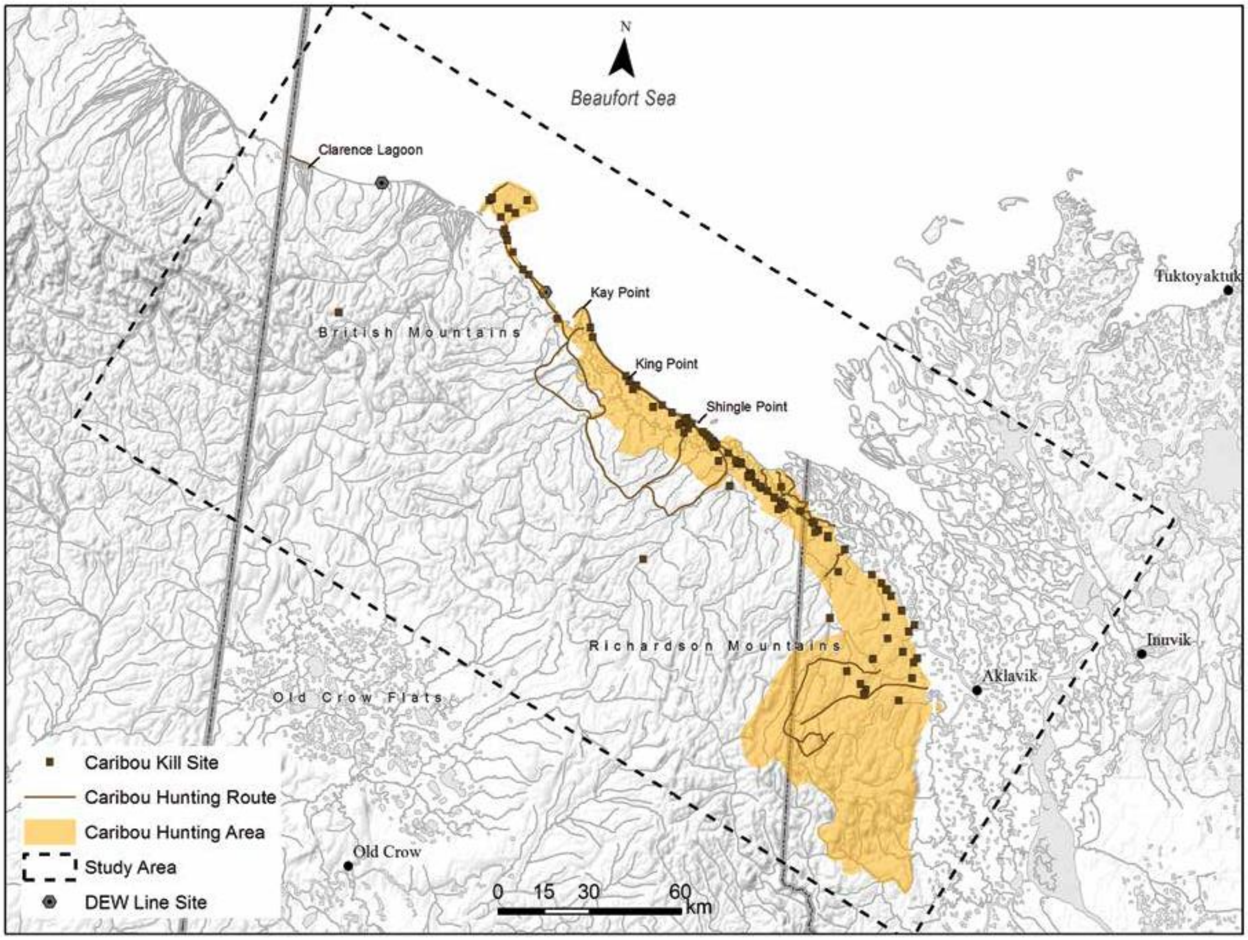
Traditional Use

> "That's our food. Right now I'm cooking caribou meat, because the last few days I've been eating another kind of food, and I don't feel like I'm getting anything at all. So I told my kids today I'm going to cook caribou meat today, because we have to have caribou meat."
>
> Annie B. Gordon in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 75)
>
> "I use caribou every day just about … For my grandson and my boy."
>
> Jacob Archie in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 75)

The importance of caribou to Inuvialuit, particularly Aklavik residents, cannot be overstated. For this reason, the *Yukon North Slope Wildlife Conservation and Management Plan* (2021) puts considerable emphasis on the herd and its protection. In the Aklavik Community Conservation Plan (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016), Tuktu is described as a "highly valued food resource, historically also for clothing and tools." Inuvialuit harvest accounts for approximately 20% of the total annual harvest of the Porcupine caribou herd throughout its range (PCMB, 2010a). Areas where Aklavik Inuvialuit hunt caribou and routes taken by hunters are shown in Map 5- 2. In recent times, caribou harvesting opportunities have been largely facilitated by boat access along the coast. This map, representing use patterns from living memory, is based on traditional use interviews conducted to provide information for the Plan. Current harvest areas on the Yukon North Slope are along the coastal plain and in the Richardson Mountains. However, the geographic relationship between caribou and Inuvialuit on the Yukon North Slope has shifted over time, reflecting changes in seasonal and year-round use areas, as well as a changing socioeconomic context. For example, caribou-related traditional use was centred more to the west early in the 20th century when Inuvialuit lived permanently at Qikiqtaruk. Expression of traditional use is strongly influenced by access and availability.

> "Get enough for what you need. Never harvest a whole bunch. Not unless you got a big family and feeding someone else, too. If you don't share with other people, don't get a whole bunch. But if you got a big family, one or two hunters, it doesn't matter how much they get, as long as they share with their families. That's what I think … You gotta have respect for any animal, not only caribou. Try not to kill too many… Like fish, for instance. You don't get a whole lot. You think you got enough, you just quit. "
>
> Participant in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 73)

Map 5- 2. Caribou harvest areas and routes taken by hunters identified in 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 6.

On average, 643 caribou were harvested annually by Aklavik Inuvialuit over the ten-year period from 1988 to 1997, as reported through the Inuvialuit Harvest Study (Inuvialuit Harvest Study, 2003, Table 21). The reported harvest of Porcupine caribou by Inuvialuit from 2016 to 2018 was considerably lower—an average of 208 caribou were harvested annually over this three-year period (IRC, 2019). Reported harvest across years is influenced by a range of factors, including socioeconomic conditions, changes in study methodology or participation rates, and ecological changes. In a 2009 study of Aklavik local and traditional knowledge of Porcupine Caribou, interviewees noted that for multiple, complex reasons, at the time of the study many people were not able to access caribou to meet their families' needs (WMAC (NS) & Aklavik HTC, 2009). In the same study, some interviewees suggested that the herd's migration patterns had changed; some stated that the herd uses a variety of different migration routes and their use of those routes at different times depends on a variety of factors (WMAC (NS) & Aklavik HTC, 2009). More recently, people in Porcupine caribou herd user communities have reported that, in years when the harvest is low, it is because the caribou are too far from the community (ABEKS, 2019). Harvester perception of caribou availability can be influenced by environmental conditions that affect caribou distribution; temperature and snow cover both play a role (Gagnon et al., 2020). Most people who do not hunt caribou report that the reason is that they do not have enough time (Chapter 1: Traditional Use provides additional context on changing patterns of traditional use of the Yukon North Slope).

> "I don't think the caribou follow the same route, never. They always go a different route 'cause that stuff they eat, it grows real slow. That's what we found out—they grow slow those plants, the lichen. "
>
> Jerry Arey in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 22)

A 1991 dietary survey concluded that caribou is of prime importance in the diet of Aklavik Inuvialuit (Wein & Freeman, 1992). Caribou was the most frequently consumed food item in the 36 households surveyed, eaten on average 145 times during the previous year. Caribou was eaten in all but one of the households. Caribou meat and dry meat, tongue and heart were in the list of top ten preferred foods. A health survey of 36 Inuit communities across the Canadian Arctic concluded that caribou is the top source of protein for Inuit, and the primary source of several essential vitamins and minerals (Kenny, Fillion, Simpkin, Wesche, & Chan, 2018).

Traditional uses of caribou

Anything, everything [is used], guts, even the bag inside … well, even that is used. They can have it hanging and if it dries, they just cut pieces off it and they just throw it in when you're boiling meat, just to give that meat a flavour.

– Annie B. Gordon

We never waste meat. We don't use the bone—long ago they used the bone, chop it up and boil it and make some fat out of it for making bread. But we like the marrow, really, that's a delicacy.

– Anonymous

Nowadays we just eat the meat. When I was growing up, we had caribou-skin shoes, caribou-skin pants, caribou skin for outerwear, it's windproof. You don't see that now. Long ago when I was growing up everybody had that. [It changed] when school started … in the 50s, '54, '55.

– George Selamio

Source: *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009), p.80 and p.86

Habitat for Caribou

Overview

Currently one of the world's largest migratory barren ground caribou herds, the Porcupine herd ranges over 250,000 square kilometres of land straddling northeastern Alaska, northern Yukon, and the northwestern edge of the Northwest Territories. Sources of information about the Porcupine caribou herd's seasonal movements and favoured habitats include traditional knowledge about caribou and many years of studies, surveys, and tracking of the movements of individual caribou equipped with collars.

Porcupine Caribou Satellite Collar Location Program

This cooperative Canada/US program, which started in 1985, maintains satellite radio collars on caribou to document migration routes and habitat use over the seasons. Caribou collars have a GPS unit that records the location of the caribou at intervals over the day. The location data are sent from the collar to the satellite, which then transfers the data to a secure webserver back on Earth, where it is downloaded by caribou biologists.

(PCMB, 2020b; WMAC (NS), 2005)

I think the whole thing is important for the caribou. There's no spots where they stay, they're always travelling.

Dennis Arey in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 24)

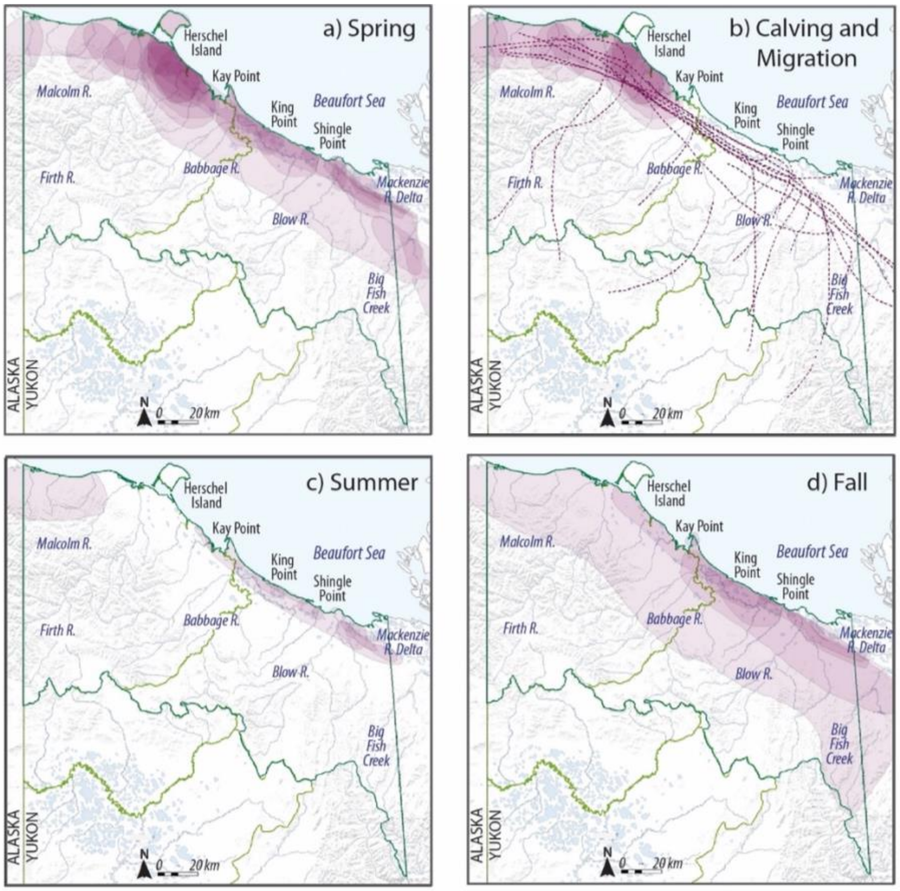
Based on the stories that interviewees shared about caribou migrations, Porcupine caribou rely on the availability of a variety of migration routes to adapt to change. The routes caribou take seem to depend on the following factors: food availability; weather conditions associated with rain, snowfall, and wind; air, boat, and land-based traffic; seismic activities and oil development; and hunting practices.

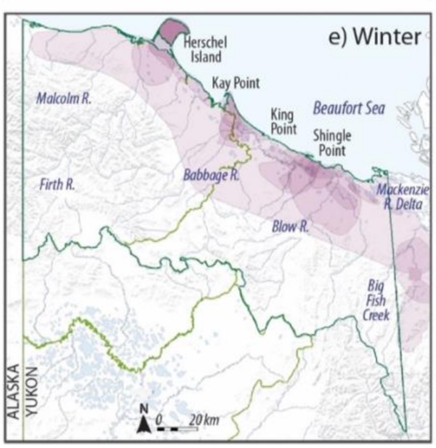
From *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009, p. 24)

Caribou Seasonal Movements and Habitat Use

Thirty-six years of caribou collar data echoes Inuvialuit knowledge: the entire Yukon North Slope, excluding the edge of the Mackenzie Delta, is used by caribou, though their routes through the landscape vary over the years.

Map 5- 3. Traditional knowledge about caribou distribution on the Yukon North Slope over the seasons





From WMAC (NS) and Aklavik HTC (2018a), maps 2 through 6, plus migration route information. Where people travel and hunt over the seasons influences these records of caribou distribution. Summer travel is mainly by boat.

Spring

In spring, caribou migrate from the taiga wintering grounds to the coast. Spring migration normally begins by early April, but timing and progress is largely dependent on snow conditions along the route. Although they prefer to travel along forested valley bottoms, in deep snow years the herd uses snow blown ridgetops when available. By late May pregnant cows are on the coastal plain and foothills of the western Yukon North Slope. Depending on snowmelt patterns, when they reach the coast they can spread along the foothills into Alaska or remain to calve in Yukon. Typically, this migration averages 245 kilometres, although the actual route is not a straight line. This travel takes place over an average of 33 days (Gurarie et al., 2019).

> Well, in the springtime, the cows like to be in the flats… most of the time the bulls always come last… [They] follow the cows.
>
> (WMAC (NS) & Aklavik HTC, 2018a, p. 14)

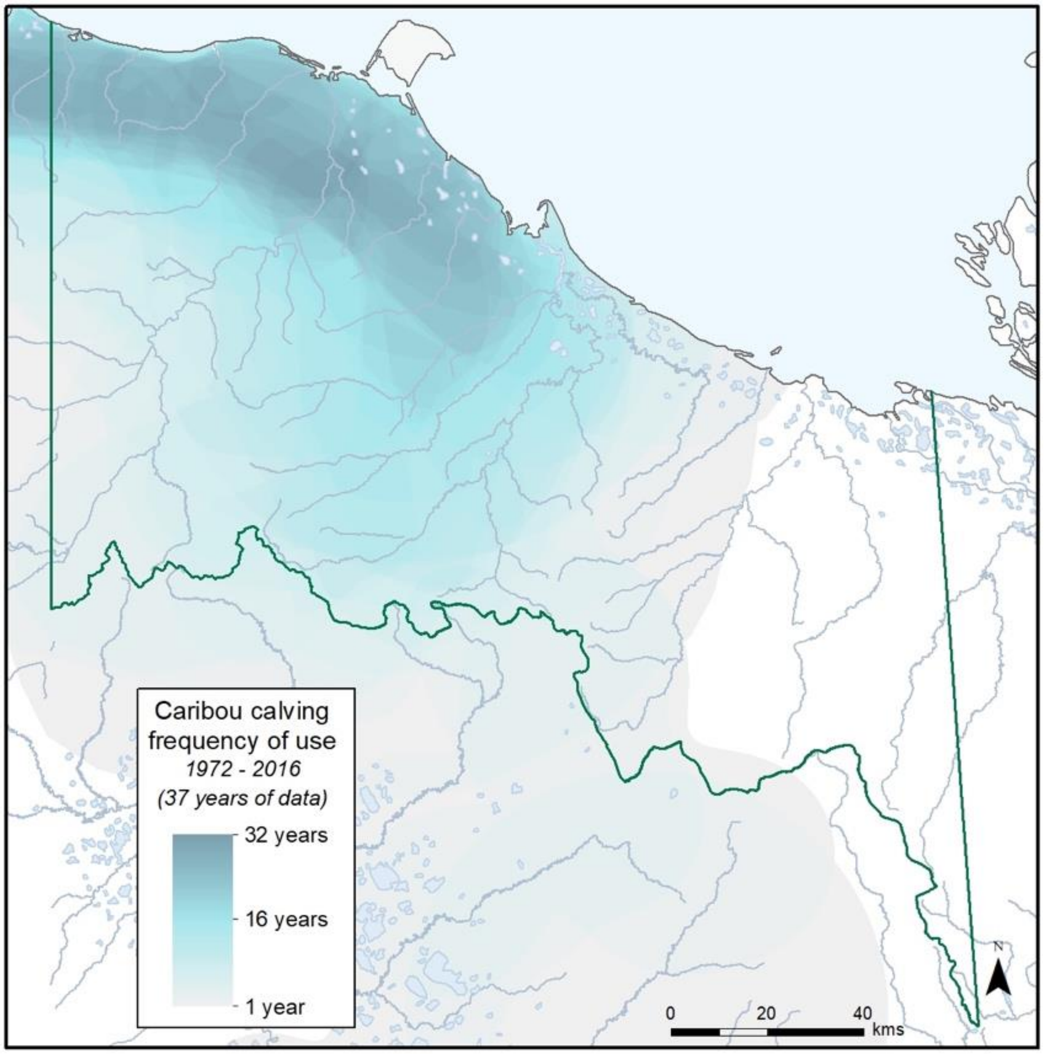
Calving and Post-Calving

Calving habitat is flat, open country close to the coast, where caribou can reduce exposure to predators and find relief from insects. They feed on fresh green plants, high in much-needed nitrogen. Calves are born on the coastal plain of Alaska and Yukon (Map 5- 4), with a long-term emphasis on the Alaskan 1002 Lands and areas directly south and east of them. Calving locations vary from year to year in response to snow conditions and pattern of snowmelt.

> [The calving grounds are] flat, rolling hills… you could see for miles… You [can] see out to the ocean, you can see all the way to Stokes Point, all the way to King Point.
>
> It's all [tundra], you know, there's a lot of good eating there, I guess… they're away from the mosquitoes [when they're] along the coast there.
>
> (WMAC (NS) & Aklavik HTC, 2018a, p. 18)

Some people have observed changes in calving locations, with calving further east or further inland, especially within the past 10 years (WMAC (NS) & Aklavik HTC, 2018a). This observation is consistent with climate data that shows that, over the last ten years, May 15 snow depth in the 1002 lands has been increasing, while snow depth to the east has decreased.

Map 5- 4. Caribou calving locations on the Yukon North Slope, based on 37 years of data on calving locations of collared caribou



This map is from the Plan (WMAC (NS), 2022, Appendix 1). Based on 37 years of data spanning 1972 to 2016, this map shows how frequently caribou calve in different areas of the Yukon North Slope. If an area has dark shading, caribou were located there in most years, while if it has very light shading, caribou were only located in that area during one or two years. Calving was mapped using collared caribou locations between May 26 and June 10 each year and the calving period seasonal range was estimated using a 95% kernel estimator. From this, overlapping polygons were enumerated to describe the relative frequency of use. Only data from calving females were used in this analysis. (Data source: Environment Yukon, in preparation)

Although calving generally takes place along the Alaska North Slope, east of the Canning River and west of Herschel Island, there is considerable annual variation. If snow conditions permit, pregnant females typically move west along the foothills of the Brooks Range and then north out onto the coastal plain, following the snowmelt pattern. However, if snowmelt is late, they may calve in the foothills and if really late, they may remain in Canada to calve. Although there is a low amount of new plant growth, what's there has the valuable nitrogen required to produce milk and replenish weight lost over the winter. Normally the first plants to emerge are the flower heads of cottongrass, followed by other flowering plants and finally willows and other shrubs. Regardless of where they calve, as snow disappears, the cows with their newborns move into the Alaska National Wildlife Refuge, tracking fresh plant growth.

Summer and Early Fall

Soon after calving, as temperatures warm, insect harassment intensifies. Cows form larger and larger groups and are soon joined by bulls, juveniles, and cows without calves. How long these groups stay together depends on insect harassment. In the Porcupine herd, groups of many as 100,000 caribou may move an average of 25km a day, dispersing into smaller groups as they move into the mountains. As insect season ends, usually in early August, groups split up and concentrate on undisturbed feeding.

This period is critical for cows because they must gain mass before the fall rut in order to become pregnant. The late summer and early fall period is one of the few periods of the year where cow caribou have the capability of building up their body reserves. They feed on shrubs, grasses and sedges, and mushrooms, making up for foraging time lost to avoiding insects earlier in the year (D. E. Russell, Martell, & Nixon, 1993).

Aullaviat/Aunguniarvik and Caribou

The summer season is a crucial one for caribou, particularly for cows, as it is a time to put on critical body mass. Over time, the effects of insufficient weight gain include reduced parturition rates and reduced survival. Together, these have a negative effect on herd population numbers.

For the Porcupine caribou herd, the summer months are regularly spent in Aullaviat/Aunguniarvik (the Eastern Yukon North Slope) (see Map 5- 5). The herd has returned to the nutrient-rich landscape of Aullaviat/Aunguniarvik nearly every year for the past two decades. The importance of this place is captured in its Inuvialuktun name, which means: *where the people and animals travel/where the people hunt.*

For more information on Aullaviat/Aunguniarvik, please refer to Companion Report 4: Aullaviat/Aunguniarvik.

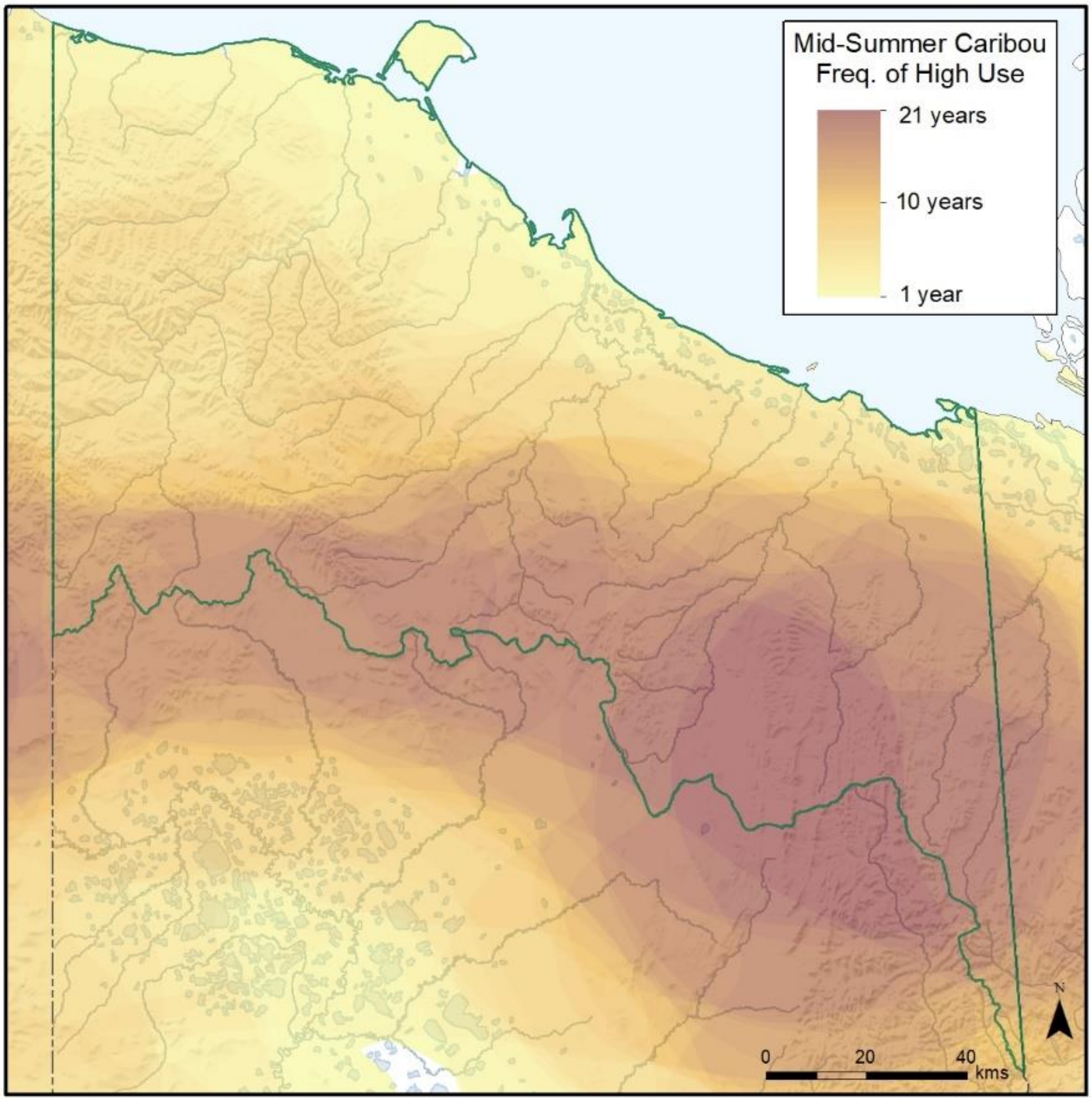
(Environment Yukon, in preparation)

Although movement paths during this period vary, caribou generally migrate eastward from habitats in Alaska into Yukon's North Slope, normally arriving at the Blow River and Big Fish River area by mid to late July. Some caribou may also move northeast along the coast, selecting open tundra and flatlands with a good supply of green vegetation and sea breezes that provide insect relief. People also observe caribou in summer on hillsides or in the mountains, seeking relief from insects and predators. Collar data collected for the herd supports these observations, showing that most of the herd is typically found in the interior of the eastern Yukon North Slope from mid-July through late August or into September.

Sometimes they come early, sometimes they come late—in August, all the time though, in August. Summertime only in August we expect caribou to come, but not the same time. Some time in the middle of August, end of August, sometime—last part of August. When they travel … they start showing in August, last part of August, like the 15th. That's why those old people always try to go to mountain August 15th or 10th, so they could look for caribou.

(Alice Husky, WMAC (NS) & Aklavik HTC, 2009, p. 20)

Map 5- 5. Caribou mid-summer locations, based on 20 years of collared caribou data



This map is from the Plan (WMAC (NS), 2022, Appendix 1). It is based on overlaying the annual seasonal ranges of caribou from July 16 to August 7, using 20 years of collar data spanning the period 1990 to 2016 (ranges are based on 95% kernel density estimation). The map shows how often caribou use an area during the mid-summer season. If an area has dark shading, caribou were located there in most years, while if it has very light shading, caribou were only located in that area during one or two years. This map highlights areas that are very important for caribou in all or most years, but also that there is variability from year to year in use, which indicates that caribou need flexibility in habitat availability. Caribou cows with their calves arrive on the eastern North Slope every year around July 16 and will remain in the area until early September in most years. Data from all collared caribou were included in this analysis, i.e. males and parturient and non-parturient females. (Data source: Environment Yukon, in preparation)

People observe caribou in summer along the coast, on hillsides, or in the mountains, seeking relief from insects and predators. Snow patches provide important refuge from heat and insects.

> …they [caribou] hang out there [on snow patches] 'cause it's hot and, you know, it's warming up, June, July, and the mosquitoes are coming out… they go to the snow… 'cause it's cool and the mosquitoes won't bother [them] as much.
>
> (WMAC (NS) & Aklavik HTC, 2018a, p. 20)

Fall Migration, Breeding, and Winter

The main part of the Porcupine caribou herd will remain north of the Porcupine River if September and October are mild. Early, heavy snowfall often acts as a trigger for the herds to move south of the Porcupine River at the onset of fall migration. If fall storms end they may do a loop around Old Crow and cross the Porcupine River again. In the second to third week of October the Porcupine herd is in their breeding season, the rut. Usually, open landscapes are used during the rut, although the location varies, depending on how far south they are on their migration.

Small groups of caribou can remain on or near Qikiqtaruk over winter. Caribou select areas where wind blows the snow off vegetation. In winter, they eat lichens, sedges, and dried leaves.

> …they're eating along where they can easily access [vegetation], like a little high on the mountain and the sides [of hills].
>
> …Sometimes there will be west wind and they'll be on the west side, and sometimes it will be east wind and they'll be on the east side…. The wind always blows the snow off the top of the tundra … and they'll always be around… feeding around that area.
>
> (WMAC (NS) & Aklavik HTC, 2018a, p. 24)

Caribou Population

Species Conservation Status

The decision by COSEWIC to assess barren-ground caribou in Canada as Threatened in 2016 was based on the dramatic decline of most herds with no sign of recovery, and the presence of unprecedented cumulative threats related to climate change, industrial exploration and development on caribou ranges. Only 2 of 15 herds were determined to be increasing, one of which was the Porcupine caribou herd (Canada, n.d.; COSEWIC, 2016).

Table 5- 1. Barren-ground caribou conservation status

Status assigned by	Applies to	Status	References
Species at Risk Act (SARA)	Canada	Under consideration for addition to Schedule 1	(Canada, n.d.)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Canada	Threatened; last assessed 2016.	(COSEWIC, 2016)

Yukon	Yukon	S3S4: Vulnerable to Apparently Secure*	(Yukon, 2020)
International Union for Conservation of Nature (IUCN)	Global (*Rangifer tarandus*- all caribou)	On Red List of threatened species: status Vulnerable, population trend Decreasing; last assessed 2016	(Gunn, 2016; IUCN, 2020)

*Following the ranking system developed by NatureServe, an international network of conservation data centres (NatureServe, n.d.). S=Subnational

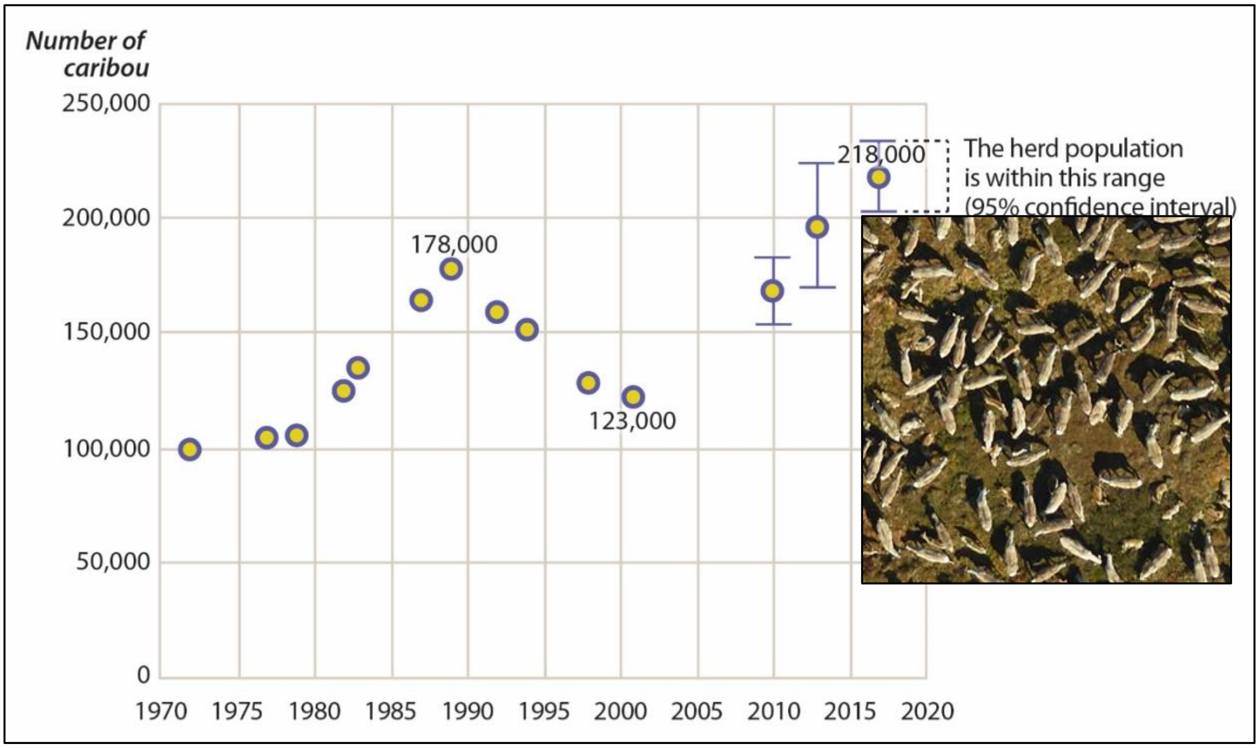
In 2016, the Porcupine caribou herd made up approximately one quarter of the total population of barren-ground caribou in Canada (COSEWIC, 2016). Understanding the complex factors that allow this herd to be increasing at a time when most herds are facing steep declines can help us plan for caribou recovery elsewhere. The highly collaborative, proactive management model in place for Porcupine caribou is a valuable example for other jurisdictions where caribou are not faring so well.

Porcupine Caribou Herd Status and Trends

Population counts have been conducted periodically since 1972, using aerial photographs of post-calving aggregations of caribou on or near the coastal plain (Figure 5- 1). In some years aggregations are as far east as the northern Richardson Mountains. Counts are scheduled for every 2 to 3 years but have to be postponed if weather conditions make visibility too poor, or if the herd is too spread out. These factors account for a period of uncertainty about the herd's status between counts in 2001 and 2010 (COSEWIC, 2016). Other population measures, such as proportion of calves to cows, number of bulls, and calf survivorship, are either taken from the population count or through additional surveys (Porcupine Caribou Technical Committee, 2019a, 2019b).

Population estimates since 2010 have confidence intervals—a range within which the true population is expected to fall. The estimates are based on the minimum count from the aerial survey and also make assumptions about groups without radio-collars as well as known radio-collars not detected in the aerial survey (Rivest, Couturier, & Crepeau, 1998). The most recent population estimate (2017) for the herd was 218,000, with a range between about 202,000 and 235,000 caribou.

Figure 5- 1. Porcupine caribou herd population size, 1972 to 2017



Population levels are minimum counts from 1972 to 2001, while estimates starting in 2010 are derived from minimum counts and modelling (based on Porcupine Caribou Technical Committee, 2019a, Figure 2). The photo is a segment of an aerial photo from the 2017 population count (photo: Alaska Department of Fish and Game).

What Influences the Abundance of Porcupine Caribou?

Participants in the study *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009) described influences on the health of the Porcupine caribou herd: predation, overharvesting, and, especially, weather.

> The wolves would take an awful lot, they take a lot of caribou. And overharvesting is another one. Hard winter, tough winter, like [cold and windy] this kind of weather is not good for the land because the snow is getting hard on top. If it rains it's going to freeze and the caribou can't break through that ice barrier to get down to where they want, you know, under the snow where the lichens and grass they eat are.
> Anonymous, p.44

> It's all important, wherever they can find food. They got to follow the food. If it rains in the fall time it's real bad—freeze-up. Under that snow it turns to ice. That's when the caribou starve. If it's good fall, not much rain or not too warm weather, they'll stay healthy.
> Anonymous, p.29

> Some years [herd health] is good and some years it's bad. Never the same all the time. Depends on the food that's growing up and the freezing rain, freezing snow and everything like that. It's not good for the caribou.
> Donald Aviugana, p.89

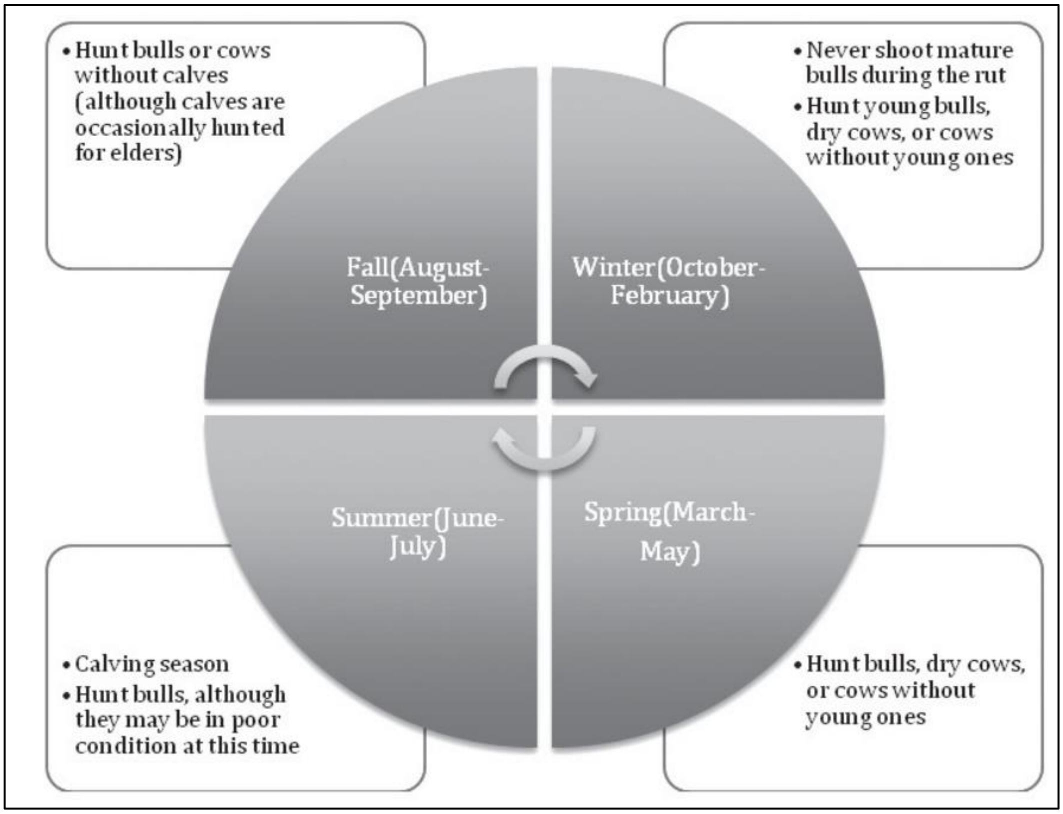
> When there's lots of rain it's good—not lots of rain, but rain once in a while [during the growing season]. Everything grows better … When it's too hot everything don't grow.
> Jacob Archie, p.30

Traditional knowledge and Western science-based studies suggest that barren-ground caribou go through natural fluctuations or cycles in abundance. These long-term shifts in populations are likely driven by large-scale decadal patterns in climate, interacting with changes in forage, predators, and pathogens (Gunn et al., 2011). Caribou face various challenges at critical times over the seasons and over their lifetimes, including from adverse weather, predation, or insects. The calving and post-calving periods are critical for the herd (International Porcupine Caribou Board, 1993). In the first month of life, an average of 25% of caribou calves die. In 2000 and 2001, over 40% of the calves died in the first month. Those years had deep snow which melted very late and many calves were born during migration, some south of the Porcupine River. If calves are born on the Alaskan coastal plain, the average survival rate increases with increasing plant growth. If they calve on the Yukon North Slope, calf survival declines with increasing March snow depth (Griffith et al., 2002; Russell & Gunn, 2019).

Harvest Management

Inuvialuit traditional hunting and meat preparation is described in *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009). Respectful harvest of caribou is based on many traditions, including letting the leaders pass, not wasting food, and adjusting harvest to the season.

Figure 5- 2. Summary of Aklavik Inuvialuit seasonal hunting of Porcupine caribou



(WMAC (NS) & Aklavik HTC, 2009, Figure 9)

On the Yukon North Slope, Inuvialuit have the exclusive right to harvest caribou in Ivvavik National Park and Herschel Island-Qikiqtaruk Territorial Park, and the preferential right to harvest caribou on the Eastern Yukon North Slope (Canada, 1984). A limited bull-only harvest by Yukon residents is permitted on the Eastern Yukon North Slope, subject to the herd status.

Harvest management in Canada is coordinated through the Porcupine Caribou Management Board (PCMB, 2020b), which was created through the *Porcupine Caribou Management Agreement* (Government of Canada et al., 1985). Management measures may include hunter education, recommendations on bull-only harvesting, and recommendations on restrictions on harvest.

Recommendations on harvest management measures in Canada are issued following each annual harvest meeting (PCMB, 2020a). In times when caribou abundance is low, all caribou user groups face tough decisions about harvest restrictions. The Porcupine Caribou Harvest Management Plan (PCMB, 2010a) provides guidance (see section on Links to Plans and Programs). The *Porcupine Caribou Herd Native User Agreement* (2019) includes provisions for coordinating harvest management efforts and reaching decisions on allocation of the harvest during times when the herd numbers are low (Vuntut Gwitchin Government, Tr'ondek Hwechin'in, First Nation of Na-Cho Nyak Dun, Inuvialuit Game Council, & Gwich'in Tribal Council, 2019).

No commercial harvest is permitted, but the *Porcupine Caribou Management Agreement* permits the sale and barter of meat among Canadian Indigenous user groups. Guidelines for these transactions have been established by the Porcupine Caribou Management Board (PCMB, 2011).

Transboundary Considerations

The range of the Porcupine caribou herd includes many jurisdictions: national and territorial regimes, land claim settlement areas, protected areas, and land use planning regions. Agreements, boards and committees, and some of the plans in place for these jurisdictions are described in the section on Links to Plans and Programs.

Observations, Concerns, and Threats

Cumulative Effects

The health and productivity of the Porcupine caribou herd is affected by a number of complex factors that interact in compounding ways (PCMB, 2012). Taking a cumulative effects approach to assessing the impacts from human-caused changes on the herd's range means taking a holistic view and considering potential impacts in relation to other pressures on caribou across their extensive range throughout the year. Stressors for caribou generally fall into two categories: naturally occurring pressures such as insect harassment, disease and parasites, forage quality, quantity and availability, predation, and weather; and human-caused pressures including climate change, seismic disturbance, range displacement, auditory, visual and mechanized displacement, contaminants, habitat loss and modification, harvesting, human harassment, and migratory disruption. The human-caused pressures can compound or amplify naturally occurring pressures. The resulting cumulative effects can manifest as habitat loss, displacement to marginal habitat, reduced high quality forage intake, decline in health, increased predation, and distribution shifts.

In line with environmental assessment legislation in the United States and Canada, new development proposals in Porcupine caribou herd range must assess the potential impacts of the proposed development on caribou. This includes transboundary impacts. Moreover, the requirement is not only to assess the isolated impact of the new development but rather the cumulative impact of the new development on top of impacts associated with other existing and future developments to the herd. Thus, if someone proposes a road into the winter range of a caribou herd, there is not only a need to assess the direct impact on wintering caribou, but also, how that adds to the existing impacts of other development and future climate trends within the entire range of the herd.

While the Porcupine herd's range is to date relatively undisturbed by development and has land management regimes that include several protected areas (Map 5- 1), potential development activities, including exploration and construction of infrastructure on the range, is a concern.

Climate change, the other principal human-related influence on the Porcupine caribou herd, presents a complicated suite of primary and secondary effects, some known and many that are subtle and not well understood (COSEWIC, 2016). While it is now well-established that the planet will continue to warm into the coming decades as a result of human activity (IPCC, 2021), the effects of climate change on Porcupine caribou are expected to be mixed, at least in the near-term. For example, more frequent freezing-rain events and increased snow pack depth are expected to have a negative effect on the herd, reflected in metrics like calf survival (Russell & Gunn, 2019). However, warmer temperatures in the fall and an increase in overall growing degree days may be beneficial for caribou (Russell & Gunn, 2019).

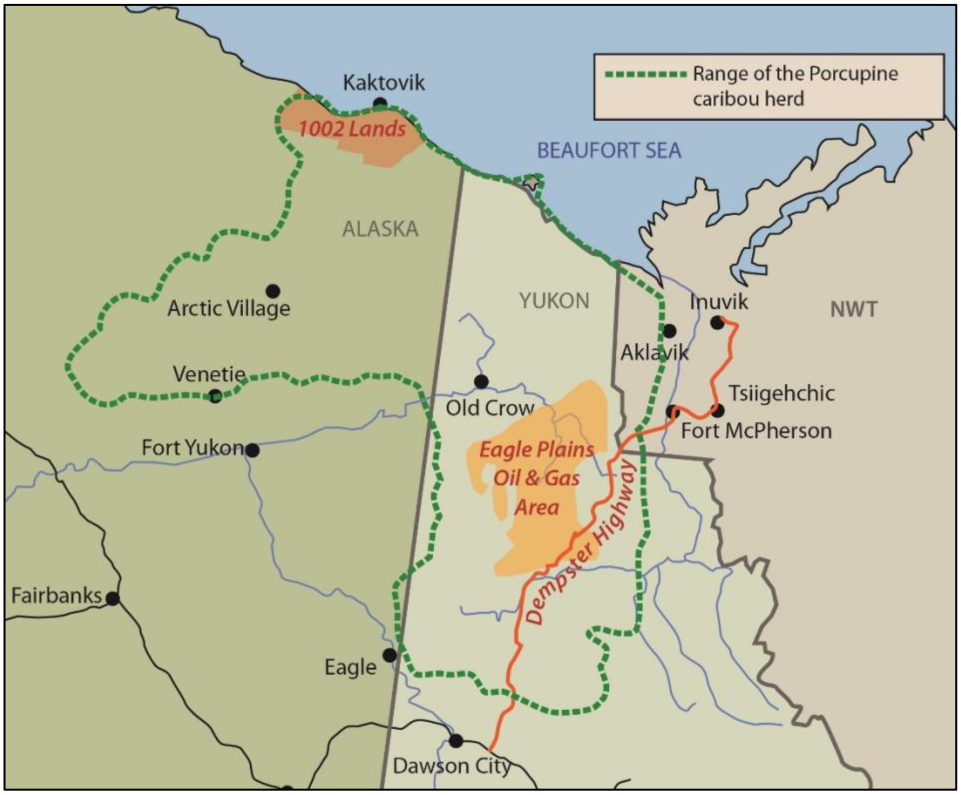
The uncertainty that comes with climate change raises the possibility for a plethora of complex, interacting effects that may influence caribou ecology. The Porcupine herd's range is immense – there are numerous local systems across that range that may shift as the climate warms. Maintaining connectivity for caribou across this massive landscape as the climate changes is crucial. Buffering against cumulative effects related to climate change is possible though. Decades of collecting movement data from collared caribou shows that while the herd may not use the same seasonal areas every year, those lesser used areas are necessary in years when conditions in high-use areas are not favourable, or the areas themselves are not accessible. Conserving large, healthy areas that support caribou and the migration routes that connect them is key to buffering for change.

Development on the Herd's Range

Main areas of current and proposed development and infrastructure within the herd's range are shown on Map 5- 6:

- 1002 Lands, Alaska, critical calving and post-calving habitat for the herd
  Section 1002 of the act that established the Arctic National Wildlife Refuge in 1980 deferred a decision about whether or not to allow oil and gas exploration and development in an area of the coastal plain that is now referred to as the "1002 Lands". In 2017, a provision requiring over half of the 1002 Lands to be opened to oil and gas leasing was signed into U.S. law. (For a cumulative effects assessment of this project, see Russell & Gunn, 2019.)
- Eagle Plains, Yukon, in the herd's winter range
  Oil and gas exploration in the Eagle Plains basin dates back to the 1950s. Renewed interest in exploiting these resources over the past decade led to a 2017 Yukon Government moratorium on exploration activities to provide time for consultations and development of agreements with First Nations governments.
- Dempster Highway, Yukon and NWT, crossing the herd's winter range
  The Dempster Highway connects Inuvik to Dawson City. The road provides an access corridor for harvesters. Road traffic can accidentally kill caribou and disturb migration (see Johnson & Russell, 2014).

Map 5- 6. Range of the Porcupine caribou herd showing the Dempster Highway and areas with approved or proposed opening to oil and gas development



Adapted from maps on the PCMB website (PCMB, 2020b)

The effects of development on migratory caribou have been studied in Canada and Alaska and are summarized in COSEWIC (2016). These effects include direct and indirect habitat loss, altered movement and migration patterns, and changes in behaviour.

Studies at Prudhoe Bay, on the Central Arctic caribou herd, found calving areas shifted away from areas with industrial development, even when the new areas had poorer forage conditions for nursing cows (Wolfe, 2000). A recent analysis, after 40 years of development within the Central Arctic herd's range, indicates that calving caribou are still avoiding roads and traffic (H. E. Johnson, Golden, Adams, Gustine, & Lenart, 2020).

The Porcupine caribou herd's avoidance response to development on and adjacent to the Dempster Highway was examined by analyzing 27 years of data on caribou locations in relation to the changing footprint of development features over the herd's range (C. J. Johnson & Russell, 2014). Caribou demonstrated the strongest avoidance response to settlements, followed by main roads and minor disturbance features, such as wells and seismic lines.

Effects of Climate Change

Inuvialuit land users who participated in the study *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* noted changes in calving locations, with a move to further east or further inland, especially within the previous 10 years. Interviewees suggested possible reasons, including earlier springs with earlier green-up, increased river flows disrupting migration routes, and human disturbance:

> …a lot of the times, these past 10, 15 years, it's been a hell of a lot warmer, earlier, you know? More land, more grasses and that exposed…"
>
> …springtime, you know, they [caribou] used to come down here [Alaska and western calving grounds] and calve, but… it's earlier springs and… then they're calving right from Barge Lake area… all the way… down the coast now.
>
> You know, it's just a matter of the timing of… things… you know, with everything being early… or later spring… depends on how far they make it before they start [to calve]…"

(WMAC (NS) & Aklavik HTC, 2018a, pp.18-19)

Aklavik Inuvialuit have observed changes in migration patterns in spring and fall, with caribou spending less time along the coast, particularly in the fall, and changes in timing, depending on the weather. Migrations are becoming less predictable:

> They [caribou] don't hang around very long; they're just beelining straight up towards Old Crow and Alaska.
>
> …well, about 15–20 years ago, there used to be tons [of caribou] all over the North Slope… and then lately, now it's just more scattered bunches… like around 40 to 50…. Sometimes you'll get a couple hundred.

(WMAC (NS) & Aklavik HTC, 2018a, p. 24)

Many participants in the study *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009) said they see more mosquitoes now than in the past. People attributed the increase to rising temperatures, and rain and flood events that create good breeding conditions for mosquitoes. People also observed that access to the land has changed:

> All the land where we travel long ago, easy to travel, it's not like that anymore. It's too much changes now, the creeks are drying out, the lakes is getting shallow. You'd be lucky to get into some places where we used to just go in with boats. It's not like that anymore.

Annie B. Gordon, p. 63

Research and monitoring supports Inuvialuit land users' observations of changes to the seasons and their effects on caribou and on traditional use. Overviews of climate change effects on barren-ground caribou subpopulations are in COSEWIC (2016), Gunn et al. (2011) and Mallory and Boyce (2017). Climate change effects include changes to timing and quality of forage, increased frequency of extreme weather events restricting access to food, changes in seasonal migration patterns, and large-scale changes to ranges, such as alteration of winter habitat by fires.

Actual impacts will be herd-specific. For example, the Porcupine caribou range in summer is a permafrost-dominated landscape. Summer warming will result in an increased active layer, making more moisture available for plants. On the Canadian Shield, herds like the Bathurst caribou herd summer on bedrock-dominated substrates. Summer warming results in less available moisture with increasing drought conditions.

This broad and complex subject is covered in more depth in Chapter 2 of this report, Climate Change Effects.

Additional Threats

Contaminants

Mercury and cadmium, though they do build up in Porcupine caribou organs, are at safe levels and have not increased in recent years (Gamberg Consulting, 2017; Gamberg, Poulain, Zdanowicz, & Zheng, 2015). Other contaminants, including radioactivity and persistent organic pollutants, are low in Porcupine caribou (Macdonald, Elkin, & Tracy, 2007; Stocki et al., 2016). Results of ongoing monitoring of caribou for contaminants are regularly presented at Porcupine Caribou Management Board meetings. Studies on contaminants in caribou are discussed in more depth in Chapter 3 of this report, Contaminants.

Parasites and Disease

As climates and ecosystems change, ungulate diseases and parasites can extend their ranges or become more prevalent in Arctic wildlife (COSEWIC, 2016; Kutz et al., 2012; Verocai et al., 2012). Warble and bot flies, common caribou parasites, can have a significant effect on caribou populations. The larvae directly affect caribou health. The adult flies can leave caribou with inadequate time to forage due to time spent avoiding the flies. The infection levels of these parasites depend on temperature and wind speed. An example of a parasite that may be expanding its range is a nematode legworm (*Onchocerca cervipedis*). This parasite 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).

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.

Conservation and Management

Agreements

The framework for conservation and management of the Porcupine Caribou Herd is set out in three agreements that provide goals, strategic directions, and mechanisms for ongoing cooperation among the many jurisdictions over the range of the herd (**Error! Reference source not found.**).

Table 5- 2. Agreements on Porcupine caribou herd conservation and management

Agreement	Geographic scope	Parties to the Agreement	Boards/ commission established
Agreement Between the Government of Canada and the Government of The United States of America on the Conservation of the Porcupine Caribou Herd (1987)	Range of the herd in Canada and the United States	· Canada · United States	International Porcupine Caribou Board
Porcupine Caribou Management Agreement (1985) This agreement is part of the *Inuvialuit Final Agreement* (Canada, 1984, Annex L)	Range of the herd in Canada	· Government of Canada · Government of Yukon · Government of the Northwest Territories · Council for Yukon Indians · Inuvialuit Game Council · Dene Nation and Metis Association of the Northwest Territories	Porcupine Caribou Management Board
Porcupine Caribou Herd Canada Range-Wide Native User Agreement (2019)	Range of the herd in Canada	· Vuntut Gwitchin Government · Tr'ondek Hwechin'in · First Nation of Na-Cho Nyak Dun · Inuvialuit Game Council · Gwich'in Tribal Council	Porcupine Caribou Native User Commission

Boards and Committees

- International Porcupine Caribou Board (Government of Canada, 2020)

  The board is made up of four members appointed by the US and four members appointed by Canada. The board meets annually.

- The Porcupine Caribou Management Board (PCMB, 2020b)
  The Canadian PCMB was established "to communicate information about the herd and provide recommendations to agencies responsible for managing the herd." The Board has representation from the five native user groups (**Error! Reference source not found.**) and the federal and territorial governments.

- Porcupine Caribou Native User Commission (Vuntut Gwitchin Government et al., 2019)
  This commission is tasked with coordinating harvest allocation and harvest management among the native user communities in Canada, based on the recommendations of the PCMB.

- The Porcupine Caribou Technical Committee (Government of Canada, 2020; PCMB, 2010a)
  This committee was recommended in the international agreement on Porcupine caribou. The PCTC, which predated the 1987 agreement by a decade, is made up of Alaskan and Canadian agency biologists and other researchers with expertise on Porcupine caribou biology, ecology, and management. The committee's work includes developing research and monitoring priorities, coordinating monitoring and other initiatives, and reporting on results. The PCTC also provides technical information and advice to various governments and boards.

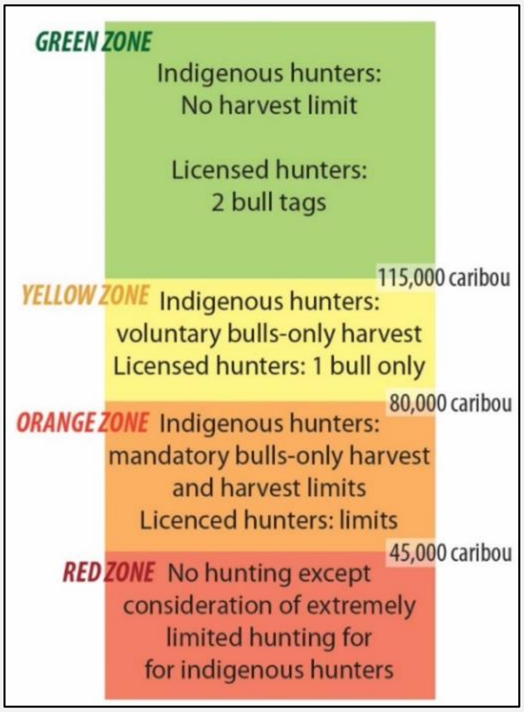
Plans

- *Harvest Management Plan for the Porcupine Caribou Herd in Canada* (PCMB, 2010a, 2010b) and the accompanying Implementation Plan (PCMB, 2016)

  The management goal is "to try to conserve the Porcupine Caribou Herd by adjusting the number and sex of caribou we harvest based on the changes in the herd size and population trend" (PCMB, 2010a, p. 6). Education and communication at the community level is a priority. Harvest management actions are based on current herd status, using a colour system (**Error! Reference source not found.**-3).

  The implementation plan, revised in 2016, outlines roles, responsibilities and tasks for harvest management, monitoring, evaluation, and adaptive management.

Figure 5- 3. Porcupine caribou harvest management colour chart



The colour zones represent the herd status and associated harvest management measures. Caribou numbers are herd size estimates, which is the main indicator for determining the herd status. All hunters must report their harvest in all colour zones. (PCMB, 2010a, 2016)

➢ *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016)
The plan identifies values for Special Designated Lands. Porcupine caribou, including calving and caribou hunting, is an identified value for the Eastern North Slope (Site 725DE). The Big Fish River watershed (Site 720DE) is identified as important caribou habitat; Ivvavik National Park (Site 727E) is identified as important for migration route and calving for Porcupine caribou; Herschel Island-Qikiqtaruk Territorial Park (Site 730E) is identified as year-round habitat for caribou.

Some caribou conservation measures in the Aklavik Inuvialuit Community Conservation Plan (p. 99):

- Identify and protect important habitats from disruptive land uses.
- Avoid shooting mature bulls during the rut.
- Do not harvest more than is needed.
- Convey and promote traditional means of using all of each animal harvested; discourage waste of meat.

- *Ivvavik National Park of Canada Management Plan* (Parks Canada, 2018)
  The main purpose of the park is to conserve wildlife, wildlife habitat, and traditional Inuvialuit use. Calving grounds within the park are part of Zone II–Wilderness, the highest level of protection. The plan recognizes that "The Porcupine caribou herd plays a critical role in sustaining Inuvialuit cultural traditions and life on the land", and that "maintaining its health is a key focus of conservation efforts (Parks Canada, 2018, p. 8).

> **Ivvavik**, meaning "a place for giving birth, a nursery," recognizes the park's significant role as the calving ground for the Porcupine caribou herd - the traditional subsistence wildlife resource for the Inuvialuit and other Indigenous peoples for thousands of years.
>
> *Ivvavik National Park of Canada Management Plan*

- *Herschel Island-Qikqtaruk Territorial Park Management Plan* (Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018)
  Conservation of caribou is encompassed by the goals and actions to maintain ecological integrity (Goal #1) and to maintain traditional use and cultural connection (Goal #4).

- As the Porcupine caribou's range crosses land claim, territorial, and national boundaries, management and land use plans for jurisdictions beyond the Yukon North Slope are important in conserving the herd and its habitat:

  Vuntut National Park of Canada Management Plan (Parks Canada, 2010)

  Vuntut National Park (**Error! Reference source not found.**) establishes legal protection of portions of the Porcupine caribou herd's spring and fall migration range. The plan recognizes the critical importance of the herd to the Vuntut Gwitchin, and sets out commitments to continued cooperative management, education, research, and monitoring. The condition and trend of the herd is a key indicator of ecological integrity for the park.

  Arctic National Wildlife Refuge Comprehensive Conservation Plan (USGS & USFWS, 2015)

  The first purpose of the Arctic National Wildlife Refuge (**Error! Reference source not found.**) is "to conserve fish and wildlife populations and habitats in their natural diversity" (p. S-15). Caribou, the most abundant large mammal in the refuge, is recognized as an important subsistence species for Iñupiat and Athabascan (Gwich'in) hunters. The plan includes goals and objectives for conservation of ecological processes; preservation of wilderness areas; research and monitoring; incorporation of traditional knowledge in decision-making; and addressing concerns about proposals that may affect subsistence use.

  North Yukon Regional Land Use Plan (Vuntut Gwitchin Government & Yukon Government, 2009)

  The Porcupine caribou herd is considered the most significant wildlife resource in the planning area and holds a special place in the plan. A key issue addressed is oil and gas development in Eagle Plains. The plan includes best management practices to protect caribou from disturbance, especially at critical times of the year.

Map 5- 7. Yukon land use planning regions and Gwich'in Settlement Area

(Vuntut Gwitchin Government & Yukon Government, 2009, Figure 1.1)

Peel Watershed Regional Land Use Plan (Peel Watershed Planning Commission, 2019)

Porcupine caribou may winter throughout the planning region (**Error! Reference source not found.**), though they are mainly down the Richardson Mountains into the Hart, Blackstone, and Ogilvie drainages. The plan contains provisions for avoiding or reducing activities that would disturb caribou during this time window. There is oil and gas potential within the planning region.

Working for the Land: Gwich'in Land Use Plan (Gwich'in Land Use Planning Board, 2003)

This land use plan is for the Gwich'in Settlement Area, shown in Map 5– 7. The Porcupine caribou herd is a principal resource requiring protection in three of the plan's special management zones:

1. Porcupine Caribou (Vàdzaih): in the Richardson Mountains, an area used during spring migration)
2. Stoney Creek (Gwatoh Taii Tshik): in the foothills of the Richardson Mountains, also part of the caribou's spring migration corridor
3. Dempster Highway Yukon/NWT Border to Peel River

These three special management zones have conditions designed to protect caribou .

Research and Monitoring Programs

- Indicators and monitoring through the Porcupine Caribou Management Board and Porcupine Caribou Technical Committee (Porcupine Caribou Technical Committee, 2018, 2019b, 2019a)

  A set of population, body condition, and habitat indicators is monitored and reported on annually to aid in decision making.

Table 5- 3. Porcupine caribou indicators

Population size and trend		Body condition	Habitat
• Population size • Population trend • Adult cow survival • Calf birth rate • Calf survival	• Calf:cow ratio late June • Calf:cow ratio March • Bull ratio • Peak of calving date	• Average back fat • Hunter assessment • Condition of caribou	• Snow conditions • Wildland fires • Linear disturbance and human development

Porcupine Caribou Technical Committee (2019a)

- Inuvialuit Harvest Study (IHS) 2016-2019 (IRC, 2017, 2018, 2019)

  From 2016-2019, annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This included caribou harvest monitoring. Inuvialuit Community Resource Technicians collected harvest information, including harvest locations, through monthly interviews with active harvesters. Inuvialuit caribou harvest was reported by the Inuvialuit Game Council at the Porcupine Caribou Management Board's annual harvest meetings (IGC, 2018, 2019).

- Arctic Caribou Contaminant Monitoring Program (Gamberg, 2015, 2017, 2018)

  This ongoing monitoring of the Porcupine and Qamanirjuaq caribou herds is part of the Northern Contaminants Program (Government of Canada, 2018). Monitoring goals are to determine if contaminants are affecting Canadian Arctic caribou populations or the safety of caribou as food, and to see if contaminant levels are changing over time.

- Arctic Borderlands Ecological Knowledge Society (ABEKS, 2020)(ABEKS, 2018)

  The Aklavik Hunters and Trappers Committee is a partner in this community-based monitoring program that includes several Porcupine caribou user communities. The program has been in operation since 1996. Monitoring consists of structured interviews with active hunters, conducted annually, and features questions about caribou, such as about body condition and about how successful harvesters were at meeting their needs for caribou each year. Results are presented at the Porcupine Caribou Management Board annual harvest meeting (ABEKS, 2019).

- Reports and presentations presented at the Annual Harvest meeting or collected by the Porcupine Caribou Management Board
  These include reports by the Inuvialuit Game Council and the Arctic Borderlands Ecological Knowledge Society (ABEKS, 2019; for example, IGC, 2018, 2019). The reports and presentations summarize results of meetings and interviews, including hunters' observations and Inuvialuit knowledge about Porcupine caribou, and inform decision making at these annual meetings.

Selected Studies and Research Relevant to the Yukon North Slope

There is a solid base of both traditional and scientific knowledge about the Porcupine caribou herd throughout its range. Inuvialuit traditional knowledge about caribou has been recorded through several studies and is documented on an ongoing basis through community-based monitoring and harvest management initiatives. Ongoing research and monitoring by government agencies and researchers includes habitat and migration studies, periodic estimates of the herd size, and monitoring of body condition, herd composition, and survival rates. Studies provide information on natural and human-influenced sources of mortality and threats to caribou health or productivity, including predation, insect harassment, unfavourable snow and ice conditions, contaminants, parasites, and disease. Research on caribou energetics has improved knowledge about caribou needs over the seasons and over their life cycles, and their vulnerability to impacts from industrial development and climate change.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- *Aklavik Local and Traditional Knowledge about Porcupine Caribou* (WMAC (NS) & Aklavik HTC, 2009)
  This study is based on interviews with 14 local experts. Spatial information was recorded on maps. The results are referenced throughout this chapter.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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. The results were used in developing the Plan and are described and referenced throughout this chapter.

Assessments and Syntheses of Study Results

- Porcupine caribou studies from 1970 to 2001

  Results from this body of research and monitoring are presented and synthesized in two publications:
  - *Movements and Distribution of the Porcupine Caribou Herd, 1970-1990* (D. E. Russell, Whitten, Farnell, & van de Wetering, 1992) compiles results from surveys by industry and government across the international range of the herd.
  - *Range Ecology of the Porcupine Caribou Herd in Canada* (D. E. Russell et al., 1993) presents results of work carried out by the Canadian Wildlife Service as a joint project with the Yukon Department of Renewable Resources from 1979 to 1987. The report includes studies on range conditions, habitat selection, diet, and activity over the annual life cycle of caribou, and findings on caribou energetics.
  - A chapter on the Porcupine caribou herd in *Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries* (Griffith et al., 2002) contains summaries of scientific investigations of the Porcupine caribou herd and its habitat, updating and building on the information from an earlier resource assessment of the Arctic National Wildlife Refuge (Clough, Patton, & Christensen, 1987). Although the focus is the 1002 Lands in Alaska, this report includes summaries of studies up to 2001 over the entire range of the herd in Alaska and Canada.

- *Sensitive Habitats of the Porcupine Caribou Herd* (International Porcupine Caribou Board, 1993)

  This report provides a foundation for habitat conservation over the international range of the Porcupine caribou herd. It categorizes the periods in the caribou's annual cycle by their importance to the long-term survival of the herd and summarizes knowledge about habitat use and land status of sensitive habitats during each period. The report is based on the 1970 to 1990 data compiled in Russell et al. (1992).

> At different times of the year, caribou need special places in order to stay healthy and raise their young. As the seasons change, the caribou travel from one special place or "habitat" to the next according to their needs for food, safety, escape from flies or shallower snow depths.
> (International Porcupine Caribou Board, 1993, p. 3)

- *Summer Ecology of the Porcupine Caribou Herd* (D. E. Russell & McNeil, 2005)

  This report consolidates science-based knowledge about the ecological factors that affect caribou during the critical calving and post-calving periods and knowledge about the known and potential effects of climate change and oil and gas development on caribou. The report is based primarily on research results reported in Griffith et al. (2002).

- *Vulnerability Analysis of the Porcupine Caribou Herd to Potential Development of the 1002 Lands in the Arctic National Wildlife Refuge, Alaska* (D. E. Russell & Gunn, 2019) and *A decision support tool for assessing cumulative effects on an Arctic migratory tundra caribou population* (D. Russell, Gunn, & White, 2021)
  The report and associated paper synthesize science-based information and provide projections of potential impacts of development of the 1002 lands using the Caribou Cumulative Effects Model. Some conclusions from this risk assessment are in the section on Cumulative Effects.

- *Assessment and Status Report on the Caribou* Rangifer tarandus *Barren-ground Population in Canada* (COSEWIC, 2016)
  This assessment report summarizes knowledge on Canadian barren-ground caribou and provides the rationale for its designation by COSEWIC as Threatened.

References

ABEKS. (2020). Arctic Borderlands Ecological Knowledge Society. Retrieved February 3, 2019, from https://www.arcticborderlands.org/

ABEKS. (2019). *2018-19 ABEKS Update for PCMB Annual Harvest Meeting*. Retrieved from Arctic Borderlands Ecological Knowledge Society. Presentation to: Annual Harvest Meeting Inuvik, NT, February 12-13 website: http://www.pcmb.ca/resources

ABEKS. (2018). *Arctic Borderlands Ecological Knowledge Society Strategic Plan – 2017-2020*.

ABEKS. (2019). *2018-19 ABEKS Update for PCMB Annual Harvest Meeting*. Retrieved from Arctic Borderlands Ecological Knowledge Society. Presentation to: Annual Harvest Meeting Inuvik, NT, February 12-13 website: http://www.pcmb.ca/resources

ABEKS. (2020). Arctic Borderlands Ecological Knowledge Society. Retrieved February 3, 2019, from https://www.arcticborderlands.org/

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

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

Canada. *The Inuvialuit Final Agreement, as Amended, Consolidated Version April 2005*. , (1984).

Clough, N. K., Patton, P. C., & Christensen, A. C. (1987). *Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment: Report and recommendation to the Congress of the United States and final legislative environmental impact statement*. Washington, DC: U.S. Fish and Wildlife Service, U.S. Geological Survey, and Bureau of Land Management.

COSEWIC. (2016). *COSEWIC Assessment and Status Report on the Caribou* Rangifer tarandus *Barren-ground Population in Canada*.

Gagnon, C. A., Hamel, S., Russell, D. E., Powell, T., Andre, J., Svoboda, M. Y., & Berteaux, D. (2020). Merging indigenous and scientific knowledge links climate with the growth of a large migratory caribou population. *Journal of Applied Ecology*, *57*(9), 1644–1655. https://doi.org/10.1111/1365-2664.13558

Gamberg Consulting. (2017). *Report to the hunters of the Porcupine caribou - July, 2017*. Information sheet distributed at the Northern Contaminants Program 25th Anniversary Results Workshop, September 26-28, 2017, Yellowknife, NWT.

Gamberg, M. (2015). *Arctic Caribou Contaminant Monitoring Program*. Government of Canada.

Gamberg, M. (2017). *Arctic Caribou Contaminant Monitoring Program*. Government of Canada.

Gamberg, M. (2018). Arctic Caribou Contaminant Monitoring Program. Retrieved July 4, 2020, from https://www.science.gc.ca/eic/site/063.nsf/eng/h_97700.html#13

Gamberg, M., Poulain, A. J., Zdanowicz, C., & Zheng, J. (2015). Mercury in the Canadian Arctic Terrestrial Environment: An Update. *Science of The Total Environment*, *509–510*, 28–40. https://doi.org/10.1016/J.SCITOTENV.2014.04.070

Government of Canada. (2018). Northern Contaminants Program - Background. Retrieved January 18, 2019, from http://www.science.gc.ca/eic/site/063.nsf/eng/h_67223C7F.html

Government of Canada. (2020). Canada-United States agreement on Porcupine caribou herd conservation.

Retrieved June 9, 2020, from https://www.canada.ca/en/environment-climate-change/corporate/international-affairs/partnerships-countries-regions/north-america/canada-united-states-porcupine-caribou-conservation.html

Government of Canada, & Government of the United States of America. (1987). *Agreement Between the Government of Canada and the Government of The United States of America on the Conservation of the Porcupine Caribou Herd*.

Government of Canada, Government of Yukon, Government of the Northwest Territories, Council for Yukon Indians, Inuvialuit Game Council, & Dene Nation and Metis Association of the Northwest Territories. *Porcupine Caribou Management Agreement*. , (1985).

Griffith, B., Douglas, D. C., Walsh, N. E., Young, D. D., McCabe, T. R., Russell, D. E., … Whitten, K. R. (2002). The Porcupine caribou herd. In D.C. Douglas, P. E. Reynolds, & E. B. Rhode (Eds.), *Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries* (pp. 8–37). Chapter 3. U. S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD BSR-2002-0001.

Gunn, A. (2016). *Rangifer tarandus. The IUCN Red List of Threatened Species 2016*. https://doi.org/http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T29742A22167140.en

Gunn, A., Russell, D. E., & Eamer, J. (2011). *Northern caribou population trends in Canada*. Ottawa, ON: Canadian Councils of Resource Ministers.

Gurarie, E., Hebblewhite, M., Joly, K., Kelly, A. P., Adamczewski, J., Davidson, S. C., … Boelman, N. (2019). Tactical departures and strategic arrivals: Divergent effects of climate and weather on caribou spring migrations. *Ecosphere*, *10*(12). https://doi.org/10.1002/ecs2.2971

Gwich'in Land Use Planning Board. (2003). *Nành' Geenjit Gwitr'it T'igwaa'in Working for the Land: Gwich'in Land Use Plan*.

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

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

IGC. (2018). *PCMB Annual Harvest Meeting 2018 (presentation)*. Inuvialuit Game Council.

IGC. (2019). *Inuvialuit Game Council PCMB Annual Harvest Meeting*. Retrieved from Presentation to: Annual Harvest Meeting Inuvik, NT, February 12-13 website: http://www.pcmb.ca/resources

IGC, WMAC (NS), WMAC (NWT), & FJMC. (2018). *Submission of The Inuvialuit Game Council (IGC), Wildlife Management Advisory Council (North Slope) (WMAC (NS)), Wildlife Management Advisory Council (Northwest Territories) (WMAC (NWT)), and Fisheries Joint Management Committee (FJMC) Part*.

International Porcupine Caribou Board. (1993). *Sensitive Habitats of the Porcupine Caribou Herd*. Retrieved from http://www.pcmb.ca/resources

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

IPCC. (2021). Habitat selection by calving caribou of the Central Arctic Herd, 1980-1995. *Cambridge University Press*, (In Press), In Press.

IRC. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*.

Inuvialuit Regional Corporation.

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

IUCN. (2020). The IUCN Red list of Threatened Species. Retrieved July 2, 2020, from https://www.iucnredlist.org/

Johnson, C. J., & Russell, D. E. (2014). Long-term distribution responses of a migratory caribou herd to human disturbance. *Biological Conservation*, *177*, 52–63. https://doi.org/10.1197/jamia.M2384.Introduction

Johnson, H. E., Golden, T. S., Adams, L. G., Gustine, D. D., & Lenart, E. A. (2020). Caribou Use of Habitat Near Energy Development in Arctic Alaska. *Journal of Wildlife Management*, *84*(3), 401–412. https://doi.org/10.1002/jwmg.21809

Kenny, T. A., Fillion, M., Simpkin, S., Wesche, S. D., & Chan, H. M. (2018). Caribou (Rangifer tarandus) and Inuit Nutrition Security in Canada. *EcoHealth*. https://doi.org/10.1007/s10393-018-1348-z

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

Macdonald, C. R., Elkin, B. T., & Tracy, B. L. (2007). Radiocesium in caribou and reindeer in northern Canada, Alaska and Greenland from 1958 to 2000. *Journal of Environmental Radioactivity*, *93*(1), 1–25. https://doi.org/10.1016/j.jenvrad.2006.11.003

Mallory, C. D., & Boyce, M. S. (2017). Observed and predicted effects of climate change on Arctic caribou and reindeer. *Environmental Reviews*, *25*(June 2017), 1–13. https://doi.org/10.1139/er-2017-0032

McFarland, H. R., Caikoski, J., Lenart, E., & Taras, M. (2017). *Porcupine Caribou News [newsletter]*. Alaska Department of Fish and Game, Division of Wildlife Conservation.

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

Parks Canada. (2010). *Vuntut National Park of Canada Management Plan*.

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

PCMB. (2010a). *Harvest Management Plan for the Porcupine Caribou Herd in Canada*. Retrieved from Porcupine Caribou Management Board website: https://www.pcmb.ca/documents/Harvest Management Plan 2010.pdf

PCMB. (2010b). *Summary : Porcupine Caribou Harvest Management Plan*. Retrieved from http://www.pcmb.ca/resources

PCMB. (2011). *Guidelines for the Sale , Trade and Barter of Porcupine Caribou Meat*. Porcupine Caribou Management Board.

PCMB. (2012). Cumulative effects project overview. *Caribou Update*, (December). Retrieved from http://www.pcmb.ca/PDF/researchers/Habitat/Caribou Update Dec 2012 re Cumulative Effects Project.pdf

PCMB. (2016). *Implementation Plan, A Companion Document to the Harvest Management Plan for the Porcupine Caribou Herd in Canada*.

PCMB. (2020a). *Porcupine Caribou Harvest Management Plan Annual Harvest Meeting: Porcupine Caribou*

Management Board Recommendations to the Parties, February 2020. Retrieved from Porcupine Caribou Management Board website: http://www.pcmb.ca/resources

PCMB. (2020b). Porcupine Caribou Management Board web site. Retrieved June 8, 2020, from http://www.pcmb.ca/

Peel Watershed Planning Commission. (2019). *Peel Watershed Regional Land Use Plan*.

Porcupine Caribou Technical Committee. (2018). *Porcupine Caribou Annual Summary Report 2017-2018*. Retrieved from http://www.pcmb.ca/resources

Porcupine Caribou Technical Committee. (2019a). *Porcupine Caribou Annual Summary Report 2018-2019*.

Porcupine Caribou Technical Committee. (2019b). *Summary of Indicators 2019*. Retrieved from Presentation to: Annual Harvest Meeting Inuvik, NT, February 12-13 website: http://www.pcmb.ca/resources

Rivest, L.-P., Couturier, S., & Crepeau, H. (1998). Statistical Methods for Estimating Caribou Abundance Using Postcalving Aggregations Detected by Radio Telemetry. *Biometrics*, *54*(3), 865. https://doi.org/10.2307/2533841

Russell, D. E., & Gunn, A. (2019). *Vulnerability Analysis of the Porcupine Caribou Herd to Potential Development of the 1002 Lands in the Arctic National Wildlife Refuge, Alaska*. Report prepared for: Environment Yukon, Environment and Climate Change Canada, and NWT Environment and Natural Resources.

Russell, D. E., Martell, A. M., & Nixon, W. A. C. (1993). Range Ecology of the Porcupine Caribou Herd in Canada. *Rangifer*, *13*(5), 1. https://doi.org/10.7557/2.13.5.1057

Russell, D. E., & McNeil, P. (2005). *Summer Ecology of the Porcupine Caribou Herd - 2nd Edition*. Retrieved from Porcupine Caribou Management Board website: http://www.pcmb.ca/resources

Russell, D. E., Whitten, K. R., Farnell, R., & van de Wetering, D. (1992). *Movements and Distribution of the Porcupine Caribou Herd, 1970-1990*. Technical Report Series No. 138. Pacific and Yukon Region. Environment Canada Canadian Wildlife Service.

Russell, D., & Gunn, A. (2017). *Assessing Caribou Vulnerability to Oil and Gas Exploration and Development in Eagle Plains, Yukon*. Whitehorse, Yukon.

Russell, D., Gunn, A., & White, R. (2021). A decision support tool for assessing cumulative effects on an arctic migratory tundra caribou population. *Ecology and Society*, *26*(1). https://doi.org/10.5751/ES-12105-260104

Stocki, T. J., Gamberg, M., Loseto, L. L., Pellerin, E., Bergman, L., Mercier, J. F., … Wang, X. (2016). Measurements of cesium in Arctic beluga and caribou before and after the Fukushima accident of 2011. *Journal of Environmental Radioactivity*, *162–163*, 379–387. https://doi.org/10.1016/j.jenvrad.2016.05.023

USGS, & USFWS. (2015). *Arctic National Wildlife Refuge Revised Comprehensive Conservation Plan/Final Environmental Impact Statement, Executive Summary*.

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

Vuntut Gwitchin Government, Tr’ondek Hwechin’in, First Nation of Na-Cho Nyak Dun, Inuvialuit Game

Council, & Gwich'in Tribal Council. (2019). *Porcupine Caribou Herd Canada Range-Wide Native User Agreement*. https://doi.org/10.1017/CBO9781107415324.004

Vuntut Gwitchin Government, & Yukon Government. (2009). *North Yukon Regional Land Use Plan*.

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). Porcupine caribou satellite collar location program. *Wildlife Watch*, *15*(1), 1.

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

WMAC (NS), & Aklavik HTC. (2009). *Aklavik Local and Traditional Knowledge about Porcupine Caribou*. Retrieved from Wildlife Management Advisory Council (North Slope) website: http://www.wmacns.ca/pdfs/287_WMAC_rpt_pcbou_knwldg_web.pdf

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).

Wolfe, S. A. (2000). Habitat Selection by Calving Caribou of the Central Arctic Herd, 1980-1995.

Yukon. (2020). Yukon Wildlife: Barren-ground Caribou. Retrieved April 20, 2020, from https://yukon.ca/en/barren-ground-caribou

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.

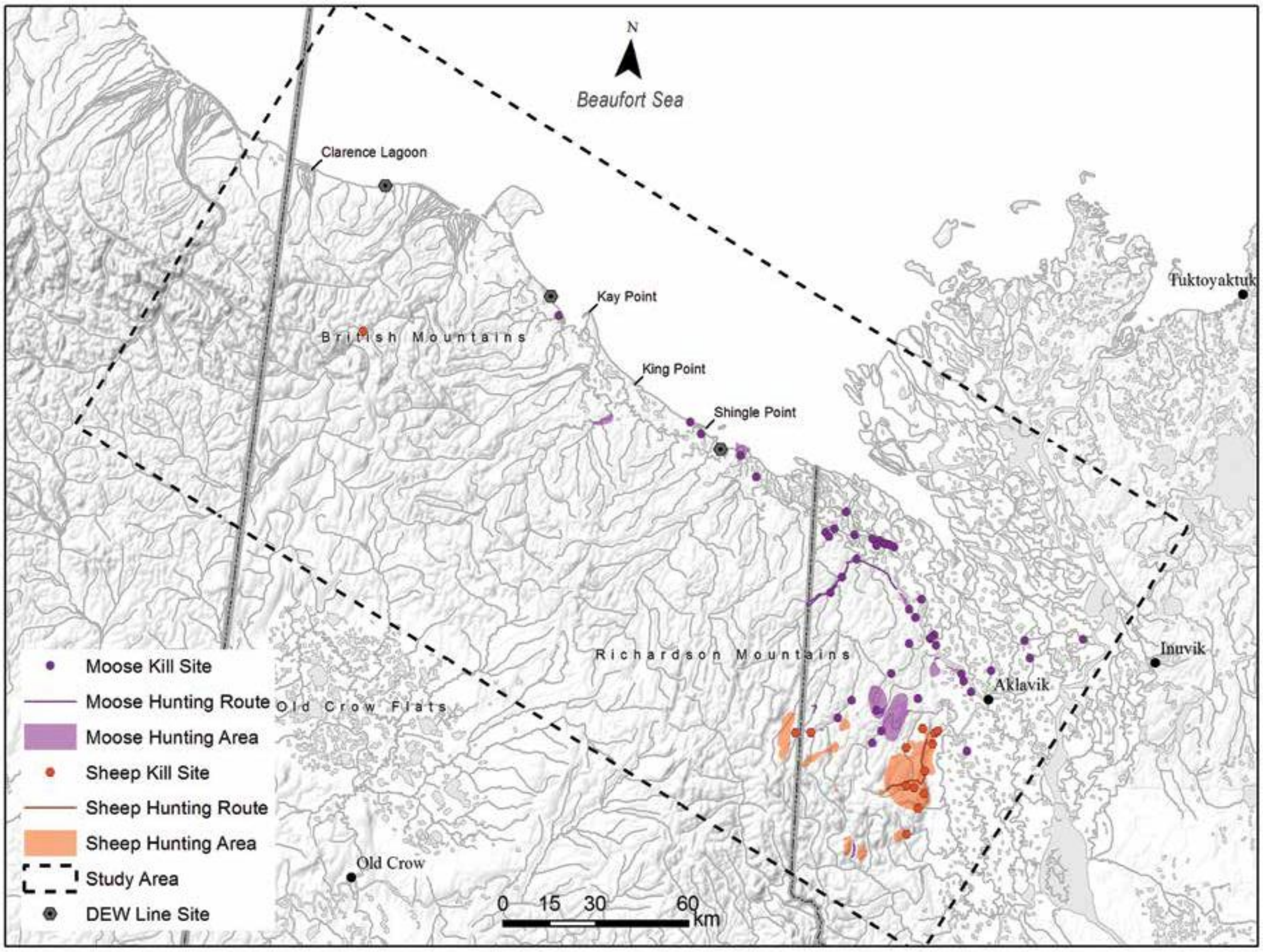
In a 1991 dietary survey of Aklavik Inuvialuit households, half of the 36 households surveyed reported eating moose at least once over the previous year (Wein and Freeman, 1992). Compared with caribou, moose was not frequently consumed. It was eaten on average 14 times a year, while caribou was on the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

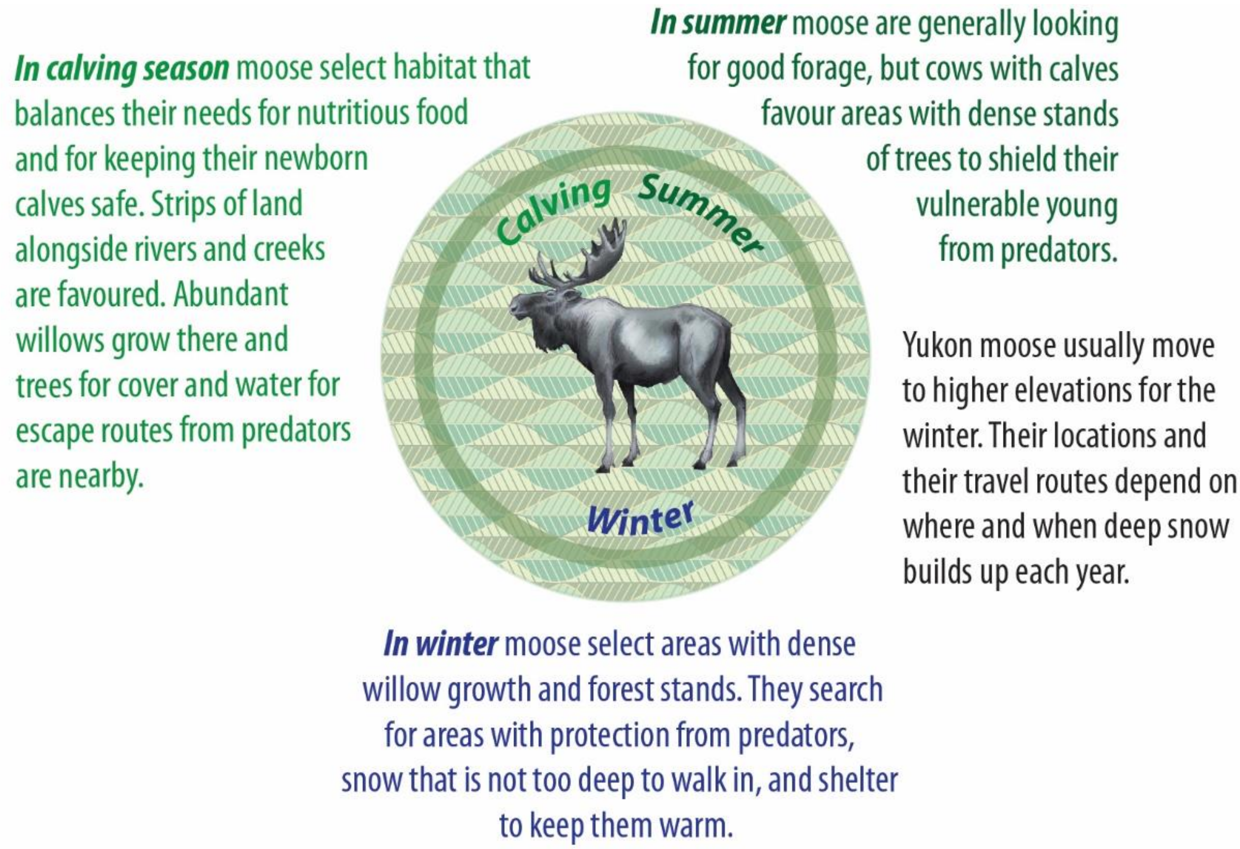
Introduction

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

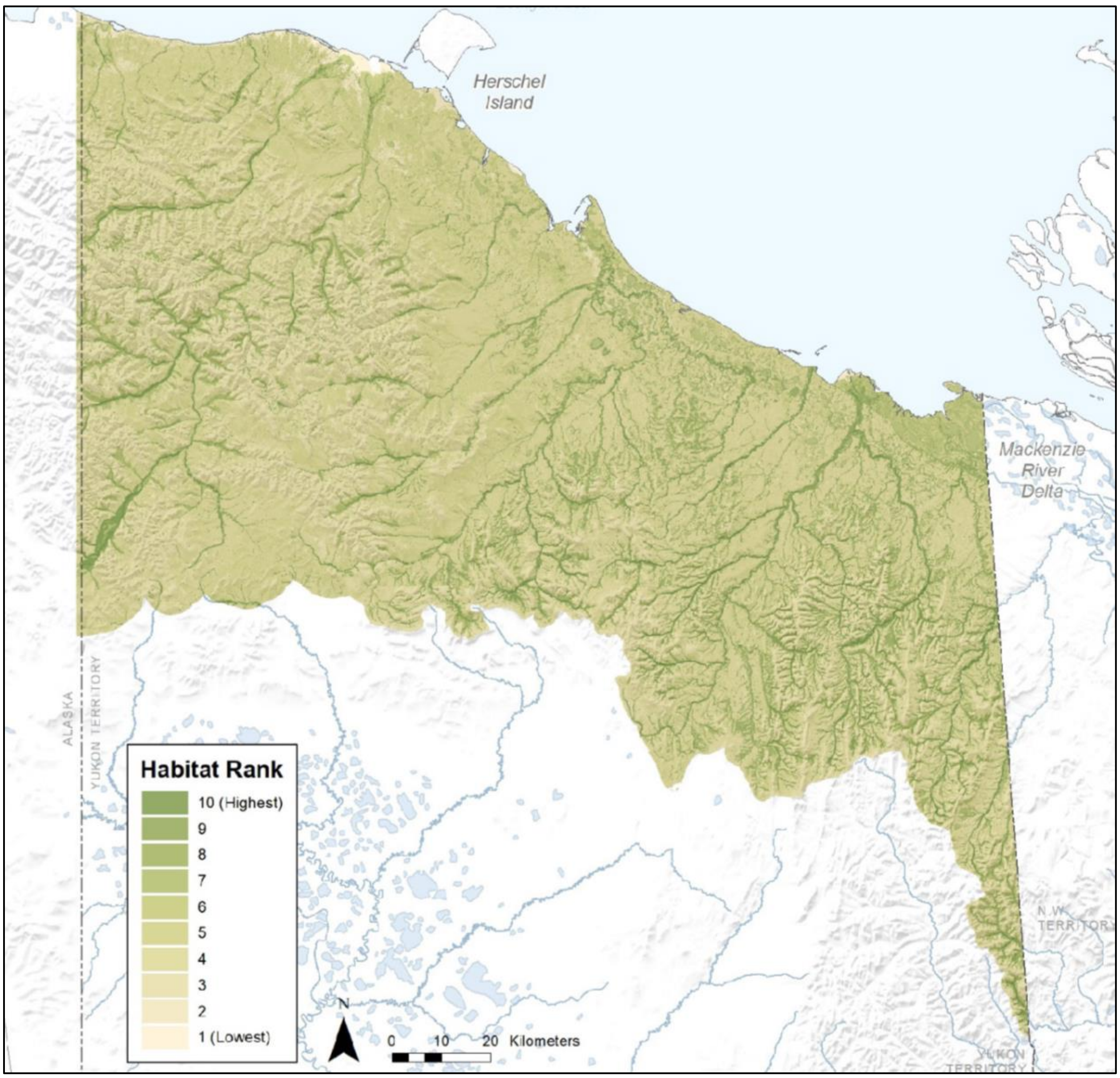
Habitat classification	Weight	GIS query (how the category was drawn on a map)
Willows in River Bed	9	Willows in "valley" landform (canyons, shallow valleys, U-shaped valleys), buffered 30m
Mountain Creeks	10	Streams in mountains with some presence of willow, occurring in and represented by any of three 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

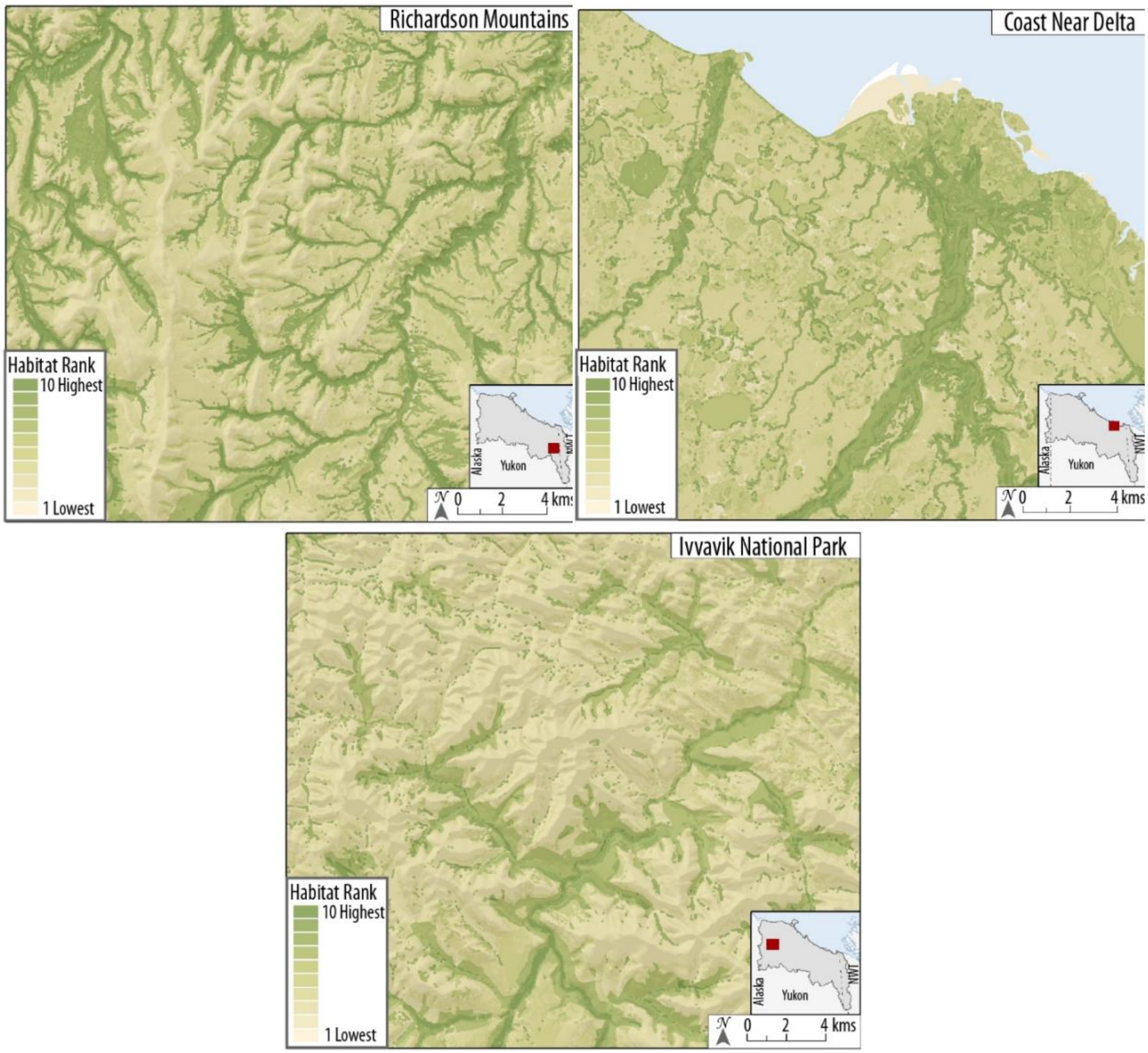
Mackenzie Delta, and western Ivvavik National Park (Map 6- 3). The TK-based habitat model shows that moose habitat is concentrated along rivers and in other areas where willow is found. The highest quality moose habitats cover 27% of the YNS. Overlaying the TK-based habitat model with moose locations 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

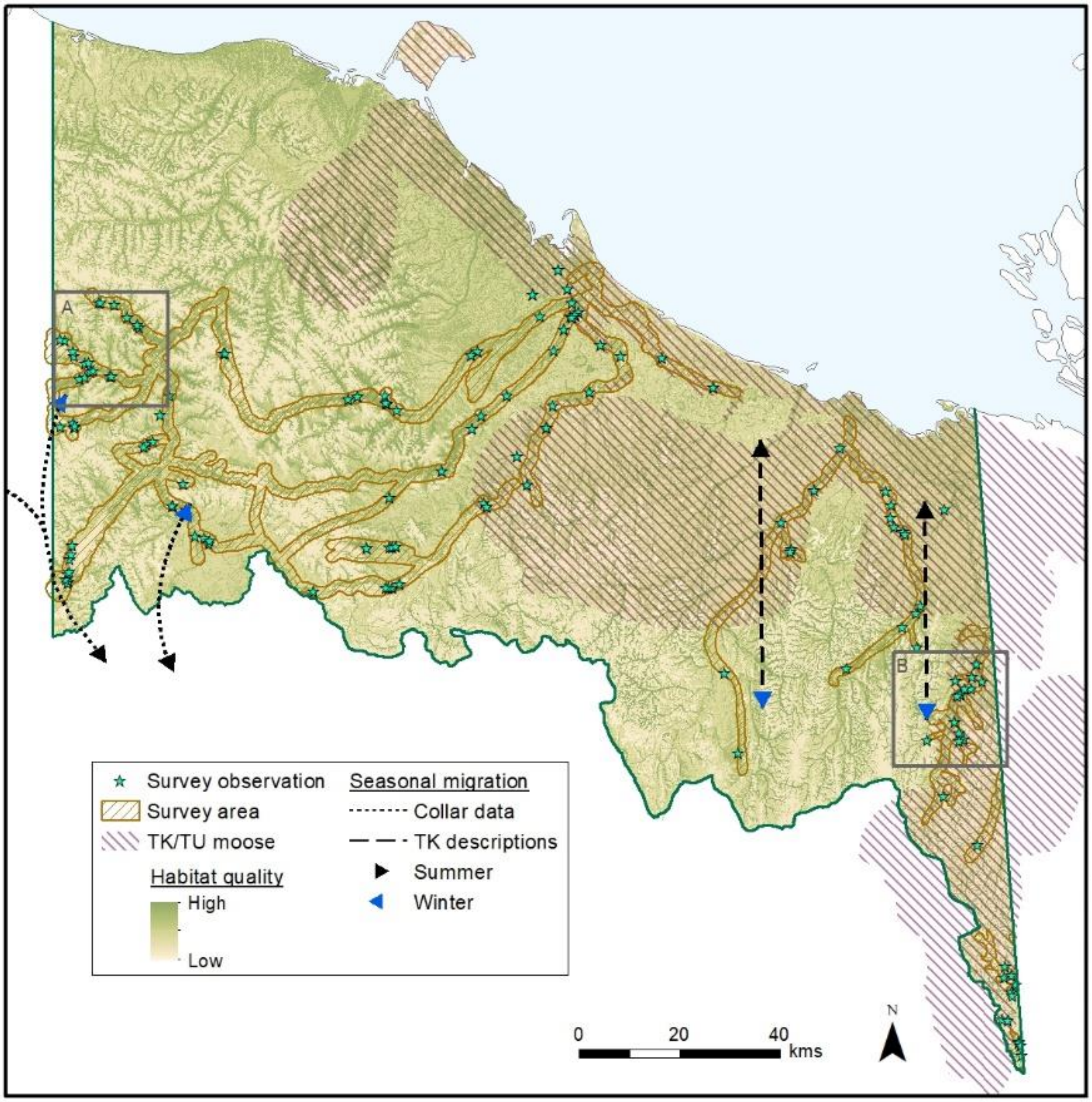


Round River Conservation Studies (2019), Maps 4, 5, and 6

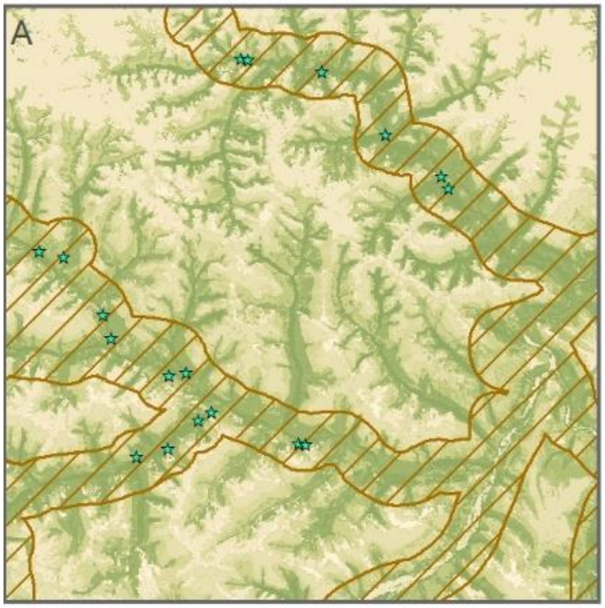
Moose Habitat Occupancy

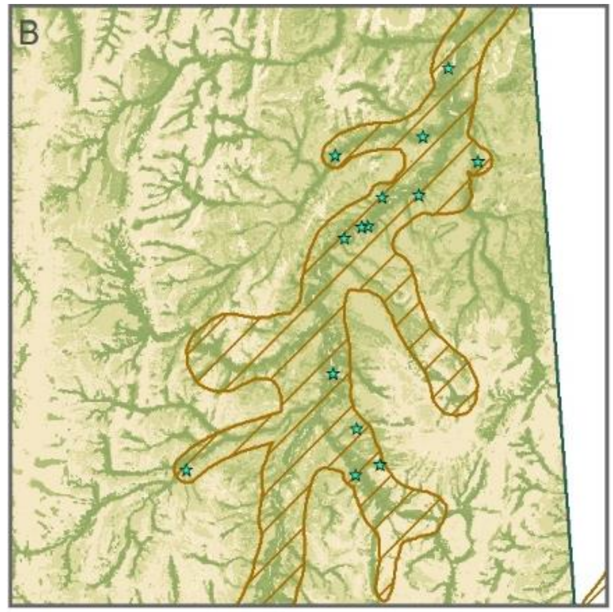
While the habitat suitability model predicts where there are high and low quality habitats for moose, it does not identify where moose are actually found. There is evidence that moose may be more limited in distribution than predicted by the distribution of potential moose habitat. Map 6- 4 shows the 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).

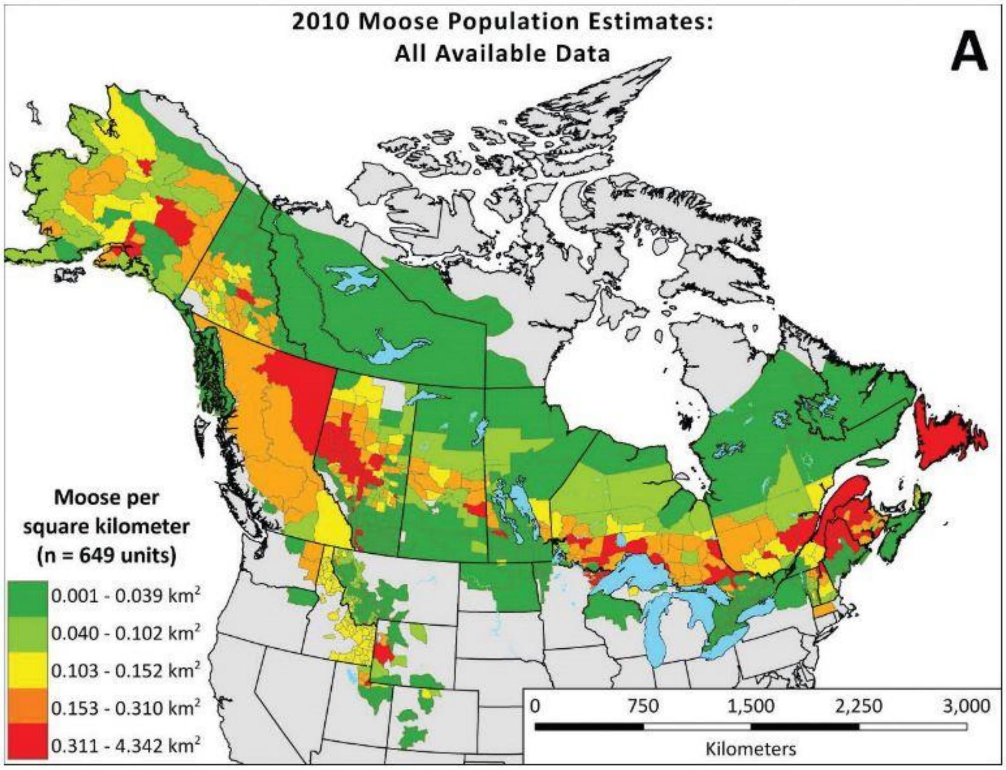
Harvest Management

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

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 7:
Grizzly Bear / Akłaq

Publication Information

Cover photo: Grizzly bear in Ivvavik National Park, © Parks Canada, 2014

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 7: Grizzly Bear / Akłaq

Table of Contents

Maps

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 four 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: Grizzly Bear / Akłaq

This companion report provides information on the conservation requirements for grizzly bear 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 grizzly bear, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for grizzly bear on the Yukon North Slope

1. Conservation of multiple ecosystem types grizzly bears depend on, with unimpeded passage for bears throughout the Yukon North Slope.
2. Identification and protection of denning sites from disturbance. Where ongoing or proposed activities are in areas with dens or denning habitat, den sites should be identified and activities relocated away from these sites, particularly through winter until early June.
3. Non-harvest mortality kept to a minimum.

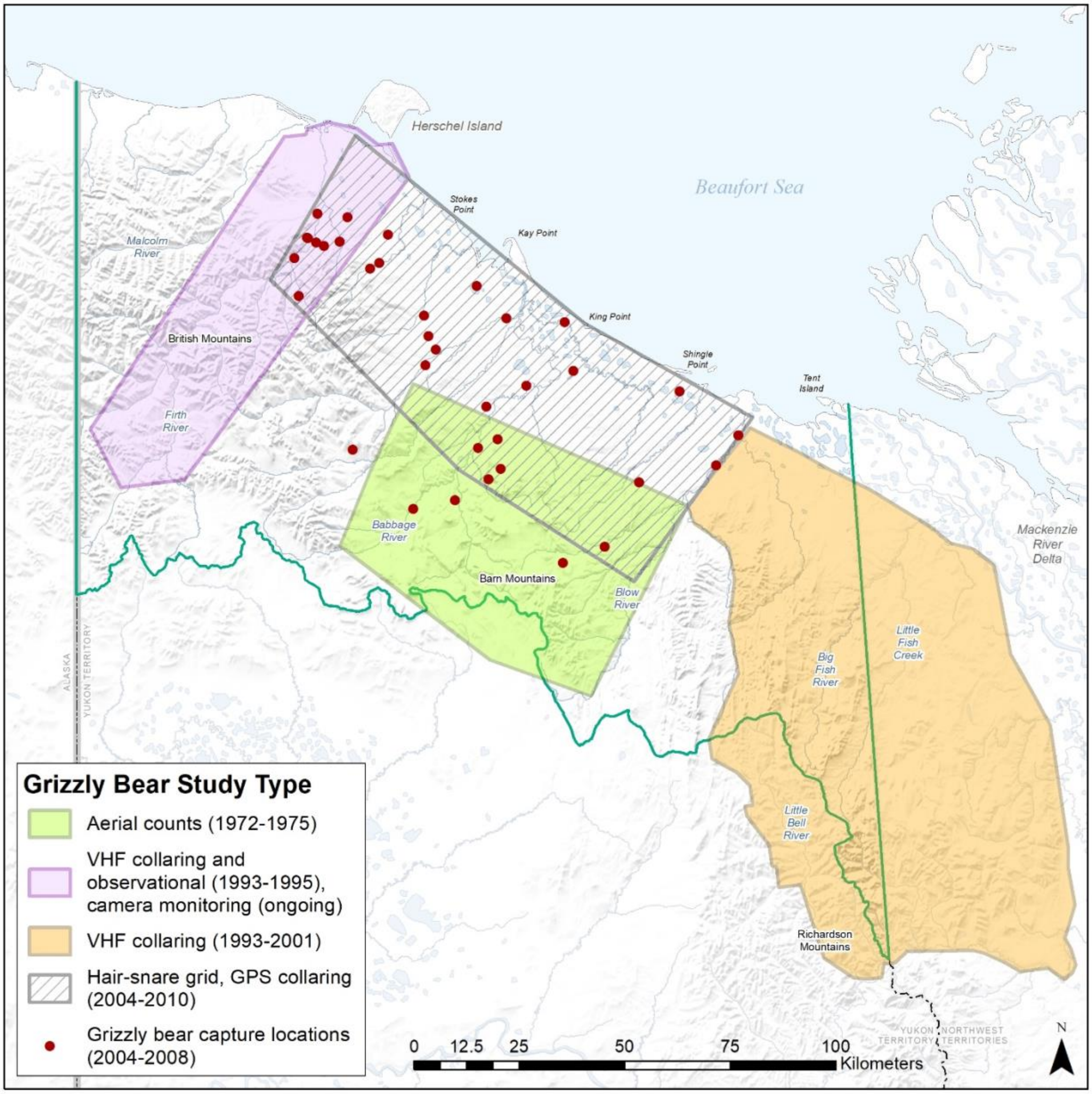
From the *Yukon North Slope Wildlife Conservation and Management Plan* (WMAC (NS), 2022)

Grizzly bear on the Yukon North Slope

Grizzly bears (Akłaq, *Ursus arctos*) occupy all areas of the Yukon North Slope, but their habitat use varies greatly by season and by sex. Grizzly bears require abundant space. Their annual home ranges cover large areas in the Yukon North Slope: on average 585 km^2 and 3368 km^2 for females and males, respectively (Triska & Heinemeyer, 2020). In all seasons, except when denning, grizzly bears traverse the landscape in search of food, and they require large tracts of relatively undisturbed and connected habitat. Denning habitat is not currently limited in the Yukon North Slope, but the threat of climate change and decreased permafrost may cause future degradation of den sites.

The knowledge base about grizzly bears on the Yukon North Slope includes the collection of traditional knowledge via interviews and mapping, and field studies to monitor and track grizzly bears using camera, hair-snaring and collaring. These studies span from the early 1970s to the present (Map 7- 1). Traditional knowledge and scientific studies have occurred across the Yukon North Slope and document grizzly bear population parameters, denning and seasonal habitat associations, food habits and movements, morphological characteristics, and Inuvialuit uses and harvest techniques. The most recent studies include camera studies on the Firth River (on-going) as well as traditional knowledge studies in 2006-2007 and 2016 that complement a large hair-snag and GPS collar study (2004-2010) to estimate population status and inform seasonal habitat models.

Map 7- 1. Focal study areas of previous grizzly bear studies in the Yukon North Slope



The locations of prior grizzly bear studies completed on the Yukon North Slope. Grizzly bear capture locations were from the Babbage River Drainage study area; however, some bears were captured outside of the study area boundary (gray hatched area). Source: Adapted from (Parks Canada and Yukon Government, 2014) and (WMAC (NS), Yukon Environment, Aklavik HTC, & Parks Canada, 2008)

Population estimates and traditional knowledge of grizzly bears in the Yukon North Slope generally suggest a stable grizzly bear population; however, there are likely differences in population status between the three mountain ranges in the region (British, Barn and Richardson) (Parks Canada and the Yukon Territorial Government, 2014; WMAC (NS) & Aklavik HTC, 2018a).

Traditional Use

Historically, grizzly bears were harvested by Inuvialuit for their meat, fat, hides, and claws, though they were not associated with daily life as often as other species, such as caribou, muskrat, arctic fox, beluga, or polar bear (WMAC (NS) & Aklavik HTC, 2008). Traditionally grizzly meat was eaten, and the grizzly paws were noted as a particularly good part. Unrendered fat was used in breads and mixed with certain roots to make "moo shoo" [*sic*]. Fat rendered into oil was used to waterproof skins for use as tarps or tents, burned in lamps, and used in cooking. The grizzly hides were used for shoes or as sleeping pads. Currently, grizzly bears are harvested mainly for income from sales of their hides with only some of the meat being taken home to eat (WMAC (NS) & Aklavik HTC, 2008).

Traditional Use of Grizzly Bears

Oil was rendered from bears for consumption and, as we have seen, to waterproof tent covers made of skin. It was also boiled with leaves and applied on dog faces to protect them from mosquitoes.

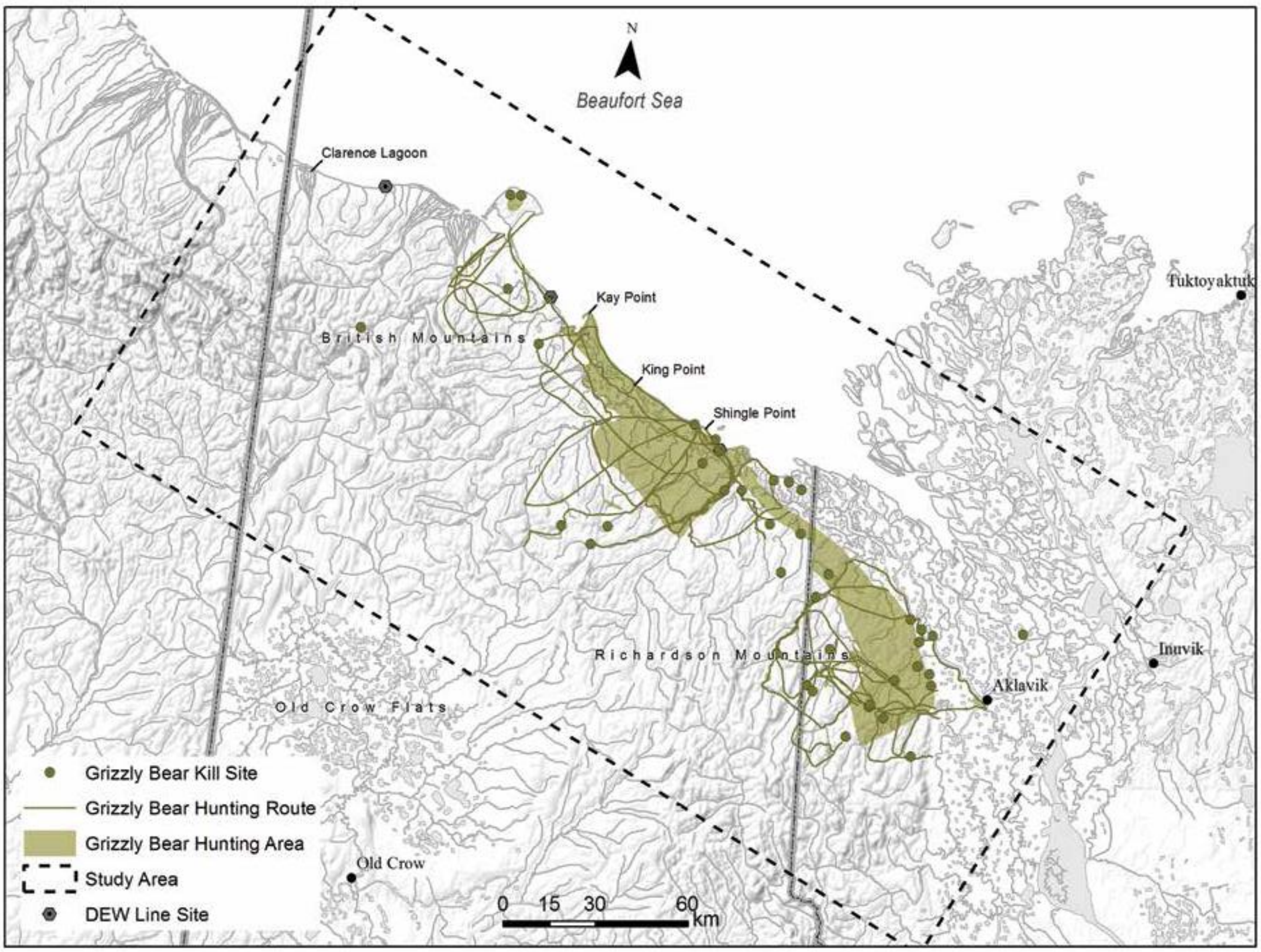
Lily Lipscombe recalls how her mother rendered oil from grizzly bears, as cited in Yukon North Slope Inuvialuit Oral History (Nagy, 1994, pp. 95).

In the past, subsistence hunting occurred throughout the year, including summer. Now, most subsistence hunting primarily occurs in the spring, when hides are worth the most, or occasionally in the fall (WMAC (NS) & Aklavik HTC, 2008). In the late 1980s, Aklavik Inuvialuit became concerned that the harvest of grizzly bears on parts of their lands was too high, undermining productivity and the long-term abundance of the species. To address this issue, a grizzly bear hunting area was created for the community of Aklavik by the Inuvialuit Game Council (IGC) in 1994 (WMAC (NS) & Aklavik HTC, 2008). This led to the development of a quota system, which is co-managed by the Inuvialuit and the Governments of Canada, NWT and Yukon (J. A. Nagy & Branigan, 1998). Under this quota system, hunters are given a limited number of tags for their yearly harvest. Tags are administered by the Aklavik Hunters and Trappers Committee. The current quota allows 18 grizzly bears, of which 5 can be female, to be harvested within the Yukon North Slope (J. A. Nagy & Branigan, 1998; NWT ENR, 2019).

The locations of grizzly bear harvest activities have not changed much over the past 20 years (Map 7- 2). Most bears are harvested from the Richardson Mountains west of Aklavik and the Barn Mountains behind Tapqaq (Shingle Point) due to their proximity to homes and seasonal camps (WMAC (NS) & Aklavik HTC, 2018b). However, a few harvesters still travel to the British Mountains in Ivvavik National Park to harvest bears (WMAC (NS) & Aklavik HTC, 2018b).

We'd travel along the beach looking for sign, always looking for sign. And as we're travelling along the coast, we're looking on land and out from the land [onto the ice], because we got both tags. We've got a grizzly bear tag and a polar bear tag, because we're going so far from town. We're doing more than a few days out on the land. All this area here has been covered….over a span of 20 years. We've covered this area here [pointing to map]….a lot. The hunters are finding they're going further and further to find bigger bears because the smaller bears are moving in, and they're not as big as what they used to be. From a 2016 interview. Source: WMAC (NS) and Aklavik HTC, 2018b, p. 65

Map 7- 2. Grizzly bear hunting routes and harvest locations identified in Inuvialuit traditional use interviews



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

Habitat for Grizzly Bear

Overview

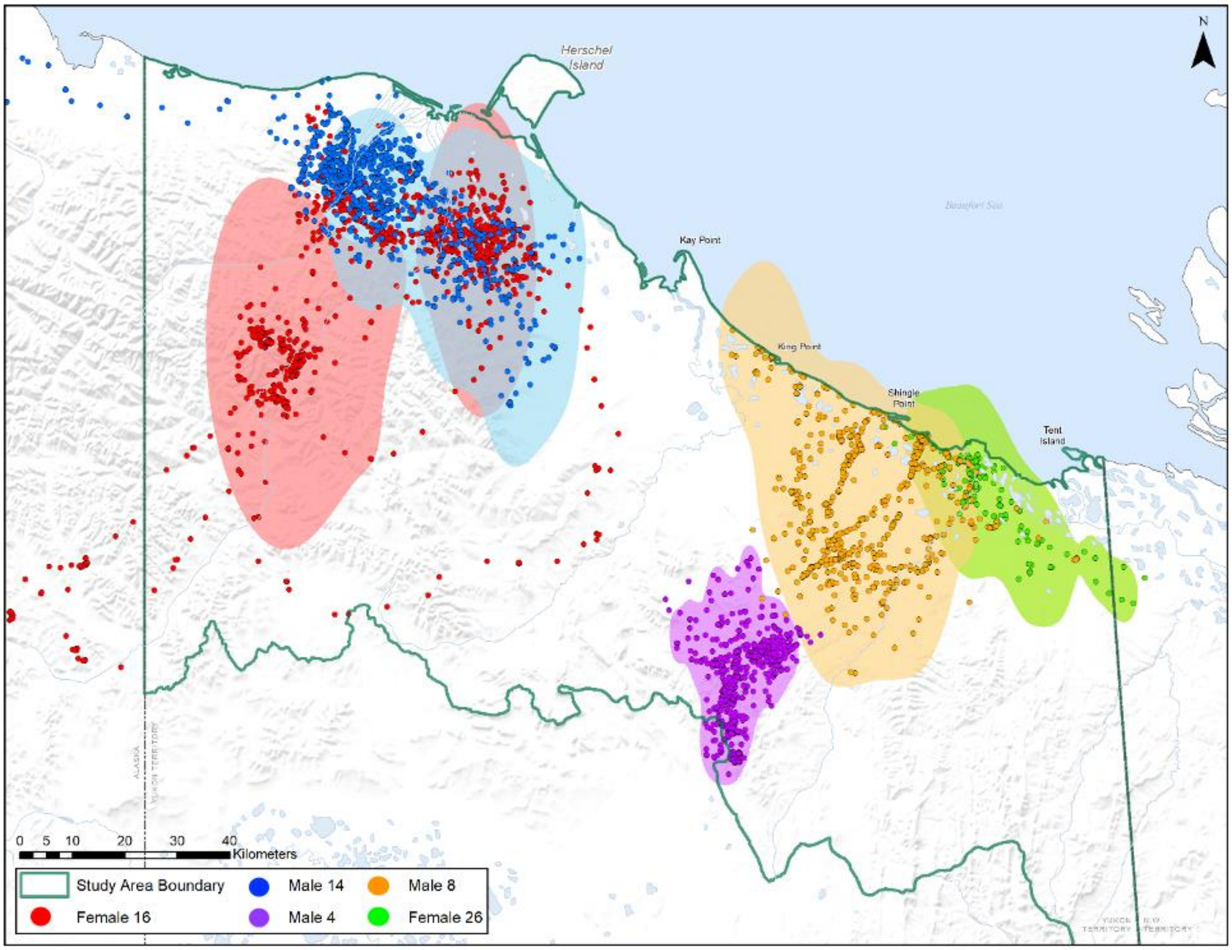
Grizzly bears are widely distributed in western Canada and portions of western United States. Historically, their distribution was even wider. They are found across this distribution in a wide variety of ecosystems, from temperate and boreal forests in the south, to the tundra and sparsely treed landscapes of the Yukon North Slope. Grizzly bears are well-known as a species that requires vast landscapes to thrive. In less-productive northern and arctic landscapes, such as the Yukon North Slope, grizzly bears need even more space, to allow them to move long distances to meet their food needs. Wherever they live, grizzly bears need a range of habitat features:

- Ecosystems with a sufficient amount of seasonally available food;
- Large tracts of undisturbed land; and
- A diversity of landscape features.

Research on the Yukon North Slope shows that while some grizzly bears may move beyond their home ranges over the course of a year, most stay within their large home ranges (Map 7- 3). They feed mainly on vegetation (e.g., crowberry (*Empetrum nigrum*), horsetail (*Equisetum arvense*), bearflower (*Boykinia richardsonii*), bog blueberries (*Vaccinium uliginosum*)), ground squirrels, caribou and large carcasses when they are available (MacHutchon & Wellwood, 2003). Grizzly bear distribution and habitat use on the Yukon North Slope is likely strongly influenced by the distribution and availability of seasonally important foods such as *Hedysarum* (Eskimo potato, bear root), grasses, forbs, berries, ground squirrels, and caribou (Machutchon, 2001; MacHutchon & Wellwood, 2003). A seasonally important prey and carrion source is the Porcupine caribou herd, which migrates through and calves in portions of the Yukon North Slope. Due to natural fluctuations in prey abundance, in arctic ecosystems grizzly bears may benefit from the diversity of ungulates that are present on the Yukon North Slope: caribou, Dall's sheep, muskoxen, and moose. Some studies suggest that increased predation on muskoxen may occur as the availability of other ungulates, such as Dall's sheep, decreases (Arthur & Del Vecchio, 2017; Lambert Koizumi & Derocher, 2019).

To satisfy changing seasonal requirements and widely different seasonal food sources, grizzly bears require large tracts of undisturbed land. Recently, the average annual home ranges for female and male grizzly bears in the Yukon North Slope were calculated as 585 km^2 and 3368 km^2, respectively (Triska & Heinemeyer, 2020). These calculations accord with previous estimates of expected sizes for northern grizzly bears in YNS and NWT (Collins, Kovach, & Hinkes, 2005; McLoughlin et al., 2003; John A. Nagy & Haroldson, 1990).

Map 7- 3. Movements of five grizzly bears with representative home ranges on the Yukon North Slope



The point locations of five grizzly bears, two females and three males, and their representative home ranges. The map displays two years of data for all bears except Female 26 (one year). Most bears' movements were within established home ranges (95% kernel densities, the shaded shapes); however, two bears (Male 14 and Female 16) displayed long walkabouts. Male 14 traveled into Alaska in September-October. Female 16 completed a loop into Alaska in August-September of one year and did another large loop within the YNS in May-June of the following year, returning to her home range each time (Triska & Heinemeyer, 2020).

Inuvialuit Traditional Knowledge About Grizzly Bear Habitat on the Yukon North Slope

Traditional knowledge holders emphasize that grizzly bears are always on the move and feed on plants and animals in many habitat types (Table 7- 1). Records of seasonal grizzly bear habitat use are summarized in *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope;* the quotes below are from the same source (WMAC (NS) and Aklavik HTC, 2018a, pp. 30-34).

Spring

In early spring the bears emerge from their dens and immediately start digging for roots of Alpine hedysarum and overwintered berries such as crowberry and bearberries (*Arctostaphylos* spp.), and hunting ground squirrels on hillsides. Then they move from the mountains and their den site locations toward the coast. The grizzly bears travel along river systems and forage in areas of early snow melt, to reach the rolling hills and flat coastal tundra. They follow caribou, hunting them and scavenging wolf kills, and increasingly they are seen near muskoxen. Grizzlies also scavenge whale carcasses and hunt seals out on the ice.

Summer

During summer bears range widely, traversing the landscape using river drainages in the mountains and coastal plain. They feed on common horsetail and bearflower. Along the coast, they are often searching for whale carcasses and avoiding insects. They also follow caribou in the summer, moving along the coast and into caribou calving grounds as the Porcupine herd travels through the area.

Fall

In the fall, bears are found in a variety of landscapes; however, food sources determine fall grizzly bear locations and movement. They feed extensively in areas with berries and roots, specifically bog blueberries, crowberries, horsetails, and bearflowers, in preparation for denning. Bears also follow the Dolly Varden as they migrate up the rivers. They hunt and scavenge caribou, moose, muskox and ground squirrels.

Denning

Den sites generally occur on steep hillsides, near a water source and on south-facing slopes (Table 7- 2). However, some dens occur in flatter, lower lands. Grizzly bear denning areas are being affected by slumping along hillsides, a consequence of climate change.

> I was taught to use ground squirrels as an alarm clock for [grizzly bears]… You know if you see a ground squirrel up and about, running around… there's going to be grizzly bears moving.
>
> When they come out of the den, they're always running towards the ocean… They can smell the seals. That's where they mostly go [the coast] when they're coming down the mountains… because there's no animals up here [in the mountains] in the wintertime… they go for the sea ice where there's seals.
>
> The past… six, seven years… we notice that… with the muskox numbers getting bigger on Herschel, that they're [grizzly bears] eating muskox. No one knew that before, from what I know.
>
> Most times… they are moving into [the mountains]. I've seen myself, in the fall, I'm working [the] lower Firth… counting the Arctic char… in one day there were 14

grizzly bears walk by us, going upstream... I never, ever seen a bear come down river, they were all moving upriver.

Table 7- 1. Major grizzly bear habitat classes and subclasses and the number of interviewees selecting each class during spring, summer, and fall

Habitat class/subclass	# selecting	Major uses	Season
Mountains and hillsides	16	Hunting ground squirrels, foraging for bear root and berries, denning habitat	spring, fall
Tundra	12	General travel, hunting caribou and muskox, foraging for berries	spring, summer, fall
Rivers, creeks, streams	11	Travel corridor, fishing, hunting caribou and moose	spring, summer, fall
Coast and beaches	11	Scavenging whale and seal carcasses, hunting caribou and muskox, avoiding insects	spring, summer, fall

Traditional knowledge descriptions used to classify habitat classes and subclasses in grizzly bear seasonal models. Source: (WMAC (NS) & Aklavik HTC, 2018a)

Table 7- 2. Major grizzly bear habitat classes and subclasses selected for denning, and the number of interviewees selecting each class

Habitat class/subclass	# selecting	TK description
Hillsides	10	Any hillside steep enough to dig into; small hillsides; hillsides generally
Aspect South	7	Top of hill facing south with good dirt (no permafrost), south facing hillsides
Slope	4	Not necessarily high elevation, but steep bank; steep hillsides
Distance to rivers	4	Above drainage/river; steep riverbanks; hillsides like riverbanks

Traditional knowledge descriptions used to classify habitat classes and subclasses in grizzly bear denning habitat model. Source: (Triska & Heinemeyer, 2020)

Yukon North Slope Seasonal Habitat Use

Seasonal grizzly bear traditional knowledge and GPS collar data and denning observations were used to model grizzly bear seasonal habitat on the Yukon North Slope. Models were completed for males and females during the spring, summer, fall, and denning periods, and validated by bear GPS collar locations not used in the modeling (Triska & Heinemeyer, 2020).

Spring

In spring, both males and females displayed preferences for areas near the coast, close to rivers and river valleys within the mountains. Females and males significantly selected for lower elevation and increasing slope, while males additionally selected for rounded ridgetops near the coast.

Summer

In the summer, males and females tended to prefer mountains over areas near the coast, and both were linked to presence of willows and areas close to rivers. There was broad use of the Yukon North Slope during the summer, with the major river drainages having the highest concentrations of high value habitats for both females and males. Additionally, males selected areas within the summer distribution of caribou.

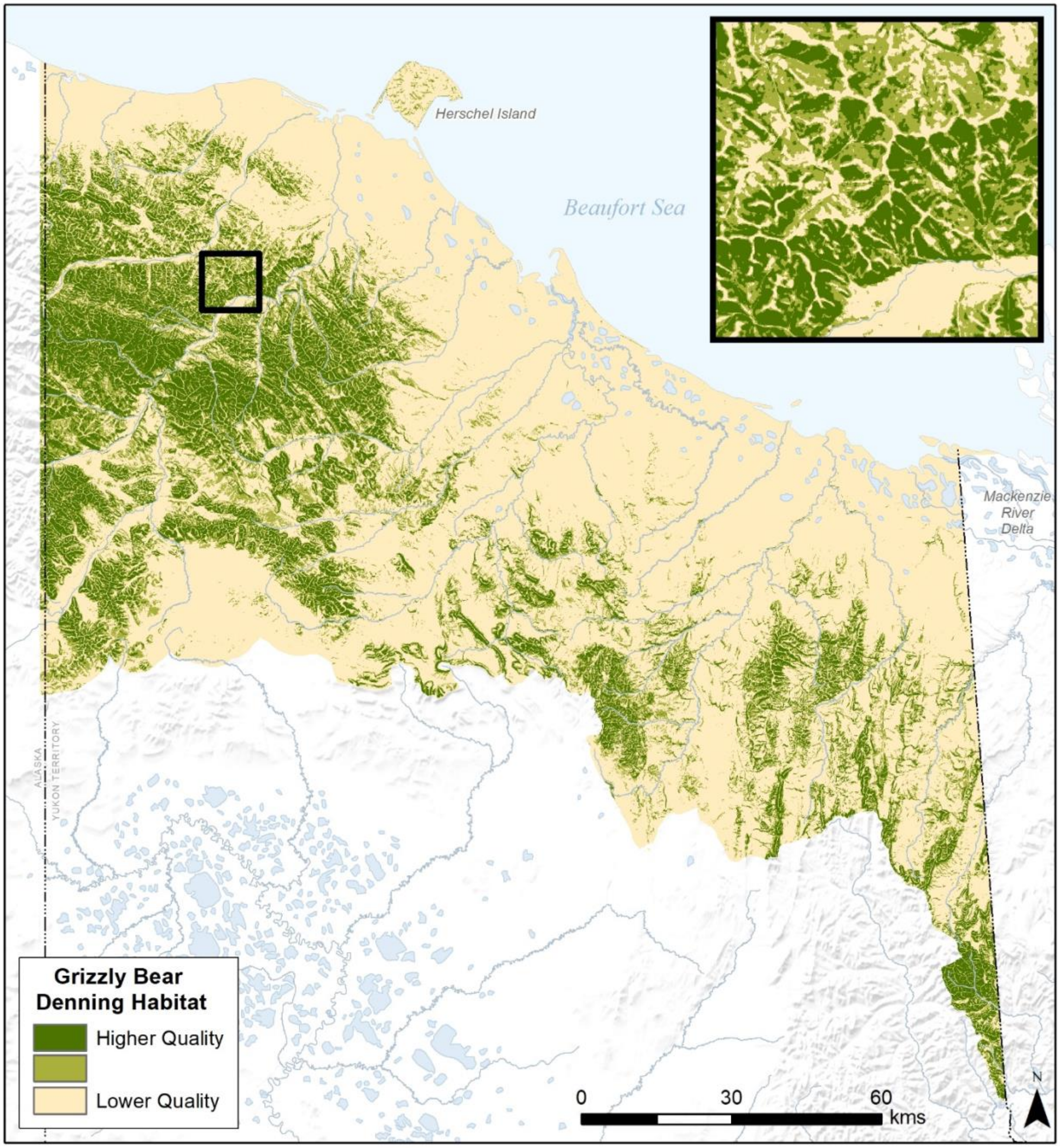
Fall

During the fall, male and female grizzly bears preferred mountains, with females selecting for shallow and moderate slopes and males selecting for increasingly steep slopes. Areas that encompass good berry habitats were used by both sexes, including areas close to wetlands and vegetation classes that have higher berry-producing species. The highest concentration of high-quality habitats was in the mountainous portions of the Yukon North Slope, with Ivvavik National Park having most high-quality fall habitats.

Denning

A model for grizzly bear dens (Map 7- 4), incorporating both male and female bears, showed use of slopes and southern aspects. This model also incorporated hillsides, and a preference for rivers, but showed that bears avoided tundra. Den selection includes a narrow suite of moderate and high value habitats, covering 13% and 14% of the study area, respectively. These areas are found in the mountains, and were most available in Ivvavik National Park and in the southern mountains of eastern Yukon North Slope.

Map 7- 4. Predictive relative importance of habitat for grizzly bear den sites in the Yukon North Slope.

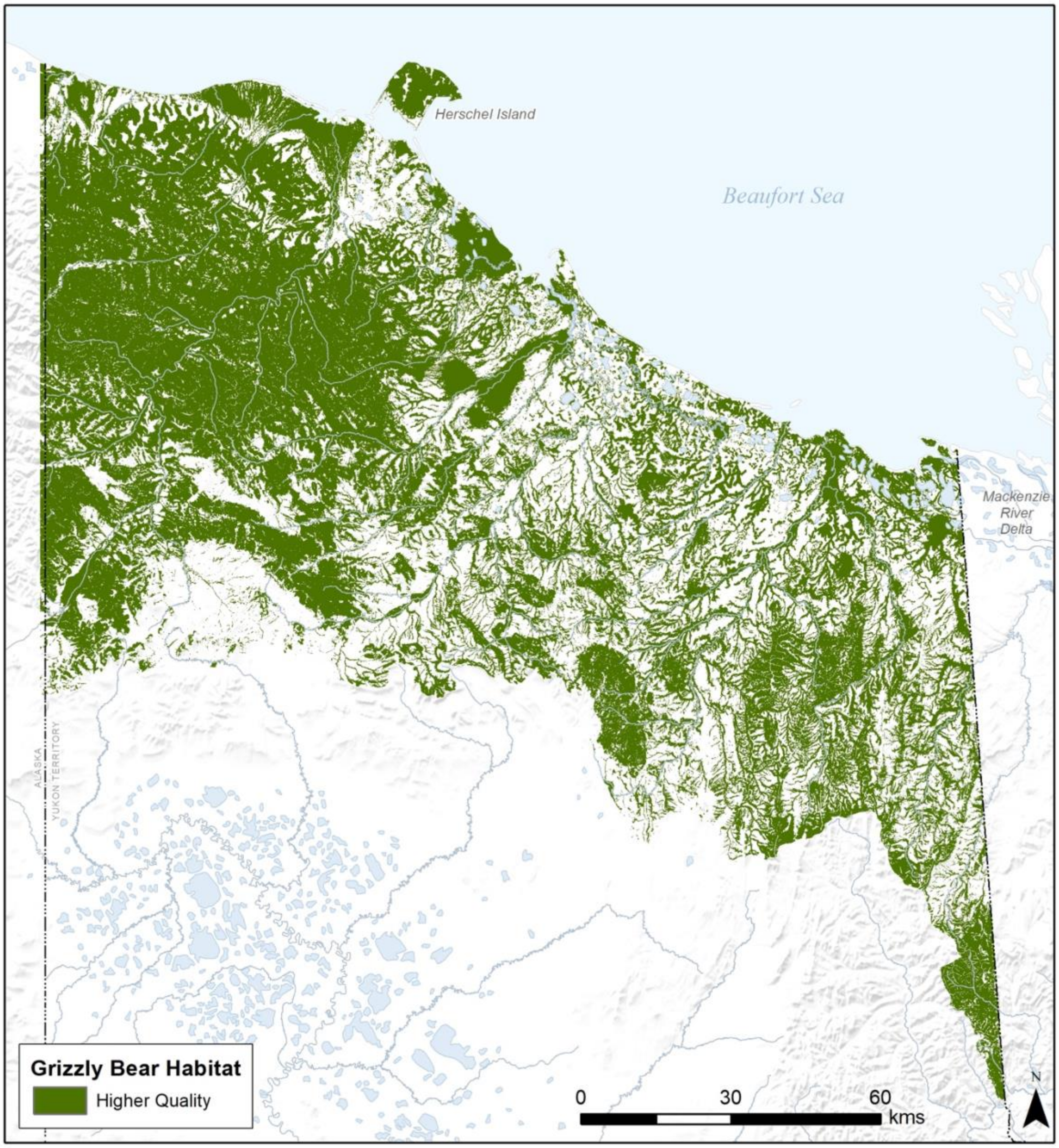


Model results were classified into three equal-area bins. Source: (Triska & Heinemeyer, 2020)

Combined Seasonal Model

The high value habitats from each seasonal habitat model (spring, summer, fall and denning) for males and females were used to provide a compilation of habitats that are important to grizzly bears during one or more seasons (Map 7- 5). This highlights that grizzly bears use habitat throughout the Yukon North Slope, including river valleys and drainages, mountains (Barns, British and Richardson) and the coastal plain, during the year.

Map 7- 5. Grizzly bear habitat overview: high value habitats from seasonal habitat models



This map displays habitat rated as high value by males or females during a minimum of one season or denning. It combines the results from seasonal habitat models in Triska and Heinemeyer (2020) and displays the highest ranked equal-area bin from each model. Note that white areas in the Yukon North Slope do not equate to non-habitat, but indicate lower quality habitat.

Grizzly Bear Population

The Canadian western population of grizzly bear is designated as Special Concern under the Species at Risk Act due to naturally low reproductive rates, increasing pressures from resource extraction, high mortality risk in areas of human activity, cumulative impacts, and a high sensitivity to human disturbance (COSEWIC, 2012). Yukon North Slope grizzly bears have limited or no exposure to human activities, road infrastructure, and industry. These are likely one of the few remaining grizzly bear populations, even in the North, that may be naturally regulated and at carrying capacity, meaning the population size is around the highest that the ecosystems can support (Government of Yukon, 2016; Parks Canada and the Yukon Territorial Government, 2014).

Species Conservation Status

Information on the conservation status of the western population of grizzly bear is in Table 7- 3.

Table 7- 3. Grizzly bear conservation status: Canada, Yukon, and global

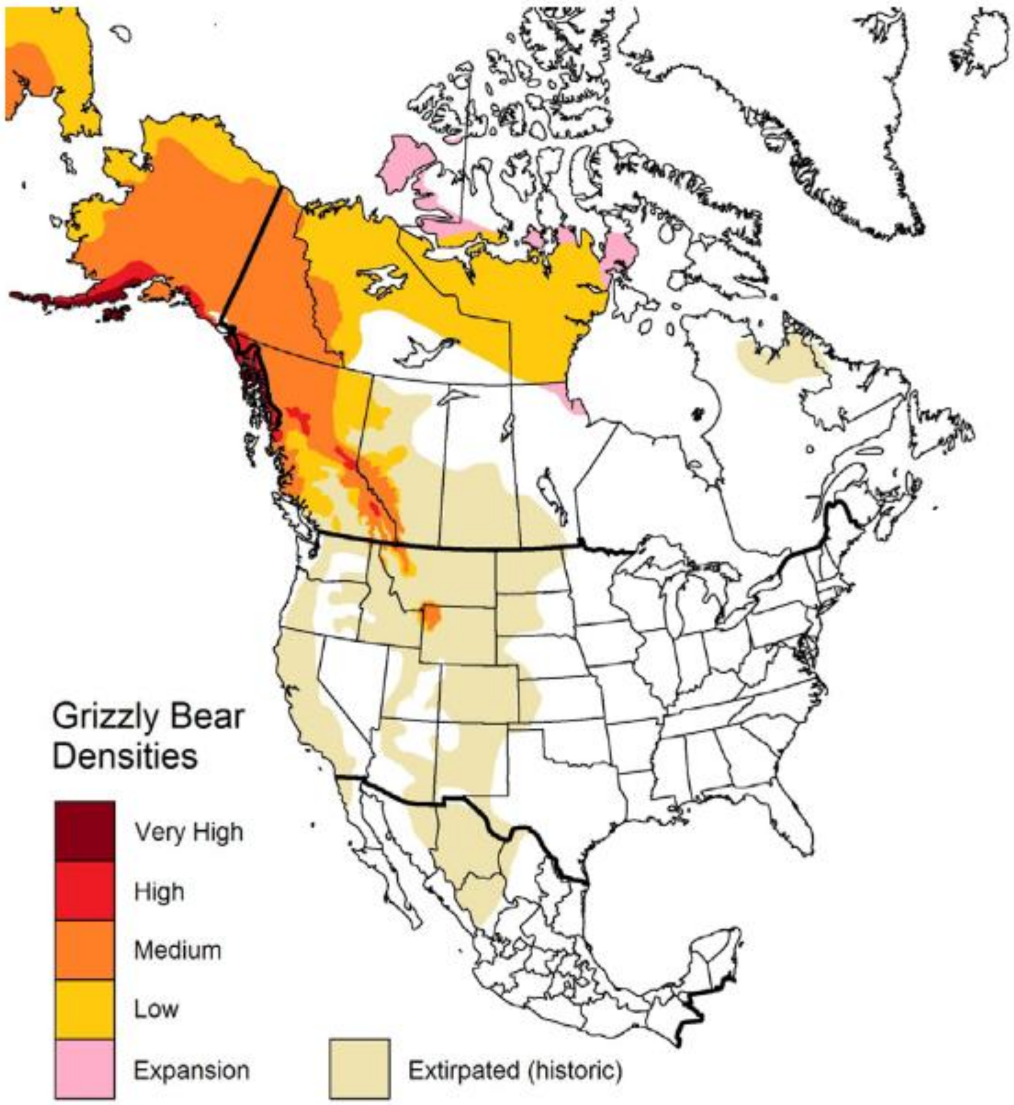
Status assigned by	Applies to	Status	References
Species at Risk Act (SARA)	Canada	Listed as Special Concern on Schedule 1 in 2018	(Canada, n.d.)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Canada	Special Concern; last assessed 2012	(Canada, n.d.)
Canadian Endangered Species Conservation Council (General Status of Species in Canada)	Canada	N3: Vulnerable*	(Canadian Endangered Species Conservation Council, 2016)
Yukon	Yukon	S3: Vulnerable*	(Yukon, 2020)
NatureServe	Global	TNR: No Status Assigned (not assessed)*	(NatureServe, n.d.)

*Following the ranking system developed by NatureServe, an international network of conservation data centres (NatureServe, n.d.). N=National; S=Subnational; T=subspecies or population

Historically, grizzly bears ranged from Alaska to Mexico, and east to the western shores of the Hudson Bay. However, their range has been drastically reduced – by over 50% – since the 1800s, due to persecution and habitat loss as North America was settled (COSEWIC, 2012). Currently, populations persist predominantly in Alaska and western Canada, with small populations remaining in Idaho, Wyoming and Montana Map 7- 6. Conditions for grizzly bears are worsening in the southern part of their range and populations are declining. Grizzly bears are sensitive to human disturbance and vulnerable to high rates of mortality (COSEWIC, 2012).

Therefore, western, and particularly northern, Canada represents a significant core of grizzly bear range. The highest bear densities are associated with seasonally rich food sources, specifically salmon. The Yukon North Slope provides habitats that support low to moderate densities of bears, given the low productivity of the arctic ecosystems. Still, the undisturbed and connected landscapes of the Yukon North Slope make it a rare and extremely important region for maintaining this species.

Map 7- 6. Grizzly bear historic distribution and current relative densities in North America



Current and historic (19th century) grizzly bear distribution in North America. Source: McLoughlin, from multiple sources (COSEWIC, 2012)

Population Trends on the Yukon North Slope

Traditional knowledge collected in 2016 (WMAC (NS) & Aklavik HTC, 2018a) revealed there was no consensus regarding population trends. Some respondents noted an increase in bear population, while others suggested a decrease and some noticed no change in the population. However, there was consensus that smaller bears are generally occurring closer to Aklavik with larger bears occurring in Ivvavik National Park.

> …sometimes they [hunters] come back with small bears and that kind of frustrates me… they should focus way over in the park… they're big over there.
>
> 2016 interview from WMAC (NS) and Aklavik HTC, 2018a, p. 41

A capture-recapture study completed from 2004-2010 suggested that the grizzly bear population in the Yukon North Slope may have been slightly declining over this time period; however, the study determined this reflected natural population fluctuations and that the population is stable (Parks Canada and the Yukon Territorial Government, 2014). The study estimated a population of 431 grizzly bears (95% confidence interval: 349-532) with a 60:40 Male/Female sex ratio within the Yukon North Slope.

The study found that that females within the region did not to give birth until they were approximately 9 years old (Parks Canada and the Yukon Territorial Government, 2014). Similarly, Nagy et al. (1983) found the first litter to be at 6-8 years of age. This is older than average; in Canada, the first age of reproduction is estimated at 6 years (COSEWIC, 2012). Grizzly bears in the Yukon North Slope had a mean litter size of 2.05 (SE ± 0.20) which is consistent with average litter sizes in Canada of 1-3 cubs (COSEWIC, 2012). Survival of adult bears was high. However, cub survival was low, making the survival of adult females particularly important for the population stability of Yukon North Slope grizzly bears. Cub survival on the Yukon North Slope was estimated as 0.40 (SE ± 0.13); for comparison, cub survival is generally expected to range from 0.60-0.70 (Bunnell & Tait, 1985).

Population Trends on Yukon North Slope by Ecodistrict

Grizzly bear population trends and estimates were projected within the Yukon North Slope by ecodistrict. Population trends from a Parks Canada and Yukon Territorial Government (2014) study indicate that the grizzly bears in the British Mountain ecodistrict are increasing, whereas grizzly bears in the Barn Mountains and the Coastal Plains ecodistricts are at carrying capacity or in slight decline. Additionally, population density estimates (bears/1000km^2) for these regions were generated by Nagy (1990) and reassessed by Parks Canada and the Yukon Territorial Government (2014) (Table 7- 4). The trends identified in 2014 were based on the estimated population growth rate from data collected, using survival and reproductive rates estimated over the six years of field study.

Table 7- 4. Grizzly bear population density estimates by Yukon North Slope ecodistrict

Location	Density estimate (bears/1000 km^2)
Barn Mountains	13.0
British Mountains	43.1
Coastal Plains	10.8

Source: (Parks Canada and the Yukon Territorial Government, 2014)

Population Management

The adaptive management of grizzly bears in the Yukon and Northwest Territories integrates scientific and traditional knowledge to set and maintain harvest (Clark & Slocombe, 2011). In addition, population management decisions incorporate feedback from the communities. Grizzly bear research on the Yukon North Slope has included traditional knowledge studies and scientific studies, which inform management for the species on the Yukon North Slope. These studies document traditional uses and harvest techniques, and identify morphological characteristics, population parameters, denning and seasonal habitat associations, food habits and movements. Since 2014, Parks Canada has worked within Ivvavik National Park along the Firth River using camera traps to capture variations in occupancy (M. Suitor and D. Tavares, personal communication, November 16, 2020).

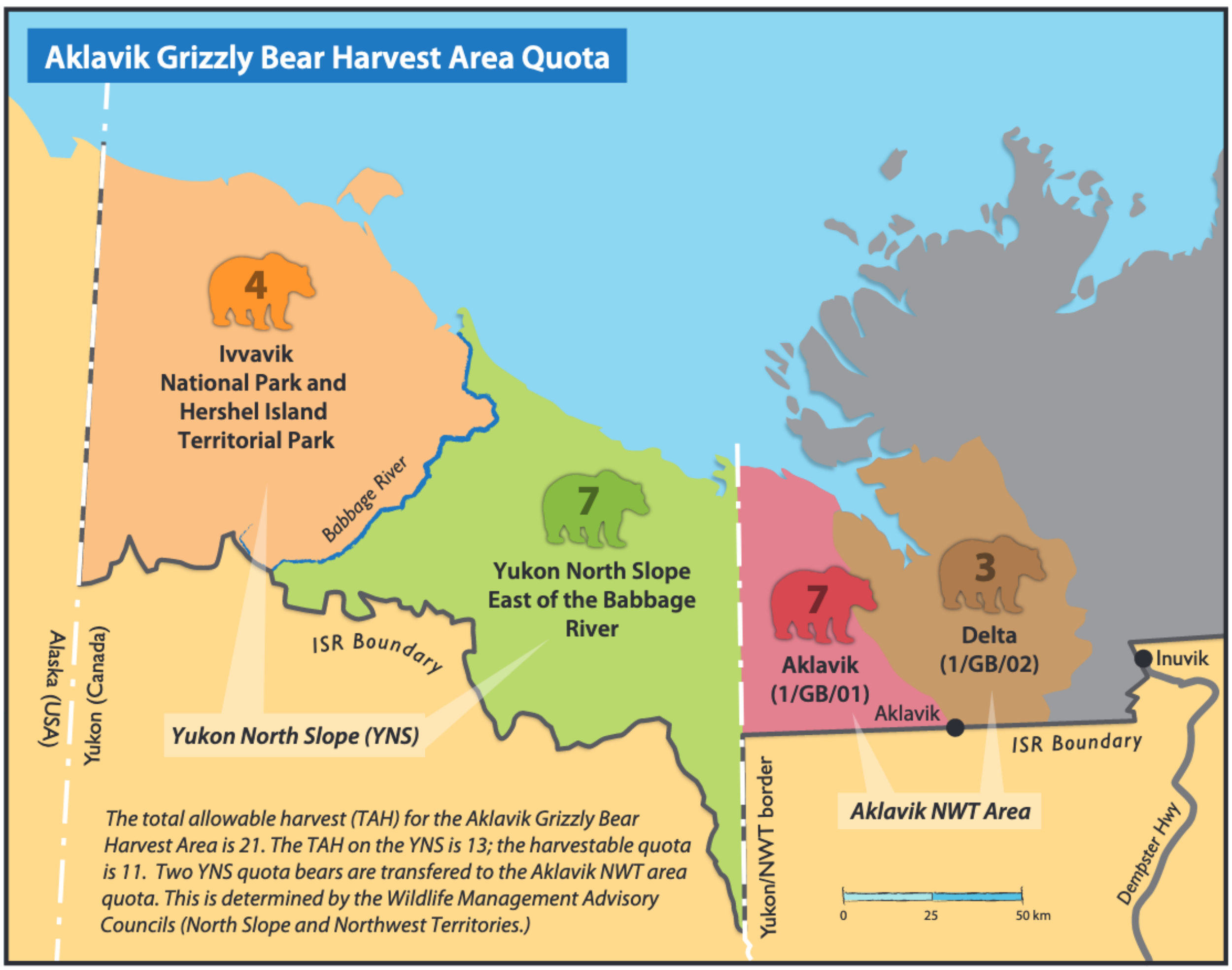
Under the terms of the IFA, the Inuvialuit have the exclusive right to harvest grizzly bear in Ivvavik National Park and anywhere in the NWT portion of the Inuvialuit Settlement Region, including the Mackenzie Delta to the west and northwest of Aklavik. They hold a preferential right to harvest grizzly bear on the eastern Yukon North Slope between Ivvavik National Park and the NWT-Yukon border. Since 1994, grizzly bear hunting has been co-managed by the Inuvialuit and the Governments of Canada, NWT and Yukon using a quota system whereby hunters are given a limited number of tags for their yearly harvest (J. A. Nagy & Branigan, 1998). The tags are assigned to specific harvest zones in the Aklavik Grizzly Bear Hunting Area. Quotas affect where bears are harvested and how the harvest effort is distributed across the YNS. However, harvest zones that are further away (e.g., Ivvavik National Park) often have unfilled quotas, reflecting the increased travel required. Each harvested bear must have a tag applied. Samples, such as a tooth, are collected for each harvested bear. The samples help determine the age of the bear, which allows for further insight into the population structure of YNS grizzly bears and harvest patterns over time. All human-caused bear deaths (including Defense of Life and Property kills) are accounted for under the quota.

Lower harvest rates than the allotted quota are typical across the Yukon North Slope, and over the last 5 years the cumulative quotas within each harvest zone were not reached. For example, between July 2015 and June 2020, 3 bears were harvested of 20 allotted for Ivvavik National Park and Herschel Island, 15 of 35 were harvested for Eastern Yukon North Slope, and 20 of 35 for Aklavik-NWT. However, in some years the maximum number of females bears allotted were harvested (NWT ENR, 2019). It is important to note that the reasons for low harvest rates are complex (for further information, see the Traditional Use companion report).

In addition to traditional uses, grizzly bears are also killed in Defense of Life or Property (DLP). DLP kills are the result of human-bear conflict. As such these kills are centred around sites of human use, such as camps, cabins, and communities. These are included in the quota and used to inform management decisions.

The population evaluation completed by Parks Canada and the Yukon Territorial Government (2014) resulted in a management recommendation to maintain the existing quota of a ~4% harvest rate adjusted for the updated point population estimate (M. Suitor, personal communication, November 16, 2020). The 2014 report indicates that this option requires concurrent monitoring.

Map 7- 7. Grizzly bear harvesting zones and quotas on the Yukon North Slope and adjoining N.W.T. harvesting zone



This image reflects current quotas in 2021. Source: WMAC(NS)

Transboundary Considerations

Grizzly bears move beyond the boundaries of the Yukon North Slope to the NWT, Alaska, and south within the Yukon. This movement was observed in collared bears (2004-2010 study by YG and Parks Canada) used to assess seasonal habitat use (Triska & Heinemeyer, 2020). Prior studies in the Alaskan Brooks Range (Harry Reynolds, 1976; H. V. Reynolds & Hechtel, 1987) have been used to supplement data in the Yukon North Slope and inform management decisions (Parks Canada and the Yukon Territorial Government, 2014). Alaska's North Slope grizzly bear population is believed to be stable and harvested lower than the allowed maximum sustainable yields (Lenart, 2015). There is no formal transboundary management between Canada and Alaska, but it is important that Yukon North Slope managers remain aware of changes in the population size, structure, and harvest rates/methods in Alaska.

Observations, Concerns, and Threats

Impacts of Climate Change

Traditional knowledge collected in 2016 suggests that climate change may be affecting grizzly bear habitat and behaviour. Interviewees reported that grizzly bears enter dens later in the fall and emerge earlier in the spring, and also that slumping along hillsides associated with permafrost melt may be altering habitat and making old dens unusable and the establishment of new dens more difficult (WMAC (NS) & Aklavik HTC, 2018a).

Increased temperatures will likely lead to grizzly bear expansion north where this is possible. The Yukon North Slope is bounded by the Beaufort Sea but, east of the Yukon North Slope, grizzly bears have been expanding north into the Canadian Arctic Archipelago (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016; Pongracz, Paetkau, Branigan, & Richardson, 2019). Where grizzly bears overlap with polar bears, this could result in increased hybridization and competition with polar bears (*U. maritimus*) becoming more common (COSEWIC, 2012; Pongracz et al., 2019). Grizzly bears and polar bears have overlapped on the Yukon North Slope since the 19th century (COSEWIC, 2012); hybridization in the region has not been reported in any available sources. However, competition for whale carcasses in the autumn has been documented along the Beaufort Sea in the Arctic National Wildlife Refuge of Alaska (Miller, Wilder, & Wilson, 2015). Although interspecific interactions were not typically aggressive, grizzly bears predominantly displaced polar bears when present at the same time (Miller et al., 2015).

Few research studies related to climate change on grizzlies have been completed, but COSEWIC (2012) suggests that following (additional) issues may arise for grizzly bears:

- Potential decreases in food sources as seasonal foods fail, which may reduce survival
- Changes in caribou, moose, and muskox populations (either positive or negative) may reduce or promote survival
- Increased competition from black bears expanding north and to higher altitudes
- Loss of permafrost loss may decrease den stability
- Increased human development as the North becomes more amenable to agriculture or other activities may displace bears or increase bear/human interactions

Impacts from Human Activities

Disturbance by humans greatly influences grizzly bears and they are at high mortality risk in areas with human activities and where roads generate access points (COSEWIC, 2012). Human activities can alter the habitat in which bears live, displace bears, disrupt the bear's social system, causing high energetic responses compared to normal behavior, and increase mortality (McLellan, 1990). Additionally, availability of human food sources or trash may lead to further disruptions for grizzly bears, increased conflict with humans, and increased mortality (Clark & Slocombe, 2011; Mattson, 1990).

Elsewhere in their Canadian range, where grizzly bears overlap areas with high human use, non-harvest-related mortality is a significant cause of declines and a key reason for listing western Canadian grizzly bears as a species at risk (COSEWIC (2012). While human-bear conflict has not precipitated population decline in the ISR, the effect of Defense of Life or Property (DLP) kills is an important consideration in management. DLP grizzly bear kills on the Yukon North Slope are most likely to occur at seasonal camps (e.g., Tapqaq), where there is the potential for increased attractants. DLP kills are more common in the vicinity of the community of Aklavik, though, where the unfenced landfill is a significant attractant. While not on the Yukon North Slope, these kills are important to consider in Yukon North Slope management as the community is adjacent to the region.

COSEWIC (2012) recommends that ongoing or proposed activities or developments with the potential to lead to grizzly bear mortality should be carefully scrutinized and measures put in place to minimize this risk. Within the Yukon North Slope, non-harvest kills (e.g., in defense of life and property) count towards the harvest quota to best maintain a sustainable harvest level (Clark & Slocombe, 2011; WMAC (NS) & Aklavik HTC, 2008).

Table 7- 5. Mean annual recorded human-caused grizzly bear mortalities in Canada 1990 - 1999

	Hunting kills			Non-hunting kills			
Jurisdiction	Males	Females	Unknown	Illegal	DLP	Other	Total
Alberta	9.1	4.7	0.0	3.7	4.2	3.1	24.8

British Columbia	187.3	101.6	0.0	5.9	40.2	n/a	335.0
Yukon	51.0	27.5	0.0	n/a	13.2	1.5	93.2
NWT and Nunavut	8.1	1.7	1.0	n/a	9.4	n/a	20.2
ISR and GSA	21.1	5.2	4.1	Included in hunter kills			30.4
Total	276.6	140.7	5.1	9.6	67.0	4.6	503.6

Note: DLP refers to Defense of Life or Property. The number of bears killed combined (hunter and non-hunting kills) is highlighted in the final column. Redrawn from Source: (Yukon Grizzly Bear Conservation and Management Plan Working Group, 2019)

Table 7- 6. Mean annual harvest of Yukon North Slope grizzly bears, June 2009 - July 2020

Harvest Zone	Males	Females	Total	DLP
Ivvavik National Park	0.7	0.2	0.9	0
Yukon North Slope	2.9	0.6	3.6	0
Aklavik-NWT	3.2	1.5	4.5	1.3

Note: DLP refers to Defense of Life and Property. DLP harvests are counted against the annual harvest quota and therefore are included in the total harvest count. Bears of unverified sex are counted as females. Source: Government of the Northwest Territories unpublished data, 2020. Quotas as of 2021 can be seen in Map 7-7.

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.

Grizzly Bear Conservation and Management

Multiple plans, guidelines and agreements relate to the harvest management of grizzly bears on the Yukon North Slope.

Table 7- 7. Information used to inform grizzly bear harvest management measures in 2019

Species	Management Plans, Guidelines, and Agreements	Harvest Management Measures (2019) for the Yukon North Slope
Multiple	– Inuvialuit Harvest Study (1988-1996) – Community Based Monitoring Program, including the updated Harvest Study (2016-present) – Arctic Borderlands Ecological Knowledge Co-op	Both current programs collect information relating to the harvest of species and conditions on the land during harvest activities. These results of these programs have been used in adaptive harvest management for Yukon North Slope species.

Species	Management Plans, Guidelines, and Agreements	Harvest Management Measures (2019) for the Yukon North Slope
Grizzly bear	– Plan for ISR (J. A. Nagy & Branigan, 1998) – Yukon plan (Yukon Environment, 2018) – SARA plan for the Western Population in Canada (to be developed)	– Harvest limited by an annual quota for the Yukon North Slope harvest area, based on bear density estimates – Non-Inuvialuit resident harvest may be permitted with quota allocation – The Yukon plan does not apply to the Yukon North Slope but affects the management of neighbouring grizzly bear populations in Yukon

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016)
  Identifies the Richardson Mountains, Richard's Island, Mackenzie River Delta, major river drainages, eskers, and southerly slopes (for denning) as important grizzly bear habitat. It also notes that there has been an increase of grizzly bear sightings on Arctic Islands in recent years and identifies a need to set sustainable harvest quotas and to assess potential impacts of human disturbance.

- *Ivvavik National Park of Canada Management Plan* (Parks Canada, 2018)
  Conservation and management of grizzly bear 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" (Parks Canada, 2018).

- *North Yukon Regional Land Use Plan* (Vuntut Gwitchin Government & Yukon Government, 2009)
  Lists the grizzly bear as a species of national conservation concern. Identifies land management units that are high priority grizzly bear habitat in the region.

Research and Monitoring Programs

- Species surveys
  Grizzly bear monitoring
  - Aerial counts of bears in the Barn Mountains from 1972 to 1975, radio-collared bears in the Richardson Mountains from 1993 to 2001 (J. A. Nagy & Branigan, 1998; J. A. Nagy et al., 1983; John A. Nagy & Haroldson, 1990)
  - Radio collar study of 5 bears in the Firth Valley from 1994 to 1995, plus observational monitoring of bears, scats and feeding sites from 1993-1995 to assess grizzly bear diet, activity budget and patterns (Mackenzie & MacHutchon, 1996).
  - GPS collar study of 35 grizzly bears focusing on the Babbage River Drainage from 2004-2010; however, bears traversed the Yukon North Slope and into Alaska and the NWT (Parks Canada and the Yukon Territorial Government, 2014; Yukon Environment, Parks Canada, WMAC (NS), & Aklavik HTC, 2008).
  - Hair snag grid focused on the Babbage River Drainage from 2004-2010 (Parks Canada and the Yukon Territorial Government, 2014).

- Harvest and population structure monitoring / Tag program and sample collection:
  Government of Yukon works cooperatively with the Government of the Northwest Territories (GNWT). GNWT and the Aklavik HTC distribute tags (up to the amount of the quota for each zone) for grizzly bear harvest on the Yukon North Slope. Each harvested bear (including DLPs) must have a tag applied. The tag program allows for very accurate harvest monitoring from year to year, and all human-caused mortalities are tracked. For each harvested bear, there is also mandatory sample collection of a tooth and proof of sex. The tooth allows for aging the bear, which provides insight into the population structure.

- Harvest monitoring: Inuvialuit Harvest Study (IRC, 2017, 2018, 2019)
  Annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included grizzly bear harvest monitoring. The ISR Community-Based Monitoring Program was revised after 2014 to focus on harvest. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information, including harvest locations, through annual interviews with active harvesters. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Use and Traditional Knowledge Studies

- Aklavik Local and Traditional Knowledge about Grizzly Bears of the Yukon North Slope (WMAC (NS) & Aklavik HTC, 2008)
  Collaborative 6-year study between Yukon Department of the Environment, Parks Canada (Western Arctic Field Unit), Aklavik Hunters and Trappers Committee (AHTC) and the Wildlife Management Advisory Council (North Slope). Beginning in 2004, this project was designed to increase understanding of grizzly bears. From 2006-2007 this included traditional

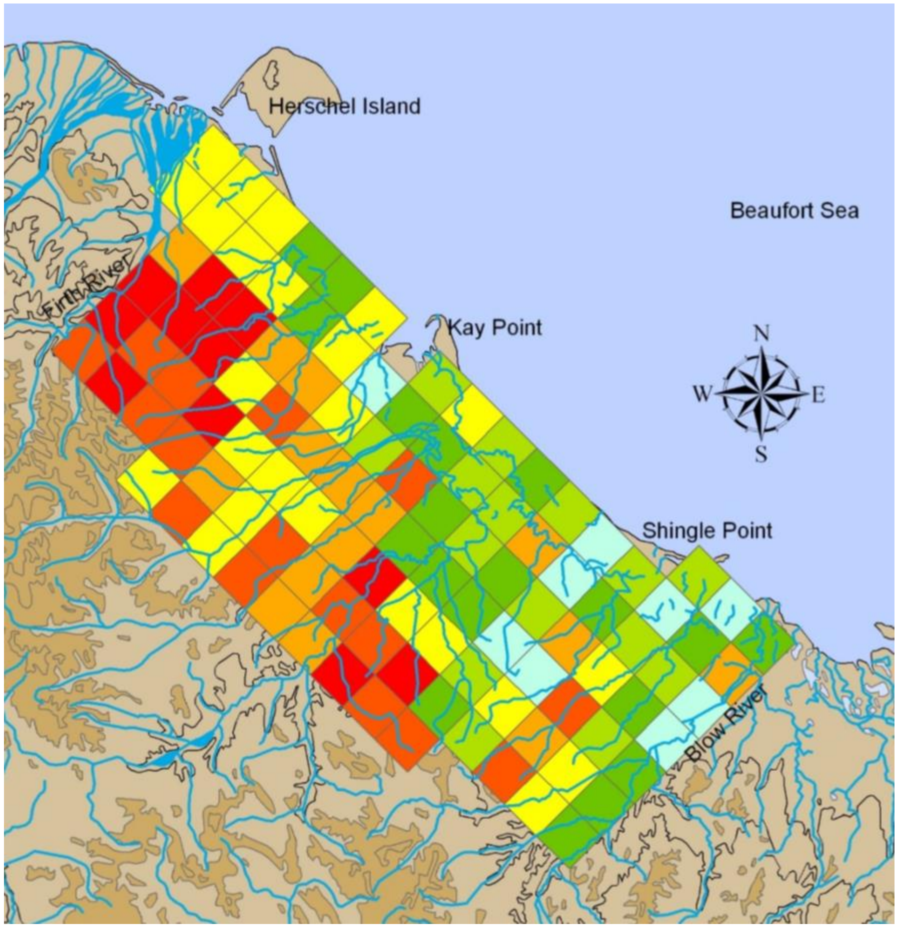
knowledge interviews in relation to harvest activity and techniques, population trends, habitat use and movement patterns. This document is referenced throughout this chapter.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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.

Research

- Home range and population parameters (John A. Nagy & Haroldson, 1990)
- Additional home range and population parameters (J. A. Nagy & Branigan, 1998)
- Activity budget and patterns within the Firth River Valley (Machutchon, 2001)
  Study of activity of 5 radio-collared bears and visual observations of bears from 1994-1995. Grizzly bears were observed feeding on plants and caribou, and spent more time feeding and less traveling or resting if they were eating predominantly plants.
- Food habits in the Yukon, Canada 1993-1995 (MacHutchon & Wellwood, 2003)
- Adaptive co-management and grizzly bear-human conflicts (Clark & Slocombe, 2011)
  Compares co-management plans in two northern Canadian communities and how they are influenced by grizzly bear-human conflicts. In Baker Lake, Nunavut there is evidence that wildlife management would benefit from the inclusion of Traditional Knowledge. The ISR in NWT/YK provides a management framework that incorporates scientific and Traditional Knowledge within a quota system.
- Assessment and status report on the grizzly bear in Canada (COSEWIC, 2012)
- Spatially-explicit capture-recapture population estimates for grizzly bears (Parks Canada and the Yukon Territorial Government, 2014)
  Data from the hair-snag grid (Map 7- 8) completed across the Babbage River Drainage from 2004-2010 were analysed using spatially explicit capture-recapture analysis. They generated overall population trends and point estimates for the Yukon North Slope and population density estimates (bears/1000km^2) for three ecodistricts within the Yukon North Slope.

Map 7- 8. Location of hair-snag grid – data used for spatially explicit capture-recapture analysis – covering the Babbage River Drainage in the Yukon North Slope



The intensity of hair-snag events with high intensity in red and orange cells, low intensity in light and dark green cells and no events in blue cells. Hair snag events were combined over 2006 and 2007 sampling. Source: (Parks Canada & Yukon Territorial Government, 2014)

- Research on predation of muskoxen (Arthur & Del Vecchio, 2017)
  In northeastern Alaska from 2000-2006, grizzly bear predation accounted for 58 and 62% of muskoxen calves and adults, respectively. Predation occurred during the later winter and spring indicating the importance of muskoxen during periods of limited food availability and potentially reduced populations of other ungulates.

- Bayesian approach to identifying grizzly bear habitat values (Triska & Heinemeyer, 2020)
  This study develops grizzly bear habitat models for denning, spring, summer, and fall. The Bayesian approach provides a resource selection model for each season that incorporates traditional knowledge and GPS collar locations to identify male and female seasonal habitat preferences. A denning habitat model was also developed using traditional knowledge and

den site locations compiled over many years. Combined output from these models are contained in the ‘Habitat’ section of this chapter.

References

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

Arthur, S. M., & Del Vecchio, P. A. (2017). Effects of grizzly bear predation on muskoxen in northeastern Alaska. *Ursus*, *28*(1), 81–91. https://doi.org/10.2192/URSUS-D-16-00023.1

Bunnell, F. L., & Tait, D. E. N. (1985). Mortality Rates of North American Bears. *Arctic*, *38*(4), 318–323. https://doi.org/10.14430/arctic2151

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

Clark, D. A., & Slocombe, S. (2011). Adaptive Co-Management and Grizzly Bear-Human Conflicts in Two Northern Canadian Aboriginal Communities. *Human Ecology*, *39*(5), 627–640. https://doi.org/10.1007/s10745-011-9423-x

Collins, G. H., Kovach, S. D., & Hinkes, M. T. (2005). Home range and movements of female brown bears in southwestern Alaska. *Ursus*, *16*(2), 181–189. https://doi.org/10.2192/1537-6176(2005)016[0181:HRAMOF]2.0.CO;2

COSEWIC. (2012). *COSEWIC Assessment and Status the Grizzly Bear Ursus arctos Western Population Ungava Population in Canada*. Retrieved from http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_ours_grizz_bear_1012_e.pdf

Government of Yukon. (2016). *Yukon North Slope Grizzly Bear Population Extimation and Demographic Analysis*. Whitehorse, Yukon, Canada.

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

IRC. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

Lambert Koizumi, C., & Derocher, A. E. (2019). Predation risk and space use of a declining Dall sheep (Ovis dalli dalli) population. *PLoS ONE*, *14*(4), 1–16. https://doi.org/10.1371/journal.pone.0215519

Lenart, E. A. (2015). Units 25A, 25B, 25D, 26B and 26C brown bear. In P. Harper & L. A. McCarthy (Eds.), *Brown bear management report of survey and inventory activities 1 July 2012 - 30June 2014* (Species Ma, p. 23). Juneau, Alaska, USA: Alaska Deartment of Fish and Game.

Machutchon, A. G. (2001). Grizzly Bear Activity Budget and Pattern in the Firth River Valley, Yukon. *Ursus*, *12*(2001), 189–198.

MacHutchon, A. G., & Wellwood, D. W. (2003). Grizzly bear food habits in the northern Yukon, Canada.

Ursus, *14*(2), 225–235. https://doi.org/10.2307/3873022

Mackenzie, W., & MacHutchon, A. G. (1996). *Grizzly Bear Habitat Classification for the Firth River Corridor, Ivvavik National Park*. Inuvik, Northwest Territories, Canada.

Mattson, D. J. (1990). Human Impacts on Bear Habitat. *Bears: Their Biology and Management*, *8*, 33–56.

McLellan, B. N. (1990). Relationships between Human Industrial Activity and Grizzly Bears. *Bears: Their Biology and Management*, *8*, 57–64.

McLoughlin, P. D., Cluff, H. D., Gau, R. J., Mulders, R., Case, R. L., & Messier, F. (2003). Effect of spatial differences in habitat on home ranges of grizzly bears. *Ecoscience*, *10*(1), 11–16. https://doi.org/10.1080/11956860.2003.11682744

Miller, S., Wilder, J., & Wilson, R. R. (2015). Polar bear-grizzly bear interactions during the autumn open-water period in Alaska. *Journal of Mammalogy*, *96*(6), 1317–1325. https://doi.org/10.1093/jmammal/gyv140

Nagy, J. A. (1990). *Biology and Management of Grizzly Bear on the Yukon North Slope*. Whitehorse, Yukon, Canada.

Nagy, J. A., & Branigan, M. (1998). *Co-management Plan For Grizzly Bears in the Inuvialuit Settlement Region, Yukon Territory and Northwest Territories*. Inuvik, Northwest Territories: Wildlife Management Advisory Council (North Slope) and Wildlife Management Advisory Council (NWT).

Nagy, J. A., Russell, R. H., Pearson, A. M., Kingsley, M. C. S., & Goski, B. C. (1983). *Ecological Studies of Grizzly Bears in the Arctic Mountain, Northern Yukon Territory, 1972 to 1975*. Edmonton, Alberta, Canada.

Nagy, John A., & Haroldson, M. A. (1990). Comparisons of Some Home Range and Population Parameters among Four Grizzly Bear Populations in Canada. In *Bears: Their Biology and Management, Vol. 8, A Selection of Papers from the Eighth International Conference on Bear Research and Management, Victoria, British Columbia, Canada, February 1989* (pp. 227–235).

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

NWT ENR. (2019). *Summary of Harvest Data for Species Under Quota in the Inuvialuit Settlement Region, July 2014 to June 2019*. Department of Environment and Natural Resources, Inuvik Region, Government of the Northwest Territories.

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

Parks Canada and the Yukon Territorial Government. (2014). *Yukon North Slope Grizzly Bear Population Extimation and Demographic Analysis*. Whitehorse, Yukon, Canada.

Pongracz, J. D., Paetkau, D., Branigan, M., & Richardson, E. (2019). *Recent Hybridization between a Polar Bear and Grizzly Bears in the Canadian Arctic*. *70*(2), 151–160.

Reynolds, Harry. (1976). *North Slope Grizzly Bear Studies*. Juneau, Alaska: Alaska Department of Fish and Game.

Reynolds, H. V., & Hechtel, J. L. (1987). *Grizzly bear population ecology in the western Brooks Range, Alaska*. Anchorage, Alaska, USA.

Triska, M., & Heinemeyer, K. (2020). *Yukon North Slope Grizzly Bear Seasonal Habitat Models*. Round River Conservation Studies.

Vuntut Gwitchin Government, & Yukon Government. (2009). *North Yukon Regional Land Use Plan*.

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

WMAC (NS), & Aklavik HTC. (2008). *Aklavik Local and Traditional Knowledge about Grizzly Bears of the Yukon North Slope: Final Report*. 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).

WMAC (NS), Yukon Environment, Aklavik HTC, & Parks Canada. (2008). *Yukon North Slope Grizzly Bear Population Study (Mid-Term Project Report)*.

Yukon. (2020). Yukon Wildlife: Grizzly Bear. Retrieved April 20, 2020, from https://yukon.ca/en/grizzly-bear

Yukon Environment. (2018). *A Conservation Plan for Grizzly Bears (Ursus arctos) in Yukon (Draft)*.

Yukon Environment, Parks Canada, WMAC (NS), & Aklavik HTC. (2008). *Yukon North Slope Grizzly Bear Research Project Newsletter Volume 5-Winter 2008: Yukon North Slope Grizzly Bear*.

Yukon Grizzly Bear Conservation and Management Plan Working Group. (2019). *Developing a Conservation Plan for Grizzly Bears (Ursus arctos) in Yukon: Supporting Information*. Whitehorse, Yukon: Government of Yukon, Department of Environment.

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 8:
Polar Bear/Nanuq

Publication Information

Cover photo: © 2019 GNWT-ENR/Steven Baryluk

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 8: Polar Bear / Nanuq

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 four 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: Polar Bear / Nanuq

This companion report provides information on the conservation requirements for polar bear 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 polar bears, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for polar bear on the Yukon North Slope

1. Protection of denning areas, and summer refugia if or when they are identified.
2. Conservation of nearshore habitats critical to polar bears.
3. Cooperative, adaptive management of the Southern Beaufort Sea polar bear subpopulation across jurisdictions.

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

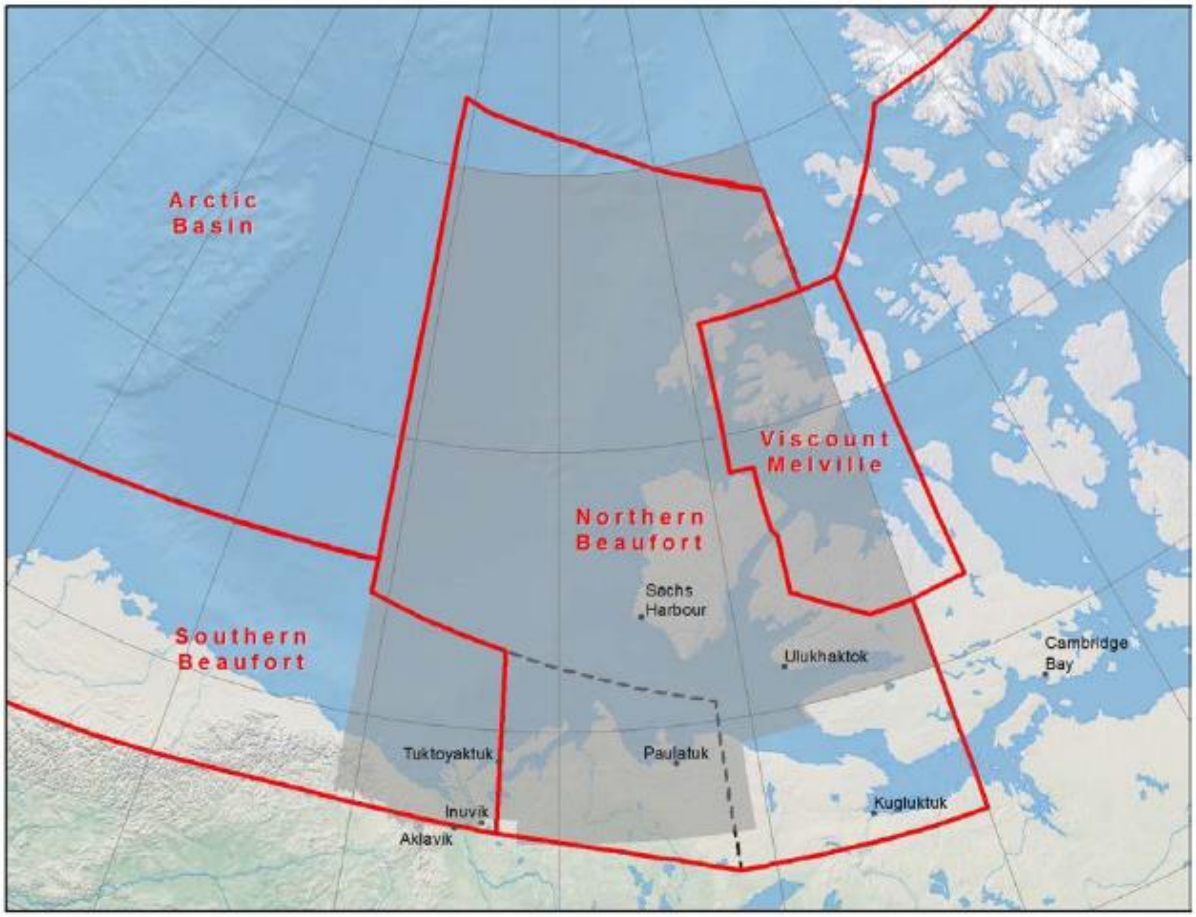
Polar bears on the Yukon North Slope

Polar bears (Nanuq, *Urus maritimus*) on the Yukon North Slope are part of the Southern Beaufort Sea (SB) subpopulation (Map 8- 1). Their seasonal distribution is linked to sea ice and the availability of seals that are their primary food year-around. They typically move north with receding sea ice from May-August and south in October as ice reforms along the coast (Amstrup, Durner, Stirling, Lunn, & Messier, 2000).

Polar bears move extensively to find ideal ice conditions for hunting, and to search for mates and maternal dens (Amstrup, 2003; Amstrup & Gardner, 1994; Species at Risk Committee, 2021). They can swim long distances in open water and are adapted to crossing varied terrain, including thin ice. They move swiftly on ice. Their foot pads are densely covered in fur during the winter, which improves traction (Amstrup, 2003; US Fish and Wildlife Service, 2020). Other adaptations which suit polar bears to living in Arctic marine environment include: white coloration for camouflage, water repellent guard hairs, dense underfur, black skin for absorbing warmth, specialized teeth for a carnivorous diet and the ability to store large amounts of fat for times when food is scarce (Amstrup, 2003; US Fish and Wildlife Service, 2020).

Polar bears are typically solitary and persist at low densities. Their reliance on sea ice for breeding, hunting, and most parts of their life history puts them at risk due to current and projected sea ice losses that come with climate change (COSEWIC, 2018; Species at Risk Committee, 2020).

Map 8- 1. Polar bear subpopulation boundaries in the Inuvialuit Settlement Region



Current (as of 2013) subpopulation boundaries (red lines) and previous deviations (dashed lines) in the ISR (light grey). Source: (Joint Secretariat, 2017)

Cultural Importance

> I think the Inuvialuit are always concerned about the health of the polar bear and the population, because the polar bear has been a part of our lives all along and will continue to be. I think that if we notice a big difference in the number of polar bears or a loss of polar bears, it would have a great effect on the Inuvialuit. Just to see them is great! You don't necessarily have to be hunting them all the time.
> PIN 102, Inuvik page 203 (Joint Secretariat, 2015)

Inuvialuit have lived near and harvested polar bears (nanuq) for many generations (JS, 2015). The Inuvialuit way of life has always been deeply intertwined with polar bear harvesting. Polar bears are a species of great importance, and are deeply respected. Polar bears are an integral part of Inuvialuit culture, spirituality, and economy. Inuvialuit knowledge of polar bears has grown through generations of living alongside and harvesting nanuq. This experience includes tracking and observing their behaviours, which can help us understand long-term changes in polar bear populations, including how polar bears may respond to climate change effects (Joint Secretariat, 2015).

> …But you know, there's things like polar bear hunting that is a part of our life, has been part of our lives, and will be part of our lives for, I'm hoping forever and ever. Because it's a part of us, eh?
> PIN 163, Paulatuk page 202 (Joint Secretariat, 2015)

Inuvialuit often refer to polar bears as the most intelligent animal in the Arctic. They are further characterized as strong, agile animals, ones that require great skill to harvest (Joint Secretariat, 2015; D. V. W. Slavik, 2013; Species at Risk Committee, 2021). The practice of harvesting polar bears requires intimate knowledge of travel routes, ice conditions, weather patterns, and animal behavior. It often serves as a vessel for knowledge transfer between generations (Joint Secretariat, 2015; D. V. W. Slavik, 2013).

Inuvialuit have a unique relationship with polar bears and the species holds a venerated position in their beliefs and culture (Wenzel, 1983; Keith et al., 2005; Dowsley and Wenzel, 2008). Polar bears feature prominently in Inuvialuit mythology, spirituality, storytelling, art, song, and other forms of expression. Strong community values continue to guide polar bear hunting. Harvesters adhere to culturally derived rules, such as not speaking disrespectfully about polar bears, giving younger bears a chance to grow, not letting animals suffer, avoiding denning bears, and not bothering females when they are with cubs (D. V. W. Slavik, 2013).

Traditional Use

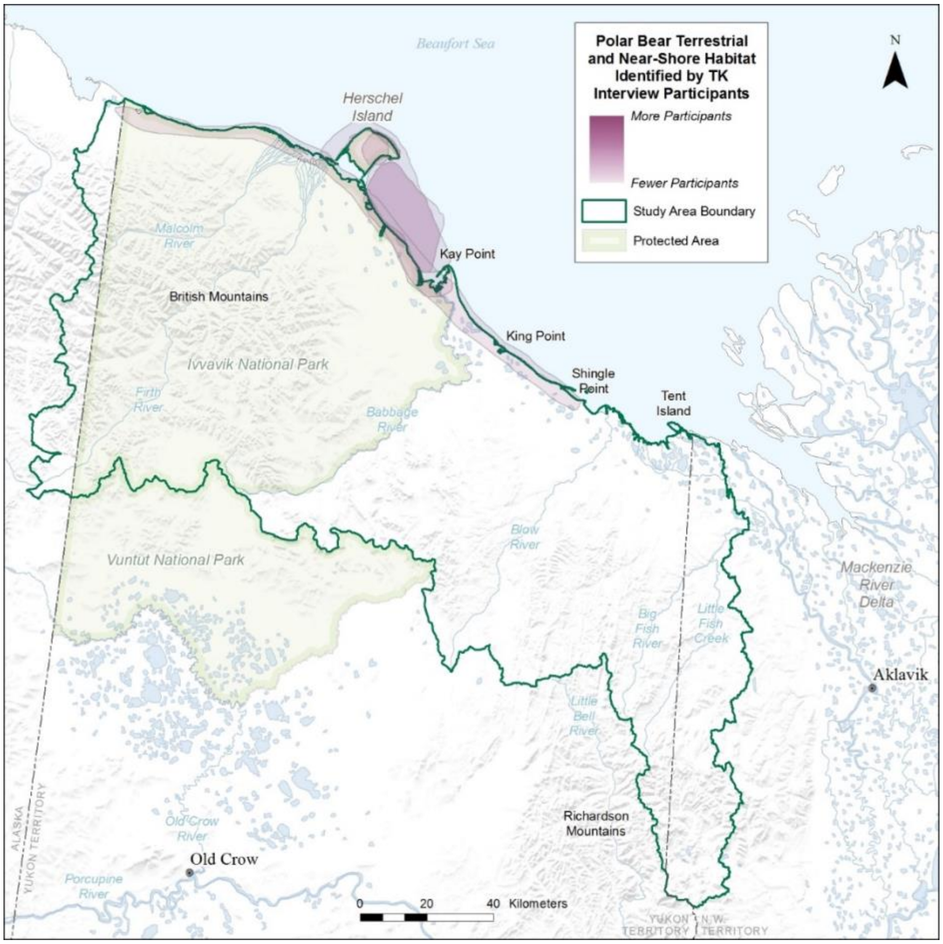
Polar bears are harvested in the wintertime when their furs are in prime condition (ICC, TCC, & ACC, 2006). Historically, the meat was used to sustain people and their dogs when food was in short supply, and the pelts were used for clothing, mattresses, and maintaining sled dog runners (Joint Secretariat, 2015). Today, selling polar bear pelts is an important economic opportunity that supports the ability of Inuvialuit to maintain their traditional harvesting practices and connection to the land.

Harvest of polar bears is conducted within the bounds of the co-management system created by the Inuvialuit Final Agreement (1984) (see Population Management section). There are many external factors that influence Inuvialuit traditional use on the Yukon North Slope broadly, and polar bear harvest specifically. The impact of rapid change on Inuvialuit way of life throughout the 20th and 21st centuries (a shift to community-based living, participation in the wage economy, globalization, intergenerational trauma and the ongoing impacts of residential schools) has affected traditional use. Current examples include: the cost of gas and equipment, the global price of polar bear hides, and the demand for and cost of sport hunting (Joint Secretariat, 2015). These factors are complex and dynamic.

> We always see big polar bears. We always see big ones way out this way. But they always be out across the open leads, so we can't get to them. It's so rough out here that we can't drive a Skidoo out there. It's really rough.... In between the open water and here.... They always come along here, and they always stay in the open water. They're smart. Sometimes, they go close to the island, but they always stay on the rough ice and close to the open water.
> PIN 13, Aklavik page 86 (Joint Secretariat, 2015)

Inuvialuit harvest of polar bears involves traveling self-sufficiently over vast distances in changing ice conditions. Inuvialuit, therefore, have significant knowledge about the wildlife, habitats, and ice conditions they travel through to harvest polar bears. *Inuvialuit and Nanuq* (2015) summarizes the holistic nature of Inuvialuit culture, worldview, and polar bear harvesting: "The most important aspects of Inuvialuit knowledge concerning polar bears are intergenerational knowledge (acquired from parents, grandparents and other elders) combined with direct experience. In general, this is what Inuvialuit mean by Traditional Knowledge (TK): personal knowledge acquired by travelling across ice, hunting seals and polar bears, running dog teams, reading wind directions, snow and cloud patterns, geographic features, currents and stars, and by intergenerational transmission." (p. 9)

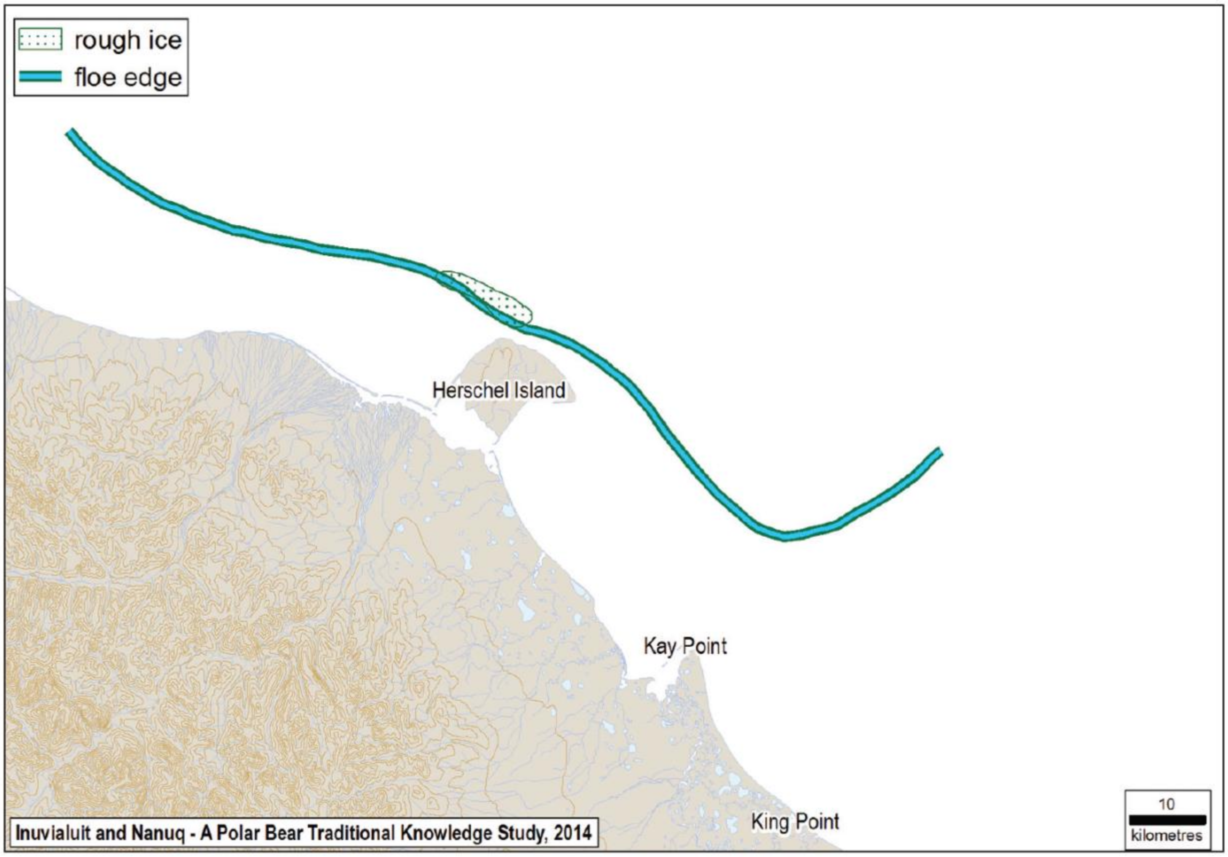
Map 8- 2. Overland and near-shore areas used by Polar bear in the Yukon North Slope for travel and foraging, identified through traditional knowledge interviews



Darker shades of purple indicate overlap in areas drawn by multiple Inuvialuit land users. Source: Map 7 (WMAC (NS) & Aklavik HTC, 2018a)

Traditional knowledge holders reported observing and harvesting polar bears primarily near Qikiqtaruk (Herschel Island). Polar bear presence near Qikiqtaruk is linked to its close proximity to the floe-edge, the interface between landfast ice (ice attached to the shore) and moving ice and open water (Map 8- 3) (Joint Secretariat, 2015). The floe-edge and open leads of water, exposed when ice cracks apart in response to pressure from winds, tide and currents, occur where new ice forms. This area often contains hauled-up seals and breathing holes (Joint Secretariat, 2015).

Map 8- 3. Approximate location of an area of rough ice and the floe-edge near Qikiqtaruk (Herschel Island)



Source: Map 24 (Joint Secretariat, 2015)

Habitat for Polar Bear

Polar bears predominantly live on sea ice and along the coastline. They rely on sea ice for travel, breeding, and hunting. Its presence is intertwined with polar bear survival. However, they travel, den, and occasionally feed on land.

The SB polar bear subpopulation occupies the Beaufort Sea along the Yukon, NWT, and Alaska coastline (Map 8- 1). This area has divergent sea ice: the ice melts away from the coast in the summer, is carried offshore by the currents, and sea ice cover returns to the coast in the autumn (Species at Risk Committee, 2020). Therefore, during the summer individual bears can either remain onshore or on sea ice. In the Yukon North Slope, polar bears predominantly occupy offshore sea ice. Their distribution and habitat use is directly linked to dynamic sea ice conditions, such as ice type, thickness, and location (Joint Secretariat, 2015, 2017; Species at Risk Committee, 2020). SB polar bears display a strong preference for floe-edge or moving ice situated over shallow waters of the continental shelf. This is likely due to the high productivity of these marine areas and the density of ringed seal (natchiq, *Pusa hispida*) (Durner et al., 2009). As the sea ice melts in the summer and retreats from the coast, polar bears typically remain on the pack ice (Pongracz & Derocher, 2017). In the autumn, ice returns to the coast, and polar bears may scavenge near land and establish maternal dens either on the sea ice or inland.

A small proportion of animals remain near the coast on land rather than on the sea ice. The numbers of bears on land during the summer has been increasing (Schliebe et al., 2008). Polar bears utilize the coastline for hunting and scavenging, and may travel inland for denning (Map 8- 2; Eric V. Regehr, Hunter, Caswell, Amstrup, & Stirling, 2010; Species at Risk Committee, 2021; WMAC (NS) & Aklavik HTC, 2018a). In the late winter and early spring adult females with cubs are often located on landfast ice (i.e., ice fastened to the coastline) versus floe-edge and moving ice (Ian Stirling, 2002). It is likely females with cubs avoid sea ice to protect their cubs from adult males and the risk of infanticide (Ian Stirling, 2002). As the climate warms and summer sea ice decreases, the reliance of polar bear on land sites for denning and habitat may increase (Amstrup, 2003; Species at Risk Committee, 2020).

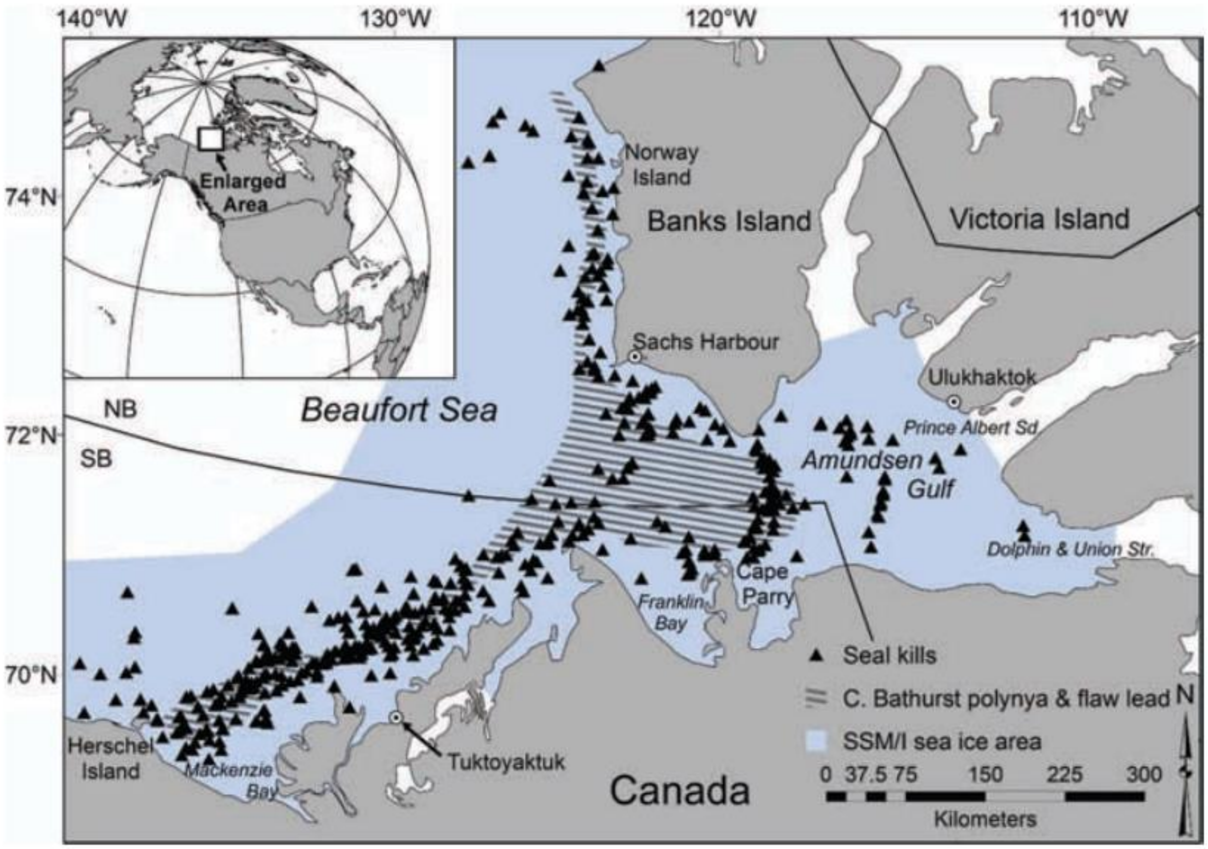
Feeding Habitat

Polar bear feeding habitat is areas with annual sea ice that provide easy access to abundant seal populations (Joint Secretariat, 2017; Thiemann, Iverson, & Stirling, 2008). SB Polar bear diets predominantly contain ringed seals (natchiq, *Pusa hispida*) year around, regardless of sex or age class (Florko, 2018). Studies have shown that ringed seal productivity and ice conditions are linked to polar bear body condition, survival and reproduction (Eric V. Regehr et al., 2010; Species at Risk Committee, 2021; Ian Stirling, 2002). Bears hunt seals from their breathing holes, where they are hauled up on the ice, and from their spring dens (D. V. W. Slavik, 2013; Species at Risk Committee, 2021). Polar bears are opportunistic predators and will pursue other seal species along the sea ice edge including bearded (*Erignathus barbatus)*, harp (*Pagophilus groenlandica*), and harbour seals (*Phoca vitulina*) (Thiemann et al., 2008). Close to the shoreline they may hunt walrus (*Odobenus rosmarus*) (Species at Risk Committee, 2021). They also hunt beluga whales (*Delphinapterus leucas*) that are stranded in open leads, or scavenge beached beluga and bowhead whale (*Balaena mysticetus*) carcasses. There is also evidence that polar bears use bowhead whale bone piles from subsistence-harvested animals (Mckinney, Atwood, Iverson, & Peacock, 2017; Pongracz & Derocher, 2017). The consumption of ringed seals and bowhead whales (via bone piles) have independently been linked to improved polar bear body condition (Amstrup, 2003; Florko, 2018; Mckinney et al., 2017).

Ringed seals have adapted to life on sea ice. Their body condition, distribution and abundance are directly influenced by sea ice properties (COSEWIC, 2018; Species at Risk Committee, 2021). Changes in sea ice and snow conditions exacerbated by climate change may reduce seal availability and abundance (Andrew E. Derocher, Lunn, & Stirling, 2004; Hezel, Zhang, Bitz, Kelly, & Massonnet, 2012). Polar bears rely on ringed seals year-round, but particularly in the spring when seal pups are abundant (Map 8- 4) (Pilfold, Derocher, Stirling, & Richardson, 2015; Ian

Stirling, 2002). In the eastern Beaufort Sea, years displaying reduced abundance of ringed seal pups were followed by reduced polar bear birth rates, suggesting a direct relationship between ringed seal and polar bear abundance (I. Stirling & Lunn, 1997).

Map 8- 4. Locations (n=650) of seals killed by polar bears from early-April through late-May, 1985-2011, in the Beaufort Sea



The solid black line on the left side of the map represents the old boundary between the Northern and Southern Beaufort polar bear subpopulation. The current boundary occurs just east of Tuktoyaktuk (see Map 8-1). Source: Figure 1 (Pilfold et al., 2015)

Denning Habitat

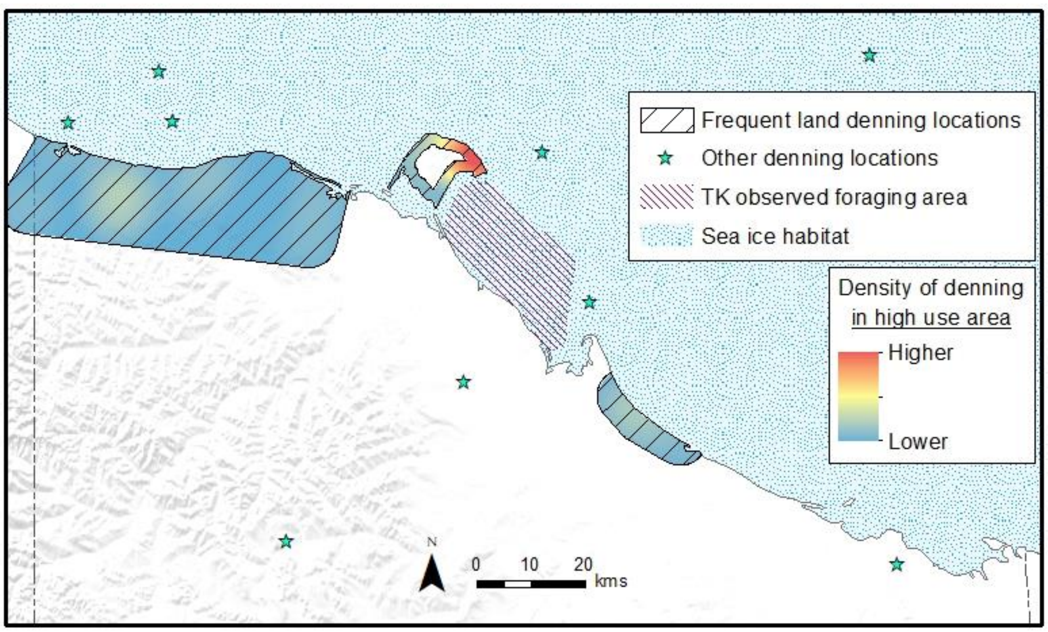
Most polar bears forage for seals on sea ice through the winter. Usually only pregnant females enter dens (Amstrup, 2003). Pregnant females establish maternal snow dens in autumn or early winter. They give birth and nurture the young for 4-5 months until they venture out of their dens (Joint Secretariat, 2017). Polar bear cubs are born very immature and dependent upon their parent. Denning is recognized as a critical part of the polar bear's life cycle (Amstrup, 2003).

Den location is influenced by presence of adult males, decreased disturbance potential, avoidance of adverse weather and proximity to prey (Joint Secretariat, 2017; US Fish and Wildlife Service, 2020). Dens may be located in snowbanks near the coastline, on the sea ice (typically multi-year pack ice) or inland in ravines and small valleys (Amstrup & Gardner, 1994; Joint

Secretariat, 2017). On land, dens typically occur near the coast, but dens up to 20 km from the coast are not uncommon. In the Alaska portion of the SB subpopulation, critical denning habitat is defined as 32 kilometres or less from the coast (Amstrup, 2003; US Fish and Wildlife Service, 2020). Along the Yukon North Slope coast, dens are known to occur on the coastal plain of Ivvavik National Park and between Kay and King points. Dens are also common on Qikiqtaruk (Map 8- 5) (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016; Amstrup & Gardner, 1994; ICC et al., 2006; WMAC (NS) & Aklavik HTC, 2018a).

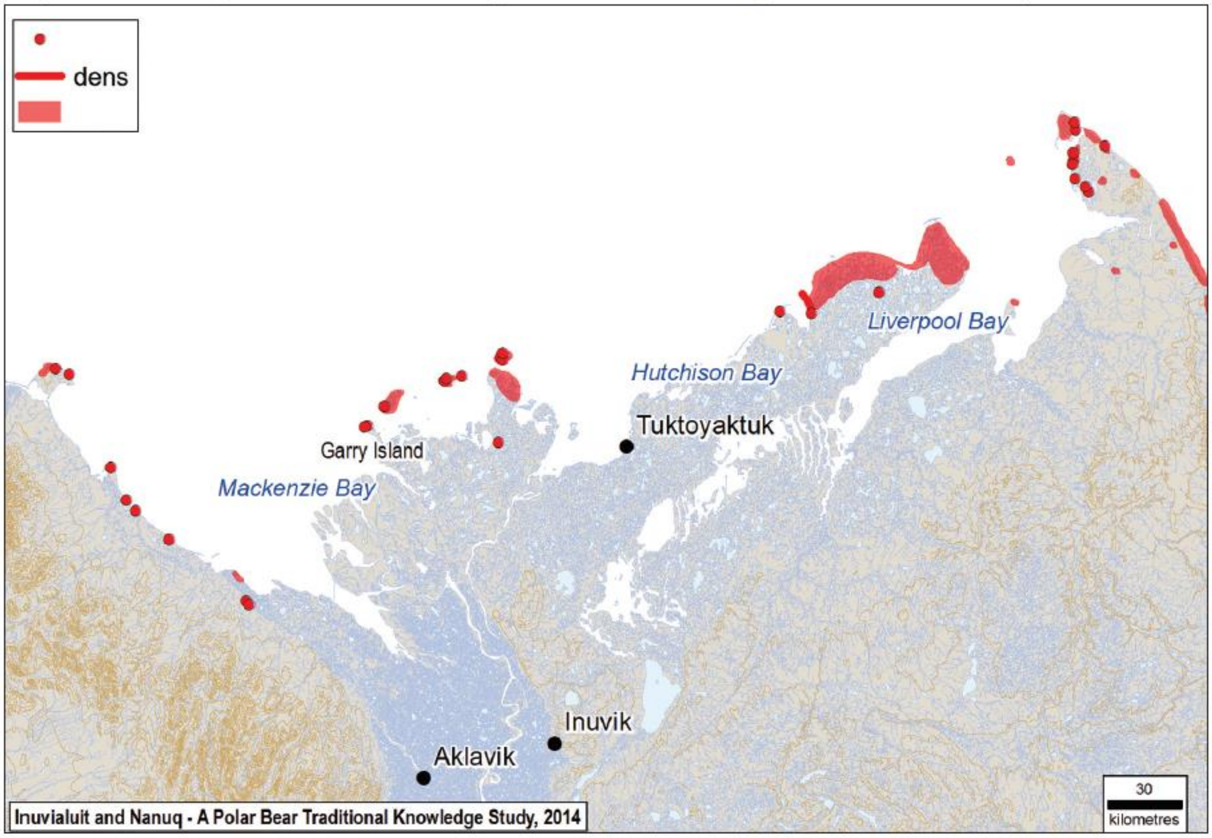
Den site fidelity has not been identified in the SB subpopulation, but bears displayed a den selection preference for either pack ice or land (Amstrup, 2003). In comparison to other subpopulations, a slightly greater proportion of SB polar bears historically selected pack ice versus on-land dens (Amstrup & Gardner, 1994). Of radio collared polar bears (n=90) ~53% denned on multi-year pack ice up to 300km offshore (Amstrup & Gardner, 1994). The success of bears denning on pack ice versus land did not differ (Amstrup & Gardner, 1994). Reductions in the availability and quality of pack ice due to climate change has been linked to decreased pack ice denning. Sea ice denning in the Alaskan range of the SB subpopulation decreased by 30% over a 20-year timespan (1985-1994 to 1998-2004) (Fischbach, Amstrup, & Douglas, 2007). The trend of increased denning on land is expected to continue as sea ice declines, unless a point is reached at which autumn sea ice is too far from land for pregnant females to access the coast prior to denning (Fischbach et al., 2007).

Map 8- 5. Polar bear den sites and an area important to polar bears and Inuvialuit, based on surveys of den sites and interviews with Inuvialuit experts



Map sources: USGS 2010, Environment Yukon and Parks Canada; unpublished traditional knowledge data

Map 8- 6. Maternity den locations from the Tuktoyaktuk Area and along the Yukon North Slope



Source: Map 38 (Joint Secretariat, 2015)

Polar Bear Demographics and Management

Polar bears are not strictly territorial but are generally solitary and nomadic. They occur at low densities, although they can be found in groups occasionally, for mating or feeding (D. Slavik, Inuvialuit Game Council, Wildlife Management Advisory Council (North Slope), & Wildlife Management Advisory Council (NWT), 2009; Species at Risk Committee, 2021). Polar bears have very large ranges. Their movements are influenced by the complex spatial and temporal dynamics of sea ice. In the Beaufort Sea region, the annual core activity areas for females ranged from 13,000km^2 to 597,000km^2 (Amstrup et al., 2000).

Demographics and Reproduction

The maximum recorded age of polar bears harvested in the SB was 25 years for males and 34 years for females (S. Baryluk, personal communication, July 20, 2021); this age is similar to longevity recorded elsewhere. Few polar bears survive more than 25 years (Ian Stirling, 2002). In the SB subpopulation, females are able to breed at 5 years of age, whereas males do not begin to breed until 8-10 years of age (A. E. Derocher & Stirling, 1998; Hensel & Sorensen, 1980; Ramsay & Stirling, 1988; Saunders, 2005; I. Stirling, Pearson, & Bunnell, 1976). In most parts of the Canadian Arctic, female polar bears begin breeding at 4 years of age, and the later breeding in SB females has been linked to lower ringed seal densities in the region compared to other areas in the Arctic (Amstrup, 2003). Breeding may occur throughout a female's lifespan, but it is possible that reproduction potential declines after 20 years of age (Amstrup, 2003).

Polar bears breed in the spring, with females in estrus from March to June; implantation is delayed until autumn (Amstrup, 2003; Ian Stirling, 2002). Typically, polar bears have 1-3 cubs, with pairs being the most usual (Joint Secretariat, 2015). Cubs are born every 3 years on average. Cubs in the SB remain with their mothers until they are 2.5 year of age (Stirling 2002). Survival rates are lowest for cubs-of-the-year followed by yearlings and senescent adults (≥21 years of age) (Amstrup, 2003; Species at Risk Committee, 2021).

Species Conservation Status

Across Canada, in jurisdictions with species at risk legislation, polar bears are variably listed as special concern, vulnerable, or threatened, with projected sea ice decline identified as the primary threat to the persistence of the species (COSEWIC, 2018). The Northwest Territories Species at Risk Committee re-assessed the status of polar bears in the Northwest Territories in 2021. This assessment included the SB subpopulation; Northwest Territories polar bears were assigned a status of special concern (Species at Risk Committee, 2021).

Table 8- 1. Polar bear conservation status: Canada, Yukon, and global

Status assigned by	Applies to	Status	References
Species at Risk Act (SARA)	Canada	Special Concern; listed on Schedule 1 since 2011	(Canada, n.d.)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Canada	Special Concern, last assessed in 2018	(Canada, n.d.)
Northwest Territories (includes SB subpopulation)	Northwest Territories	Special Concern, last assessed in 2021; listed since 2014	(Government of the Northwest Territories, n.d.)
Canadian Endangered Species Conservation Council (General Status of Species in Canada)	Canada	N3: Vulnerable*; 2015 status	(Canadian Endangered Species Conservation Council, 2016)
Yukon	Yukon	S1: Critically Imperiled*	(Yukon, 2020)
NatureServe	Global	G3: Vulnerable*; last reviewed 2016	(NatureServe, n.d.-b)

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

Southern Beaufort Sea Subpopulation Trends

A comprehensive study of Inuvialuit knowledge of polar bears (Joint Secretariat, 2015) conducted interviews with 72 polar bear harvesters from the six Inuvialuit Settlement Region communities. The study found that overall, polar bear body condition has remained stable over time, with significant variation within and between years. Since the mid-1980s, there have been fewer very large bears, and they are not as fat. The mid-1980s is when knowledge holders began to observe major climate-related changes in sea ice conditions. The study also found that polar bear abundance has remained generally stable over time (Joint Secretariat, 2015).

Polar bear observations

"From my general observations, the polar bear population in the Western Arctic at least, I think is in good, stable condition. You do see them during the winter months, travelers that are out on the land, out on the coast; and during the spring months when I can do the work at Herschel, in and out, two weeks off, two weeks in. The observations that I have made I think the polar bears are still, even though the ice conditions in the springtime are going out a lot earlier, the polar bears seem to still be in stable condition; the numbers are still up there… I don't think there's a change in the numbers [of polar bears] at all, no… We've never seen a fluctuation or a de-fluctuation of bears."

Source: Aklavik, *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study* (Joint Secretariat, 2015. p.19).

The most recent population estimate for the SB subpopulation is 1,215 bears as of 2006; this estimate is used for management purposes (Griswold et al., 2017). The population estimate was derived from a re-analysis of Regehr et al. (2006) that adjusted the abundance estimate from that study in consideration of the 2013 boundary change between the SB and NB subpopulations (Griswold et al., 2017). The Griswold et al. (2017) estimate cannot be compared with historic estimates to infer trends in abundance because of the boundary change. However, the Regher et al. (2006) population estimate of 1,526 bears can be compared to the previous (Amstrup et al., 2001) population estimate of 2,272 bears (from the period 2001-2006); while the more recent estimate is lower, the difference is not statistically significant. Prior subpopulation estimates were: approximately 1,480 bears in 1992 (Amstrup, 1995), and 1,788 bears in 1972-3 (Amstrup et al., 1996)

Recent research has explored trends in relative abundance and body condition (from 2001-2015) in the SB subpopulation. A 2015 analysis completed suggested that the SB subpopulation experienced a decline in abundance of ~25-50% from 2004-2006; this decline was followed by comparatively stable adult and cub survival from 2007-2010 (Bromaghin et al., 2015). The Bromaghin et al. (2015) analysis contained caveats, including that the data were not collected using the same methods on the Alaskan and Canadian sides of the border. More recently, Atwood et al. (2020) analyzed data from the Alaska portion of the SB subpopulation and found a similar trend, with abundance and body condition declining in the mid-2000s. Furthermore, Atwood et al. (2020) found that abundance and body condition stabilized from the mid 2000s through to 2015.

Polar bear observations

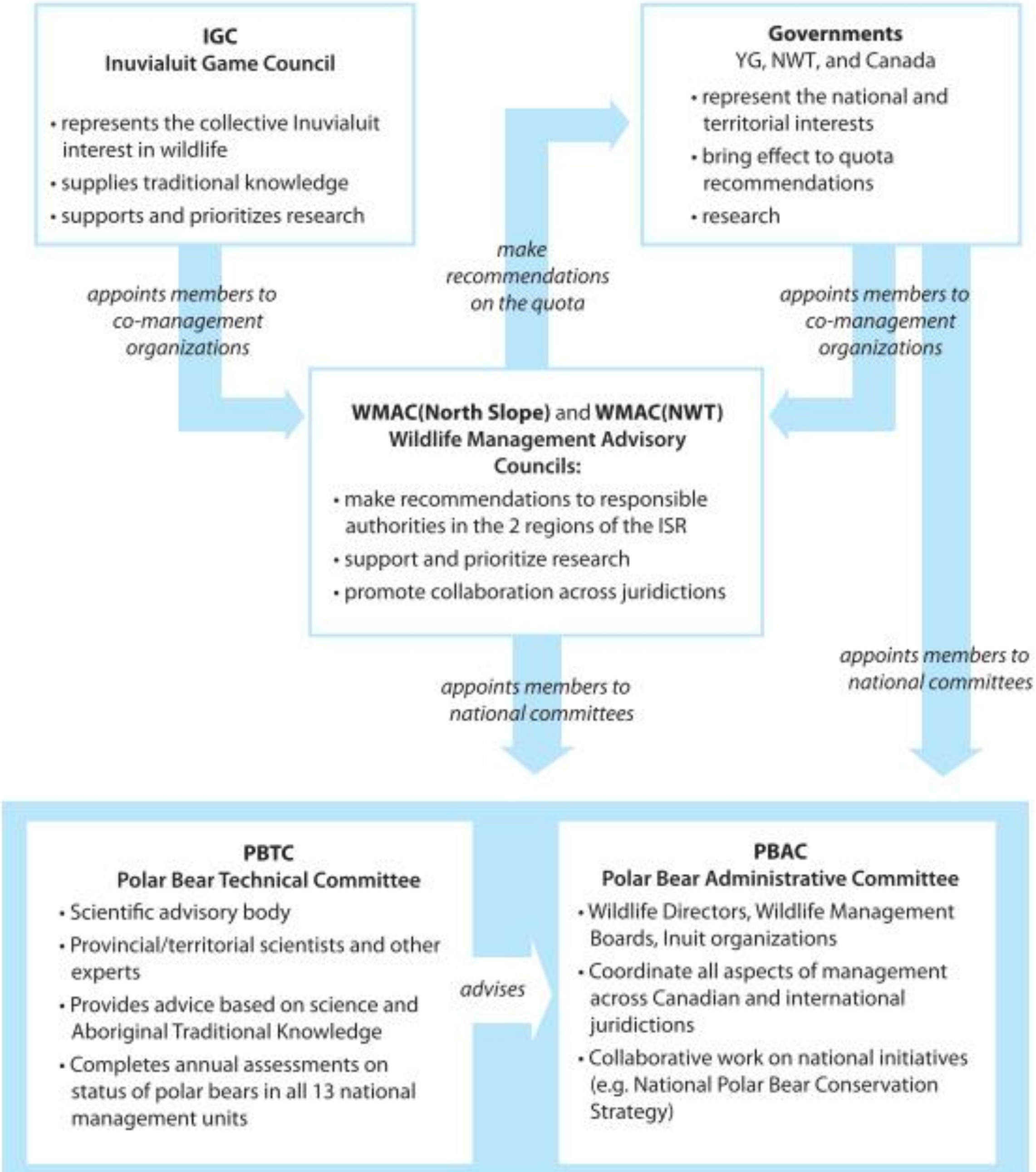
"The bears that I do see are in good shape. They're hunting and they are being successful and getting fed. If polar bears were starving, you think they would start to pop up here – they would be here and there. And that's not happening."

Source: *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study* (Joint Secretariat, 2015, p.9).

Population Management

Management of polar bears is jurisdictionally complex. In the Inuvialuit Settlement Region, the Inuvialuit Final Agreement (IFA) (1984) sets out the wildlife management regime. In implementing the IFA, Inuvialuit jointly manage polar bears with the governments of Canada, the Northwest Territories, and Yukon. The SB subpopulation is shared with Alaska; the Inuvialuit-Inupiat Polar Bear Management Agreement in the Southern Beaufort Sea (1988, revised in 2011) facilitates transboundary cooperation for managing SB polar bears. The agreement includes a provision to manage harvest on a sustainable yield basis. Harvest is managed carefully and monitored closely. Within Canada, the Inuvialuit have the exclusive right to harvest polar bear in the ISR and annual quotas are allocated to Inuvialuit communities. Figure 8- 1 illustrates the co-management system outlined in the ISR as it applies to polar bears. For a detailed description of polar bear management in the ISR, see the *Inuvialuit Settlement Region Polar Bear Joint Management Plan* (Joint Secretariat, 2017).

Figure 8- 1. Inuvialuit Settlement Region (ISR) co-management system for polar bear research and management.



Source: (Joint Secretariat, 2015)

The current quota system and tags for SB polar bear harvest in Yukon and NWT are coordinated by representatives from the governments of Yukon and Northwest Territories, Parks Canada, Inuvialuit Game Council and Wildlife Management Advisory Councils (North Slope and NWT). These quotas are based on Western science and Indigenous knowledge and currently allow for

~4.5% of the total estimated population to be harvested. There is also a harvest sex ratio of 2:1 males to females. All harvest is reported though the quota system. In the SB, however, this annual quota is typically not met (Joint Secretariat, 2015; Joint Secretariat, 2017). Additionally, a small fraction of the polar bear tags is provided to guided sport hunts. Sport hunts generally target larger male polar bears (Amstrup, 2003). Sport hunts also have a conservation role; tags assigned to a sport hunt are considered used even if the hunt is unsuccessful and are not available to be assigned to others.

Transboundary Considerations

SB polar bears traverse the coastal region along the Beaufort Sea in Canada and the USA. Polar bear management occurs at the local level up to the international scale.

Formal international agreements exist in regards to polar bear conservation, including management, harvest and research (Inuvialuit-Inupiat Polar Bear Management Agreement in the Southern Beaufort Sea, 2000; Agreement on the Conservation of Polar Bears, 1973). Polar bear Range States (Canada, Norway, Greenland, the Russian Federation, and the United States) meet biennially to coordinate circumpolar polar bear management (Polar Bears in Canada, 1973). The range states have the support of the IUCN and have established domestic and inter-jurisdictional polar bear research and management criteria.

In the USA, polar bears are listed as Threatened under the Endangered Species Act (since 2008) and are protected under the Marine Mammal Protection Act of 1972 (U.S. Fish and Wildlife, 2015). Native Alaskans who live along the coast may conduct subsistence harvest of polar bears; however, no sport hunting is allowed (U.S. Fish and Wildlife, 2015).

The Canadian Polar Bear Administrative and Technical Committees coordinate polar bear research and management at the national level.

Observations, Concerns, and Threats

Impacts of Climate Change

Extreme variations in weather, climate, snow, and sea ice patterns have been observed by Inuvialuit since the 1980s (Joint Secretariat, 2015). It is clear that climate in the Arctic is changing (see Chapter 2: Climate Change Effects), resulting in variable sea ice conditions. These include reduced ice extent, reduced thickness of multi-year ice, longer ice free periods, and changes in the seasonal timing of spring ice break-up (earlier) and autumn ice freeze up (later) (Derksen et al., 2019; Joint Secretariat, 2015, 2017; Zhang et al., 2019).

In the shorter term, reductions in seasonal sea ice may increase polar bear access to ringed seals via thin and channeled ice. However, in the long-term, sea ice reductions may negatively impact polar bears (COSEWIC, 2018; Durner et al., 2009; Eamer et al., 2013). Changes in hunting grounds may occur as sea ice retreats to deep polar waters beyond the continental shelf that provides preferred ringed seal habitat (Durner et al., 2009). An earlier break-up of sea ice followed by longer open water times may shorten the time sea-ice hunting grounds are accessible, causing diet shifts (Andrew E. Derocher et al., 2004; Thiemann et al., 2008). It is likely that multiple years of continual sea ice retreat may lead to reduced body condition, reproduction, and survival of polar bears, related to these shifts in prey abundance and the increased energy requirements and risk associated with open water travel (Bromaghin et al., 2015; Andrew E. Derocher et al., 2004; E. V. Regehr, Amstrup, & Stirling, 2007).

Parasite and viral infections may increase as polar bears shift or expand their food sources or begin to eat seal intestines and internal organs versus just their fat or blubber in response to changing conditions and prey availability due to climate change (Andrew E. Derocher et al., 2004). Additionally, reductions in sea ice and changes in wind and snow conditions may influence maternal denning habitat (Andrew E. Derocher et al., 2004; Joint Secretariat, 2015). Land-based denning may increase, or bears may remain on sea ice year-round (Fischbach et al., 2007).

The magnitude of the impact of sea ice decline on polar bears is unknown. When available, sea ice is highly used by polar bears, but individuals can persist in areas with ice-free summers; therefore population responses to declining sea ice are expected to vary across Canada (COSEWIC, 2018; Species at Risk Committee, 2021).

Inuvialuit observations of sea ice change

- “Freeze-up occurs a month later than it did previously;
- Break-up occurs a month earlier…
- Ice is thinner, and wind and currents can easily break it up and rubble it;
- Ice does not ground on shoal areas the way it used to because it is thinner…
- There have been significant reductions in multi-year ice in many parts of the Beaufort Sea region;
- Floe edges are closer to shore
- Pressure ridges that used to form predictably in the same location from one year to the next are no longer there;
- There is more open water than ever before…
- Winds shift unpredictably across a number of directions, … wind velocities have increased noticeably …”

(Joint Secretariat, 2015, p.162)

Adaptation

> This global warming is happening, and these bears will have to adapt to what's happening.
>
> PIN 19, Aklavik page 195 (Joint Secretariat, 2015)

The 2015 Inuvialuit traditional knowledge study of polar bears concluded its discussion on climate change effects on polar bears with the statement: "For the Inuvialuit, the future cannot be predicted; it could be good or bad as far as polar bears are concerned. However, the consensus among the workshop participants was that polar bears are highly intelligent animals that can adapt to climate change because they have been adapting to many things for thousands of years" (Joint Secretariat, 2015).

Western science also recognizes that polar bears can shift their diet based on food availability and adapt to periods of low-food by altering their metabolism to enter a hibernation-like state (Andrew E. Derocher, Nelson, Stirling, & Ramsay, 1990). During these periods, they make use of refugia or shelter dens; thus this habitat may become increasingly critical during the summer and winter seasons (Ferguson, Taylor, Rosing-Asvid, Born, & Messier, 2000). Polar bears may use terrestrial and sea ice for summer refugia when nearshore ice is absent (Pongracz & Derocher, 2017).

Additionally, polar bears may shift their range north as the ice retreats. Inuvialuit state that some polar bears are expanding north to find multi-year ice and stable seal populations (Species at Risk Committee, 2021). Some bears may move further inland (Andrew E. Derocher et al., 2004; Species at Risk Committee, 2020). Polar bears in the SB subpopulation have been recently reported travelling further inland than was historically common.

Impacts from Human Activities

Resource extraction and shipping

Sea ice reductions have led to the shear zone (the area between landfast and pack ice) occurring closer to shore. This opens access for increased shipping, transport, and tourism, as well as oil and gas exploration and development (Species at Risk Committee, 2021). Offshore oil and gas exploration (which are not expected to be a threat in the near-term future) and development increases the risk for pollution and disturbance. Increased dumping or accidents may negatively impact polar bears and their prey (Andrew E. Derocher et al., 2004). The use of the Northwest Passage by marine traffic may contribute to multi-year ice decline as open leads are prevented from freezing (Species at Risk Committee, 2021).

Human waste management

Polar bears in the SB subpopulation have been observed eating refuse in recent years, and harvested bears have been found to have significant amounts of garbage (up to the size of a beach towel) in their stomachs. In many cases, bears that consume indigestible garbage cannot pass it through their system. An accumulation of indigestible waste in the stomach can eventually lead to starvation.

Contaminants

Polar bears are apex predators, and are thus likely to accumulate environmental contaminants (persistent organic pollutants (POPs) and heavy metals) in their tissues, which may decrease their overall health (Joint Secretariat, 2017; Species at Risk Committee, 2021). POPs were detected in SB polar bear samples collected in the 1980s, indicating that historic exposure may be underestimated (Liu et al., 2018). Polar bear exposure to contaminants may increase if shipping and oil and gas exploration and development expand. Increased exposure to contaminants is likely to stress their immune systems, making polar bears more vulnerable to expanding diseases and parasites (Andrew E. Derocher et al., 2004).

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.

Polar Bear Conservation and Management

- *Agreement on the Conservation of Polar Bears (1973)* and *Circumpolar Action Plan* (2015)
  This Agreement is an international coordination of polar bear research and management, intended to protect the polar bears as a significant resource of the Arctic region through conservation and management measures. It includes ecosystem protection measures and prohibitions against taking of polar bears aside from subsistence purposes, and trade in polar bears or polar bear parts. The goal of the Circumpolar Action Plan (2015) is "to secure the long-term persistence of polar bears in the wild that represent the genetic, behavioral, life-history and ecological diversity of the species."

- *Inuvialuit-Inupiat Polar Bear Management Agreement in the Southern Beaufort Sea* (1988, last revised in 2011) (Inuvialuit Game Council & North Slope Borough Fish and Game Management Committee, 2000)
  Agreement between the Inuvialuit in Canada and the Inupiat in Alaska on the harvest of polar bears, which promotes transboundary cooperation and information sharing, and facilitates coordinated management for the SB polar bear subpopulation.

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016)
  This is a community-based planning document which identifies important habitats on the Yukon North Slope, traditional use, management plans and research priorities for polar bears on the Yukon North Slope and in the NWT.

- *Inuvialuit Settlement Region Polar Bear Joint Management Plan* (Joint Secretariat, 2017) and implementation agreement (NWT Conference of Management Authorities, 2018)
  Describes the management goals and objectives for polar bears across the ISR. The management goal is "to ensure the long-term persistence of healthy polar bears in the ISR while maintaining traditional Inuvialuit use."

- *Ivvavik National Park of Canada Management Plan* (Parks Canada, 2018)
  Conservation and management of polar bear 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".

- *Species Status Report for Polar Bear* (*Ursus maritimus*; Nanuq) (Species at Risk Committee, 2021)
  The Species at Risk Committee was established under the Species at Risk (NWT) Act and they assess the biological status of species at risk, including polar bear. This report compiles and analyzes information on the biological status of polar bears in the NWT, including potential threats and positive influences. These threats and influences are likely to be similar in the Yukon North Slope portion of the SBS polar bear subpopulation.

Research and Monitoring Programs

- Interjurisdictional cooperation

  Canadian Polar Bear Administrative Committee and Canadian Polar Bear Technical Committee

  Forums of representatives of federal, territorial, and provincial governments, Indigenous authorities, and wildlife management bodies. The administrative committee shares and coordinates information, management objectives, and policy for Canada's polar bear populations. The technical committee undertakes an annual assessment of Canada's 13 polar bear subpopulations and provides technical advice to the administrative committee.

  Polar Bear Range States

  Biennial meeting of signatories to the 1973 *Agreement on the Conservation of Polar Bears* (Norway, Canada, Greenland, the Russian Federation, and the United States) to coordinate circumpolar polar bear management.

  Inuvialuit-Inupiat Southern Beaufort Polar Bear Commission

  Annual meeting of Inuvialuit and Inupiat representatives to address population and harvest management and research of Southern Beaufort polar bears.

- Harvest monitoring: Inuvialuit Harvest Study (IRC, 2017, 2018, 2019a)
  Annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. From 2017-2019, this program included polar bear harvest

monitoring. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

There is a solid base of both traditional and Western scientific knowledge about polar bears of the southern Beaufort Sea region. Inuvialuit traditional knowledge about polar bears has been recorded through a major research project which documents polar bear relationship to the environment they occupy including climate, geography, fauna, weather, and ice conditions (Joint Secretariat, 2015). Traditional knowledge is documented through ongoing community-based monitoring and harvest management initiatives (IRC, 2019b; Joint Secretariat, 2017).

Research and monitoring by US and Canada government agencies and researchers occurs through international cooperation agreements. Polar bear research using Western science methodologies is very expensive and occurs in remote locations with inherent danger, including rapidly changing weather patterns and ice conditions. These factors influence both study frequency and success. Multiple studies (current and historic) have assessed polar bear movement, population dynamics, denning habits, foraging, and TK in the region (Amstrup et al., 2000; Amstrup & Gardner, 1994; Bromaghin et al., 2015; Durner et al., 2020; Florko, 2018; Eric V. Regehr et al., 2010; Ian Stirling, 2002; Thiemann et al., 2008; WMAC (NS) & Aklavik HTC, 2018a). In fact, the Southern Beaufort Sea polar bears are one of the most studied subpopulations of polar bears. Research has also assessed the potential influence of climate change effects on polar bears (Andrew E. Derocher et al., 2004; Durner et al., 2009). These studies provide a baseline for current and future management including sustainable harvest and potential population changes due to climate change and other factors.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study (Joint Secretariat, 2015)
  This study documents Inuvialuit knowledge on polar bears. Seventy-two traditional knowledge holders in 6 communities were interviewed. Interviews were typically conducted during a single session, included around 145 questions, and lasted up to 3 hours. Follow-up verification workshops were held with some participants (n=12) to address differences in polar bear demographics, behaviour, habitat, and ecology related to climate change.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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. 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.

Assessments and Syntheses of Monitoring and Research Findings

- Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: A synthesis of population trends and ecological relationships over three decades (Ian Stirling, 2002)
  Includes population trends of polar bears from their overharvest during the 1960s (and potentially 1950s), across their recovery to current conditions including declining sea ice and links to seal population health. At the time of this publication, the authors note that the population estimates for polar bears in the SBS are outdated.
- Polar bears in a warming climate (Andrew E. Derocher et al., 2004)
  Climate change models predict that preferred polar bear habitats (sea ice) will decrease or be substantially altered in the future. Polar bears are expected to alter behaviours, but the authors propose that their highly specialized nature will restrict their ability to adapt to great changes in their preferred habitat.
- Polar bear diets and arctic marine food webs: insights from fatty acid analysis (Thiemann et al., 2008)
  The fatty acid signatures of 1783 individual polar bears, sampled in the Canadian Arctic over 30 years, were evaluated. This study indicates that polar bears are opportunistic foragers who may alter their foraging habits to take advantage of locally abundant prey, potentially compensating for variation in their dominant prey. However, polar bear dependence on the availability of ringed and bearded seals may make them further vulnerable to climate-related changes.
- Assessment and Status Report for Polar Bear *Ursus maritimus* in Canada (COSEWIC, 2018)
  The COSEWIC report summarizes available information on population status and trends and on threats to polar bears in Canada. The report presents the rationale for the designation of polar bear as a species of Special Concern.

- Species Status Report for Polar Bear (Ursus maritimus) in the Northwest Territories (Species at Risk Committee, 2021)
  The Species at Risk Committee report summarizes available Indigenous and community knowledge and scientific knowledge about polar bears in the Northwest Territories (which includes part of the SB subpopulation). The report presents the rationale for the designation of polar bear as a species of special concern.

References

Agreement on the Conservation of Polar Bears. (1973). Canada, Denmark, Norway, U.S.S.R, U.S. Retrieved April 26, 2019, from Nunavut Department of Environment and Environment and Climate Change Canada website: https://www.polarbearscanada.ca/en/legislation/international/1973-agreement-conservation-polar-bears

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

Amstrup, S. C. (2003). The Polar Bear - Ursus maritimus. In G. A. Feldhamer, B. C. Thompson, & J. A. Chapman (Eds.), *Wild mammals of North America: biology, management, and conservation* (pp. 587–610). https://doi.org/10.2307/j.ctt1ffjg74.68

Amstrup, S. C., Durner, G. M., Stirling, I., Lunn, N. J., & Messier, F. (2000). Movements and distribution of polar bears in the Beaufort Sea. *Canadian Journal of Zoology*, *78*(6), 948–966. https://doi.org/10.1139/cjz-78-6-948

Amstrup, S. C., & Gardner, C. (1994). Polar Bear Maternity Denning in the Beaufort Sea. *The Journal of Wildlife Management*, *58*(1), 1–10.

Bromaghin, J. F., McDonald, T. L., Stirling, I., Derocher, A. E., Richardson, E. S., Regehr, E. V., … Amstrup, S. C. (2015). Polar bear population dynamics in the southern Beaufort Sea during a period of sea ice decline. *Ecological Applications*, *25*(3), 634–651.

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

COSEWIC. (2018). *Assessment and Status Report on the Polar Bear Ursus maritimus in Canada*. Committee on the Status of Endangered Wildlife in Canada.

Derksen, C., Burgess, D., Duguay, C., Howell, S., Mudryk, L., Smith, S., … Kirchmeier-Young, M. (2019). Changes in snow, ice, and permafrost across Canada. In E. Bush & D. S. Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 194–260). Ottawa, ON: Government of Canada.

Derocher, A. E., & Stirling, I. (1998). Maternal investment and factors affecting offspring size in polar bears (Ursus maritimus). *Journal of Zoology*, *245*(3), 253–260. https://doi.org/10.1111/j.1469-7998.1998.tb00099.x

Derocher, Andrew E., Lunn, N. J., & Stirling, I. (2004). Polar Bears in a Warming Climate Polar. *Integr. Comp. Biol.*, *44*, 163–176.

Derocher, Andrew E., Nelson, R. A., Stirling, I., & Ramsay, M. A. (1990). Effects of Fasting and Feeding on Serum Urea and Serum Creatinine Levels in Polar Bears. *Marine Mammal Science*, *6*(3), 196–203. https://doi.org/10.1111/j.1748-7692.1990.tb00243.x

Durner, G. M., Amstrup, S. C., Atwood, T. C., Douglas, D. C., Fischbach, A. S., Olson, J. W., … Wilson, R. R. (2020). *Catalogue of Polar Bear (Ursus maritimus) Maternal Den Locations in the Beaufort Sea and Chukchi Seas and Nearby Areas, 1910–2018*. https://doi.org/https://doi.org/10.3133/ds1121

Durner, G. M., Douglas, D. C., Nielson, R. M., Amstrup, S. C., Mcdonald, T. L., Stirling, I., … Derocher, A. E. (2009). Predicting 21st-century polar bear habitat distribution from global climate models. *Ecological Monographs*, *79*(1), 25–58. https://doi.org/10.1890/07-2089.1

Eamer, J., Donaldson, G. M., Gaston, A. J., Kosobokova, K. N., Larusson, K. F., Melnikov, I. A., … von Quillfeldt, C. H. (2013). *Life linked to ice: A guide to sea-ice-associated biodiversity in this time of rapid change*. Iceland: Conservation of Arctic Flora and Fauna.

Ferguson, S. H., Taylor, M. K., Rosing-Asvid, A., Born, E. W., & Messier, F. (2000). Relationships between denning of polar bears and conditions of sea ice. *Journal of Mammalogy*, *81*(4), 1118–1127. https://doi.org/10.1644/1545-1542(2000)081<1118:RBDOPB>2.0.CO;2

Fischbach, A. S., Amstrup, S. C., & Douglas, D. C. (2007). Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. *Polar Biology*, *30*(11), 1395–1405. https://doi.org/10.1007/s00300-007-0300-4

Florko, K. R. N. (2018). *Polar bear (Ursus maritimus) foraging ecology in the Western Canadian Arctic*. York University, Tornoto, Ontario, Canada.

Government of the Northwest Territories. (n.d.). Polar Bear. Retrieved June 7, 2021, from https://www.nwtspeciesatrisk.ca/species/polar-bear

Hensel, R. J., & Sorensen, F. E. (1980). Age Determination of Live Polar Bears. *Bears: Their Biology and Management*, *4*, 93. https://doi.org/10.2307/3872849

Hezel, P. J., Zhang, X., Bitz, C. M., Kelly, B. P., & Massonnet, F. (2012). Projected decline in spring snow depth on Arctic sea ice caused by progressively later autumn open ocean freeze-up this century. *Geophysical Research Letters*, *39*(17), 6–11. https://doi.org/10.1029/2012GL052794

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 Game Council, & North Slope Borough Fish and Game Management Committee. (2000). *Inuvialuit-Inupiat Polar Bear Management Agreement in the Southern Beaufort Sea*.

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

IRC. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

IRC. (2019b). Inuvialuit Harvesters Assistance Program. Retrieved June 24, 2019, from Inuvialuit Regional Corporation website: https://www.irc.inuvialuit.com/program/inuvialuit-harvesters-assistance-program

Joint Secretariat. (2015). *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Joint Secretariat, Inuvialuit Settlement Region.

Joint Secretariat. (2017). *Inuvialuit Settlement Region Polar Bear Joint Management Plan*. Joint Secretariat, Inuvialuit Settlement Region.

Liu, Y., Richardson, E. S., Derocher, A. E., Lunn, N. J., Lehmler, H. J., Li, X., … Martin, J. W. (2018). Hundreds of

Unrecognized Halogenated Contaminants Discovered in Polar Bear Serum. *Angewandte Chemie - International Edition*, (2). https://doi.org/10.1002/anie.201809906

Mckinney, M. A., Atwood, T. C., Iverson, S. J., & Peacock, E. (2017). Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use. *Ecosphere*, *8*(1). https://doi.org/10.1002/ecs2.1633

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

NWT Conference of Management Authorities. (2018). *Consensus Agreement Respecting Implementation of the Inuvialuit Settlement Region Polar Bear Joint Management Plan and Framework for Action*.

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

Pilfold, N. W., Derocher, A. E., Stirling, I., & Richardson, E. S. (2015). Multi-temporal factors influence predation for polar bears in a changing climate. *Oikos*, *124*(8), 1098–1107. https://doi.org/10.1111/oik.02000

Polar Bears in Canada. (1973). 1973 Agreement on the Conservation of Polar Bears. Retrieved April 26, 2019, from Nunavut Department of Environment and Environment and Climate Change Canada website: https://www.polarbearscanada.ca/en/legislation/international/1973-agreement-conservation-polar-bears

Pongracz, J. D., & Derocher, A. E. (2017). Summer refugia of polar bears (Ursus maritimus) in the southern Beaufort Sea. *Polar Biology*, *40*(4), 753–763. https://doi.org/10.1007/s00300-016-1997-8

Ramsay, M. A., & Stirling, I. (1988). Reproductive biology and ecology of female polar bears (Ursus maritimus). *Journal of Zoology*, *214*(4), 601–633. https://doi.org/10.1111/j.1469-7998.1988.tb03762.x

Regehr, E. V., Amstrup, S. C., & Stirling, I. (2007). *Polar Bear Population status in the Southern Beaufort Sea*.

Regehr, Eric V., Hunter, C. M., Caswell, H., Amstrup, S. C., & Stirling, I. (2010). Survival and breeding of polar bears in the southern Beaufort Sea in relation to sea ice. *Journal of Animal Ecology*, *79*(1), 117–127. https://doi.org/10.1111/j.1365-2656.2009.01603.x

Saunders, B. L. (2005). *the Mating System of Polar Bears in the Central Canadian Arctic*.

Schliebe, S., Rode, K. D., Gleason, J. S., Wilder, J., Proffitt, K., Evans, T. J., & Miller, S. (2008). Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the Southern Beaufort Sea. *Polar Biology*, *31*(8), 999–1010. https://doi.org/10.1007/s00300-008-0439-7

Slavik, D., Inuvialuit Game Council, Wildlife Management Advisory Council (North Slope), & Wildlife Management Advisory Council (NWT). (2009). *Inuvialuit Knowledge of Nanuq: Community and Traditional Knowledge of Polar Bears in the Inuvialuit Settlement Region*. Inuvik, NT.

Slavik, D. V. W. (2013). *Knowing Nanuut : Bankslanders knowledge and indicators of polar bear population health by Master of Science in Rural Sociology © Daniel Slavik Fall 2013 Edmonton , Alberta In memory of : Andy Carpenter Sr . Geddes Wolki Sr .* University of Alberta.

Species at Risk Committee. (2020). *Draft Species Status Report for Polar Bear*. Yellowknife, NT, Canada.

Species at Risk Committee. (2021). *Species Status Report for Polar Bear*. Retrieved from https://www.nwtspeciesatrisk.ca/sites/enr-species-at-risk/files/polar_bear_status_and_reassessment_report_final_april2021.pdf

Stirling, I., & Lunn, N. J. (1997). Environmental fluctuations in arctic marine ecosystems as reflected by variablity in reproduction of polar bears and ringed seals. In S. J. Woodin & M. Marquiss (Eds.), *Ecology of Arctic environments* (pp. 167–181). Oxford, Blackwell Science Ltd.

Stirling, I., Pearson, A. M., & Bunnell, F. L. (1976). Population ecology studies of polar and grizzly bears in northern Canada. *Transactions, Forty-First North American Wildlife and Natural Resources Conference, March 21-25, 1976, Washington, D.C.*, *41*, 421–429. Retrieved from https://www.cabdirect.org/cabdirect/abstract/19770640309%0Ahttp://parkscanadahistory.com/wildlife/paper-42.pdf

Stirling, Ian. (2002). Polar Bears and Seals in the Eastern Beaufort Sea and Amundsen Gulf : A Synthesis of Population Trends and Ecological Relationships over Three Decades. *Arctic*, *55*(Supp.1), 59–76.

Thiemann, G. W., Iverson, S. J., & Stirling, I. (2008). Polar bear diets and arctic marine food webs: Insights from fatty acid analysis. *Ecological Monographs*, *78*(4), 591–613. https://doi.org/10.1890/07-1050.1

U.S. Fish and Wildlife. (2015). *Polar Bear (Ursus maritimus) Conservation Management Plan*. Anchorage, Alaska, USA.

US Fish and Wildlife Service. (2020). Polar Bears. Retrieved February 25, 2021, from https://www.fws.gov/alaska/pages/marine-mammals/polar-bear

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

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: Polar Bear. Retrieved April 20, 2020, from https://yukon.ca/en/polar-bear

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., … Kharin, V. V. (2019). Changes in Temperature and Precipitation Across Canada. In E. Bush & D. S. Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 112–193). Ottawa, ON: Government of Canada.

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 9:
Dolly Varden / Iqaluqpig

Publication Information

Cover photo: Dolly Varden at Tapqaq, Yukon North Slope. © Michelle Gruben, 2016.

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 9: Dolly Varden/ Iqaluqpig

Table of Contents

Maps

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 four 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: Dolly Varden / Iqaluqpig

This companion report provides information on the conservation requirements for Dolly Varden (which are locally known as 'Char') 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 Dolly Varden, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for Dolly Varden on the Yukon North Slope

1. Minimize disturbance to spring-fed spawning and overwintering sites and ensure access to these spots by Dolly Varden is not impaired by human activity.
2. Conservation of productive summer feeding conditions along the coast.
3. Track hydrological and fish passage changes to key spawning and overwintering rivers associated with new or increased beaver infrastructure. Rivers on the Yukon North Slope are likely to become more favourable for beaver habitat over time, with increased shrubification.

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

The *Integrated Fisheries Management Plan (IFMP) for Dolly Varden* (DFO et al., 2019) informs the conservation requirements above, and is referenced throughout this report. The IFMP's development and implementation is an adaptive co-management process between the Government of Canada, Inuvialuit, and Gwich'in organizations and groups. It identifies objectives, strategies and measures for managing the fisheries and fish habitats, and for sustaining and rebuilding Dolly Varden populations.

IFMP conservation measures of particular relevance to the *Yukon North Slope Wildlife Conservation and Management Plan* are listed in Table 9- 1.

Table 9- 1. Selected conservation measures from the Integrated Fisheries Management Plan for Dolly Varden, 2019 update

Conservation measure	Priority
Apply the precautionary and ecosystem-based approaches	High
Develop management regimes for the Firth and Babbage rivers	Medium
Manage Coastal Fisheries to ensure no stock is over- harvested	High
Protect habitats	High
Monitor harvests	High
Research and monitoring measures: monitor harvests; conduct periodic stock assessments; collect coastal and Mackenzie Delta (mixed-stock fisheries) samples for genetic analyses; undertake life-cycle studies; Identify, assess, and monitor critical, sensitive, and limiting habitats; gain better understanding of Dolly Varden ecosystem interactions; and gather local observations on environmental conditions and climate change.	High

(DFO et al., 2019, Table 4)

Dolly Varden on the Yukon North Slope

(General references for this section: Brewster, Neumann, Ostertag, & Loseto, 2016; COSEWIC, 2010; DFO, FJMC, GRRB, & Parks Canada, 2019)

The Inuvialuktun name Iqaluqpig can also refer to Arctic char (*Salvelinus alpinus*). Dolly Varden on the Yukon North Slope are also commonly called "Dolly Varden", "Arctic char", or "char". In this report, "Dolly Varden" or "char" refers to the northern form of Dolly Varden (*Salvelinus malma malma*), known in Canada as Western Arctic Dolly Varden.

Dolly Varden (Iqaluqpig) are related to Arctic char, trout, and salmon. After rearing in freshwater, most Dolly Varden 3 to 5 years of age begin to migrate between feeding habitats in the sea in summer and spawning and overwintering areas in the upper reaches of river systems. These are known as searun, or anadromous, Dolly Varden. Young Dolly Varden remain in small mountain streams in the summer, feeding on insects, shellfish, and fish eggs. Searun Dolly Varden eat other fish and eat invertebrates when feeding in the ocean (McCart, 1980).

Two types of Dolly Varden stay in rivers and streams all their lives:

1) Stream-resident – mainly male fish that live alongside searun fish in headwater streams but do not migrate to the sea;
2) Isolated Dolly Varden that live their entire lives upstream of impassable waterfalls on the Babbage and Big Fish rivers.

Freshwater winter habitat is crucial to all Dolly Varden as they are not able to overwinter in the sea. Dolly Varden spend the winter in headwater areas of watersheds, in reaches of rivers and streams under the aufeis. They usually also spawn in these spring-fed areas, or fish holes. In winter, groundwater from the springs can freeze into thick sheets of ice (aufeis) below the fish holes. The aufeis melts slowly over the summer, helping to maintain good water conditions for the fish.

Dolly Varden are important as a food source for Aklavik Inuvialuit (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016). Harvest locations are in rivers, most commonly the Big Fish River (fish hole and river mouth), the Mackenzie Delta around Aklavik, and in coastal areas of the Beaufort Sea (Lea, Gruben, Gallagher & Costa, 2020).

Dolly Varden are also an important component of Yukon North Slope marine food chains. They eat bottom-dwelling marine invertebrates and Arctic cisco (locally known as herring). Dolly Varden, in turn, are eaten by beluga whales, seals, larger fish, and birds.

Traditional Use

Dolly Varden are fished for by the Inuvialuit and Gwich'in peoples of Aklavik and the Fort McPherson Gwich'in (DFO (Department of Fisheries and Oceans Canada) et al., 2019). The major fisheries are on the Mackenzie Delta, and the Rat and Big Fish rivers, which are close to the two towns, and along the Yukon coast. Big Fish River and Rat River fisheries have declined since the 1970s due to fish stock reductions, but harvest has resumed at levels considered sustainable (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

An historical perspective on fishing for Dolly Varden

Before 1930 there were many traditional fishing locations (Byers et al., 2019; Papik et al., 2003). Inuvialuit fishing was concentrated along the western Beaufort Sea coast between the Alaska border and the Mackenzie Delta, and at the Big Fish River overwintering area (the fish holes). Inuvialuit began fishing the lower reaches of the Big Fish River in the 1960s. Gwich'in fished primarily in the Mackenzie Delta and Peel River drainage, and Vuntut Gwich'in from the Yukon fished Yukon North Slope rivers, especially the Firth and Babbage. The direct and indirect effects of socioeconomic change over the last century have resulted in a shift in Inuvialuit fisheries, with more remote locations being fished less frequently.

Traditional fishing methods included baleen, sinew and willow gill and sweep nets used in deeper waters, and rock, driftwood and willow traps and spears used in shallow streams and river beds. Now, more efficient cotton and nylon gill nets are used, and the mesh size has changed from 76-127 mm (3.0-5.5 inches) to 102-114 mm (4.0-4.5 inches), and to 89 mm (3.5 inch) at Shingle Point. An 89 mm (3.5 inch) mesh had been popular as it caught smaller, tastier fish. Voluntary gear restrictions and

The Dolly Varden harvest is identified in traditional use studies (Brewster, Neumann, et al., 2016; Papik, Marschke, & Ayles, 2003; WMAC (NS) & Aklavik HTC, 2018b) and in the Aklavik Inuvialuit Community Conservation Plan (Aklavik HTC et al., 2016) as an important component of the traditional Inuvialuit way of life. A 1991 dietary survey demonstrated the importance of these fish in the diet of Aklavik Inuvialuit (Wein & Freeman, 1992). On average, Dolly Varden (locally known as char) had been served 31 times over the previous year in the 36 households surveyed, and char and dry fish were among the top ten preferred foods.

Inuvialuit and Gwich'in Dolly Varden harvest levels declined in the 1980s and have not returned to previous levels, although there is a lot of year-to-year variation. The decline may be a result of fewer fish, combined with other factors, such as higher gas prices (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

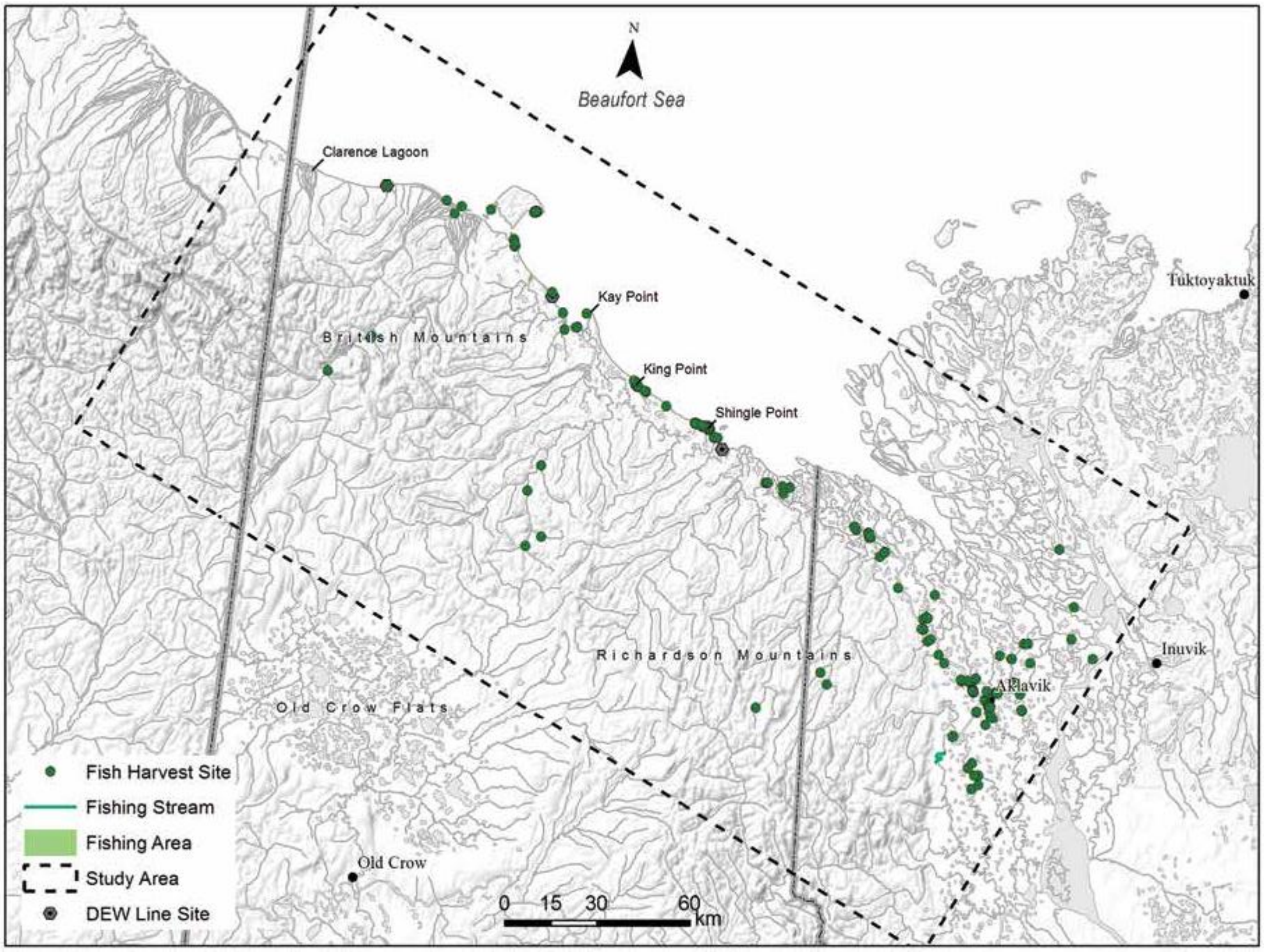
Annual harvests of Dolly Varden by Aklavik Inuvialuit vary according to coastal fishing conditions and Big Fish River closures and catch guidelines. When the Big Fish River was closed to fishing, Aklavik Inuvialuit were able to catch Dolly Varden in Aklavik, south of Aklavik, and through the coastal fishery. In recent years, a limited harvest has occurred in the Big Fish River as an alternative to the coastal fishery and to revitalize use of traditional fishing locations (Lea, Gruben, Gallagher & Costa, 2020). Since the mid-1980s the annual Aklavik Inuvialuit reported harvest has varied from over 2,500 to fewer than 50 char (DFO (Department of Fisheries and Oceans Canada) et al., 2019, Table A1-1).

> [The Big Fish River has] traditionally been where everybody fished for char. People are trying to maintain their ties to the land, to where we've been before, and we like to continue to see tradition stay because our membership in Akłarvik is pretty traditional. We like to keep things going if we can. So, I think that's good because it lets our young people know: this is where my dad fished, my grandpa fished, and that's important to us. —Billy Storr (Lea, Gruben, Gallagher & Costa, 2020)

The Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b) provides documentation of past and current fishing locations on the Yukon North Slope (Map 9-1). This observation by an older interviewee shows the relationship between Dolly Varden (referred to as char, below) and sea ice and how ice conditions affect the success of fishing on the coast:

> They go as far as Fish Hole for getting char, and down [to] Shingle Point to get char. When ice used to come in close [to shore], we would go down farther, King Point, in that area, where the ice get close. Seem to get more char when the ice is close to the land.... We don't use very long net. We just use short net and string it out. But when there's no ice, it's different fishing. At Shingle Point we're just lucky because it's where it [the ice] comes when it [char] runs. (WMAC (NS) & Aklavik HTC, 2018b, p. 81)

Map 9- 1. Fish harvest locations identified in the Inuvialuit traditional use interviews



The fishing locations are for all species of fish. The interviewers asked Inuvialuit land users to identify fishing areas and harvest sites used within living memory. Source: WMAC (NS) and Aklavik HTC (2018b), Map 11.

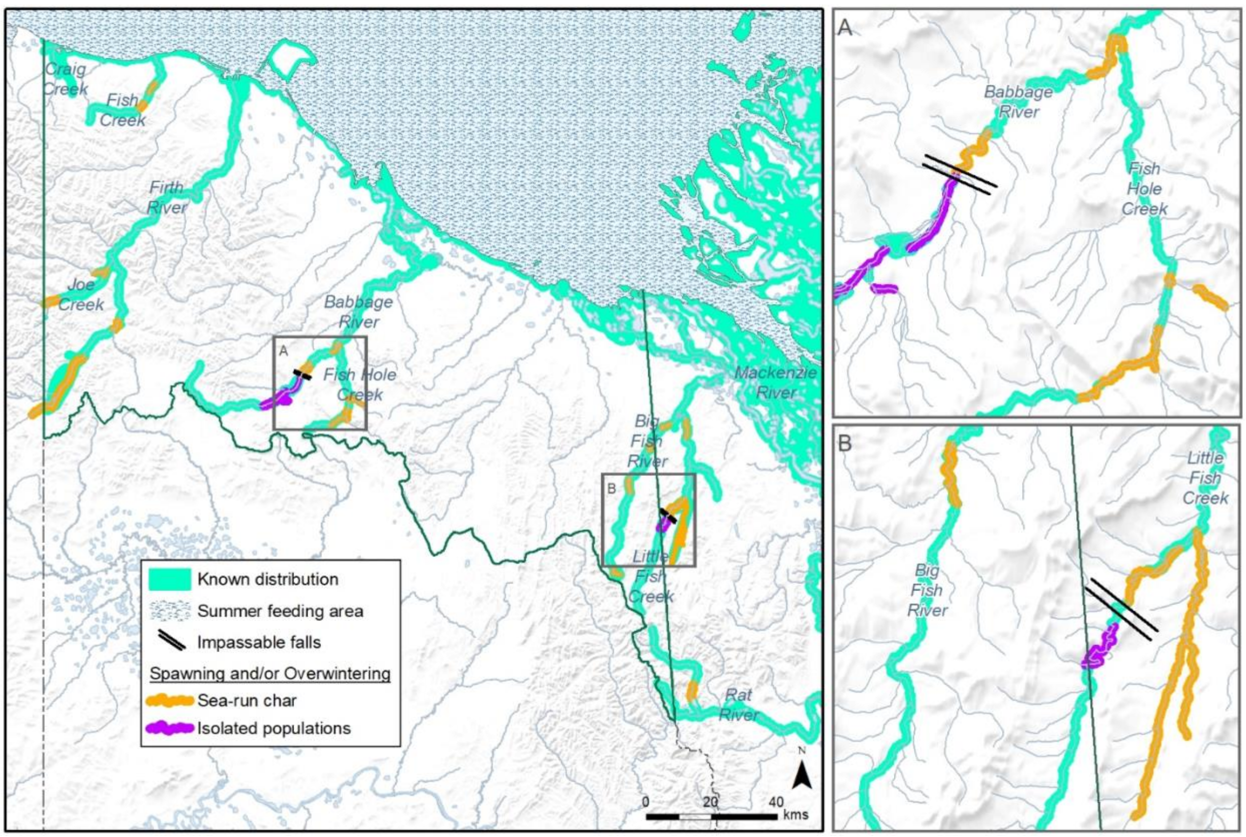
Climate change effects on sea ice, wave and erosion patterns have impacted Inuvialuit fishing on the Yukon North Slope. Fishing locations have changed because of changes to the bays and deltas. Gravel has built up at King Point, closing off the harbour. King Point is still used for fishing on day trips from Shingle Point (Byers, Reist, & Sawatzky, 2019). Phillips Bay and the Firth River delta are shallower now than they were decades ago and less suitable as harbours (Papik et al., 2003). Sea ice is often not as close to the coast as it was historically, which also impacts the ability to safely boat and fish along the coast (WMAC (NS) and Aklavik HTC, 2018b).

Habitat for Dolly Varden

Yukon North Slope Habitat

Yukon North Slope habitat includes the coastal marine area, where Dolly Varden feed during the summer period, estuaries and river reaches that provide migration corridors, and overwintering, spawning, and fish rearing areas at the headwaters of rivers and creeks (Map 9- 2). Overwintering areas, often also used for spawning, are limited to a few distinct locations. Recent research has emphasized the importance of the Beaufort Sea for Dolly Varden and suggests that Dolly Varden are widely distributed in the offshore Beaufort Sea and may use marine waters throughout their range (Courtney et al., 2018).

Map 9- 2. Dolly Varden habitat: known distribution, overwintering and spawning locations, and summer marine feeding zone, based on surveys and Inuvialuit traditional knowledge



This map is from the Plan (WMAC (NS), 2022, Appendix 1). It is based on surveys and Inuvialuit traditional knowledge (Dave Tavares, personal communication, April 2019; Ellen Lea, personal communication, March 2019; WMAC NS and Aklavik HTC, 2018b). Note that the distribution in Craig Creek (based on data from Fisheries and Oceans Canada [DFO]) is not spawning or overwintering.

Habitat with year-round groundwater discharge is a limiting factor of Dolly Varden abundance (Loewen et al., 2015). The proportion of habitat within each watershed that is associated with groundwater discharge in winter is small—for example, it is less than 5% of the Babbage River system downstream of the falls (Mochnacz, Schroeder, Sawatzky, & Reist, 2010).

The total known winter habitat for Western Arctic Dolly Varden in Canada is only 0.63 km^2, of which 47% is within the Yukon North Slope (Table 9- 2). A further 0.35 km^2 has been identified as potential Dolly Varden winter habitat. This is almost entirely (98%) within the Yukon North Slope. The largest blocks of both known and potential winter habitat are in the Firth River watershed.

Table 9- 2. Estimates of known and potential winter habitat for Western Arctic Dolly Varden on the Yukon North Slope and over the entire Canadian range

		Firth River	Joe Creek	Babbage River	Total for Yukon North Slope	Entire Canadian range	Percent of all Canadian habitat that is within the Yukon North Slope
Winter habitat (km^2)	Known	0.190	0.022	0.084	0.296	0.632	47%
	Potential	0.330	0.009	0.002	0.341	0.350	98%

The totals for the entire Canadian range include the Big Fish, Little Fish, Rat, Gayna, Vittrekwa, and Blackstone rivers, in addition to the rivers listed. Although headwater reaches of Little Fish Creek, Big Fish River, and the Rat River are within the Yukon North Slope, the main Dolly Varden overwintering areas are in the NWT, just downstream of the territorial boundary (Data from Mochnacz et al., 2010, Table 3).

Firth River and Joe Creek Char Habitat

The headwaters of the Firth River and Joe Creek are in Alaska, in the Arctic National Wildlife Refuge. Fish holes on both streams are in the Yukon, close to the border with Alaska and high up in the watershed. Groundwater discharge and summer temperatures are important in maintaining habitat in these mountain streams. The thick aufeis downstream of the fish holes rarely melts completely—meltwater from the aufeis maintains water levels in the summer.

The Firth River and Joe Creek fish holes are designated as Zone 1 Special Preservation areas of Ivvavik National Park, the highest level of protection afforded through the national park zoning system (Parks Canada, 2018a).

Babbage River Char Habitat

The upper reaches of the Babbage River and its tributaries are shallow. Flow is maintained by groundwater upwelling. The lower reaches freeze to the river bottom. Fish holes are along a 1.5 km section on Wood Creek and Fish Hole Creek (Canoe River), on the east side of the Babbage and thus not within Ivvavik National Park. There is also an isolated Dolly Varden population in the mainstem of the Babbage River, upstream of the falls and within Ivvavik National Park.

Char Habitat in Other Yukon North Slope Rivers

In addition to the habitat for the larger populations described above, Fish Creek (in the Komakuk Beach area, within Ivvavik National Park) supports Dolly Varden. There is known to be a wealth of traditional knowledge of Dolly Varden in this area; research about Dolly Varden in this area began in 2016 (Gallagher and Lea, personal communication, 2019).

Habitat Extending Beyond the Yukon North Slope

Dolly Varden originating in the Big Fish River and Rat River are caught in the Inuvialuit coastal fishery. Both of these rivers have headwater streams within the Yukon North Slope. For both rivers, the majority of overwintering and spawning habitat for searun Dolly Varden is downstream in the NWT.

Big Fish River Char Habitat

Big Fish River and its tributary Little Fish Creek cross the Yukon/Northwest Territories boundary. The headwaters are in Yukon North Slope, but much of the key habitat, including the overwintering habitat, is in the NWT. The main fishing areas historically used by Aklavik Inuvialuit are in the NWT (Fish Hole Creek close to the Yukon boundary, and at the mouth of the Big Fish River).

Waterfalls upstream of Fish Hole are a barrier to fish movement. There is an isolated population of Dolly Varden upstream of the falls and within the Yukon North Slope planning area.

Aklavik fish harvesters identified deterioration in the spawning and overwintering areas of the Big Fish Rivers as a likely cause of the decline in char abundance since the 1960s and 1970s. The water at Fish Hole is less salty and the water level has dropped (Papik et al., 2003). Earthquake activity in the 1970s probably changed groundwater flows (Stephenson, 2003). At the mouth of the Big Fish River, another harvest location, harvesters note that water levels seem lower than in the past, with more exposed gravel beds (Papik et al., 2003). Protection of the Big Fish/Little Fish watershed was identified by the Aklavik Hunters and Trappers Committee (HTC) as a priority for the Plan.

Rat River Char Habitat

Most of the Rat River drainage is southeast of the Inuvialuit Settlement Region (ISR). The headwaters of Fish Creek, a tributary of Rat River, are in the Yukon. An overwintering area for searun and juvenile Dolly Varden has been identified on upper Fish Creek, within the Yukon North Slope. The known overwintering and spawning habitat for Rat River Dolly Varden is downstream on Fish Creek, in the Gwich'in Settlement Area (GSA) in the NWT.

Dolly Varden Populations

Species Conservation Status

Western Arctic Dolly Varden were assessed as Special Concern in 2010, and then listed legally as Special Concern in 2017. Western Arctic Dolly Varden populations are ranked as Critically Imperiled in the Yukon and are on the Yukon Conservation Data Centre animal track list (Yukon CDC, 2019).

Table 9- 3. Dolly Varden, Western Arctic populations: conservation status

Status assigned by	Applies to	Status	References
Species at Risk Act (SARA)	Canada	Special Concern; listed on Schedule 1 since 2017	(Canada, n.d.)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	Canada	Special Concern; last assessed 2010	(Canada, n.d.)
Yukon	Yukon	S3S4: Vulnerable/apparently secure*	(Yukon, 2020)

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

Dolly Varden Fisheries, Populations, and Management

Fisheries

The main Dolly Varden fisheries within this area are the Inuvialuit fishery along the Yukon North Slope coast, and Inuvialuit and Gwich'in fisheries on Big Fish River (at Fish Hole and at the river mouth) and Rat River respectively, and the Mackenzie Delta (which is outside the Yukon North Slope).

Recreational fishing is allowed throughout the Yukon North Slope, either with a Yukon fishing license and subject to Yukon fishing regulations, or, in Ivvavik National Park, through the Park's permitting system. There were two short-lived commercial fisheries of char on the Yukon North Slope, one in the early 1960s at Shingle Point, and a second in the mid-1960s at Pauline Cove and Ptarmigan Bay (Steigenberger, Elson, Bruce, & Yole, 1975). There is currently no commercial quota for Dolly Varden within the ISR or the GSA (E. Lea, DFO, personal communication, 2020).

Management

Collaborative management is integrated across the ISR and GSA with Inuvialuit and Gwich'in participation, including the Aklavik HTC and the Fisheries Joint Management Committee (FJMC). Management planning and decision making are guided by working groups for the Rat and Big

Fish populations and an Integrated Fisheries Management Plan (IFMP) for all Dolly Varden populations within the ISR and the GSA.

The Integrated Fisheries Management Plan for Dolly Varden of the ISR and the Gwich'in Settlement Area for 2011 to 2015 (DFO, 2010a) encouraged monitoring programs, recommended preferred fishing gear and methods, and listed locations closed to fishing. The plan recommended following voluntary quotas set by the Rat River Working Group and the West Side Working Group. An updated plan was released in 2019 (DFO (Department of Fisheries and Oceans Canada) et al., 2019). It includes: updated stock assessments; updates on knowledge about Dolly Varden; updates on knowledge about threats and limiting factors; and management objectives, strategies, and measures. For information on the history and status of Dolly Varden populations and their management in the ISR and GSA, see the Integrated Fisheries Management Plan (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Mixed-Stock Coastal Fishery

The main Yukon North Slope Inuvialuit fishery for Dolly Varden is the coastal fishery at Tapqaq (Shingle Point) and Qikiqtaruk (Herschel Island). Dolly Varden are also caught at other locations along the coast: Komakuk Beach, Nunaluk Spit, Ptarmigan Bay, Phillips Bay (e.g., Niakolik Point), King Point, Sabine Point, and near the mouth of Running River (C. P. Gallagher et al., 2013). The fishery at Shingle Point is mainly for Arctic cisco (called herring, Qaaqtaq, *Coregonus autumnalis*) and inconnu (called coney, Sirrgarq, *Stenodus leucichthys*), though Dolly Varden and broad whitefish (Aanaarlirq, *Coregonus nasus*) are also caught (Brewster, Neumann, et al., 2016). Fisheries further west, including Qikiqtaruk, use larger mesh gill nets and have a greater focus on Dolly Varden (DFO, 2017a). Harvest takes place from July to early September (most commonly July to mid-August) (C. P. Gallagher et al., 2013).

Genetic studies show that fish caught in coastal waters are from populations that overwinter and spawn in several river systems: Firth River system, Babbage, Big Fish, Rat, and Vittrekwa rivers, as well as Alaskan rivers. The population composition of the fish caught varies from year to year. Dolly Varden originating in the Babbage River made up the majority of the Shingle Point harvest in a study from 2011 to 2014 (C. P. Gallagher, Howland, Bajno, Sandstrom, & Reist, 2018). The harvest at Qikiqtaruk has a higher contribution from the Firth River system and Alaskan rivers than the Tapqaq harvest. Comprehensive annual harvest monitoring and collection of biological data about the fish harvested began in 2011 for the coastal fishery (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Firth River and Joe Creek Char Populations

Firth River and Joe Creek may support genetically distinct populations (see Harris et al., 2015). The Firth River system populations are harvested by mixed-stock coastal fisheries on the Alaskan and Yukon North Slopes. The main freshwater fishery is recreational fishing on the Firth River by Park visitors on river trips. Ivvavik National Park issues fishing permits with a catch and possession limit of one Dolly Varden per day. Recreational fishing is closed in areas used for spawning and overwintering in the upper reaches of Joe Creek and the Firth River (Parks Canada, 2018b).

Babbage River Population

Results from monitoring the harvest and assessing the status of this population suggest that Babbage River Dolly Varden are harvested sustainably at several locations along the Yukon North Slope coast and the population is stable (DFO (Department of Fisheries and Oceans Canada) et al., 2019; DFO, 2017a). The highest proportions of Babbage River stock in harvests is at King/Sabine and Shingle points; few are caught at Herschel Island (DFO, 2017a).

Recreational fishing is closed over the range of the isolated Dolly Varden population above the falls on the Babbage River (Parks Canada, 2018b).

Big Fish River Population

Stock assessments and Inuvialuit knowledge show a decline in Big Fish Dolly Varden abundance since the 1970s and 1980s (Stephenson, 2003). Inuvialuit also observe a decline in Arctic grayling in this river system.

The most recent formal assessment of Big Fish river Dolly Varden (DFO, 2013a) concluded that there are no immediate concerns for this population at the current harvest rate. Big Fish Dolly Varden are caught at Fish Hole and at the mouth of the river, although there have been harvest closures on the Big Fish River since 1987. Harvest at safe levels has been permitted under variation orders and Aboriginal Communal Fishing Licences since 2012 (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Western scientific and traditional knowledge was used by the West Side Working Group to establish a safe harvest level and design a monitoring program at the mouth of the Big Fish River, beginning in 2012 (Lea, Gruben, Gallagher & Costa, 2020).

Decline of Big Fish Dolly Varden

Aklavik harvesters observed that the numbers and size of the fish at Fish Hole declined from the 1970s to 1980s and agreed to a fishing closure for 5 years in 1987. Limited re-openings of the Big Fish for Dolly Varden in the 1990s showed that the population was still at a low level. Earthquake activity near Fish Hole in the 1970s may have changed groundwater flows and led to habitat loss. Combined harvest in the river, at the river mouth, and in the coastal fishery may have been too high to maintain the previous population abundance.

(Stephenson, 2003)

This commitment to the sustainable management and monitoring of Dolly Varden by the Aklavik Hunters and Trappers Committee and the community has led a community harvest at the fish holes each fall since 2014, and provided the opportunity for harvesters to fish and report back on their total catch (Lea, Gruben, Gallagher & Costa, 2020).

> As Inuvialuit, we're taught not to over-harvest. I think that's why Akłarvik HTC kept pushing to get it open at the Big Fish River fish hole. And today, I'm proud to say that our community members could look forward to fishing there on their own — Michelle Gruben (Lea, Gruben, Gallagher & Costa, 2020)

Genetic studies indicate that Big Fish Dolly Varden are also caught in the coastal fishery at Shingle and King points (C. P. Gallagher et al., 2013).

Rat River Population

Although all but the highest reaches of headwater streams of the Rat River are outside of the Yukon North Slope, the population is of interest to Inuvialuit fishers because char originating in this river are caught in the Yukon coastal fishery and in the Mackenzie Delta. Several sources of information indicate that this population is stable (DFO, 2017b).

Rat River fishing was reopened in 2009 when the voluntary closure ended. A safe fishing level was established and it is reviewed annually through the Rat River Working Group (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Transboundary Considerations

The northern form of Dolly Varden spawn in rivers in Alaska, Yukon, and NWT. In Canada, the range includes the western part of the ISR and the GSA.

There is no management plan or formal arrangement that encompasses the full range of the northern form of Dolly Varden. Dolly Varden from Alaskan and Canadian rivers migrate both east and west along the coast during their summer feeding period. A 1999 study found that Firth and Babbage Dolly Varden made up as much as 25% of harvest at some locations in Alaska and that 65% of the catch in at Phillips Bay was from Alaskan populations (reported in C. P. Gallagher, Roux, Howland, & Tallman, 2012). A study that attached radio tags to Dolly Varden in the Canning River (Alaska) located a small number of these tagged fish overwintering in the Firth River (Brown, Courtney, & Seitz, 2018).

The Integrated Fisheries Management Plan (DFO (Department of Fisheries and Oceans Canada) et al., 2019; DFO, 2010b, 2010a) brings together jurisdictions and interests within Canada, including Inuvialuit and Gwich'in, Yukon and Northwest Territories, and Parks. The plan is for the ISR and GSA. It does not cover Dolly Varden ranges that are in the Sahtu Settlement Area and the Yukon south of the Yukon North Slope (DFO (Department of Fisheries and Oceans Canada) et al., 2019). The plan, however, includes a strategy to promote cooperation with the Sahtu, Yukon, and Alaska.

Observations, Concerns, and Threats

Overview of Identified Threats

Main threats to Dolly Varden identified in the Integrated Fisheries Management Plan and the COSEWIC species assessment (COSEWIC, 2010; DFO (Department of Fisheries and Oceans Canada) et al., 2019; DFO, 2010a) fall into three categories:

- Threats from climate change (high concern);
- Threat of stock depletion from over-fishing at fish holes (high concern) and in the coastal fishery (medium concern);
- Threats from human activities related to resource extraction (mainly rated as medium concern and not currently an issue in streams in the ISR and GSA; threat of impacts from possible hydrocarbon exploration and development is rated as a high concern for coastal locations).

Levels of concern in the above list are from the Integrated Fisheries Management Plan (DFO (Department of Fisheries and Oceans Canada) et al., 2019, Table 3). In the IFMP, natural habitat change is also identified as a threat of high concern. Habitat changes listed are slumping and erosion, water flow and groundwater level changes, and changes in river salinity. The major area of concern for groundwater and salinity changes is the Big Fish River. These natural changes may increase in rate and/or magnitude with climate change.

Contaminants and Dolly Varden

Research on contaminants in Dolly Varden has been mainly on mercury levels because mercury has been found at high levels in some Arctic char populations in the Eastern Arctic. Studies on Rat, Vittrekwa, and Babbage river Dolly Varden indicate that mercury levels are low in Dolly Varden (Evans, Muir, Keating, & Wang, 2015; Tran, Reist, & Power, 2016). However, mercury uptake by fish is influenced by water temperatures and other factors affected by climate change, such as the fish's position in the food web. In addition, warming temperatures may increase the amount of mercury in marine feeding areas. A study comparing mercury in Rat River and Firth River Dolly Varden collected in the 1980s with char collected in the 2010s from the same rivers concluded that mercury levels have increased slightly in Rat River char, but not in Firth River char (Tran, Reist, Gallagher, & Power, 2019). The study also concluded that there are local variations in how mercury is accumulated by char and that it is important to continue to monitor mercury levels and to gain a better understanding of mercury uptake.

Impacts of Climate Change

Aklavik Inuvialuit land users identified climate change impacts on habitat as a threat to Dolly Varden through the study documenting traditional knowledge about Yukon North Slope wildlife and habitat (WMAC (NS) & Aklavik HTC, 2018a). Participants described climate-change related impacts that they had observed:

- Erosion along riverbanks and coastlines, which was observed to deposit sediment in rivers, making them shallower and less clear;
- Change in the timing of migration, largely referring to Dolly Varden moving through summer fishing locations earlier in the year;
- Observations of salmon moving into the region, attributed to warmer temperatures;
- Decrease in summer sea ice, impacting marine habitat; and
- Less snowpack, leading to lower water levels in spawning areas.

Observations from people interviewed:

> …you know, we've never had salmon in the area before, and now they're starting to… pop up in places where we're getting the Arctic char.
>
> …the erosion on the hills…make the creek shallow… Probably harder [for Dolly Varden char] to get up to where they're supposed to spawn.
>
> Probably about ten years [ago] was a really thick ice… And it was really good fishing… you could see the char coming, you could see their little ripples… along the edge of the water… That's what the normal used to be back then. (WMAC (NS) & Aklavik HTC, 2018a, p. 42)

Participants in a traditional knowledge study conducted on the Yukon North Slope reported a change in the timing of arrival of Dolly Varden to the Shingle Point area (Brewster, Neumann, et al., 2016). Most people observed an earlier arrival. People interviewed attributed the change to increased sea water temperatures, commenting that Dolly Varden prefer cool water.

Main threats to Dolly Varden from climate change were identified in the COSEWIC assessment (COSEWIC, 2010) and the IFMP (DFO (Department of Fisheries and Oceans Canada) et al., 2019):

1. Less groundwater and surface water in the fish holes and small headwater reaches that are crucial habitat for Dolly Varden, due to hotter summers and less rain (as is currently occurring);
2. Damage to habitat in fish holes from permafrost thawing and slumping;
3. Competition from Pacific salmon if they become more common and widespread;
4. Change to coastal habitat, including decreased salinity and shoreline erosion;
5. Changes in virus or parasites related to changes in habitat. Salmon could also introduce new parasites or diseases.

A multi-party ArcticNet integrated regional impact study (IRIS) of the Canadian Western and Central Arctic (Stern & Gaden, 2015) noted the following key finding about impacts of climate change:

> Permafrost thaw and lake expansion are expected to continue as temperatures in the Arctic increase. Lake growth has the potential to transport large sediment loads to freshwater and coastal habitats, degrading quality of habitat (e.g. lower oxygen levels in fall and winter resulting from increased organic matter decomposition) which is particularly problematic for Dolly Varden… (Stern & Gaden, 2015, p. 16)

The study highlights Dolly Varden as being particularly vulnerable to climate change because they have a limited distribution, they are dependent on small sections of headwater habitats fed by groundwater, and they grow slowly and mature late. The capacity of Dolly Varden to adapt to a changing environment is an important consideration. Tracking changes in conditions and responses of the fish will aid in setting management priorities (Stern & Gaden, 2015).

There is some evidence that Dolly Varden are responding to changing marine conditions. Dolly Varden captured in Beaufort and Chukchi sea studies in Alaska since 1969 showed an increase in maximum fish length over the 50-year period (Courtney, DeSanto, & Seitz, 2019).

Impacts on Dolly Varden from Human Activities

In Rivers and Streams

Activities such as road building, seismic testing, gravel extraction, water removal, or modifications of river channels can cause damage to key wintering, spawning, and rearing areas for Dolly Varden in streams, or disruption of migratory pathways in rivers (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Human activities in streams beyond the Yukon North Slope (for the Big Fish, Rat, and Vittrekwa rivers) could affect the availability of Dolly Varden to the Inuvialuit coastal fishery. Adults of these char populations spend the summer in Yukon North Slope marine waters.

In the Beaufort Sea

Dolly Varden are considered one of the key species to protect in the event of an oil spill in the Beaufort Sea, because of their importance to the Inuvialuit traditional fishery. The Beaufort Regional Environmental Assessment produced a vulnerability profile for Dolly Varden and other key marine wildlife species (BREA, 2015, 2016). The vulnerability profiles assembled biological data, including seasonal distribution maps to assess vulnerability to potential spills and accidents from marine oil and gas exploration and development. Disruption of Dolly Varden movement and impacts on the quality of marine ecosystems for feeding in the Beaufort Sea could result from offshore infrastructure, reduction in benthic invertebrates from disturbance to the ocean floor, or damage from oil spills.

The IFMP (DFO et al., 2019) also identifies shipping as a potential threat to Dolly Varden in the Beaufort Sea. Shipping activity may interfere with Dolly Varden migration and feeding. Satellite-tagged Dolly Varden have been shown to occupy waters up to 150 kilometres offshore (Gallagher, unpublished data), which increases concern for the impact of marine development on their populations.

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.

Fisheries Management

- Integrated Fisheries Management Plan (DFO (Department of Fisheries and Oceans Canada) et al., 2019)

  Full title: *Integrated Fisheries Management Plan for Dolly Varden* (*Salvelinus malma malma*) *of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope*. *Volume 1: The Plan–2019 Update*.

This plan, an update of the first IFMP for Dolly Varden (DFO, 2010a) provides the species conservation actions required of a SARA species management plan for Dolly Varden within the ISR and the GSA.

> **[The Integrated Fisheries Management Plan]** identifies objectives, strategies and measures for managing the fisheries and fish habitats, and for sustaining and rebuilding Dolly Varden populations. This IFMP will be used by fishers, communities, Gwich'in, Inuvialuit, Government of Canada and other stakeholders in managing day-to-day and longer-term activities, and is intended to achieve the long-term conservation, sustainable use and rebuilding of Dolly Varden populations in the GSA and ISR.
>
> Extract from the plan (DFO (Department of Fisheries and Oceans Canada) et al., 2019, p. 7)

IFMP objectives (DFO (Department of Fisheries and Oceans Canada) et al., 2019, pp. 23-24):

1. To maintain healthy stocks of Dolly Varden throughout the GSA and ISR;
2. To preserve and protect Dolly Varden habitats in all rivers in the GSA and ISR and along the Beaufort Sea coast to ensure that Dolly Varden stocks continue to thrive;
3. To manage the Dolly Varden fisheries using adaptive management processes with full community participation;
4. To ensure the maintenance of Dolly Varden in the GSA and ISR to provide subsistence food and to support traditional Gwich'in and Inuvialuit culture;
5. To manage, to the extent possible, the Dolly Varden fisheries in a manner consistent with Gwich'in and Inuvialuit cultural practices.

- West Side Working Group

  Established in 2001 to advise on Dolly Varden fisheries management west of the Mackenzie River to the Alaskan border. Membership: Aklavik HTC, FJMC, DFO, Aklavik Elders, Parks Canada, and Herschel Island–Qikiqtaruk Territorial Park. The West Side Working Group was instrumental in development of the IFMP and will continue to advise on its implementation (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

Habitat Conservation

- Aklavik Inuvialuit Community Conservation Plan (Aklavik HTC et al., 2016)

The Aklavik conservation plan's sections on Dolly Varden are mainly concerned with the Big Fish population. The plan notes that when the coastal fishery for Dolly Varden is unsuccessful, the mouth of the Big Fish River and the Fish Hole are alternative locations for Aklavik to harvest this important food.

Special Designated Lands include:

- Fish Hole and Big Fish River. Importance to Aklavik: historically important for harvesting Dolly Varden; overwintering and spawning habitat on Cache Creek (also known as Little Fish River).
- Firth and Babbage River watersheds. Importance to Aklavik: both rivers support stocks of Dolly Varden; overwintering and spawning for the Babbage watershed is in Fish Hole Creek (eastern tributary of the Babbage, also known as Canoe River); fish hole at the top of the Babbage River (inside Ivvavik National Park) is a traditional fishing area.

Plan priorities include:

- Responding to the community's great concern over change in char abundance and water quality at Fish Hole (Big Fish River), and the strong interest in winter habitat research
- Improving knowledge about biology and movement of Dolly Varden (a high research priority)

Conservation measures for Dolly Varden include:

- Identify and protect important habitats from disruptive land uses.
- "Ensure harvest is sustainable" and "Do not take more than needed"

- Ivvavik National Park of Canada Management Plan (Parks Canada, 2018a)

Zone 1 Special Preservation areas designated in the park include the Firth River fish holes and Joe Creek fish holes.

- Beaufort Sea Conservation and Management

Beaufort Sea ecosystems are the main foraging areas for searun Dolly Varden. Plans and programs for integrated management of Beaufort Sea ecosystems include:

Beaufort Sea Partnership (BSP, 2020)

This partnership provides a forum for information sharing and discussion of mutual interests and responsibilities for Beaufort Sea conservation and management, guided by an integrated ocean management plan (BSP, 2009).

Tarium Niryutait Marine Protected Areas Management Plan (DFO, 2013b) and *Monitoring Plan* (DFO & FJMC, 2013)

The management plan recognizes the importance of these protected areas for fish, including Dolly Varden. The monitoring plan includes fish surveys and fish sampling to assess status and trends of fish populations, fish health, and marine food webs.

Research and Monitoring Programs

Dolly Varden populations in the Big Fish and Rat rivers have been monitored and assessed since declines were observed in the 1970s. Inuvialuit and Gwich'in traditional knowledge has informed estimates of trends and understanding of habitat needs and changes. Population assessments on the major searun populations, traditional knowledge documentation, harvest monitoring, and research on Dolly Varden genetics and ecology have taken place in response to the assessment of Dolly Varden as Special Concern in 2010 by the Committee on the Status of Endangered Wildlife in Canada, and through the development and implementation of the 2010 Integrated Fisheries Management Plan. Due to community concerns about declines in some Dolly Varden populations, working groups were established to support local decision-making through an adaptive co-management approach. Fishing plans were created to reflect community priorities and knowledge. Representation from harvesters, co-management organizations, and territorial and federal governments on working groups led to the co-development of the comprehensive management plan. This work is ongoing, guided by the recently updated management plan (Lea, Gruben, Gallagher & Costa, 2020).

Inuvialuit have also worked closely with Gwich'in leadership on Dolly Varden populations originating in the Gwich'in Settlement Area, as part of the Rat River Working Group. Since 2009, Akłarvingmiut and biologists have conducted annual tagging (mark-recapture study) at the 'fish hole' in the Big Fish and Babbage Rivers (Lea, Gruben, Gallagher & Costa, 2020).

As part of the implementation of the IFMP, Yukon North Slope Dolly Varden research and monitoring has been expanded to provide updated information on all Yukon North Slope searun populations. Currently, data are collected annually on the Firth River, Joe Creek, Fish Creek (Komakuk Beach), Babbage River, and Big Fish River (Map 9- 3). Inuvialuit Park Rangers at Qikiqtaruk (Herschel Island) Territorial Park have also been working with DFO since 2011 to collect biological samples and catch information from Dolly Varden harvests (Gallagher et al., 2013).

Map 9- 3. Yukon North Slope 2018 harvest monitoring and fish tagging locations for Dolly Varden

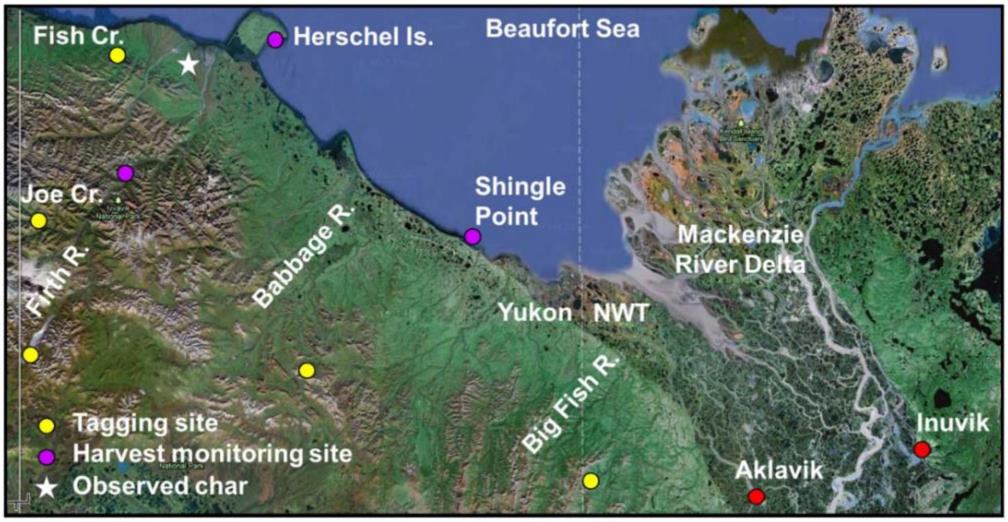


Figure provided by C. Gallagher

Annual harvest monitoring in the ISR from 2016-2019 was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included Dolly Varden harvest monitoring (Inuvialuit Harvest Study, 2003). Inuvialuit harvest study annual monitoring is part of a larger, comprehensive, co-management monitoring program for Dolly Varden. This program is managed adaptively to help community harvesters and co-managers make informed decisions (Lea, Gallagher, Maier, & Ayles, 2021).

Selected Studies and Research Relevant to the Yukon North Slope

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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.

- *Compilation and Synopsis of Literature on the Traditional Knowledge of Aboriginal Peoples in the NWT Concerning Dolly Varden* (Byers et al., 2019)
  This report synthesizes documented Inuvialuit and Gwich'in traditional knowledge about Dolly Varden in the NWT and Yukon North Slope. The purpose is to prepare for further COSEWIC assessments of this species. In addition to information on Dolly Varden, the report summarizes traditional knowledge on changes to coastal landscapes and weather that may be affecting Dolly Varden migration and feeding.

- *Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on changes in the environment and fish populations* (Brewster, Neumann, et al., 2016)
  In 2015 a traditional ecological knowledge survey was conducted at Shingle Point at the request of the FJMC and Aklavik HTC. This study complemented the fish and marine monitoring program in place since 2010. The 15 participants included elders and younger participants.

Assessments and Syntheses of Survey Results

- Volume 2 (Appendices) to the 2010 Dolly Varden Integrated Fisheries Management Plan (DFO, 2010b)
  Reviews of research, stock assessments, habitat mapping, and monitoring are in Volume 2 of the 2010 plan. The 2019 plan notes that several sections of this supplementary volume will be updated (DFO (Department of Fisheries and Oceans Canada) et al., 2019).

- *COSEWIC Assessment and Status Report on the Dolly Varden Salvelinus malma malma Western Arctic Populations in Canada* (COSEWIC, 2010)
  The COSEWIC report summarizes available information on population status and trends and on threats to Dolly Varden. The report presents the rationale for the designation of Dolly Varden as a species of Special Concern.

- *Assessment of Northern Dolly Varden Habitat in Canada* (Mochnacz et al., 2010)
  Habitat is described for known populations. This DFO report is based on literature review and field surveys from 2008 and 2009.

- Synthesis of biological and harvest information (C. P. Gallagher et al., 2012)
  This DFO report presents summaries of available information for each Dolly Varden population, pointing out gaps in knowledge. It includes harvest data for river and coastal fisheries.

- *Beaufort Regional Environmental Assessment* (BREA, 2016)
  BREA was a four-year research program (2012-2015) focused on research to inform decision-makers on offshore oil and gas development in the Beaufort Sea. The assessment included a project to develop vulnerability profiles for key marine species, including Dolly Varden.

- Population (stock) assessments
  - Big Fish River population assessment, 2009 to 2011 (DFO, 2013a), supported by a DFO research document (C. P. Gallagher et al., 2013). Abundance estimates are based on mark and recapture studies at the Little Fish River fish hole. The reports also cover biological characteristics, harvest reporting and management (including studies to identify Big Fish Dolly Varden in the coastal fishery), and population trends.
  - Babbage River population assessment, 2010-2014 (DFO, 2017a). This assessment reviews studies undertaken to implement the 2010 Integrated Fisheries Management Plan, including monitoring at Shingle Point and Herschel Island, and provides updated estimates of Babbage River char population size and characteristics. It is supported by a DFO research document (C. P. Gallagher et al., 2018).
  - Rat River population assessment, 2009-2014 (DFO, 2017b; Colin P Gallagher, Bajno, Reist, & Howland, 2020). Although this river is mainly outside of the Yukon North Slope, Rat River Dolly Varden are caught in the coastal fishery, mainly at Shingle Point.

Research

- *New insights into the biology of anadromous Dolly Varden, Canning River, Arctic National Wildlife Refuge, Alaska* (Brown et al., 2018)
  This 2-year study used radio tags to study movements of Dolly Varden in the Canning River, Alaska, and nearby rivers. The Firth River, including Joe Creek, was included in the surveys. Some findings:
  - Almost 40% of the fish that had been tagged in the Canning River migrated to other rivers for overwintering– but not for spawning. Dolly Varden rarely return to a different drainage for spawning. Some fish tagged in the Canning River were recorded during winter in the Firth River and Joe Creek.
  - Migration to sea was over a brief period in the first half of June, but fish returned to rivers over an extended period of about 3 months.
  - Spawning fish migrated to spring-fed upstream reaches and remained there in the winter, while non-spawners overwintered in spring-fed reaches of the river mainstem.

- *Life-history characteristics and landscape attributes as drivers of genetic variation, gene flow, and fine-scale population structure in northern Dolly Varden in Canada* (Harris et al., 2015)
  This study investigated landscape and life-history variables driving variation in genetic diversity and population structure. The study concluded that searun and isolated

populations are genetically distinct, but resident forms of Dolly Varden (the fish that remain in rivers their entire lives) are genetically the same as searun populations in the same rivers.

- *Assessing conservation risks to Dolly Varden populations* (Harris et al., 2017)
  This study looked at genetic make-up and abundance of populations of Western Arctic Dolly Varden. The authors concluded that the various populations of Dolly Varden likely have a common origin and diverged in the past, and there is limited gene flow at present (meaning that they remain true to their spawning areas). The management implication is that it is most effective to manage fisheries on a river-by-river basis.

- *Characterizing the diet and habitat niches of coastal fish populations in the Beaufort Sea Tarium Niryutait Marine Protected Area* (Brewster, Giraldo, et al., 2016)
  This study is based on analyses of carbon isotopes (different forms of carbon that can be related to the sources of food) in fish caught at Shingle Point from 2011 to 2013. The study concluded that, although searun char spend their early years and their winters as adults in rivers, the majority of the food eaten over their lifetimes is from the sea.

References

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

BREA. (2015). *Species Oil Spill Vulnerability Profiles (VPs) For Net Environmental Benefit Analysis (NEBA) In the Beaufort Sea (workshop presentation)*. Beaufort Regional Environmental Assessment 2015 Research Results Forum, Inuvik NWT, February 24-28 2015.

BREA. (2016). *Beaufort Regional Environmental Assessment Key Findings: Research and Working Group Results. March 2016*. Canada.

Brewster, J. D., Giraldo, C., Swanson, H., Walkusz, W., Loewen, T. N., Reist, J. D., … Loseto, L. L. (2016). Ecological niche of coastal Beaufort Sea fishes defined by stable isotopes and fatty acids. *Marine Ecology Progress Series*, *559*, 159–173. https://doi.org/10.3354/meps11887

Brewster, J. D., Neumann, D., Ostertag, S. K., & Loseto, L. L. (2016). *Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on changes in the environment and fish populations*. Fisheries and Oceans Canada.

Brown, R. J., Courtney, M. B., & Seitz, A. C. (2018). *New Insights into the Biology of Anadromous Dolly Varden in the Canning River, Arctic National Wildlife Refuge, Alaska*. https://doi.org/10.1002/tafs.10122

BSP. (2009). *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond*. Beaufort Sea Partnership.

BSP. (2020). Beaufort Sea Partnership. Retrieved January 10, 2020, from http://www.beaufortseapartnership.ca/

Byers, T., Reist, J. D., & Sawatzky, C. D. (2019). *Compilation and Synopsis of Literature on the Traditional Knowledge of Aboriginal Peoples in the NWT Concerning Dolly Varden Char*. Fisheries and Oceans Canada.

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

COSEWIC. (2010). *COSEWIC Assessment and Status Report on the Dolly Varden Salvelinus malma malma Western Arctic Populations in Canada*.

Courtney, M. B., DeSanto, H., & Seitz, A. C. (2019). Is Dolly Varden in Arctic Alaska Increasing in Length in a Warming Climate? *Journal of Fish and Wildlife Management In-Press*.

Courtney, M. B., Scanlon, B., Brown, R. J., Rikardsen, A. H., Gallagher, C. P., & Seitz, A. C. (2018). Offshore ocean dispersal of adult Dolly Varden Salvelinus malma in the Beaufort Sea. *Polar Biology*, *41*(4), 817–825. https://doi.org/10.1007/s00300-017-2246-5

DFO. (2010a). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope, 2011-2015. Volume 1: The Plan*. Fisheries and Oceans Canada.

DFO. (2010b). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope, 2011-2015. Volume 2: Appendices*. Fisheries and Oceans Canada.

DFO. (2013a). *Assessment of Dolly Varden From the Big Fish River, NT 2009-2011*.

DFO. (2013b). *Tarium Niryutait Marine Protected Areas Management Plan*. Fisheries and Oceans Canada.

DFO. (2017a). *Assessment of Dolly Varden from the Babbage River, Yukon Territory 2010–2014*. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/055.

DFO. (2017b). *Assessment of Dolly Varden from the Rat River, Northwest Territories 2009–2014*. Department of Fisheries and Oceans Canada.

DFO (Department of Fisheries and Oceans Canada), Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, & Parks Canada. (2019). *Integrated Fisheries Management Plan for Dolly Varden (Salvelinus malma malma) of the Gwich'in Settlement Area and Inuvialuit Settlement Region, Northwest Territories and Yukon North Slope. Volume 1: The Plan–2019 Update*. Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee, Gwich'in Renewable Resources Board, and Parks Canada Agency.

DFO, & FJMC. (2013). *Tarium Niryutait Marine Protected Areas Monitoring Plan*. Fisheries and Oceans Canada and Fisheries Joint Management Committee.

Evans, M. S., Muir, D. C. G., Keating, J., & Wang, X. (2015). Anadromous char as an alternate food choice to marine animals: A synthesis of Hg concentrations, population features and other influencing factors. *Science of the Total Environment*, *509–510*, 175–194. https://doi.org/10.1016/j.scitotenv.2014.10.074

Gallagher, C. P., Howland, K. L., Bajno, R., Sandstrom, S. J., & Reist, J. D. (2018). *Population abundance , biological characteristics , and contribution to coastal mixed-stock fisheries of Dolly Varden (Salvelinus malma malma) from the Babbage River: 2010-2014*. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/029.

Gallagher, C. P., Howland, K. L., Harris, L. N., Bajno, R., Sandstrom, S. J., Loewen, T. N., & Reist, J. D. (2013). *Dolly Varden (Salvelinus malma malma) from the Big Fish River: abundance estimates , effective population size , biological characteristics , and contribution to the coastal mixed-stock fishery*. Fisheries and Oceans Canada Canadian Science Advisory Secretariat (CSAS) Central and Arctic Region.

Gallagher, C. P., Roux, M.-J., Howland, K. L., & Tallman, R. F. (2012). *Synthesis of biological and harvest information used to assess populations of northern form Dolly Varden (Salvelinus malma malma) in Canada. Part III: Comparison among populations*. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/128.

Gallagher, Colin P, Bajno, R., Reist, J. D., & Howland, K. L. (2020). *Genetic mixed-stock analyses , catch-effort , and biological characteristics of Dolly Varden (Salvelinus malma malma) from the Rat River collected from subsistence harvest monitoring programs : 2009-2014*. (November), 2009–2014.

Harris, L. N., Bajno, R., Gallagher, C. P., Koizumi, I., Johnson, L. K., Howland, K. L., … Reist, J. D. (2015). Life-history characteristics and landscape attributes as drivers of genetic variation, gene flow, and fine-scale population structure in northern Dolly Varden (Salvelinus malma malma) in Canada. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(10), 1477–1493. https://doi.org/10.1139/cjfas-2015-0016

Harris, L. N., Palstra, F. P., Bajno, R., Gallagher, C. P., Howland, K. L., Taylor, E. B., & Reist, J. D. (2017). Assessing conservation risks to populations of an anadromous Arctic salmonid, the northern Dolly Varden (Salvelinus malma malma), via estimates of effective and census population sizes and approximate Bayesian computation. *Conservation Genetics*, *18*(2), 393–410. https://doi.org/10.1007/s10592-016-0915-5

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

Lea, E. V, Gallagher, C. P., Maier, K., & Ayles, B. (2021). *Dolly Varden (Salvelinus malma malma) fisheries in* *the Inuvialuit Settlement Region and the Gwich ' in Settlement Area 2009 – 2014: harvest , monitoring and communications in an adaptive co-management setting*. Retrieved from https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2021/2021_041-eng.pdf

Loewen, T. N., Reist, J. D., Yang, P., Koleszar, A., Babaluk, J. A., Mochnacz, N. J., & Halden, N. M. (2015). Discrimination of northern form Dolly Varden Char (Salvelinus malma malma) stocks of the North Slope, Yukon and Northwest Territories, Canada via otolith trace elements and $^{87}Sr/^{86}Sr$ isotopes. *Fisheries Research*, *170*, 116–124. https://doi.org/10.1016/j.fishres.2015.05.025

Mochnacz, N. J., Schroeder, B. S., Sawatzky, C. D., & Reist, J. D. (2010). *Assessment of Northern Dolly Varden, Salvelinus malma malma (Walbaum, 1792), Habitat in Canada*. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2926.

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

Papik, R., Marschke, M., & Ayles, B. (2003). *Inuvialuit Traditional Ecological Knowledge of Fisheries in Rivers West of the Mackenzie River in the Canadian Arctic*. Canada/Inuvialuit Fisheries Joint Management Committee Report 2003-4.

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

Parks Canada. (2018b). Special Fishing Restrictions - Ivvavik National Park. Retrieved January 3, 2019, from https://www.pc.gc.ca/en/pn-np/yt/ivvavik/visit/visit6/peche_fish

Sawatzky, C. D., & Reist, J. D. (2014). *Life History Types and Stages of Northern Form Dolly Varden , Salvelinus malma malma (Walbaum, 1792)*. Canadian Manuscript Report of Fisheries and Aquatic Sciences 3029.

Steigenberger, L. W., Elson, M. S., Bruce, P. G., & Yole, Y. E. (Eds.). (1975). *Northern Yukon Fisheries Studies, 1971-1974, Volume 2*. Environment Canada Fisheries and Marine Service.

Stephenson, S. A. (2003). *Local and Scientific Observations of Dolly Varden (Salvelinus malma) (W.) in the Big Fish River, Northwest Territories, Canada: 1995-2002*. Canadian Manuscript Report of Fishieries and Aquatic Sciences 2644.

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.

Tran, L., Reist, J. D., Gallagher, C. P., & Power, M. (2019). Comparing total mercury concentrations of northern Dolly Varden, Salvelinus malma malma, in two Canadian Arctic rivers 1986–1988 and 2011–2013. *Polar Biology*, (0123456789). https://doi.org/10.1007/s00300-019-02476-6

Tran, L., Reist, J. D., & Power, M. (2016). Northern Dolly Varden charr total mercury concentrations: variation by life-history type. *Hydrobiologia*, *783*(1), 159–175. https://doi.org/10.1007/s10750-016-2666-1

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

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: Dolly Varden. Retrieved March 9, 2020, from https://yukon.ca/en/dolly-varden

Yukon CDC. (2019). Yukon Conservation Data Centre Animal track list. Retrieved from https://yukon.ca/en/animal-track-list

Wildlife Management Advisory Council
North Slope

Wildlife Conservation and Management Plan
2021

Companion Report 10: Broad Whitefish / Aanaarlirq

Publication Information

Cover photo: Broad Whitefish, Phillips Bay, © Colin Gallagher

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 10: Broad Whitefish / Aanaarlirq

Table of Contents

Maps

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 four 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: Broad Whitefish / Aanaarlirq

This companion report provides information on the conservation requirements for broad whitefish 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 broad whitefish, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for broad whitefish on the Yukon North Slope

1. Conservation of the nearshore band of brackish water along the Yukon North Slope coastline and in bays with a freshwater surface layer.
2. Conservation of lakes and creeks along the coastal plain.

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

Broad Whitefish on the Yukon North Slope

The common English name for broad whitefish for Inuvialuit on the Yukon North Slope is whitefish. Lake whitefish (*Coregonus clupeaformis*) are called crooked backs, and round whitefish (*Prosopium cylindraceum*) are called lake fish (Brewster, Neumann, Ostertag, & Loseto, 2016).

Broad whitefish (*Coregonus nasus,* Aanaarlirq) are widely distributed in the Arctic, from Nunavut through to the Bering Sea. There are three lifeforms: lake-dwelling, river-dwelling, and searun (anadromous). Searun broad whitefish are the most common. Broad whitefish are abundant in the Mackenzie Delta area, where they overwinter in tributaries and side channels. They are present in relatively small numbers along the Yukon North Slope coast.

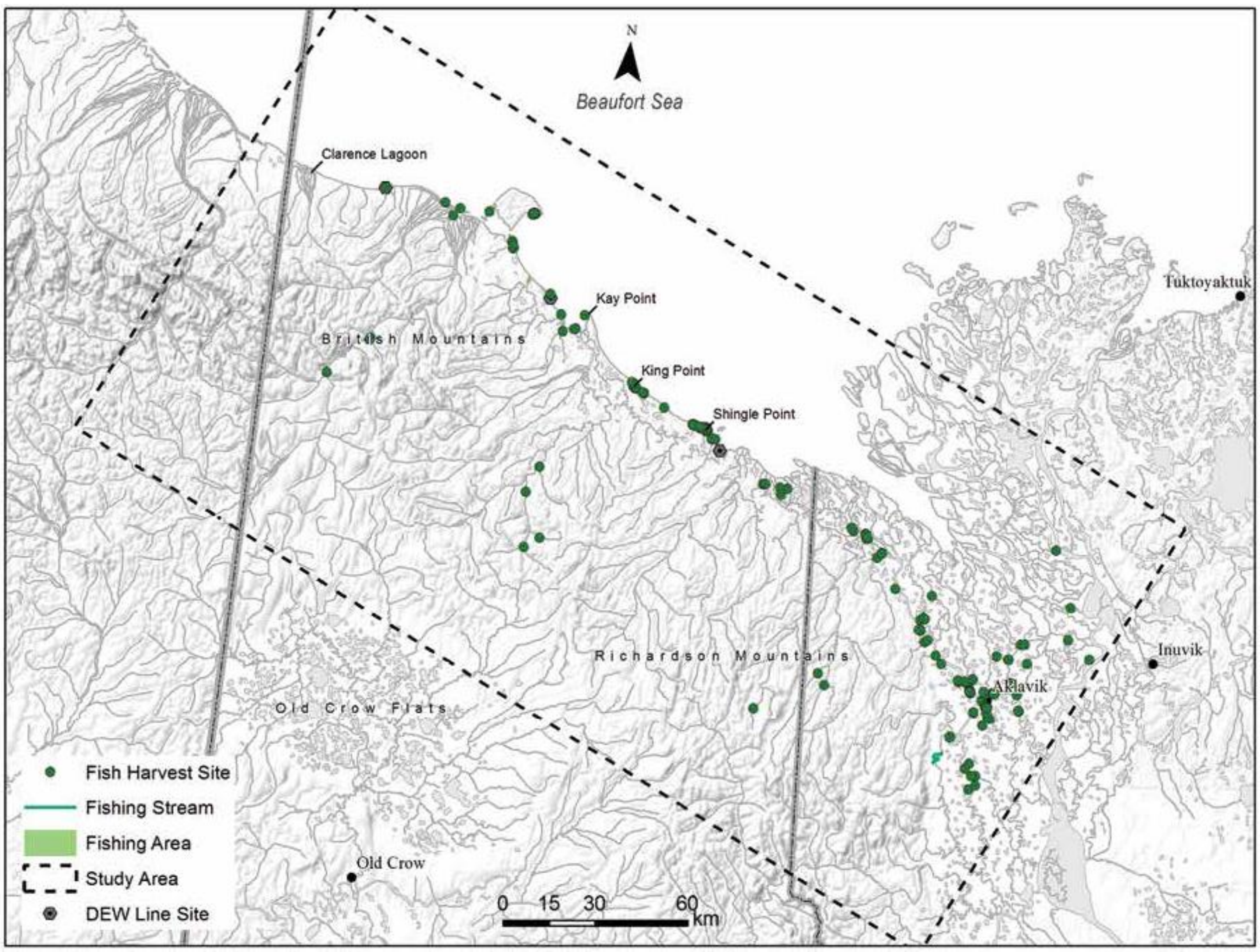
Broad whitefish of the lower Mackenzie River system are semi-anadromous, as their time in the ocean is spent only in the brackish waters of the Delta and nearshore Beaufort Sea. They avoid marine waters with high salinity. While in their nearshore coastal habitat, young broad whitefish feed on zooplankton in the open water, while adults feed on shellfish on the ocean floor. Broad whitefish are a food source for beluga and seals (DFO, 2000; USGS, 2016). Grizzly bears also feed on broad whitefish in the Mackenzie Delta (Barker & Derocher, 2009).

Broad whitefish do not spawn until they are about seven to nine years old (Eddy, 2001; Martin, 2010). Mature adults return to rivers to spawn every two or more years. Spawning adults aggregate in the Delta in mid-summer and migrate upstream from October to November, when the rivers are slow flowing. Spawning takes place upstream of the ISR in the Mackenzie River mainstem and tributaries, especially in the Peel River. Broad whitefish spawn in late fall, returning to nearshore coastal habitat gradually in small groups over the winter. Juveniles are distributed throughout the Mackenzie River and Delta and in the lakes of the Tuktoyaktuk Peninsula.

Traditional Use

Broad whitefish are harvested by net on the Yukon North Slope Coast and in the Mackenzie Delta (Map 10- 1).

Map 10- 1. Fish harvest locations identified in Inuvialuit traditional use interviews



The fishing locations are for all species of fish. The interviewers asked Inuvialuit land users to identify fishing areas and harvest sites 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 11.

On average, about 6000 broad whitefish were harvested annually by Aklavik Inuvialuit over the ten-year period from 1988 to 1997, as reported through the Inuvialuit Harvest Study (Inuvialuit

Harvest Study, 2003, Table 21). Broad whitefish was harvested in larger numbers than any other fish species over the 10-year period.

A 1991 dietary survey showed the importance of whitefish in the diet of Aklavik Inuvialuit (Wein & Freeman, 1992). Of the 36 households surveyed, 28 reported eating whitefish at least once over the previous year. The survey did not distinguish among whitefish species. This was a similar level of use as for the other main fish species: Dolly Varden char, herring (cisco), loche (burbot), and coney (inconnu). Whitefish was eaten on average 31 times over the year in the households surveyed.

Fish harvest was documented through the Inuvialuit Harvest Study's (2016-2019) monthly interviews with active harvesters. Aklavik Inuvialuit participants reported an average annual harvest of 465 broad whitefish over the three-year period from 2016 to 2018 (IRC, 2019), a steep decline from the harvests of the 1980s and 1990s.

Broad whitefish traditional uses

> "The broad whitefish is used all year round as a basic food, not like any other fish. Loche is mostly taken in the fall time, same with coney. You use it [broad whitefish] all through the early spring and summer. Whitefish is used all the time."

However, despite its importance as food, its total importance in the domestic economy has declined now that fewer people maintain dog teams and less trapping is carried out. Also, at the present time some earlier uses no longer occur. Among the earlier practices mentioned were the use of fish oil and fish liver oil as medicine, and fish broth used to treat colds and diarrhea. The oil was formerly used as a condiment (for dipping) or for greasing bread pans, and to waterproof or preserve wood. Many people remember these uses from their childhood.

The above excerpts are from a broad whitefish Inuvialuit traditional knowledge study based on interviews in Inuvik and Aklavik (Freeman, 1997, p. 32).

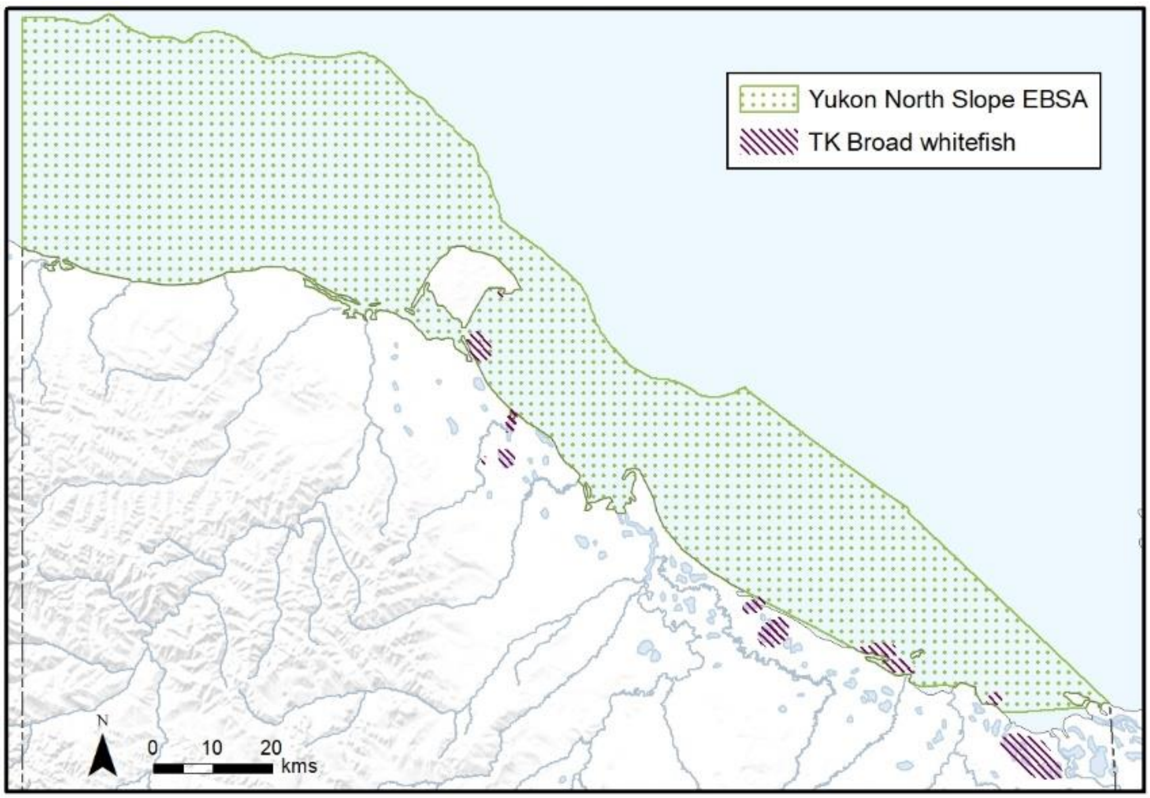
Habitat for Broad Whitefish

Overview of Habitat

Yukon North Slope broad whitefish habitat is in the nearshore coastal zone and lakes close to the seashore (Map 10- 2). Broad whitefish feed in coastal areas with a strong Mackenzie River influence. They feed on small crustaceans and shellfish on the ocean bottom, so they are exposed to coastal sediments (Brewster, Giraldo, et al., 2016). Broad whitefish habitat extends to estuaries and lower reaches of rivers along the coast (Steigenberger, Robertson, Johansen, & Elson, 1975). The fast-flowing rivers upstream of the coastal plain are generally not suitable habitat for whitefish (Reist & Chang-Kue, 1997). Inuvialuit have observed changes in broad whitefish habitat use in recent years – see *Observations, Concerns, and Threats*.

The broad whitefish conservation requirements in the *Wildlife Conservation and Management Plan for the Yukon North Slope (WMAC NS, 2021)* relate to habitat protection, including the nearshore band of brackish water along the coastline, bays with a freshwater surface layer, and lakes along the coastal plain. Streams and other waterways that connect these lakes with the Mackenzie Delta and the Yukon coast are also important habitat for conservation of broad whitefish.

Map 10- 2. Marine and coastal lake habitats of broad whitefish, based on surveys in marine waters and Inuvialuit traditional knowledge of whitefish locations



This map is from the Plan (WMAC (NS), 2022, Appendix 1). The Yukon North Slope EBSA (Ecologically and Biologically Significant Area) is shown to represent coastal habitat. Data sources: (WMAC NS and Aklavik HTC, 2018a); (DFO, 2014)

Inuvialuit participants in the *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018a) shared observations on broad whitefish habitat. Broad whitefish is considered to be primarily a delta and freshwater fish. It is not traditionally considered an ocean species. Broad whitefish habitat types identified on the Yukon North Slope were lakes and nearshore coastal waters, including:

- Lakes close to shore;
- Roland Bay;

- Nearshore coastal waters near Shingle Point, where broad whitefish are caught with Dolly Varden in the summer months.

Nearshore Coastal Waters

Broad whitefish are associated with estuaries, lagoons, and the narrow strip of brackish water along the Yukon North Slope coast (WMAC (NS), 2012). This corridor of fresh to brackish water extends from the shore to water depths of about 10 metres and runs from the Mackenzie Delta to Alaska. Further offshore, the ocean bottom drops off quite steeply. This topography, combined with wind events, results in upwelling (movement of deep, cold, nutrient-rich waters to the surface). Upwelling replenishes nutrients and provides a productive nearshore coastal area that is used for feeding and migration by anadromous fishes, including broad whitefish (Cobb, Roy, Link, & Archambault, 2014). The freshwater corridor and upwelling are attributes recognized in the designation of the Yukon North Slope Ecologically and Biologically Significant Area (EBSA) and the Tarium Niryutait Marine Protected Area (MPA).

Broad Whitefish and Tarium Niryutait MPA

Assessment of broad whitefish habitat, including documentation of Inuvialuit traditional knowledge (Freeman, 1997), was undertaken as part of the groundwork for designation of Tarium Niryutait MPA. The three marine areas that became the MPA were all identified as providing feeding and coastal migratory habitat for young-of-the-year and juvenile broad whitefish. Bays with fresh water on top of or instead of salty water provide overwintering habitat. These bays are important for all fishes that do not tolerate high salinities, including broad whitefish and coney.

Source: (BSIMPI, 2003)

The coastal nearshore waters of the Yukon North Slope are not good habitat for young-of-the-year broad whitefish. Fry migrate or are washed downstream in the Mackenzie River in spring floods in May and June (Reist & Chang-Kue, 1997). Although most of the fry are carried eastward from the Delta with prevailing water currents, some are carried westward along the Yukon North Slope at least as far as Phillips Bay (Cobb et al., 2008; Reist & Chang-Kue, 1997). The fate of these fish is uncertain, as this is not favourable habitat for fry because salinity varies (they need brackish water) and the corridor is often disrupted by storms (Reist & Chang-Kue, 1997).

Lakes

Along the western part of the Yukon coastal plain (in Ivvavik National Park), lakes and ponds that are deep enough not to freeze to the bottom may support populations of broad whitefish (Kavik-AXYS Inc., 2002), and there may be seasonal use of other ponds and lakes. Participants in a traditional knowledge study of fish west of the Mackenzie River commented that big whitefish are found in shallow lakes between Kay Point and King Point year-round (Papik, Marschke, & Ayles, 2003). Surveys undertaken in the early 1970s of 11 tundra lakes along the Yukon North Slope showed that 2 of the lakes were habitat for broad whitefish in the summer (Du Bruyn &

McCart, 1974). Broad whitefish were caught in fish surveys of 2 of 4 lakes in 1973 to 1974. In one of these lakes, traditional knowledge and sampling during the winter provided evidence of an overwintering population of broad whitefish (Steigenberger et al., 1975). Proceedings of the 1997 workshop on broad whitefish indicated that it was not known if coastal lakes support isolated lake-dwelling populations or if fry migrating along the coast could enter the lakes (Reist & Chang-Kue, 1997).

Studies indicate that broad whitefish occur in most Alaskan North Slope rivers and estuaries, and that in summer the fish frequent shallow lakes. The fish may overwinter in deeper lakes that have stream connections, or in lakes that are separated from the sea by land that floods occasionally, providing access to marine waters (George, Moulton, & Johnson, 2009).

Broad Whitefish Populations

Species Conservation Status

Table 10– 1. Broad whitefish 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	Not assessed	(Canada, n.d.; COSEWIC, n.d.)
Canadian Endangered Species Conservation Council (General Status of Species in Canada)	Canada	N5: Secure*; 2015 status	(Canadian Endangered Species Conservation Council, 2016)
Yukon	Yukon	S4: Apparently Secure*	(Yukon, 2020)
NatureServe	Global	G4G5: Apparently Secure to Secure*; last reviewed 2016	(NatureServe, n.d.-b)

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

Harvest and Management

Broad whitefish are caught by Inuvialuit fishers along the Yukon North Slope coast in the summer in relatively small numbers. In 2011, broad whitefish made up 6% of fish harvested at Shingle Point (Gallagher & Howland, 2011). They are caught from mid-July to mid-August along with Dolly Varden char (WMAC (NS) & Aklavik HTC, 2018a).

Broad whitefish are also harvested in the Mackenzie Delta, where they are abundant (Martin, 2010). The availability of broad whitefish for harvest in the Delta varies over the year and from year to year, influenced by the timing of spring break-up and the flow characteristics of the river (Reist & Chang-Kue, 1997). There is a small commercial fishery for broad whitefish and other fish species in the Mackenzie Delta (east of the Yukon North Slope); harvested fish are sold locally within the NWT (E. Lea, personal communication, 2020).

Broad whitefish are not a favoured species for sport fishing. There is no fisheries management plan that includes broad whitefish that frequent the Yukon North Slope.

Population Status and Trends

Although previous studies have focused on life history, movement patterns, and habitat-use, there are not enough data available to provide a robust quantitative assessment of population status for broad whitefish.

Genetic studies show that the broad whitefish that spawn in the lower Mackenzie basin, including those in the waters of the Yukon North Slope, are distinct from the broad whitefish from other river systems to the west (Alaska) and to the east (Reist & Chang-Kue, 1997).

Inuvialuit have observed an increase in abundance of broad whitefish in the coastal zone, based on their knowledge of fishing at Taqpaq (Shingle Point) (Papik et al., 2003; WMAC (NS) & Aklavik HTC, 2018a). Fisheries and Oceans Canada (DFO) conducted surveys of fish in nearshore Yukon coastal waters in 1986, 2007, and 2008 (Niemi et al., 2012). These coastal surveys likely include multiple migratory populations, with movements driven by complex environmental and biological factors, so they are not directly comparable. Additional surveys have been replicated on the Yukon coast to provide information on the fish community over time.

Transboundary Conservation and Management

The range and the annual movements of anadromous Mackenzie River broad whitefish cross territorial and land claim boundaries. Spawning is upstream of the ISR in the Mackenzie River and tributaries, including the Peel and Arctic Red rivers. Significant habitat for rearing, adult feeding, migrating, and overwintering is within the ISR, in the Mackenzie Delta, lakes, and in Beaufort Sea bays and other nearshore areas. Genetic analyses show that lower Mackenzie River/coastal fisheries are dominated by broad whitefish originating in the Peel River (Harris & Taylor, 2010).

This species is not associated with international conservation issues. Broad whitefish are an important subsistence fish for people in the Alaskan coastal plain, but most harvest is west of Prudhoe Bay. Most broad whitefish in Alaska remain within one river system (ADF&G, n.d.) and are genetically distinct from the broad whitefish that spawn in the Mackenzie River system (Reist & Chang-Kue, 1997).

Observations, Concerns, and Threats

Participants in the traditional knowledge study conducted by WMAC(NS) and the Aklavik HTC (2018a) shared observations on broad whitefish habitat change (p.43). These interview excerpts are about broad whitefish at Shingle Point:

> Well, whitefish never used to be at Shingle Point long ago, when I was a little girl… Now the fish from the Delta are starting to come into that area… Because our water is not as salty as before.
>
> …there's also a lake that breaks out, lets out the big lake whitefish from that area.
>
> We noticed that…[there are] more and more… freshwater fish in the sea.
>
> Only time they [broad whitefish] come out [to the ocean] is when there's a big wind and the tide comes up… And this [water] overflows and they come out.

The majority of interviewees observed a recent trend of more broad whitefish in coastal waters. Observations on habitat change included an increase in flooding and storm surges, allowing whitefish to move into the ocean from lakes that are near the coast. They also described coastal waters becoming less salty, perhaps due to more freshwater runoff due to climate change.

In a study documenting Inuvialuit knowledge of fisheries west of the Mackenzie (Papik et al., 2003), interviewees observed that, while fewer char were running at Taqpaq-Shingle Point, people were catching more broad whitefish in their nets. Some participants in the study commented that whitefish spawn earlier, and many people commented that whitefish flesh was more watery than in the past.

Inuvialuit observations on fish in the Mackenzie Delta were documented through community-based monitoring (Hynes, Wesche, & Aklavik HTC, 2017). Observations of changes relevant to broad whitefish in the Delta area include:

- Whitefish have softer meat; this is observed more regularly in the last 5 years.
- Some harvesters have lower harvest rates for broad whitefish in the Delta.
- Reduced ice thickness makes it less safe to travel to some areas (in the last 5 to 10 years). This and other climate-related changes are leading to changes in access of community members to traditional fishing areas.

Broad whitefish abundance on the Yukon North Slope could increase or decrease if there are changes to temperature-salinity regimes. Such changes would affect whitefish migratory patterns, as the fish do not tolerate high salinity. While changes in climate factors are the most obvious potential source of these changes to coastal waters, development activities can locally alter temperature-salinity regimes. A study of impacts from construction of a causeway into the Beaufort Sea at Prudhoe Bay, Alaska, found that broad whitefish use of the surrounding area decreased (Griffiths, Gallaway, Gazey, & Dillinger, 1992). The authors related this change to the fact that construction led to larger masses of high salinity water, which is avoided by broad whitefish.

Oil spills affecting the nearshore coastal zone, bays, and estuaries would pose a threat to broad whitefish. The Beaufort Regional Environmental Assessment (BREA, 2016) included broad whitefish in the list of species most sensitive to damage from oil spills.

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.

Fisheries Management

- Co-management in the Inuvialuit Settlement Region
  All fish in the Inuvialuit Settlement Region are co-managed as described in the Inuvialuit Final Agreement. This involves cooperation between the community Hunters and Trappers Committees, the Inuvialuit Game Council, the Fisheries Joint Management Committee, Government of Canada's Department of Fisheries and Oceans, Parks Canada (within National Park boundaries) and Government of Yukon (for Qikiqtaruk Herschel Island and other Yukon coastal and freshwater areas).

Habitat Conservation

- Aklavik Inuvialuit Community Conservation Plan (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016)
  Identifies Mackenzie Bay and Shallow Bay as important for whitefish overwintering.
- *Peel Watershed Regional Land Use Plan* (Peel Watershed Planning Commission, 2019)
  Management plans and habitat conservation measures in major broad whitefish spawning grounds are relevant to maintaining abundance of this fish species in the Mackenzie Delta and Yukon North Slope. The most important spawning areas for lower Mackenzie River system broad whitefish are in the Peel River and its tributaries (Harris & Taylor, 2010). The Peel Regional Land Use Plan addresses conservation of whitefish habitat, while identifying the lack of knowledge about broad whitefish spawning locations in the Peel watershed as a limitation on sustainable wildlife management.
- Beaufort Sea Conservation and Management
  Beaufort Sea nearshore ecosystems are important habitat for broad whitefish. Plans and programs for integrated management of Beaufort Sea ecosystems include:
  Beaufort Sea Partnership (BSP, 2020)

This partnership provides a forum for information sharing and discussion of mutual interests, goals, and responsibilities for Beaufort Sea conservation and management, guided by an integrated ocean management plan (BSP, 2009).

Tarium Niryutait Marine Protected Areas Management Plan (DFO, 2013) and *Monitoring Plan* (DFO & FJMC, 2013)

The plan recognizes the importance of these protected areas for fish, including broad whitefish. The monitoring plan includes fish surveys and fish sampling to assess status and trends of fish populations, fish health, and marine food webs.

Research and Monitoring Programs

- Yukon North Slope monitoring and research programs

  Objective (BSP, 2017 p. 3):

  > Arctic Coastal Ecosystem Program (ACES): To characterize the habitat and diet of coastal fish populations to develop baseline information and monitor any shifts using key monitoring species, including broad whitefish.

- Lower Mackenzie Whitefish Project ("Lower Mackenzie Whitefish Project," n.d.)

  A community-based monitoring program focused on broad whitefish harvested in the Gwich'in Settlement Area near Aklavik, Fort McPherson, and Tsiigetchic, NWT. This project was established in 2017 and it brings together community organizations, harvesters and researchers. The project collects data on harvested fish, which provides insight about whitefish body condition, population dynamics, habitat use and migration. The results of the project will contribute to the understanding of how Whitefish use the waterways of the Gwich'in Settlement Area and Inuvialuit Settlement Region.

- Inuvialuit Harvest Study (IHS) (IRC, 2017, 2018, 2019)

  Annual harvest monitoring in the ISR from 2016-2019 was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included broad whitefish harvest monitoring. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information through monthly interviews with active harvesters. Results were summarized for each community in annual newsletters. This program built on previous harvest monitoring (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge and Traditional Use Studies

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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.

- *Broad Whitefish Traditional Knowledge Study* (Freeman, 1997)
  This report is a summary of findings from interviews with elders living in Aklavik and Inuvik in 1992. The scope of the interviews was broad whitefish biology and the fishery in the lower Mackenzie River. The report is part of the proceedings of a workshop on broad whitefish in the lower Mackenzie River (Tallman & Reist, 1997).

- *Ecological Knowledge of Fisheries in Rivers West of the Mackenzie River* (Papik et al., 2003)
  This study was conducted at the recommendation of the West Side Working Group. It covers all fish species and includes observations on whitefish ecology and harvest.

- *Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on changes in the environment and fish populations* (Brewster, Neumann, et al., 2016)
  In 2015 a traditional ecological knowledge survey was conducted at Shingle Point at the request of the FJMC and Aklavik HTC. This study complemented the fish and marine monitoring program in place since 2010. The 15 participants included elders and younger participants. The report summarizes information on observations of conditions and changes affecting fisheries but does not provide information specific to broad whitefish.

Assessments and Syntheses of Survey Results

- *Fishes of the Yukon Coast* (Kendel, Johnston, Lobsiger, & Kozak, 1975)
  This report's purpose was to collect baseline information on nearshore fish resources along the Yukon coast and to identify areas that would be critically affected by oil spills. Surveys, conducted in 1974 and 1975, included the coastal sea out to 7 km offshore and lagoons and estuaries from Blow River to Herschel Island. The baseline surveys showed that upstream migration of broad whitefish into the Mackenzie River peaks during September and October and downstream migration to the Beaufort Sea occurs in late fall and early winter. Broad whitefish were not abundant but were widespread along the coast from Shingle Point to

Herschel Island. Broad whitefish made up only 0.2% to the total catch in surveys over both years. Lakes were not surveyed, but the report notes that broad whitefish are known to occur in some of the tundra lakes.

- Proceedings of a workshop on broad whitefish in the lower Mackenzie River (Tallman & Reist, 1997)
  This volume is a series of papers presenting information on broad whitefish biology, traditional knowledge, and management. Field studies and traditional knowledge documentation focus on the Mackenzie River and Delta, and lake and marine habitat east of the Mackenzie. The Inuvialuit traditional knowledge documentation is based on interviews conducted in Aklavik and Inuvik.

- Beaufort Regional Environmental Assessment (BREA, 2016)
  BREA was a four-year research program (2012-2015) focused on research to inform decision-makers on offshore oil and gas development in the Beaufort Sea. The assessment included a project to develop vulnerability profiles for key marine species, including broad whitefish.

- *Summer studies of the nearshore fish community at Phillips Bay, Beaufort Sea coast, Yukon* (Bond & Erickson, 1989)
  This report synthesizes information about abundance, biology and summer movement patterns of multiple fish species (including broad whitefish) at Phillips Bay, Yukon.

Research

- *Characterizing the diet and habitat niches of coastal fish populations in the Beaufort Sea Tarium Niryutait Marine Protected Area* (Brewster, Giraldo, et al., 2016)
  This study is based on analyses of carbon isotopes (different forms of carbon that can be related to the sources of food) in fish caught at Shingle Point from 2011 to 2013. The study indicates that broad whitefish caught in the sea feed on a wide range of prey items in a variety of habitats—they are generalists and may adapt well to changing marine feeding conditions.

- *Migratory variation in Mackenzie River system broad whitefish* (Harris et al., 2012) and genetic population structure studies (Harris & Taylor, 2010)

  Research based on analysis of otoliths (bones in the inner ears) showed that there are anadromous, river-dwelling, and lake-dwelling populations of broad whitefish in the lower Mackenzie River system, and that there is a great deal of variability in how much time fish spend in marine and estuarine habitats. The researchers also found that some broad whitefish in lakes moved between lake and marine and estuarine environments. Genetic analyses showed that there are two main genetic groups of broad whitefish: anadromous and lake-dwelling. Fish caught in the lower Mackenzie system (which would also be caught in the Beaufort Sea) were of both types, with whitefish originating in the Peel River dominating.

References

ADF&G. (n.d.). Broad Whitefish Species Profile. Retrieved February 11, 2019, from Alaska Department of Fish and Game website: http://www.adfg.alaska.gov/index.cfm?adfg=broadwhitefish.main

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

Barker, O. E., & Derocher, A. E. (2009). Brown bear (*Ursus arctos*) predation of broad whitefish (*Coregonus nasus*) in the Mackenzie delta region, Northwest Territories. *Arctic*, *62*(3), 312–316.

Bond, W. A., & Erickson, R. N. (1989). *Summer studies of the nearshore fish community at Phillips Bay, Beaufort Sea Coast, Yukon*.

BREA. (2016). *Beaufort Regional Environmental Assessment Key Findings: Research and Working Group Results. March 2016*. Canada.

Brewster, J. D., Giraldo, C., Swanson, H., Walkusz, W., Loewen, T. N., Reist, J. D., … Loseto, L. L. (2016). Ecological niche of coastal Beaufort Sea fishes defined by stable isotopes and fatty acids. *Marine Ecology Progress Series*, *559*, 159–173. https://doi.org/10.3354/meps11887

Brewster, J. D., Neumann, D., Ostertag, S. K., & Loseto, L. L. (2016). *Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on changes in the environment and fish populations*. Fisheries and Oceans Canada.

BSIMPI. (2003). *Ecological Assessment of the Beaufort Sea Beluga Management Plan— Zone 1(a) as a Marine Protected Area of Interest* (Vol. 1). Beaufort Sea Intergrated Management Planning Initiative Working Group.

BSP. (2009). *Integrated Ocean Management Plan for the Beaufort Sea: 2009 and Beyond*. Beaufort Sea Partnership.

BSP. (2017). *Tarium Niryutait MPA 2017 Annual Review*. Retrieved from Beaufort Sea Partnership website: http://www.beaufortseapartnership.ca/wp-content/uploads/2018/06/TNMPA-2017-Annual-Review.pdf

BSP. (2020). Beaufort Sea Partnership. Retrieved January 10, 2020, from http://www.beaufortseapartnership.ca/

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

Cobb, D. G., Fast, H., Papst, M., Rosenberg, D., Rutherford, R., & Sareault, J. E. (2008). *Beaufort Sea Large Ocean Management Area : Ecosystem Overview and Assessment Report Canadian Technical Report of Fisheries and Aquatic Sciences 2780*.

Cobb, D. G., Roy, V., Link, H., & Archambault, P. (2014). *Information to support the re-assessment of original ecologically and biologically significant areas (EBSAs) in the Beaufort Sea Large Ocean Management Area*. Fisheries and Oceans Canada.

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/

DFO. (2000). Eastern Beaufort Sea Beluga Whales. *Fisheries and Oceans Canada Science Stock Status Report*, (E5-38), 14.

DFO. (2013). *Tarium Niryutait Marine Protected Areas Management Plan*. Fisheries and Oceans Canada.

DFO. (2014). *Re-evaluation of ecologically and biologically significant areas (EBSA) in the Beaufort Sea*. CSAS Science Advisory Report 2014/052.

DFO, & FJMC. (2013). *Tarium Niryutait Marine Protected Areas Monitoring Plan*. Fisheries and Oceans Canada and Fisheries Joint Management Committee.

Du Bruyn, M., & McCart, P. J. (1974). Life history of grayling (Thymallus arcticus) in Beaufort Sea drainages in the Yukon Territory. In P. J. McCart (Ed.), *Fisheries Research Associated with Proposed Gas Pipeline Routes in Alaska, Yukon and Northwest Territories*. Canadian Arctic Gas Study Limited and Alaskan Arctic Gas Study Company.

Eddy, S. M. (2001). *Beaufort Sea Integrated Management Planning Initiative (BSIMPI): Coastal Resource Inventory*. Fisheries and Oceans Canada.

Freeman, M. M. R. (1997). Broad whitefish traditional knowledge study. In R. F. Tallman & J. D. Reist (Eds.), *The Proceedings of the Broad Whitefish Workshop: The Biology, Traditional Kowledge and Scientific Management of broad whitefish (Coregonus nasus (Pallas)) in the Lower Mackenzie River*. Winnipeg: Canadian Technical Report of Fisheries and Aquatic Sciences 2193, Department of Fisheries and Oceans.

Gallagher, C. P., & Howland, K. L. (2011). Monitoring the Cumulative Imapcts of Harvesting Dolly Varden (Salvelinus malma). Retrieved from http://sdw.enr.gov.nt.ca/nwtdp_upload/1240_Gallagher_CIMP_Dolly Varden Nov 16 2011.pdf

George, J. C., Moulton, L. L., & Johnson, M. (2009). *A field guide to the common fishes of the North Slope of Alaska*. (July), 1–97.

Griffiths, W. B., Gallaway, B. J., Gazey, W. J., & Dillinger, R. E. (1992). Growth and Condition of Arctic Cisco and Broad Whitefish as Indicators of Causeway-Induced Effects in the Prudhoe Bay Region, Alaska. *Transactions of the American Fisheries …*, *121*(5), 557–577. https://doi.org/10.1577/1548-8659(1992)121

Harris, L. N., Loewen, T. N., Reist, J. D., Halden, N. M., Babaluk, J. A., & Tallman, R. F. (2012). Migratory variation in Mackenzie River system broad whitefish: Insights from otolith strontium distributions. *Transactions of the American Fisheries Society*, *141*(6), 1574–1585. https://doi.org/10.1080/00028487.2012.713885

Harris, L. N., & Taylor, E. B. (2010). Genetic population structure of broad whitefish, Coregonus nasus, from the Mackenzie River, Northwest Territories: implications for subsistence fishery management. *Canadian Journal of Fisheries and Aquatic Sciences*, *67*(6), 905–918. https://doi.org/10.1139/f10-027

Hynes, K., Wesche, S. D., & Aklavik HTC. (2017). Inuvialuit Knowledge and Use of Fisheries in the Mackenzie Delta. In B. Parlee & E. Maloney (Eds.), *Tracking change: Local and Traditional Knowledge in Watershed Governance. Report of the 2016 Community-Based Research Projects in the Mackenzie River Basin* (pp. 18–21). Retrieved from www.trackingchange.ca

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

IRC. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

Kavik-AXYS Inc. (2002). *Socio-economic assessment of the proposed Beaufort Sea Marine Protected Area*. Submitted to Fisheries and oceans Canada.

Kendel, R. E., Johnston, R. A. C., Lobsiger, U., & Kozak, M. D. (1975). *Fishes of the Yukon Coast*. Victoria, B.C.: Beaufort Sea Project, Department of the Environment.

Lower Mackenzie Whitefish Project. (n.d.). Retrieved from https://whitefishresearch.weebly.com

Martin, Z. A. (2010). *Adaptation and habitat selection during the migration of an Arctic anadromous fish, Broad Whitefish (Coregonus nasus (Pallas 1776))*. University of Manitoba.

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

Niemi, A., Johnson, J. D., Majewski., A., Melling, H., Reist, J. D., & Williams, W. (2012). State of the Ocean Report for the Beaufort Sea Large Ocean Management Area. In *Canadian Manuscript Report of Fisheries and Aquatic Sciences* (Vol. 2977).

Papik, R., Marschke, M., & Ayles, B. (2003). *Inuvialuit Traditional Ecological Knowledge of Fisheries in Rivers West of the Mackenzie River in the Canadian Arctic*. Canada/Inuvialuit Fisheries Joint Management Committee Report 2003-4.

Peel Watershed Planning Commission. (2019). *Peel Watershed Regional Land Use Plan*.

Reist, J. D., & Chang-Kue, K. T. J. (1997). The life history and habitat usage of broad whitefish in the lower Mackenzie River basin. In R. F. Tallman & J. D. Reist (Eds.), *The Proceedings of the Broad Whitefish Workshop: The Biology, Traditional Kowledge and Scientific Management of broad whitefish (Coregonus nasus (Pallas)) in the Lower Mackenzie River* (pp. 63–84). Winnipeg: Canadian Technical Report of Fisheries and Aquatic Sciences 2193, Department of Fisheries and Oceans.

Steigenberger, L. W., Robertson, R. A., Johansen, K., & Elson, M. S. (1975). *Biological/Engineering Evaluation of the Proposed Pipeline Crossing Sites in Northern Yukon Territory*. Department of the Environment, Fisheries and Marine Service, Pacific Region. PAC/T-75-11.

Tallman, R. F., & Reist, J. D. (Eds.). (1997). *The Proceedings of the Broad Whitefish Workshop: The Biology, Traditional Knowledge and Scientific Management of broad whitefish (Coregonus nasus (Pallas)) in the Lower Mackenzie River*. Winnipeg: Canadian Technical Report of Fisheries and Aquatic Sciences 2193, Department of Fisheries and Oceans.

USGS. (2016). Broad Whitefish to Dolly Varden. In L. K. Thorsteinson & M. S. Love (Eds.), *Alaska Arctic Marine Fish Ecology Catalog* (pp. 112–171). U.S. Geological Survey Scientific Investigations Report 2016-5038.

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). (2012). *Species Status Reports for the Yukon North Slope*. Retrieved from Wildlife Management

Advisory Council (North Slope) website: http://www.wmacns.ca/

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

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: Broad Whitefish. Retrieved March 9, 2020, from https://yukon.ca/en/broad-whitefish

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 11:
Geese
Kanuq/ Nigliq/ Nirglingaq/ Ulugullik

Publication Information

Cover photo:	Canada Goose, Jay Frandsen. © Parks Canada/Jay Frandsen, 2018
Copyright:	2021 Wildlife Management Advisory Council (North Slope)
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 11: Geese Kanuq/ Nigliq/ Nurglingaq/ Ulugullik

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

There are fourteen companion reports, addressing four 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: Geese / Kanuq / Nigliq / Nirglingaq / Ulugullik

This companion report provides information on the conservation requirements for geese 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 geese, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for geese on the Yukon North Slope

1. Conservation of large areas across the Yukon North Slope coast, especially tidal flats and deltas, to allow for variability in habitat use and space for habitat recovery.
2. Management and monitoring of overabundant species to ensure long-term habitat health for geese and other species.
3. Avoidance, mitigation and management of significant impacts to geese from marine industrial development and associated infrastructure, and from increased ship traffic and aerial disturbance.

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

Geese on the Yukon North Slope

The Mackenzie Delta and the Yukon North Slope are on major flyways for ducks, geese, and swans. Habitat for geese extends along the entire Yukon North Slope coastal area and, for Snow Geese, inland to the foothills. Information on goose species frequenting the Yukon North Slope is in Table 11– 1. Snow Geese and Yellowlegs (Greater White-fronted Geese) are the most abundant goose species.

Table 11– 1. Species and populations of geese on the Yukon North Slope

Common names	Inuvialuit name[1]	Scientific name	Inuvialuit Observations of geese on the Yukon North Slope[2]
Snow Goose	Kanuq	*Chen caerulescens*	By mid-June Snow Geese have moved off the coast to nest further north. They arrive back in August and fatten up on grasses and berries.

Common names	Inuvialuit name[1]	Scientific name	Inuvialuit Observations of geese on the Yukon North Slope[2]
Yellowlegs; Greater White-fronted Goose	Nigliq	*Anser albifrons*	Yellowlegs fly down the West Channel and along the coast to nest in marshy areas all along the coast and at river mouths. They are common in September between the Blow River mouth and the Delta. They like grassy, muddy areas; they pull out the grass and feed on roots and eat berries.
Brant	Nirglingaq	*Branta bernicla*	Brant migrate from the Alaska coast to the Yukon North Slope in spring. Brant are seen in smaller numbers than Yellowlegs and Snow Geese.
Canada Goose	Ulugullik	*Branta canadensis*	There are not many Canada Geese along the coast.

[1] WMAC (NS) (2003) except Canada Goose, which is from WMAC (NS) (2012)

[2] Summarized from *Aklavik Inuvialuit describe the status of certain birds and animals on the Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2003).

Snow Goose | Kanuq

Snow Geese rarely nest in the Yukon. By far the largest nesting colony is on Banks Island, where over 95% of the Western Arctic population of Lesser Snow Geese breed (Hines, Latour, & Machtans, 2010). Other nesting colonies are in the large deltas along the Alaskan coast and on Kendall Island and the Anderson River delta in the NWT (Hawkings, 1987). Molting - the shedding of old feathers and growth of new ones - takes place in the summer near the nesting grounds. Geese are flightless during the molt.

Snow Geese over the Canning River Delta, Alaska North Slope, June 2012; Ian Davies / Macaulay Library at the Cornell Lab of Ornithology (ML31693361)

In the fall, most of the Lesser Snow Goose Western Arctic population is on the Yukon North Slope and adjacent Alaskan coastal areas and, to a lesser extent, the outer Mackenzie Delta. Virtually the entire Yukon coastal plain is used for staging, with some use also into the foothills (Hawkings, 1987; WMAC (NS) & Aklavik HTC, 2018a). The precise areas used vary from year to year. Snow Geese arrive in their fall staging habitat from mid to late August and depart from mid to late September, depending on weather conditions. During this period, they feed intensively, building up their energy reserves in preparation for migration. In September they head south, first following the Mackenzie River, stopping at additional staging areas in the NWT, Alberta, and Saskatchewan (Pacific Flyway Council, 2013). They winter in southern U.S. and Mexico.

Yellowlegs | Nigliq

Yellowlegs (greater white-fronted goose) nest along the Alaska Coast and in the Mackenzie Delta, but relatively few nest along the Yukon coast (Hawkings, 1987). Unlike Snow Geese, Yellowlegs do not nest in colonies—their nests are spread out along the coast on drier patches in wet tundra. After hatching, Yellowlegs move to deltas and rivers to rear their young and to molt (Sinclair, Nixon, Eckert, & Hughes, 2003). Non-breeding Yellowlegs visit the Yukon North Slope during summer, but not in large numbers (Hawkings, 1987).

Yellowlegs at Qikiqtaruk-Pauline Cove/Simpson Point, June 2011; Cameron Eckert / Macaulay Library at the Cornell Lab of Ornithology (ML63300821)

In late August and the first half September thousands of Yellowlegs migrate eastward along the Yukon coast from nesting and molting areas on the Alaska coast to staging areas in the Mackenzie Delta. They do not linger along the Yukon coast, though they can be present in large numbers in mixed flocks with Snow Geese. They winter in southern U.S. and Mexico, migrating through the prairie provinces. Few Yellowlegs pass through the Yukon North Slope during spring migration (Hawkings, 1987).

Brant | Nirglingaq

Black Brant at Qikiqtaruk-Pauline Cove/Simpson Point, June 2019; Cameron Eckert / Macaulay Library at the Cornell Lab of Ornithology (ML182490461)

Most Pacific Flyway Brant that nest in Canada pass through the Yukon North Slope in spring, heading east to breeding areas (Hawkings, 1987). Nesting is dispersed throughout coastal areas of Yukon, NWT, and Nunavut (Pacific Flyway Council, 2018). Nesting along the Yukon coast is limited to a few locations. Only the Brant that nest in the Yukon are present during molting (Hawkings, 1987). Brant nest in colonies in low-lying areas, including deltas, lagoons, and ponds. After the eggs hatch, Brant move to coastal salt marshes to raise their young (Pacific Flyway Council, 2018).

The fall migration follows the Beaufort Sea coast, with migrants heading west to Alaska along the Yukon coast from mid-August to the first week of September. Brant stop to rest and feed in tidal marshes, deltas, and lagoons, especially the Blow and Malcolm river deltas and Phillips Bay (Hawkings, 1987). Over the fall migration period many large flocks of Brant will stop at coastal sites with suitable habitat (Alexander, Barry, Dickson, Prus, & Smyth, 1988). Brant winter along the Pacific Coast, from Alaska to Mexico.

Canada Goose | Ulugullik

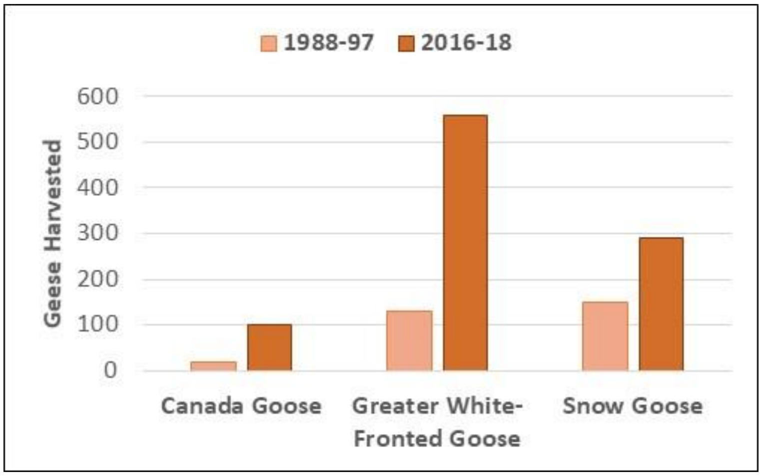
Canada Goose at Qikiqtaruk-Pauline Cove/Simpson Point, June 2016; Cameron Eckert / Macaulay Library at the Cornell Lab of Ornithology (ML46450581)

Canada Geese are uncommon spring and fall migrants and rarely breed on the Yukon North Slope. Small numbers also molt in the area. They made up less than 1% of geese in aerial surveys along coasts of Alaska and Yukon and the Mackenzie Delta in the 1970s. A few hundred are sometimes present on the Babbage River delta (Hawkings, 1987). Canada Geese winter in the US and Mexico and migrate through the prairie provinces.

Traditional Use

Snow Geese, Yellowlegs and, to a much lesser extent, Canada Geese and Brant are harvested by Aklavik Inuvialuit in the Mackenzie Delta and on the Yukon North Slope. Average annual harvests reported through the Inuvialuit Harvest Study have been higher in recent years than during the period from 1988 to 1997 (Figure 11– 1). The goose harvest varies greatly from year to year. Very few Brant are harvested (an average of two per year from 1988 to 1997).

Figure 11– 1. Average annual harvest of geese by Aklavik Inuvialuit during two periods: 1988-1997 and 2016-2018



Data are from the Inuvialuit Harvest Study (Inuvialuit Harvest Study, 2003; IRC, 2019). Greater White-Fronted Goose is also referred to in this chapter by the common local name Yellowlegs.

A 1991 dietary survey documented the importance of geese in the diet of Aklavik Inuvialuit (Wein & Freeman, 1992). Goose meat was in the list of top ten preferred traditional foods. The percentages of the 36 households surveyed that reported eating each type of goose during the previous year were: Snow Goose, eaten by 69% of households; Yellowlegs, eaten by 61% of households; Brant, eaten by 47% of households; and Canada Goose, eaten by 25% of households.

Aklavik Inuvialuit have a long tradition of hunting Yellowlegs in spring and fall and report: they are fatter and tastier than Snow Geese; they are also smarter and more wary; and Brant do not taste as good as Yellowlegs and Snow Geese (WMAC (NS) & Aklavik HTC, 2003).

In interviews and workshops in 2003 (WMAC (NS) & Aklavik HTC, 2003) and 2016 (WMAC (NS) & Aklavik HTC, 2018b), Aklavik Inuvialuit land users pointed out that changes in migration patterns for Yellowlegs and Snow Geese have affected harvesting opportunities. The fall migration route for Yellowlegs changes some years – sometimes they migrate closer to the mountains and away from the Delta. Harvesting Yellowlegs is harder, as they tend to fly higher and away from the coast. Snow Geese are farther away from camps on the coast, making it harder to harvest them. Since the mid-1990s Snow Geese have been flying over higher and feeding inland more. The spring migration over the Delta has shifted to the east, which means that fewer Snow Geese are in the West Channel.

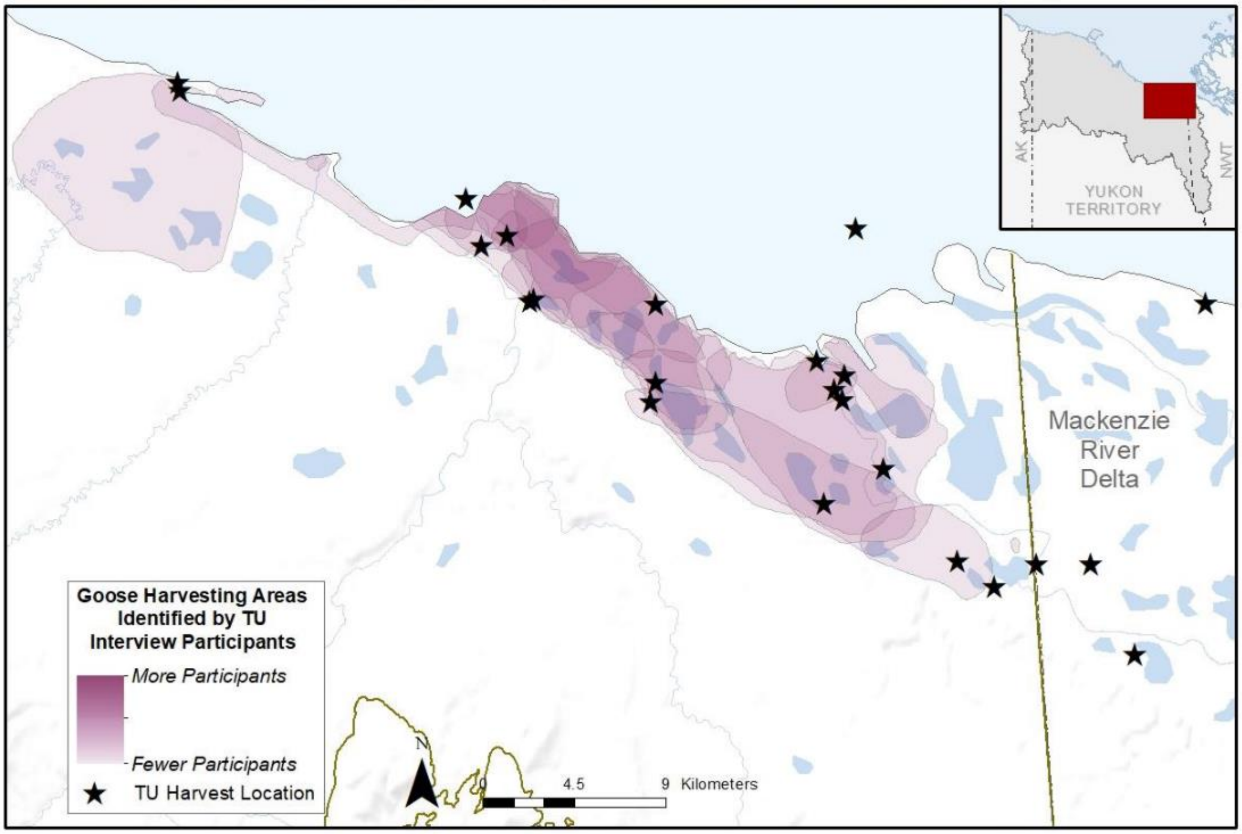
Changing goose migration patterns affect traditional use

Since the early 1990s, Inuvik, Aklavik and Tuktoyaktuk residents have seen the spring goose migration patterns shift eastward, away from their communities and into the eastern Inuvialuit Settlement Region lands. Today, longer travel is required in order to hunt geese, and, overall, these birds are harder to locate. One response has been to organize an Elders goose hunt to ease some of the difficulties that the seniors have in accessing geese.

From *Unikkaaqatigiit – Putting the Human Face on Climate Change: Perspectives from the Inuvialuit Settlement Region* (Communities of Aklavik; Inuvik; Holman Island; Paulatuk and Tuktoyaktuk, Nickels, Buell, Furgal, & Moquin, 2005)

Yukon North Slope harvest sites for waterfowl (including ducks, geese and swans) were identified by Aklavik Inuvialuit through a 2018 traditional use study (WMAC (NS) & Aklavik HTC, 2018b). Harvest sites include the lowlands near Tapqaq (Shingle Point), around Jacobs Lake, at the mouth of John Arey's Creek, the mouth of Blow River, and the shores of channels and islands east of Tapqaq. Goose harvesting locations reported by Aklavik Inuvialuit hunters are shown on Map 11- 1.

Map 11- 1. Goose harvesting locations and hunting areas identified in the Inuvialuit traditional use interviews



The interviewers asked Inuvialuit land users to identify goose harvest areas used within living memory. Source: Round River Conservation Studies (2018) based on interviews documented in WMAC (NS) (2018b)

Habitat for Geese

Important Bird Areas

Three sections of the coastal plain are designated as Important Bird Areas (IBAs), using international criteria. Many thousands of waterfowl and shorebirds congregate in these coastal areas in the fall, including significant proportions of the global populations of Western Arctic Lesser Snow Geese, Black Brant, and some shorebird species (IBA Canada, n.d.).

Yukon North Slope Important Bird Areas

(see Error! Reference source not found.)

IBA YK008: Blow River Delta (Shingle Point to Tent Island)

This IBA includes delta habitat from the mouth of the Blow River east to the edge of the Mackenzie Delta. It extends inland to include channels, ponds, and salt marshes. Storm tides flood much of the grass-sedge flats. This IBA is especially important for Snow Geese and shorebirds in the fall.

IBA YK007: Babbage and Spring River Deltas

This IBA includes coastal land and waters and swings inland at the Babbage River delta. Delta habitats include ponds, channels, grass-sedge wetlands, salt marshes, and tidal mudflats. The IBS is used for staging and molting by many birds, especially waterfowl. Brant concentrate in the delta tidal flats.

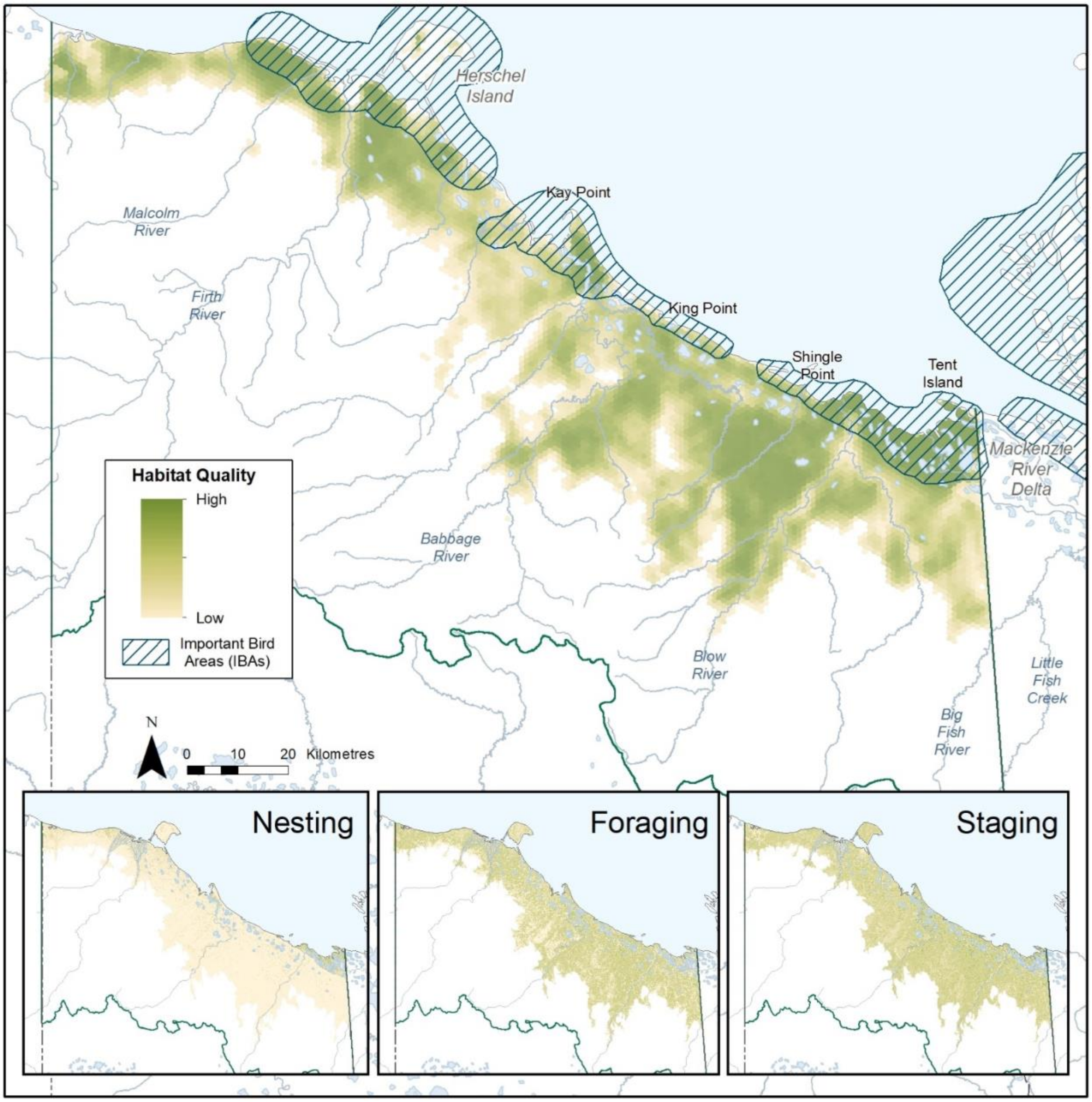
IBA YK005: Nunaluk Spit to Herschel Island

This IBA includes islands and mainland coast with sandy spits and delta wetlands, the open waters of Workboat Passage, and low Arctic tundra with dwarf shrubs, sedges, and herbs along the coastal plain. The IBA is significant for staging and migrating shorebirds, waterfowl, and gulls.

Goose Habitat Suitability Model

Traditional-knowledge-based habitat suitability models were developed as part of the baseline ecological and cultural conservation assessment work undertaken for the Plan (Round River Conservation Studies, 2018). The models provide evidence that goose habitat for nesting, foraging, and staging during migration periods is distributed along the entire Yukon North Slope (Map 11- 2).

Map 11- 2. Habitat suitable for geese nesting, foraging, and staging—mapped from a traditional-knowledge-based habitat model



This map is from the Plan (WMAC (NS), 2022, Appendix 1). The map is created from a habitat model based on Inuvialuit traditional knowledge (IBA Canada, n.d.; data sources: WMAC (NS) & Aklavik HTC, 2018a).

Methods

The goose habitat suitability models are based on traditional knowledge documented by Aklavik Inuvialuit land users and classification and mapping of the Yukon North Slope ecosystems. The report *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-based Goose Habitat Model* (Round River Conservation Studies, 2018) should be consulted for more information on the ecosystem classification system and on how the models were constructed and validated.

The habitat model is based on knowledge about goose habitat documented through interviews conducted in 2016 with 15 Inuvialuit land users (WMAC (NS) & Aklavik HTC, 2018b). Interviewees described the habitat used for nesting, staging, and foraging by Yellowlegs and Snow Geese, either by pointing out locations on a map or by selecting habitat types from a set of photos of a range of ecosystems on the Yukon North Slope. Because most people interviewed spoke of goose habitat in general, the model does not differentiate between Yellowlegs and Snow Geese. However, as the Snow Goose population that frequents the Yukon North Slope mainly nests on Banks Island, habitat identified for nesting would be mostly for Yellowlegs.

To construct the model, habitat features that study participants described were matched with ecosystem types and landscape features on a map constructed using predictive ecosystem mapping (PEM) techniques (Environment Yukon, 2016). Habitat features were weighted depending on how frequently the feature was identified.

Examples of how traditional knowledge was combined with ecosystem mapping in the model:

- Most participants identified nesting locations or described goose nesting habitat that corresponded to a wet sedge ecosystem type (PEM class hydric sedge). Locations on the map with this PEM class were given a high weight for nesting habitat.
- Participants described geese foraging in good berry habitat. Several PEM classes where berries grow were selected as foraging and weighted by the number of participants identifying berry habitat.

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.

Nesting, foraging, and staging habitat were modelled separately, each based on the specific goose habitat types identified by the study participants and on the weights assigned to each habitat type based on the number of participants that identified the feature. A grid system was used for modelling and for showing the results on maps. Each map shows the distribution of suitable goose habitat across this grid, as predicted through the model. Each grid cell has a rank number from 1 to 10, with 1 indicating the lowest quality habitat and 10 the highest.

Results

Table 11– 2. Summary of traditional knowledge about goose habitats and results from habitat suitability modelling

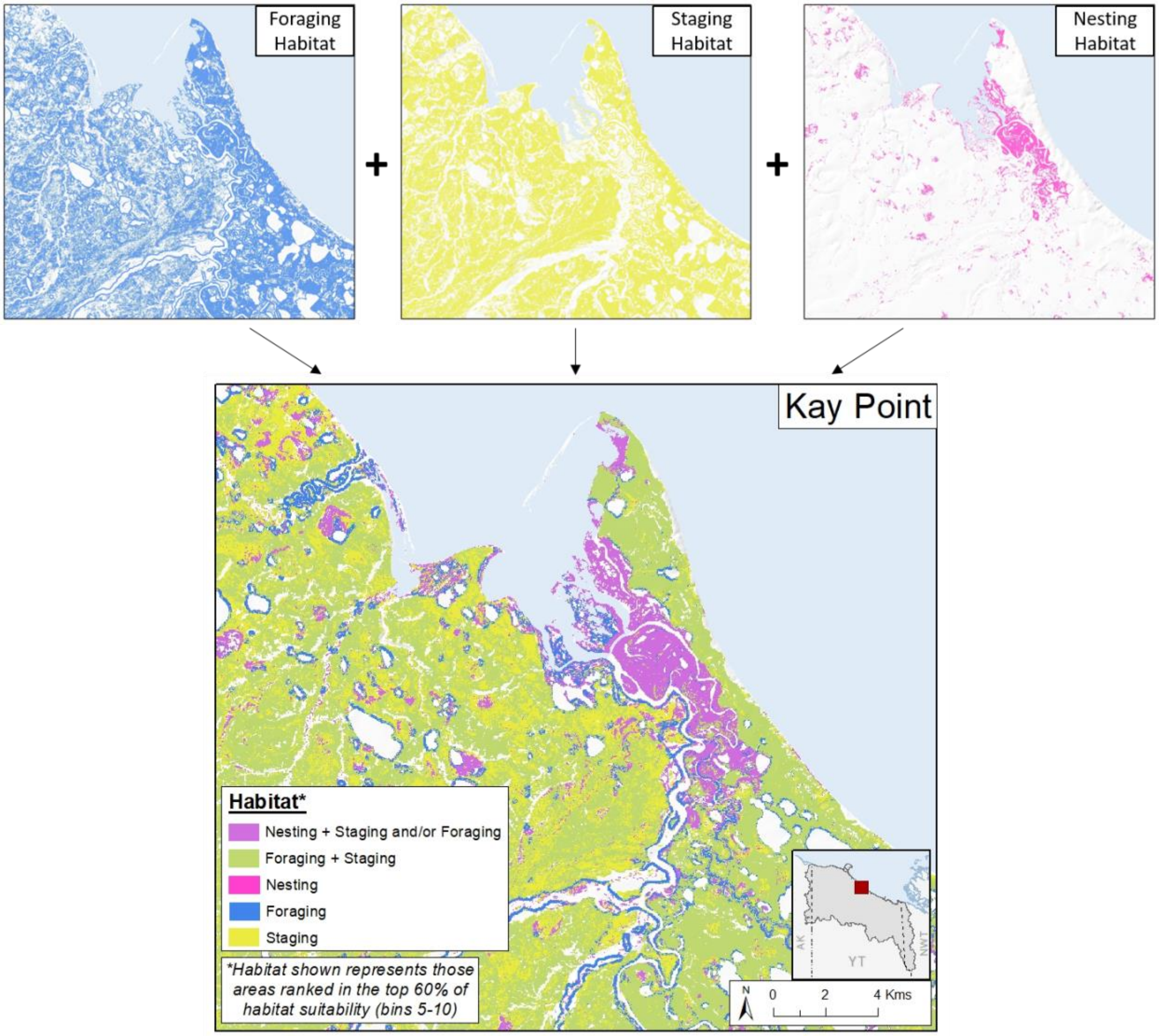
Type of habitat use[1]	Summary of traditional knowledge findings[2]	What the habitat suitability models show[1]
Nesting: where nesting geese or newborn goslings are seen.	Goose nests are on flat terrain near water, in lower swamps, upland ponds and swamps, or in low flatlands, often in grassy areas. Geese return to these nesting grounds every year.	High quality nesting habitat is in areas with large amounts of water, including river and lake shorelines and swampy ecosystem types near the coastal plain.
Staging: where geese collect in large numbers as they enter or prepare to leave the Yukon North Slope.	Staging areas are in flatter locations, often containing mud bars, including river and coastal beaches. Geese may use these areas in spring because they thaw first.	Staging habitat is widely distributed along the entire coastal plain, but not at higher elevations and inland.
Foraging: where geese are observed feeding, including while nesting and staging.	Spring foraging areas are low, wet, grassy areas. Yellowlegs remain in these areas in summer, eating grass and roots, and are joined by Snow Geese in late summer. Geese also eat uquk (blueberries), aqpik (cloudberries), and kimmingnaq (cranberries) as they ripen on open, shrubby hillside terrain.	Foraging habitat is distributed along the coastal plain. The model highlights areas further inland where conditions are good for berries to grow.

[1] Summarized from Round River Conservation Studies (2018).

[2] Based on interviews with 15 Aklavik Inuvialuit land users (WMAC (NS) & Aklavik HTC, 2018a).

The combined habitat map indicates that goose habitat on the coastal plain is widely distributed, with higher quality habitat in the Mackenzie Delta, near Kay Point, on Qikiqtaruk, and at the mouths of the Firth and Malcolm rivers. The Mackenzie Delta and Kay Point were highlighted by the study participants as areas with a high diversity of ecosystems that support geese for nesting, foraging, and staging. Map 11- 3 shows the overlapping habitat types at Kay Point. High quality nesting habitat at Kay Point is concentrated in areas next to water, while high quality foraging and staging habitats are spread out and often overlap.

Map 11- 3. Goose habitat (all uses, separately and combined) around Kay Point



Habitat rated as high quality (rank 5 to 10) is shown in each map.
Round River Conservation Studies (2018), Map 8

Inuvialuit Observations on Goose Habitats

Excerpts from the *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* report provide more detail on traditional knowledge of goose habitat:

Nesting

> [Geese] like an area where they're hard to see, and… they have to live close to the river or the lake where the young ones always…go feeding.

> [It's] mostly yellowlegs in this area… you're seeing a lot of snow geese, too… but they're… crossing over to Banks Island… that's where the snow geese nest.
>
> …first week in May, we see a whole bunch [of geese] at Blow River… during the summer they use that [area] for nesting… [It's] yellowlegs, 95%, maybe mixed 5% with snow geese.
>
> The yellowlegs usually nest around Qutaitchuraq [where the river meets the hill]… we don't usually get snow geese until we get… snow on the ground. (WMAC (NS) & Aklavik HTC, 2018a, pp. 44-45)

Staging

> …when they're [geese] flying over here [in the fall], they'll… maybe jump a mile or two and then they stop, 'til somebody scares them up. Then they take off, always going south…
>
> … they usually bunch up… thousands and thousands of geese… every spring and fall.
>
> …on this big mud plain… there's always… at least a thousand geese… during the first part of the spring, they come… they stop in there where all the water is… rushing through the Babbage. (WMAC (NS) & Aklavik HTC, 2018a, p. 48)

The Yukon North Slope goose staging areas identified in *Local Ecological Knowledge of Staging Areas for Geese in the Western Canadian Arctic* (Bartzen, 2014) correspond closely with staging areas identified in the traditional knowledge study used for the habitat suitability model (Map 11- 3).

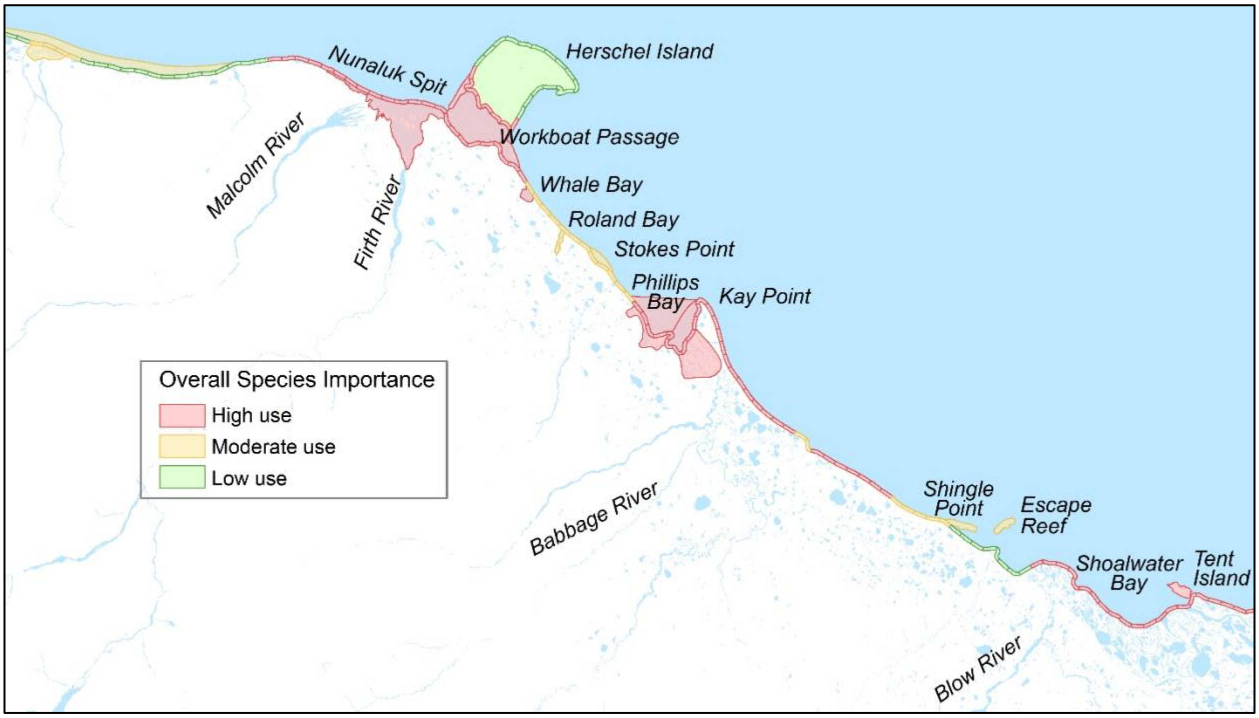
Foraging

> …they [geese] pull the roots up from [the marsh] and then they have lunch.
>
> When you watch geese… you observe the area… [the] edge of a lake or swampy area, they're pulling out the grass… they must be eating the roots.
>
> …when we stay at Shingle Point, we see them [geese] come from the ocean, then they're flying up to the high hills, up to the tundra… and eating a lot of aqpik [yellow berries]."
>
> We know they're eating berries in late fall… They always come from the ocean and they're always heading to the foothills.
>
> …soon as you see cloudberries…whoosh…that's where they [geese] go.
>
> I don't know [everything] they [geese] eat, but … when you look in their guts, you can find blueberries. (WMAC (NS) & Aklavik HTC, 2018a, pp. 46-47)

Mapping of Key Areas for Birds Along the Yukon Coast

Map 11- 4 shows key areas for waterbirds during the fall staging period. The red high use areas correspond generally with high value goose staging habitat areas identified in the traditional knowledge study used for the habitat suitability model. The high use value assigned to Workboat Passage in Map 11- 3 may reflect its importance for diving ducks and phalaropes (Alexander et al., 1988).

Map 11- 4. Key areas for birds during mid-August to late September on the Yukon Coast, based on aerial surveys



Map provided by Canadian Wildlife Service. Produced January 2013.

Goose Populations

Species Conservation Status

The goose species that frequent the Yukon North Slope are not considered at risk in Canada (Canada, n.d.). None of the species have been assessed by the Committee on the Status of Endangered Wildlife in Canada and none are currently candidates for assessment (COSEWIC, 2020). Snow Goose and Brant are on the Yukon Conservation Data Centre's animal track list (animals considered of conservation concern in the Yukon) (Yukon CDC, 2019). They are included on the list because both species have limited breeding in the Yukon and, in the case of Brant, because of vulnerability during staging.

Population Status and Trends

Snow Goose, Yellowlegs, and Canada Goose populations that frequent the Yukon North Slope have increased since the 1970s (CWS Waterfowl Committee, 2017). The mid-continent population of White-fronted Geese (Yellowlegs) is estimated to have increased approximately five-fold from 1975 to 2016, with an average population of 2.3 million adults between 2012 and 2016. Lesser Snow Goose population estimates are based on harvest estimates and band returns on their wintering grounds, where the Western Arctic population, which frequents the Yukon North Slope, mixes with the Wrangell Island population. Estimates indicate that these two Snow Goose populations combined increased from about 300,000 in the 1970s to about 1.2 million adults between 2012 and 2016. Increases in the Snow Goose and Yellowlegs populations are attributed to conditions on their winter ranges, such as changes in land use and agricultural practices (CWS Waterfowl Committee, 2017).

Surveys on their wintering range indicate that the Black Brant population has changed little since the 1960s (CWS Waterfowl Committee, 2017). However, recent estimates based on recovery of bands from Black Brant indicate a decline in the population since the 1990s (Sedinger, Riecke, Leach, & Ward, 2019).

A majority of the participants in the study on Inuvialuit traditional knowledge of wildlife habitat on the Yukon North Slope noted increases in goose populations, especially Yellowlegs. Below are some comments from participants (WMAC (NS) & Aklavik HTC, 2018a, p. 48):

> …there's a lot of geese now… I see there's more than there used to be.
>
> … over the past ten years… it's a good, healthy [population]… both snow geese and yellowlegs.
>
> One thing about yellowlegs, they're really multiplying, which is really good…. Twenty years ago, you could see very few… [but, now] around this area, I could easily say there were at least… four thousand geese…

Harvest

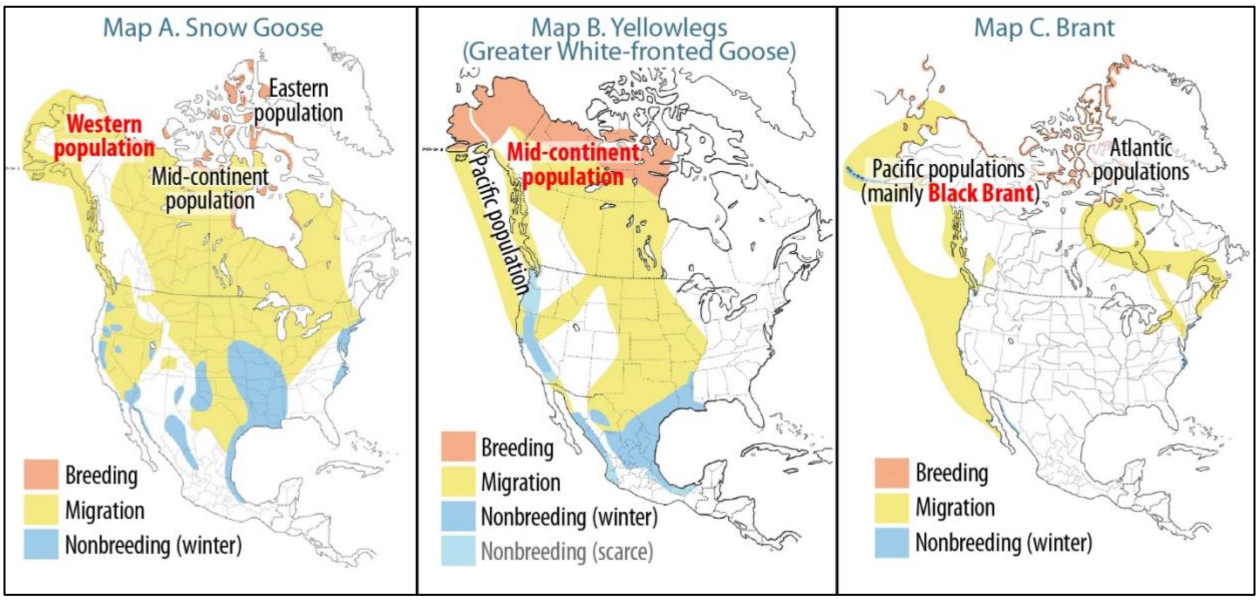
The Inuvialuit Final Agreement (1984) guarantees Inuvialuit the exclusive right to harvest geese in Ivvavik and Herschel Island–Qikiqtaruk parks, and the preferential right to harvest geese on the remainder of the Yukon North Slope. There are no restrictions (such as seasonal closures or harvest limits) on Inuvialuit goose harvest. Non-Inuvialuit hunters are subject to the Migratory Birds Regulations, which set out open and closed seasons and other restrictions. The Regulations allow for a spring hunt of Snow Geese in the Yukon and NWT (CWS Waterfowl Committee, 2018).

In 2014 the Western Arctic population of Lesser Snow Geese was designated as "overabundant" through Canada's Migratory Birds Regulations (CWS Waterfowl Committee, 2014). This designation is applied when the numbers of geese are such that they may damage habitat or lead to other negative effects. The overabundant designation provides for tools to reduce the population size, including allowing a spring harvest all along the geese's migration route through southern Canada.

Transboundary Considerations

All geese present on the Yukon North Slope have continental ranges. They migrate each spring to the Arctic to nest and return to wintering grounds each fall. Snow Geese, Yellowlegs, and Canada Geese winter in the US and Mexico. Black Brant spend the winter along the Pacific Coast from Alaska to Baja California in Mexico. **Error! Reference source not found.** shows the continental year-round ranges of the main goose species, including the populations that frequent the Yukon North Slope. Conservation and management require coordinated efforts across breeding, migration, and non-breeding (winter) rang

Map 11- 5. North American seasonal ranges of Snow Geese, Yellowlegs, and Brant



The populations labelled in red are those frequenting the Yukon North Slope. Adapted from species range maps in *Birds of North America* (Cornell Lab of Ornithology, n.d.)

Goose staging areas include several jurisdictions, as they are dispersed across the Alaskan and Yukon North Slopes and extend to the Mackenzie Delta in the NWT. During the fall staging period, geese move among staging areas, likely primarily depending on snow conditions. The Yukon and Alaska Beaufort coast and Mackenzie Delta staging areas combined are used each fall by as many as 600,000 Snow Geese (Pacific Flyway Council, 2013, based on an estimate from 1986).

Observations, Concerns, and Threats

Conservation issues identified for the three designated Important Bird Areas along the Yukon coast are:

- Potential damage from oil and gas development and associated infrastructure;

- Rapid shoreline erosion leading to loss of habitat through a decrease in area of spits and low-lying coastal lands (IBA Canada, n.d.).

A concern expressed by Inuvialuit land users is that, although Yellowlegs and Snow Geese numbers have increased in recent years, migration routes have changed, making geese less available to harvesters. The conservation requirements for geese set out in the Wildlife Conservation and Management Plan aim to address these concerns in a broad way, through space and protection from impacts of development.

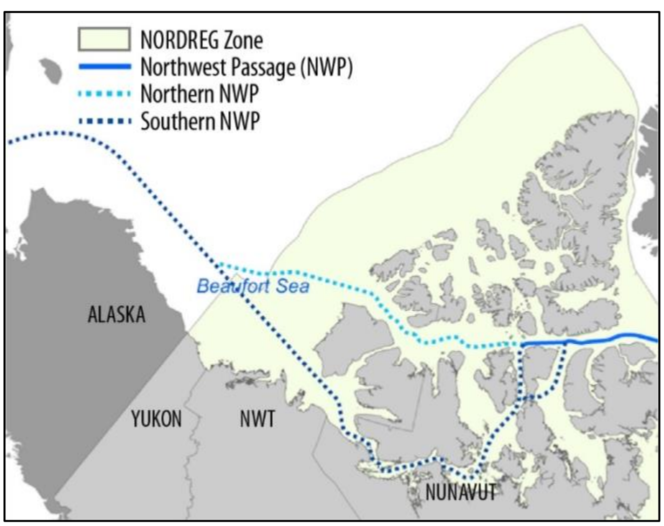
Development Activity

Impacts from development activities include disturbance of geese and other waterbirds from aircraft overflights, and risk of damage to habitat and to the birds from oil spills or other accidents, such as well blow-outs. An important source of potential impacts, in addition to oil and gas exploration and development, is ship traffic. Growing marine traffic is associated with increased risk of impacts from spills of oil or other toxic substances, as well as potential for increased disturbance to geese if nearshore boat and cruise ship activity increases.

Ship traffic is increasing in the Canadian Arctic, with additional growth expected as the seas become more navigable due to climate change impacts on sea ice. The greatest change observed in the past 15 years along the Yukon coast is an increase in traffic from pleasure craft (Dawson et al., 2020). This category of shipping includes all small craft not used for commercial purposes.

Northwest Passage shipping routes are becoming increasingly feasible for commercial shipping. Both the northern and the southern shipping routes pass through the marine waters of the Yukon North Slope, but at different distances offshore from the Yukon coast.

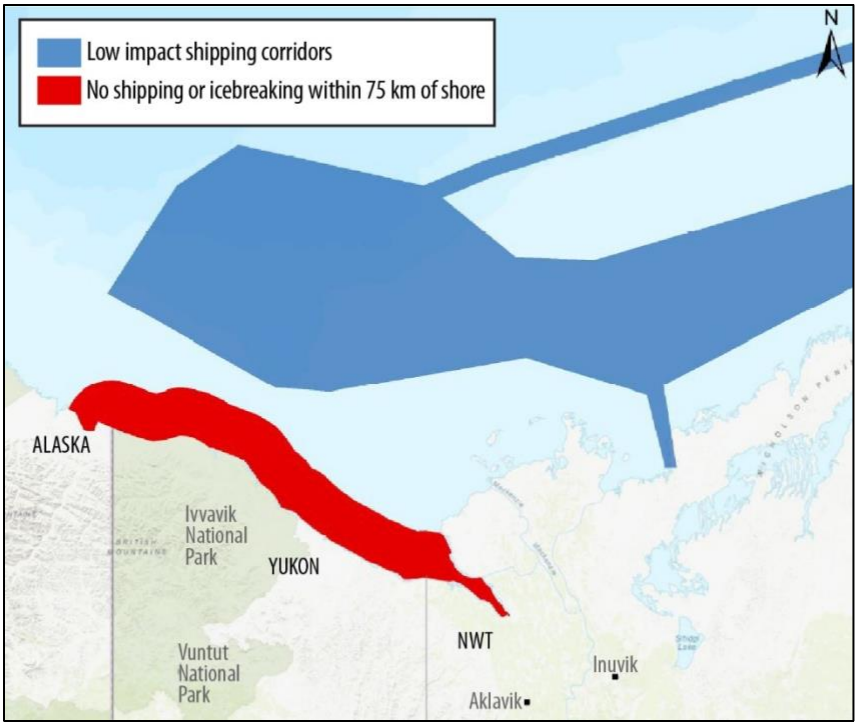
Map 11- 6. Northwest Passage shipping routes west of Hudson Bay



NORDREG = Northern Canada Vessel Traffic Services.
Adapted from Dawson et al. (2018), Figure 1.

Recommendations for low-impact shipping and no-shipping corridors, based on a Government of Canada initiative (Arctic Corridors Research, 2020) with input from the Aklavik Inuvialuit community, are shown on Map 11- 6. The recommended corridors and zone include results of consultation with Inuvialuit community members.

Map 11- 7. Recommendations for low impact shipping corridors and no shipping or icebreaking zone, Yukon North Slope and adjacent waters



From the Aklavik community report of the *Arctic Corridors and Northern Voices* initiative, Carter et al. (2018), adapted from Map 21. The no-shipping zone extends into Alaska and the NWT, reflecting Aklavik Inuvialuit traditional knowledge and use areas.

Risks of impacts from development activities on geese and other waterbirds have been studied since the 1970s in relation to proposals for oil and gas development and exploration activities. Studies are at various scales, including the Alaska and Yukon North Slopes (e.g., Davis & Wiseley, 1973, effects of aircraft flights on staging Snow Geese); the Canadian Beaufort Sea region (e.g., Dome Petroleum Ltd., Esso Resources Canada Ltd., & Gulf Canada Resources Inc., 1982, on impacts of oil spills); and studies specific to the Yukon North Slope (e.g., Gollop, Black, Felske, & Davis, 1974, on effects of disturbance on Brant; Vermeer & Anweiler, 1975, on vulnerability of birds to oil spills).

Oil Spills

Oil spills pose a greater threat to Yukon North Slope birds such as seaducks and shorebirds that feed and rest in marine habitat, than to geese, which frequently feed and rest on land (Vermeer & Anweiler, 1975). The exception is Brant geese, as they are mainly in marine and estuarine ecosystems throughout the year. Brant are particularly vulnerable to oil spills because they often nest right at the water's edge and forage in the intertidal zone. Other geese nesting on the Yukon coast (mainly Yellowlegs) would also be vulnerable to spills when they are molting, and oil could contaminate their nesting areas (Dome Petroleum Ltd. et al., 1982).

The Beaufort Regional Environmental Assessment developed oil spill vulnerability profiles for key species considered vulnerable to spills, including Snow Geese, Brant, and two species of sea ducks (BREA, 2016). The information includes areas and times of year when the key species are particularly vulnerable, and exposure and thresholds for damage from oil spills. The analysis concluded that molting and staging waterfowl would be at risk from oil slicks in near-shore bays, lagoons, and estuaries, especially in areas where they congregate (BREA, 2015). The Beaufort Regional Coastal Sensitivity Atlas (Government of Canada, 2015) provides a synthesis of environmental information relevant to oil-spill preparation and response measures, including maps showing seasonal distribution of waterfowl, shorebirds, and seabirds.

Disturbance from Aircraft

The *Inuvialuit Settlement Region Traditional Knowledge Report* (ICC, TCC, & ACC, 2006) study participants noted that aircraft activity disturbs geese and interferes with the goose harvest.

> "Geese they fly when they hear helicopters ... it's hard to hunt when they keep flying away" (ICC et al., 2006, p. 4-1)

An Alaskan study found that Brant were much more vulnerable to disturbance from aircraft than were Canada Geese, with 75% of Brant flocks taking flight in response to overflights, and only 9% of Canada Geese taking flight (Ward, Stehn, Erickson, & Derksen, 1999). Helicopter flights were more disruptive than fixed-wing overflights. A study of the behaviour of Snow Geese staging on the Yukon and Alaska North Slopes and their reaction to aircraft disturbance found that aircraft overflights reduced the time geese spent feeding during staging (Davis & Wiseley, 1973). A Quebec study concluded that human-caused disturbance can have a significant impact on geese's energy reserves (Belanger & Bedard, 1990).

While avoiding overflights is a best-practice for limiting wildlife disturbance, with overabundant geese populations on the Yukon North Slope, it is unlikely that aircraft disturbance is causing population level impacts.

Impacts from Climate Change

Interviews with Aklavik Inuvialuit land users demonstrate the range of potential effects of climate change on geese (WMAC (NS) & Aklavik HTC, 2018a, p. 48):

> Seven individuals suggested that climate change may also be altering goose habitat, although responses varied regarding specific impacts. Two interviewees noticed geese arriving at the study area earlier, and one interviewee stated concern that increasingly erratic weather may result in geese arriving to the region too soon, exposing themselves to late spring cold spells. Other concerns included drying out of nesting habitat or flooding and salt kill from coastal storms. One interviewee suggested that warmer weather might benefit geese, especially during the nesting period.

Effects on Goose Habitats

Snow Geese, Yellowlegs, and Canada Geese forage in a range of ecosystem types distributed across the coastal plain and inland. Vegetation communities on the Yukon North Slope are being affected now by climate change and are likely to change more in the future (Myers-Smith et al., 2019). These changes, including increased spread of shrubs and taller plant growth, are likely to alter the distribution and suitability of goose habitats, but the overall effect of these changes on the geese is difficult to predict.

Brant have more specific habitat needs than the other Yukon North Slope goose species, as they nest, feed, and raise their young in coastal and estuarine salt marshes (Cornell Lab of Ornithology, n.d.). Changing air and water temperatures, water flows and levels, erosion, sedimentation, and wave action are some factors that affect the extent and quality of salt marshes available to Brant. Coastal salt marshes have expanded on the Alaskan Beaufort coastal plain, due to permafrost thaw, subsidence of ice-rich tundra, and increased erosion, leading to increased sedimentation (Tape, Flint, Meixell, & Gaglioti, 2013). The increase in coastal salt marshes has been linked to a shift in distribution of Brant since the 1970s (Tape et al., 2013).

Warmer Temperatures and Earlier Springs

A study on the Alaskan North Slope looked at trends in first arrival dates of 16 migratory bird species over a period of 50 years (Ward et al., 2016). The trend was to earlier arrival—on average by 6 days over the 50-year period. This corresponds to about 1 day earlier for every 1-degree annual change in temperature. Yellowlegs and Snow Geese had the greatest rates of change in arrival date of all migratory birds: their dates of arrival advanced at a rate of almost 2 days per decade (arriving, on average, nearly 10 days earlier by 2013 than in the mid 1960s). These geese appear to be able to adjust their migration patterns to take advantage of earlier spring plant growth.

Because Brant lay their eggs soon after they arrive in the Arctic, they depend on the food in their wintering areas in Pacific coastal ecosystems for nutrition for egg development (Hupp, Ward, Soto, & Hobson, 2018). Their wintering areas are likely to become poorer for goose foraging due to effects of a warming climate on important Brant foods, especially eelgrass (*Zostera marina*) (Hupp et al., 2018; Ward et al., 2005). A study of Black Brant showed that the number of nests at a major Alaskan nesting area have been declining since the mid-1990s and that the first-year and adult survival rates for the population as a whole have also declined (Leach et al., 2017). The study authors consider that these changes may be due to poorer foraging conditions on wintering and migration habitats along the Pacific coast.

Earlier springs are likely to improve spring foraging conditions in the Arctic, which may improve reproductive success for Western Arctic Lesser Snow Geese and Yellowlegs. These geese populations spend time foraging in the Arctic before they nest—therefore they acquire most of the nutrients for egg development after they have arrived in the Arctic (Hupp et al., 2018). However, although early springs tend to favour the production and laying of eggs, the growth and survival of the goslings may be negatively affected. This can happen if the peak of spring plant growth has passed when the goslings are in most need of an abundant supply of food (Nolet, Schreven, Boom, & Lameris, 2019).

Goose Overabundance

The Western Arctic population of Lesser Snow Geese is estimated to be 1.3 million, a significant increase from the estimated 300,000 birds in the 1970s (CWS, 2020). Since Snow Geese forage by pulling out the roots of grasses and sedges, they can damage or destroy habitat for other species. This happens especially in high-use or high-density areas such as those near breeding colonies. Because of its increasing population, the Western Arctic population of Lesser Snow Geese was designated as overabundant in 2014, due to the potential for severe damage to arctic and subarctic vegetation and the other species that depend on the same habitat (CWS, 2020).

An overabundance of Snow Geese in other Arctic areas has led to overgrazing of areas where the geese nest (CWS Waterfowl Committee, 2014; Lefebvre et al., 2017). Intensive feeding by geese removes vegetation and can change soil conditions and moisture level, leading to permanent changes in ecosystems (CWS Waterfowl Committee, 2014). Overgrazing by Snow Geese has had impacts on vegetation on the main nesting grounds of the Western Arctic Snow Goose population on Banks Island, though a 2010 study concluded that these impacts were not as severe as in the Eastern Arctic (Hines et al., 2010). Snow Goose overgrazing may be contributing to a reduction in the amount of surface water on western Banks Island by altering permafrost and vegetation cover around ponds (Campbell, Lantz, & Fraser, 2018).

As many thousands of Snow Geese forage intensively on the Yukon North Slope during fall staging, overabundance could lead to impacts, especially on coastal lowland ecosystems where Snow Geese feed on the underground parts of tall cotton-grass. A research project on effects of Snow Goose foraging on the Alaskan North Slope indicated that the amount of cotton-grass, both above and below ground, was reduced by goose grazing for 2 to 4 years after feeding (Hupp, Robertson, & Schmutz, 2000). The study concluded that there were likely no long-term effects on vegetation communities because the geese move among foraging areas from year to year, allowing the cotton-grass to recover. This need to rotate areas contributes to the large spatial requirement of Snow Geese during fall staging (Hupp et al., 2000).

Aklavik Inuvialuit traditional knowledge holders, while reporting that goose numbers have increased, have not reported observations of goose overgrazing (WMAC (NS) & Aklavik HTC, 2003, 2018a). In the fall, geese spread out and forage inland on berries. Several people commented that coastal lowland goose habitat is not affected by the increase in geese; they noted that geese shift around as the rivers and ocean current change, and the swamp grass (cotton-grass) that the geese eat on mud flats grows back (WMAC (NS) & Aklavik HTC, 2003).

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.

Habitat Conservation

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016)
  The Eastern Yukon North Slope (East of the Babbage River) is identified as critical waterfowl habitat, with geese using the area for fall staging and swans using the area for summer molting and nesting.

- Important Bird and Biodiversity Areas (IBAs) (IBA Canada, n.d.)
  Canada's Important Bird and Biodiversity Areas Program aims to identify, conserve, and monitor sites that provide essential habitat for bird populations. IBAs are sites that support threatened birds, large groups of birds, and/or birds with restricted by ranges or habitat. IBAs are identified using international criteria. This designation is useful in promoting transboundary collaboration to conserve habitats and in setting conservation priorities. Three IBAs are within the Yukon North Slope (shown on Map 11- 2).

- Park plans (Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018; Parks Canada, 2018)
  Conservation of goose habitat is encompassed by the goals and actions to maintain ecological integrity (Goal 1) and to maintain traditional use and cultural connection (Goal #4) in the Herschel Island-Qikiqtaruk Plan and the strategy to understand and conserve natural resources of Ivvavik National Park (Strategy #1).

Population Management

Legislation that provides tools for population management consists of the Migratory Birds Convention Act and regulations (Canada, 2017; CWS Waterfowl Committee, 2018) and the Inuvialuit Final Agreement (Canada, 1984).

At the population level, plans and initiatives for migratory waterfowl monitoring and management are coordinated by teams with representatives from jurisdictions over the continental range of each population. Management plans are in place for three of the goose populations that frequent the Yukon North Slope. Each plan includes an assessment of the population status and trends, and conservation strategies. There is no management plan for Canada Geese in this region.

- *Pacific Flyway Management Plan for the Western Arctic Population of Lesser Snow Geese* (Pacific Flyway Council, 2013)
  Management strategies relevant to the Yukon North Slope:
  - Habitat 1.b. Assess habitat conditions at important staging areas.
  - Harvest 6. Monitor subsistence harvest in Canada involving the subsistence users as data gatherers.
- *Management Plan for Midcontinent Greater White-Fronted Geese* (Flyway Councils, 2015)
  The plan has no strategies specific to the Yukon North Slope.
- *Management Plan for Pacific Population of Brant* (Pacific Flyway Council, 2018)
  Philips Bay is identified as a nesting/molting area for Brant.
  Management strategy relevant to the Yukon North Slope:
  - Harvest Assessment 3. Determine magnitude and distribution of subsistence Brant harvest in Canada.

Research and Monitoring Programs

- *Arctic Goose Joint Venture* (Arctic Goose Joint Venture, 2019)
  The Arctic Goose Joint Venture sets priorities and facilitates research and monitoring for goose populations that breed in the Arctic and migrate to wintering areas in southern Canada, the United States, and Mexico. The Canadian Wildlife Service and Ducks Unlimited Canada are partners in this initiative.
- Harvest monitoring: Inuvialuit Harvest Study (IRC, 2017, 2018, 2019)
  Annual harvest monitoring in the ISR from 2016-2019 was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included goose harvest monitoring. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information, including harvest locations, through monthly interviews with active harvesters. Results were summarized for each community in annual newsletters. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

Knowledge about locations and ecosystems that are important, such as seasonal habitat for geese on the Yukon North Slope, is based on Inuvialuit traditional knowledge and periodic aerial surveys, particularly surveys from the 1970s and 1980s. Goose habitat models for the YNS have been developed based on traditional knowledge of important habitat characteristics for nesting, foraging and staging. Population information is based on results of banding studies, surveys, and harvest statistics, generally assessed at the continental or national scale. Traditional knowledge provides information on local population trends.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- *Aklavik Inuvialuit Describe the Status of Certain Birds and Animals on the Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2003).
  This study is based on 10 interviews and a workshop conducted in 2003. Results are presented for 21 species, including Yellowlegs, Snow Goose, and Brant. Four additional waterbirds are featured: Common Eider, Long-tailed Duck, Red-necked Phalarope, and Scoters (White-winged and Surf). Information is included on wildlife numbers, ranges, habitat, and condition.

- *Local Ecological Knowledge of Staging Areas for Geese in the Western Canadian Arctic* (Bartzen, 2014)
  This project's objectives were to identify staging areas and document observations of changes in goose migration patterns and numbers. Participants marked areas where they had observed 1,000 or more geese. The information they provided was compiled onto maps. Results for the Yukon North Slope are summarized in the Habitat for Geese section.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope (WMAC (NS) & 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. The results were used in developing the Plan and are described and referenced throughout this chapter.

Assessments and Syntheses of Surveys

- *Population Status of Migratory Waterbirds on the Yukon Coastal Plain and Adjacent Mackenzie Delta* (Hawkings, 1987)
  This Canadian Wildlife Service report summarizes survey-based information on geese and other waterbirds for the Yukon coastal area up to the mid-1980s. The author concludes that the most significant components of waterbird ecology along the Yukon coast, from a national perspective, are the fall concentrations of Lesser Snow Geese throughout the coastal plain and the midsummer concentration of molting seaducks at Herschel Island. The report includes a data appendix with results of all waterbird studies along the Yukon coast conducted from 1971 to 1985.

- *Key Areas for Birds in Coastal Regions of the Canadian Beaufort Sea* (Alexander et al., 1988)
  In this Canadian Wildlife Service report, survey data up to the mid-1980s are compiled onto maps that outline areas of high, medium, and low use for a range of waterbirds in Canadian coastal regions of the Beaufort Sea. The maps are accompanied by descriptions of key seasonal waterbird habitats. Maps are presented for the Yukon coast for spring, summer, and fall.

- *Beaufort Regional Environmental Assessment* (BREA, 2016)
  BREA was a four-year research program (2012-2015) focused on research to inform decision-makers on offshore oil and gas development in the Beaufort Sea. Research areas included:
  - Coastal and marine birds
  - Information for key species of birds, fish, and marine mammals (Valued Ecosystem Components, or VECs)—This project included assembling existing data and filling information gaps with traditional knowledge. Lesser Snow Goose and Black Brant are included in the list of priority species to protect from oil spills. Vulnerability profiles were developed for these two goose species.

- *Population Status of Migratory Game Birds in Canada* (CWS Waterfowl Committee, 2017)
  This report presents continental population status and trends for goose populations that frequent the Yukon North Slope.

- *Beaufort Regional Strategic Environmental Assessment* (BRSEA, 2018; KAVIK-Stantec Inc., 2020)
  This assessment, launched in 2016 and completed in 2020, provides analysis of environmental considerations, strategic direction, and recommendations on future offshore oil and gas activity in the ISR.

Research

Research that is of interest for goose conservation on the Yukon North Slope includes studies from other areas on impacts of climate change on Arctic-breeding geese, impacts on ecosystems from goose overabundance, and research on the effects of oil spills and disturbance on geese. Research projects related to their wintering ranges and population dynamics are also relevant. For example, an ongoing study on the populations of Lesser Snow Geese and Greater White-fronted Geese that frequent the Yukon North Slope includes research on the goose populations' wintering grounds in California, and tracking of individual geese to learn more about migration timing and routes (USGS, n.d.).

References

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

Alexander, S. A., Barry, T. W., Dickson, D. L., Prus, H. D., & Smyth, K. E. (1988). *Key Areas for Birds in Coastal Regions of the Canadian Beaufort Sea*. Edmonton, Alberta: Canadian Wildlife Service.

Arctic Corridors Research. (2020). Arctic Corridors: Research for policy on shipping governance in Arctic Canada. Retrieved January 20, 2020, from http://www.arcticcorridors.ca/

Arctic Goose Joint Venture. (2019). Arctic Goose Joint Venture. Retrieved from https://www.agjv.ca/

Bartzen, B. (2014). *Local Ecological Knowledge of Staging Areas for Geese in the Western Canadian Arctic*. Environment Canada.

Belanger, L., & Bedard, J. (1990). Energetic cost of man-induced disturbance to staging snow geese. *The Journal of Wildlife Management*, *54*(1), 36. https://doi.org/10.2307/3808897

BREA. (2015). *Species Oil Spill Vulnerability Profiles (VPs) For Net Environmental Benefit Analysis (NEBA) In the Beaufort Sea (workshop presentation)*. Beaufort Regional Environmental Assessment 2015 Research Results Forum, Inuvik NWT, February 24-28 2015.

BREA. (2016). *Beaufort Regional Environmental Assessment Key Findings: Research and Working Group Results. March 2016*. Canada.

BRSEA. (2018). Beaufort Regional Strategic Environmental Assessment. Retrieved November 25, 2018, from https://rsea.inuvialuit.com/

Campbell, T. K. F., Lantz, T. C., & Fraser, R. H. (2018). Impacts of climate change and intensive lesser snow goose (*Chen caerulescens caerulescens*) activity on surfacewater in high arctic pond complexes. *Remote Sensing*, *10*(12). https://doi.org/10.3390/rs10121892

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

Canada. *The Inuvialuit Final Agreement, as Amended, Consolidated Version April 2005*. , (1984).

Canada. *Migratory Birds Convention Act , 1994. Current to December 3, 2019. Last amended on December 12, 2017.* , (2017).

Carter, N., Dawson, J., Parker, C., Cary, J., Gordon, H., Kochanowicz, Z., & Weber, M. (2018). *Arctic Corridors and Northern Voices: Governing marine transportation in the Canadian Arcitc (Aklavik, Northwest Territories community report)*. https://doi.org/10.20381/RUOR37326

Communities of Aklavik; Inuvik; Holman Island; Paulatuk and Tuktoyaktuk, Nickels, S., Buell, M., Furgal, C., & Moquin, H. (2005). *Unikkaaqatigiit-Putting the Human Face on Climate Change: Perspectives from the Inuvialuit Settlement Region*. Ottawa, ON: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.

Cornell Lab of Ornithology. (n.d.). Birds of North America. Retrieved January 10, 2020, from https://birdsna.org/Species-Account/bna/home

COSEWIC. (2020). COSEWIC candidate wildlife species; updated March 6, 2020. Retrieved April 20, 2020, from http://cosewic.ca/index.php/en-ca/reports/candidate-wildlife-species#toc1

CWS Waterfowl Committee. (2014). *Migratory Birds Regulations in Canada: July 2014*. Canadian Wildlife Service.

CWS Waterfowl Committee. (2017). *Population Status of Migratory Game Birds in Canada*. Environment and Climate Change Canada.

CWS Waterfowl Committee. (2018). *Migratory Birds Regulations in Canada 2018/2019 and 2019/2020 Hunting Seasons*. Environment and Climate Change Canada.

Davis, R. A., & Wiseley, A. N. (1973). Normal behaviour of snow geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behaviour, September, 1973. *Arctic Gas Biological Report Series*, *27*(2).

Dawson, J., Carter, N., van Luijk, N., Parker, C., Weber, M., Cook, A., … Provencher, J. (2020). Infusing inuit and local knowledge into the low impact shipping corridors: An adaptation to increased shipping activity and climate change in Arctic Canada. *Environmental Science and Policy*, *105*(January), 19–36. https://doi.org/10.1016/j.envsci.2019.11.013

Dawson, J., Pizzolato, L., Howell, S. E. L., Copland, L., & Johnston, M. E. (2018). Temporal and spatial patterns of ship traffic in the Canadian arctic from 1990 to 2015. *Arctic*, *71*(1), 15–26. https://doi.org/10.14430/arctic4698

Dome Petroleum Ltd., Esso Resources Canada Ltd., & Gulf Canada Resources Inc. (1982). *Accidental spills*. Volume 6 of Hydrocarbon Development in the Beaufort Sea - Mackenzie Delta Region. Environmental Impact Statement.

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.

Flyway Councils. (2015). *Management Plan for Midcontinent Greater White-Fronted Geese*. Prepared for the: Central Flyway Council, Mississippi Flyway Council, Pacific Flyway Council, Canadian Wildlife Service, United States Fish and Wildlife Service.

Gollop, M. A., Black, J. E., Felske, B. E., & Davis, R. A. (1974). Disturbance studies of breeding black brant, common eiders, glaucous gulls, and Arctic terns at Nunaluk Spit and Philips Bay, Yukon Territory, July 1972. In and J. A. L. W. W. H. Gunn (Ed.), *Disturbance to birds by gas compressor noise simulators, aircraft and human activity in the Mackenzie Valley and the North Slope, 1972* (pp. 153–203). Arctic Gas Biol. Series Vol. 14.

Government of Canada. (2015). *Beaufort Regional Coastal Sensitivity Atlas*. Retrieved from http://publications.gc.ca/collections/collection_2015/ec/En4-250-2014-x-eng.pdf

Hawkings, J. S. (1987). *Population Status of Migratory Waterbirds on the Yukon Coastal Plain and Adjacent Mackenzie Delta*. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

Hines, J. E., Latour, P. B., & Machtans, C. S. (2010). *The effects on lowland habitat, breeding shorebirds and songbirds in the Banks Island Migratory Bird Sanctuary Number 1 by the growing colony of Lesser Snow Geese (Chen caerulescens caerulescens)*. Canadian Wildlife Service.

Hupp, J. W., Robertson, D. G., & Schmutz, J. A. (2000). Recovery of tall cotton-grass following real and simulated feeding by snow geese. *Ecography*, *23*, 367–393.

Hupp, J. W., Ward, D. H., Soto, D. X., & Hobson, K. A. (2018). Spring temperature, migration chronology, and nutrient allocation to eggs in three species of arctic-nesting geese: Implications for resilience to climate warming. *Global Change Biology*, *24*(11), 5056–5071. https://doi.org/10.1111/gcb.14418

IBA Canada. (n.d.). Canadian Important Bird and Biodiversity Areas. Retrieved December 8, 2018, from https://www.ibacanada.ca/index.jsp?lang=en

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. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

KAVIK-Stantec Inc. (2020). *Beaufort Regional Strategic Environmental Assessment: Data Synthesis and Assessment Report*. Retrieved from https://rsea.inuvialuit.com/docs/brsea_final.pdf

Leach, A. G., Ward, D. H., Sedinger, J. S., Lindberg, M. S., Boyd, W. S., Hupp, J. W., & Ritchie, R. J. (2017). Declining survival of black brant from subarctic and arctic breeding areas. *Journal of Wildlife Management*, *81*(7), 1210–1218. https://doi.org/10.1002/jwmg.21284

Lefebvre, J., Gauthier, G., Giroux, J. F., Reed, A., Reed, E. T., & Bélanger, L. (2017). The greater snow goose Anser caerulescens atlanticus: Managing an overabundant population. *Ambio*, *46*, 262–274. https://doi.org/10.1007/s13280-016-0887-1

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

Nolet, B. A., Schreven, K. H. T., Boom, M. P., & Lameris, T. K. (2019). Contrasting effects of the onset of spring on reproductive success of Arctic-nesting geese. *The Auk*, ?(?), ukz063. https://doi.org/10.1093/auk/ukz063

Pacific Flyway Council. (2013). *Pacific Flyway Management Plan for the Western Arctic Population of Lesser Snow Geese*.

Pacific Flyway Council. (2018). *Management Plan: Pacific Population of Brant*.

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

Round River Conservation Studies. (2018). *Yukon North Slope Baseline Ecological and Cultural Conservation Assessment: Traditional Knowledge-based Goose Habitat Model (Draft report for review)*.

Sedinger, J. S., Riecke, T. V., Leach, A. G., & Ward, D. H. (2019). The black brant population is declining based on mark recapture. *Journal of Wildlife Management*, *83*(3), 627–637. https://doi.org/10.1002/jwmg.21620

Sinclair, P. H., Nixon, W. A., Eckert, C. D., & Hughes, N. L. (2003). *Birds of the Yukon Territory*. UBC Press.

Tape, K. D., Flint, P. L., Meixell, B. W., & Gaglioti, B. V. (2013). Inundation, sedimentation, and subsidence creates goose habitat along the Arctic coast of Alaska. *Environmental Research Letters*, *8*(4). https://doi.org/10.1088/1748-9326/8/4/045031

USGS. (n.d.). Goose Population Dynamics in the California Central Valley and Pacific Flyway. Retrieved January 20, 2020, from https://www.usgs.gov/centers/werc/science/goose-population-dynamics-california-central-valley-and-pacific-flyway?qt-science_center_objects=0#qt-science_center_objects

Vermeer, K., & Anweiler, G. (1975). Oil threat to aquatic birds along the Yukon coast. *The Wilson Bulletin*, 467–480.

Ward, D. H., Helmericks, J., Hupp, J. W., Mcmanus, L., Budde, M., Douglas, D. C., & Tape, K. D. (2016). Multi-decadal trends in spring arrival of avian migrants to the central Arctic coast of Alaska: Effects of environmental and ecological factors. *Journal of Avian Biology*, *47*(2), 197–207. https://doi.org/10.1111/jav.00774

Ward, D. H., Reed, A., Sedinger, J. S., Black, J. M., Derksen, D. V., & Castelli, P. M. (2005). North American Brant: Effects of changes in habitat and climate on population dynamics. *Global Change Biology*, *11*(6), 869–880. https://doi.org/10.1111/j.1365-2486.2005.00942.x

Ward, D. H., Stehn, R. A., Erickson, W. P., & Derksen, D. V. (1999). Response of Fall-Staging Brant and Canada Geese to Aircraft Overflights in Southwestern Alaska. *The Journal of Wildlife Management*, *63*(1), 373–381.

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). (2012). *Species Status Reports for the Yukon North Slope*. Retrieved from Wildlife Management Advisory Council (North Slope) website: 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 CDC. (2019). Yukon Conservation Data Centre Animal track list. Retrieved from https://yukon.ca/en/animal-track-list

`

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 12: Furbearers

Amaruq, Qavvik, Tigiganniaq, Kayuqtuq, Kivigaluk

Publication Information

Cover photo: Kayuqtuq (Red Fox), Jay Frandsen, © Parks Canada/Jay Frandsen, 2018

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 12: Furbearers

Amaguq, Qavvik, Tigiganniaq, Kayuqtuq, Kivgaluk

Table of Contents

Maps

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 four 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: Furbearers / Amaruq, Qavvik, Tigiganniaq, Kayuqtuq, Kivigaluk

This companion report provides information on the conservation requirements for furbearers 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 furbearers, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for furbearers on the Yukon North Slope

1. Conservation of large tracts of diverse ecosystem types with ample prey.
2. Protection of denning areas for wolves.
3. Research and monitoring of distribution and seasonal movements of furbearers in relation to changing climate and changing ecosystems.

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

Furbearers on the Yukon North Slope

Furbearers are a diverse category of species that are grouped in this report based on their importance in Inuvialuit culture and land-use. These species are hunted or trapped primarily (but not exclusively) for their fur and include wolf, wolverine, lynx, arctic fox, red fox, mink, marten, snowshoe hare, and muskrat.

Traditional Use

Hunting and trapping of furbearers has played a major role in Inuvialuit culture, economy, and use of the Yukon North Slope. Fur is an important component of traditional clothing, often preferred for trim on parkas and use in moccasins (ICC, TCC, & ACC, 2006; WMAC (NS), 2012), and hunting and trapping of furbearers is a significant Inuvialuit seasonal land-use (WMAC (NS) & Aklavik HTC, 2018b). Many families have trap lines that have been passed down for generations. Others gather seasonally in the same locations to harvest furbearers. In this way, traditional use of furbearers is an important component of Inuvialuit cultural expression and knowledge transmission.

> It's our traditional rat [muskrat] camp where we spring out... from when I was a little boy growing up until I was about 15... I still go out every year, but my mother and my older sister and their kids, they always spring out every year. It's still a tradition for the family to go out... that's our traditional rat camp, where we do all the muskrat hunting, and that's where it is, on Taylor Channel.
>
> Pin 121, reproduced from *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) and Aklavik HTC, 2018, p. 74)

Inuvialuit use of furbearers on the Yukon North Slope has been resilient in the face of immense change, summarized here and expanded upon in WMAC (NS) & Aklavik HTC (2018b). Until the mid 1900s, most Inuvialuit lived off the land, from hunting, fishing, trapping and collecting. Inuvialuit on the Yukon North Slope became involved in the fur trade economy as early as 1850, trading arctic fox with the Hudson's Bay Company (Nagy, 1994; WMAC (NS) & Aklavik HTC, 2018b). The subsequent establishment of trading posts along the coast led to continued growth in the fur trade, eventually transforming the traditional economy and social fabric (Nagy, 1994). Even as commercial whaling collapsed, trade for artic fox pelts endured throughout the early 1900s with Hudson's Bay Company posts at Qikiqtaruk (Herschel Island) and Pauline Cove (WMAC (NS) & Aklavik HTC, 2018b). Additionally, muskrat and mink were heavily harvested in the Mackenzie Delta, leading Hudson's Bay Company to establish a post in Akalvik in 1912, while independent fur traders and the Canalaska Company also purchased from Inuvialuit and Gwich'in harvesters (Freeman, 1976).

While the fur trade was a driving influence in Inuvialuit land-use through the early 1900s, it was subject to the dynamics of the international market. With the end of the prosperous 1920s and the onset of the Great Depression, demand collapsed, eventually leading the Hudson's Bay Company to close its Hershel Island Post in 1938 (WMAC (NS) & Aklavik HTC, 2018b).

Despite the depressed market for fur, hunting and trapping of muskrat continued to play a major role in Inuvialuit culture, with extensive harvest on the waterways north of Aklavik and Inuvik (Freeman, 1976). Increased Canadian Government and non-Indigenous presence in the arctic significantly (and negatively) impacted Inuvialuit use of the Yukon North Slope. Christian missions in Aklavik, residential schooling (with mandatory attendance), government codification of trapping, and industrial activity associated with the centre of Inuvik fundamentally altered the lifestyles and culture of Inuvialuit. These changes caused families to live in or near communities for most of the year, forced a greater reliance on wage labour, took children away from family-centred activities, and caused the loss of language, cultural values and traditional practices. In turn, Inuvialuit grew less reliant on the trapping economy (Freeman, 1976; WMAC (NS) & Aklavik HTC, 2018b).

While the fur trade does not represent the major economic influence that it once did for Aklavik Inuvialuit, harvesting furbearers is still a part of Inuvialuit culture. Furbearers comprise part of the mixed-cash economy in Aklavik (Usher, 2002) and the sale of pelts at auction contributes to income (ICC et al., 2006; WMAC (NS) & Aklavik HTC, 2018b).

Muskrat harvesting represents a major component of seasonal land-use for Aklavik land-users. The Mackenzie Delta is well-traveled in the spring by harvesters (Map 12-1), with some harvesters choosing to set traps and others preferring to hunt with small-caliber rifles, often based out of their family camps (C.K. Turner, 2018; WMAC (NS) & Aklavik HTC, 2018b). Recent harvest studies underscore this importance, as muskrat harvest continues in high numbers (Inuvialuit Harvest Study, 2003; IRC, 2017, 2019a).

> I had caught rats [muskrats] all my life after I went to school. My grandpa used to teach me how to set them, and I rat lots. Then I teach him [her husband] how to set a fox [trap]....We had a big trapline....I skinned a lot of rats, a lot, a lot. Sometimes he'd just about get 300 a night, and that's a lot of skinning....It didn't take me very long to clean them. Then [a person] was down by his camp. He had dogs, but he didn't hunt there, because he was alone. [I] used to talk on CB [Citizens Band radio] and tell him, "Come over and get some muskrat meat for your dogs." He used to come; he used to bring a lot of cans, so we filled them up with muskrat for his dogs.
>
> *PIN 8, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p.73)*

Inuvialuit also continue to harvest a wide range of other furbearers. This includes arctic and coloured fox, lynx, marten, mink, wolf, rabbits, and wolverine (IRC, 2017, 2019a; WMAC (NS) & Aklavik HTC, 2018b). Land-users either maintain traplines or harvest these species opportunistically, hunting furbearers when they are encountered during travel. Fur is either sold at market or used for crafting or clothing (ICC et al., 2006). Species such as wolverine are highly valued for trim in parkas and moccasins (WMAC (NS), 2012).

> Of course we get lots of foxes along here and wolves. I don't think we can mark them all… Furbearers, like fox, lynx, mink and muskrat of course. This is where we hunt muskrat [pointing to map]… I don't know if we can mark it all…
>
> *Pin 2, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p.74)*

> Throughout the travel, you're going to be coming across tracks. You're looking at them and you're going to see wolf tracks. You're going to see wolverine tracks. You go out on the tundra… all you're going to see is tracks a lot of times… If you come across them, then you run them down… I travel not much for trapping, more for hunting. And I got wolverines here and there. A caribou kill up here where previous hunters had shot a caribou, [what] the guys will do is gut it, take the guts out and whatnot, leave the skin, and then you'll go back there the day after. Usually fresh

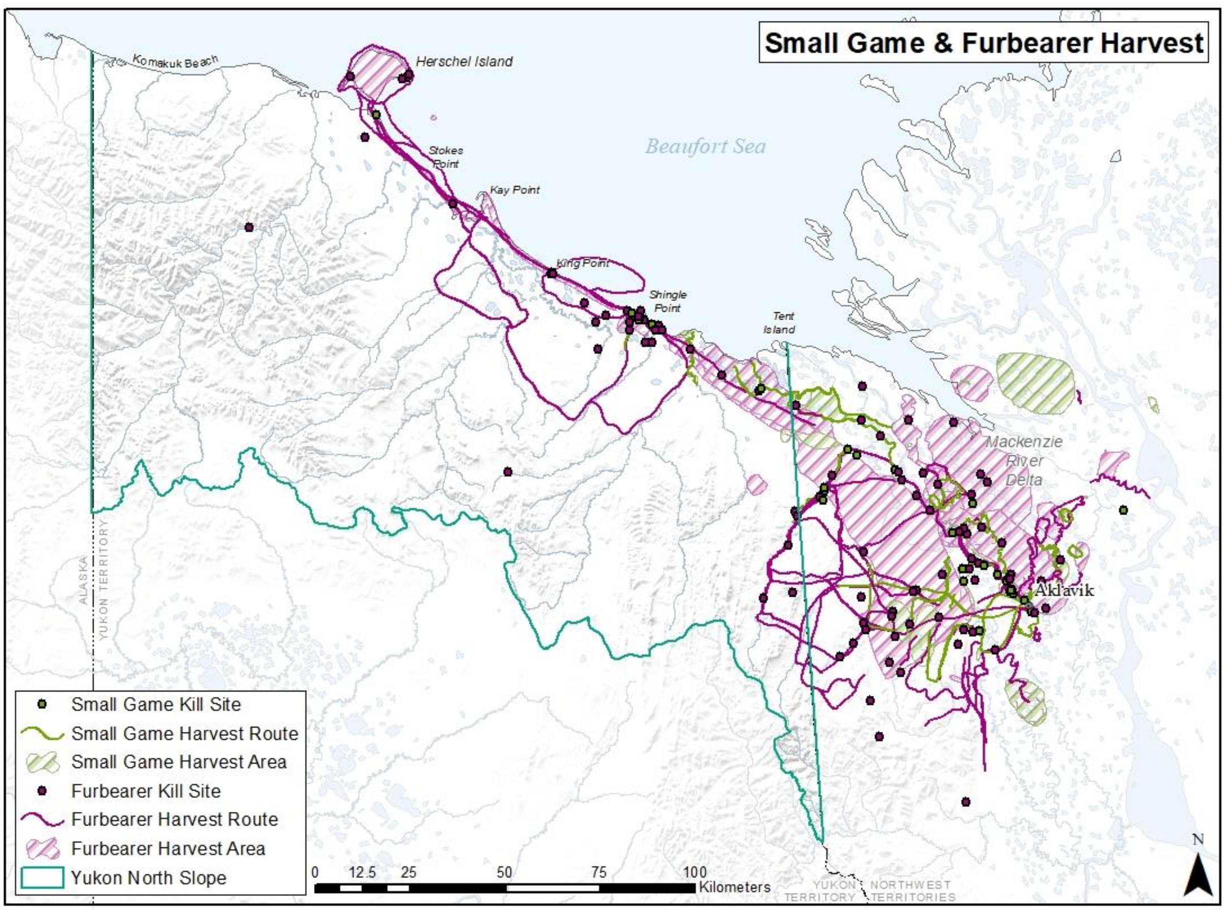
blood would attract animals; foxes, raves, wolverines… And that's where I got a wolverine – up in here [pointing to map].

Pin 101, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p.72)

There's a seismic line that goes all the way along the front of the mountains here, and then comes back out this way, and it comes all the way to this creek over here [pointing to map]. There's a whole trapline through there… [The seismic lines are] overgrown but I keep them open… Trapped a wolf… right here [pointing to map]… I got a bunch of wolves up this creek right here… same place as my trapping area; they always go there… I got wolverine all along this [pointing to map]… Over the years I got maybe twenty wolverines out there.

Pin 117, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p.73)

Map 12– 1. Furbearer and small game harvesting on the Yukon North Slope



Aklavik land-users mapped the hunting and trapping of furbearers as part of the Traditional Use Study. Source: WMAC (NS) and Aklavik HTC (2018b), Map 8.

Habitat for Furbearers

Furbearers are a diverse group of species with varying habitat and ecological requirements. They can be found in habitats across the Yukon North Slope, including sea ice, coastal plains, valleys, hillsides, and mountains. Specific habitat requirements vary. The conservation requirements for furbearers in the *Yukon North Slope Wildlife Conservation and Management Plan* include conservation of large tracts of diverse ecosystems with ample prey as well as protection of denning areas for wolves.

Wolf (Amaruq, *Canis lupus*)

Wolf habitat use is driven largely by proximity to ungulate prey. Research on the Yukon North Slope has shown a distinction between taiga and tundra dwelling wolf populations. Taiga dwelling wolves are territorial, preying upon caribou when available, but relying on moose and sheep year-round. Tundra-dwelling wolves are migratory and follow seasonal caribou movements (Hayes, Baer, & Clarkson, 2016). Denning success above treeline is dependent on sufficient ungulate populations traveling within proximity to wolves as they are rearing their pups (WMAC (NS), 2012). Suitable denning sites are limited on the Yukon North Slope, and therefore their conservation is a key requirement for maintaining healthy wolf populations. Known den locations were catalogued for internal use as part of the Inuvialuit traditional knowledge report on wildlife habitat on the Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a). Inuvialuit have also described wolves traveling to sea ice to hunt seal pups (WMAC (NS) & Aklavik HTC, 2018b).

Wolverine (Qavvik, *Gulo gulo*)

Wolverines are widely distributed across the Yukon North Slope at low densities (WMAC (NS), 2012). Inuvialuit descriptions of wolverine habitat emphasize mountains and foothills as primary habitat; however, seasonal habitat extends all the way to the near-shore ice, where wolverine have been observed hunting seals in the spring (WMAC (NS) & Aklavik HTC, 2003).There has been little targeted habitat research regarding wolverine on the Yukon North Slope. Proximity to major prey bases, such as the Porcupine caribou herd, are likely key determinants of wolverine location in any given season or year (WMAC (NS), 2012).

Research in northern Alaska aids understanding of wolverine habitat requirements in the arctic. Wolverine on the Alaskan North Slope show greater habitat occupancy in more rugged terrain with drier, well-drained soils (Poley, Magoun, Robards, & Klimstra, 2018). Persistent spring snow cover has previously been considered obligatory for successful wolverine denning, but aerial surveys of wolverine den sites on the Alaskan tundra found little persistent snow in late May, suggesting a need for further research on habitat requirements for denning (Magoun, Robards, Packila, & Glass, 2017).

> You always start seeing wolverine tracks and wolf tracks heading to the ocean. They're hunting the seal pups. As the winter moves on… we see seal pups that goes all the way to the shore, and then head back out again. That's when the wolverines and the wolves [are] heading to the ocean.
>
> *Pin 6, reproduced from Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) and Aklavik HTC, 2018, p.35)*

Arctic fox (Tigiganniaq, *Vulpes lagopus*)

Arctic fox populations are found across the Yukon North Slope and on Qikiqtaruk. Rodents comprise a major portion of their prey base, but seal carcasses left by polar bears are an important additional food source (Gallant, Reid, Slough, & Berteaux, 2013; Gallant, Slough, Reid, & Berteaux, 2012). Inuvialuit land-users have also described arctic foxes following polar bears to scavenge seal carcasses (WMAC (NS) & Aklavik HTC, 2003).

The availability of suitable denning locations, as well as competition with red foxes appear to be the limiting factors in arctic fox population numbers. Arctic foxes prefer well-drained soils and varied topography for denning, and breeding distributions tend to be concentrated on the coastal plain and Qikiqtaruk (Gallant et al., 2013; WMAC (NS), 2012). Gallant et al. (2013) found proximity to adequate shelter is the driving factor in den site selection for arctic foxes, particularly in the presence of red fox populations. Known arctic fox den locations were mapped for internal use as part of the recent report on Inuvialuit knowledge of wildlife habitat on the Yukon North Slope (WMAC (NS) & Aklavik HTC, 2018a).

Red fox (Kayuqtuq, *Vulpes vulpes*)

Red foxes are habitat generalists whose presence on the Yukon North Slope is scarcer than in the rest of the Yukon (WMAC (NS), 2012). Inuvialuit land-users have described red fox presence in varied locations, ranging from the Mackenzie Delta to Qikiqtaruk, with den sites along river channels, lake shores, and in valleys (WMAC (NS) & Aklavik HTC, 2003). Climate change is widely hypothesized to support range expansion of red fox into arctic regions. However 40 years of den surveys on the Yukon North Slope did not show a significant change in competitive balance between arctic and red foxes (Gallant et al., 2012). Red fox den site selection is driven by proximity to a large prey base, primarily of rodents (Gallant et al., 2013).

Muskrat (Kivigaluk, *Ondatra zibethicus*)

Muskrat primarily occur in the waterways of the Mackenzie Delta but also can be found in portions of the Yukon North Slope (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016). In the summer, they forage on shoreline vegetation. Submerged macrophytes and roots below the ice are muskrat food sources during the winter (Jelinski, 1989). Recent research in the Mackenzie Delta suggests that muskrats are more likely to occur in lakes with longer perimeters, higher amounts of forage biomass, and conditions that support macrophyte growth (Chanda K. Turner, Lantz, & Fisher, 2020).

Other furbearers

Other furbearers on the Yukon North Slope include snowshoe hare (Ukalliq, *Leupus americanus),* mink (Itigiaqpak, *Neovison vison),* American marten (Qavviatchiaq, *Martes americana),* and lynx (Niutuyiq, *Lynx canadensis).* Little published information exists regarding habitat for these species in the region. Beaver (Kiqiaq, *Castor canadensis*) are also moving into the Beaufort coastal plain, possibly in response to increased shrub growth (Jung et al., 2016). Snowshoe hare are common and traditional use studies indicate they are frequently harvested throughout the study area (Usher, 2002; WMAC (NS) & Aklavik HTC, 2018b). Inuvialuit land-users have described low and high shrub vegetation cover (including willows) as important for hares (WMAC (NS) & Aklavik HTC, 2003). Mink and marten are trapped in small numbers in the Mackenzie Delta and areas close to Aklavik. Lynx are also trapped near Aklavik, often along old seismic lines (WMAC (NS) & Aklavik HTC, 2018b).

Furbearer Populations

Furbearer populations fluctuate naturally across the Yukon North Slope in relation to prey and habitat availability (Hayes et al., 2016; WMAC (NS), 2012; WMAC (NS) & Aklavik HTC, 2003). Of the major furbearers in the region, only wolverine is legally designated as a species at risk (Special Concern) in Canada. This ranking is likely a result of changes elsewhere in Canada, as northern populations are thought to be stable (COSEWIC, 2014).

Table 12– 1. Furbearer statuses Canada, Yukon, and global, 2021

Species	SARA Status (Canada)	COSEWIC Status (Canada)	Canadian Endangered Species Conservation Council Status	Yukon Status*	NatureServe Status (Global)
Grey Wolf	Not at risk	Not at risk	N5: Secure	S4: Apparently Secure	G5: Secure
Wolverine	Special Concern	Special Concern	N3: Vulnerable	S3: Vulnerable	G4: Apparently Secure
Arctic Fox	No Ranking	No Ranking	N5: Secure	S2: Imperiled	G5: Secure
Red Fox	No Ranking	No Ranking	N5: Secure	S5: Secure	G5: Secure

Muskrat	No Ranking	No Ranking	No Ranking	S4/S5: Apparently Secure/Secure	G5: Secure
Canada Lynx	No Ranking	Not at risk	N5: Secure	S5: Secure	G5: Secure
American Marten	No Ranking	No Ranking	N5: Secure	S5: Secure	G5: Secure
American Mink	No Ranking	No Ranking	N5: Secure	S5: Secure	G5: Secure
Snowshoe Hare	No Ranking	No Ranking	No Ranking	S5: Secure	G5: Secure

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

Population Trends on the Yukon North Slope

There is limited quantitative data on furbearer populations across the Yukon North Slope. Many of these species' populations fluctuate naturally. Inuvialuit land-users have described a wide range in population numbers as a response to habitat or prey availability (WMAC (NS) & Aklavik HTC, 2003). The WMAC (NS) (2012) Species Status Report summarizes known population trends for some furbearers on the Yukon North Slope (Table 12-2).

Table 12– 2. Population trends of select furbearers, described in WMAC (NS) 2012 Status Report

Species	Population Trend	Details
Arctic fox (white fox) *Tigiganniaq*	Stable	Higher density of dens on Herschel Island (2-7/100km2) than on coastal plain (0-0.4/100km2)
Red fox (coloured fox) *Kayuqtuq*	Unknown	Fewer than 2 natal dens per year found in aerial surveys
Wolf *Amaruq*	Fluctuates based on ungulate availability	About 575 wolves were found in the northern Yukon in mid-1990s surveys
Wolverine *Qavvik*	Unknown	The size/density of Yukon North Slope wolverine populations is unknown
Varying hare (rabbit) *Ukalliq*	Fluctuates	No extensive research reported

Source: (WMAC (NS), 2012)

Population Trends in North America

Little information exists regarding North American population trends for many smaller furbearers. Given the globally secure status of these species (NatureServe, n.d.), there are few recovery and management plans available that summarize the greater population.

Large carnivores have been subject to significant human-caused mortality and range reductions across North America. Lethal population control has significantly reduced many large predator populations in the United States (Bergstrom et al., 2014), while habitat loss threatens population viability for species that have large home range requirements or narrow ecological niches (COSEWIC, 2014; Hornseth et al., 2014). The combination of these stressors has resulted in significant range reduction for large furbearers across North America. Species such as wolf, wolverine, and lynx have been extirpated from historic ranges (Aubry, Mckelvey, & Copeland, 2007; Devineau et al., 2010; Treves, Langenberg, López-Bao, & Rabenhorst, 2017).

Despite the significant overall reduction in large predators across North America, local population trends can vary significantly. Reintroduction efforts for species such as lynx and wolf have returned large furbearers to parts of their historic range (Devineau et al., 2010; Sime, 2012). Natural recolonization has occurred in some locations (Treves et al., 2017). Sub-population trends are often influenced by local human-wildlife dynamics, such as livestock conflict, hunting, trapping, poaching, or highway mortality (Lofroth & Ott, 2007; Sime, 2012; Treves et al., 2017), and do not necessarily correlate with a greater continental trend.

Population Management

The Inuvialuit Final Agreement grants Inuvialuit the exclusive right to harvest furbearers in the Inuvialuit Settlement Region. The Aklavik Community Conservation Plan (Aklavik HTC et al., 2016) notes that there are no species-specific management plans for the ISR but does describe several conservation measures for individual furbearer species (Table 12-3). Furbearer harvest was recorded in the Inuvialuit Harvest Study from 2016-2019 (IRC, 2017, 2018) and general conservation practices apply to all furbearers. These include avoiding den site disturbance, protecting habitat, and harvesting sustainably and only when fur is in prime condition (Aklavik HTC et al., 2016).

Table 12– 3. Community of Aklavik conservation measures for furbearers

Species	Conservation Measures
Arctic Fox Tigiganniaq	• Identify and protect important habitat • Only trap in season • Do not disturb denning foxes
Red Fox Kayuqtuq	• Identify and protect important habitat • Only trap in season • Do not disturb denning foxes
Wolf Amaruq	• Identify and protect important habitat • Do not harvest in summer when fur is poor • Hunt by traditional means, not by air or with poison • Do not disturb wolves or remove pups from den • Keep at least 500m from active dens • Submit information/samples from harvested wolves
Wolverine Qavvik	• Identify and protect important habitat • Do not disturb dens • Do not hunt in summer • Do not poison

Lynx Niutuyiq	• Harvest on sustainable basis • Identify and protect important habitat
Marten Qavviatchiaq	• Identify and protect important habitat • Only trap in season when pelt is prime
Mink Itigiaqpak	• Trap only when pelt is in prime condition • Identify and protect important habitat
Muskrat Kivigaluk	• Trap and hunt only in specific season • Identify and protect important habitat • Reduce number of beavers and otters
Snowshoe hare/rabbit Ukalliq	• Harvest sustainably • Identify and protect important habitat

Source: (Aklavik HTC et al., 2016)

Observations, Concerns, and Threats

Impacts of Climate Change

As temperature, precipitation, permafrost, and vegetation structure change, species with specific habitat requirements may be affected differently. For example, climate change may alter spring flood regimes in the Mackenzie Delta, thus altering lake forage and sediment characteristics that currently support muskrat populations (Chanda K. Turner et al., 2020). Delays in sea ice formation may impact arctic fox habitat use across the Yukon North Slope (WMAC (NS), 2012; WMAC (NS) & Aklavik HTC, 2003). And wolverine den site viability, while currently not of concern on the Yukon North Slope, may be impacted by loss of persistent snow cover (COSEWIC, 2014; Magoun et al., 2017; WMAC (NS), 2012).

Changing prey availability may impact furbearing predators. Foxes on the Yukon North Slope rely heavily on lemming (Qilakmiutaq) populations (Gallant et al., 2013), and considerable uncertainty exists regarding the impacts of climate change on lemmings in the Canadian Arctic. While there is no current evidence of lemming population changes on the Yukon North Slope, research in northern Europe has shown clear impacts of changing snow conditions on lemmings and the predator populations they support (McLennan et al., 2012).

Northward expansion of species into the region may impact traditionally harvested furbearers. Beaver populations are steadily increasing in the area, altering waterways and raising concern among Inuvialuit over impacts to muskrat populations (Aklavik HTC et al., 2016). Increasing interspecies competition has been predicted among red and arctic fox populations; however, den surveys have not shown a clear increase in generalist (red fox) populations (Gallant et al., 2012).

Climate change also impacts the quality of harvested species. Inuvialuit harvesters have commented that warmer weather and changes in seasonality have reduced the quality of harvested fur (not as thick, different colors, etc.), thus impacting the viability of the trapping economy (Nickels, Furgal, Buell, & Moquin, 2005).

Impacts from Human Activities

In areas with high levels of human activity and industrial development, furbearers may experience significant impacts. Habitat loss can significantly impact species with large home range requirements or narrow ecological niches, such as wolverine or lynx (COSEWIC, 2014; Hornseth et al., 2014). Human wildlife conflict has been a driving force behind the lethal control of numerous predators in the United States, including lynx, wolf, and wolverine (Bergstrom et al., 2014). Predator control as a part of ungulate population management has historically resulted in significant mortality rates (Government of Yukon, 2012).

On the Yukon North Slope, the intact landscape, with significantly lower human activity, reduces impacts to furbearers. There is possibility of localized decreases in species populations in areas easily accessed by Inuvialuit harvesters (WMAC (NS), 2012; WMAC (NS) & Aklavik HTC, 2003). However, Inuvialuit have a long history of sustainable, well-managed harvest and there are no immediate concerns regarding impacts from overharvesting of furbearers in the region. Research on wolf harvest in the region suggests that human hunting only has a minor effect on long-term population dynamics (Hayes et al., 2016), and wolverine harvest is considered sustainable (WMAC (NS), 2008). Little research exists on harvest impacts to other furbearer populations in the region.

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.

Furbearer Conservation and Management

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016)
  Population trends, conservation status, traditional use, and conservation measures are described for multiple furbearer species within the Aklavik planning area.
- *Ivvavik National Park of Canada Management Plan* (Parks Canada, 2018)
  Recognizes the inclusion of wolverine in national species at risk legislation.

- *Northern Yukon Regional Land Use Plan* (Vuntut Gwitchin Government & Yukon Government, 2009)
  Identifies landscape units and ecological values in the region immediately south of the Yukon North Slope. Includes consideration of furbearer habitat. Lists marten as a focal species that is tolerant of human disturbance.

- *Yukon Wolf Conservation and Management Plan* (Government of Yukon, 2012)
  Recommends management goals for wolves in the Yukon based on their ecological, cultural, and economic importance, with an aim to address human-wildlife conflict and promote education and research. Suggests an adaptive management approach to developing territorial hunting and trapping bag limits through consultation with First Nation and Inuvialuit.

- *Inuvialuit Harvesters Assistance Program* (IRC, 2019b)
  Sustainable resource harvesting is a cornerstone of Inuvialuit culture but has become more difficult due to a combination of factors, including the anti-fur lobby, decreased fur prices, and an associated reduction in incomes. The Harvesters Assistance Program was created in by the IRC, Inuvialuit Game Council, and the Government of the Northwest Territories to "provide assistance to Inuvialuit individuals and groups to engage in traditional and emerging renewable resources activities." The program also encourages the re-establishment of traditional skills needed for harvesting, particularly in youth. Subsistence harvesters can apply for funding through the program to offset the costs associated with traditional harvesting, such as equipment purchasing.

Research and Monitoring Programs

- Herschel Island Wildlife Monitoring (Cooley, Eckert, & Gordon, 2012; Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018)
  Herschel Island rangers record wildlife sightings during the operating season of mid-April-early September. The wildlife observation database spans over 20 years of field seasons and includes species accounts for furbearer observations (Table 12-4).

Table 12– 4. Observations of furbearer occurrence on Herschel Island

Species	**Herschel Island Occurrence**
Wolf *Amarguq*	Occasional visitor to the island, usually lone individuals
Arctic Fox *Tigigganniaq*	Generally present on the island when rangers arrive in April. Pairs den and rear young on island, likely leave island during the winter in search of food.
Red Fox *Kayuqtut*	Generally present on the island when rangers arrive in April, breed on Herschel but no observations of family groups on island. No evidence that red foxes are displacing arctic foxes on island.
Pine Marten *Qavviatchiat*	One record of a pine marten, photographed at Pauline cove on May 1, 2004

Ermine *Itiriakpuk*	Two records of ermine at Pauline Cove: May 1991 and August 2008
Least Weasel *Itigiaq*	Fairly common, resident species of the island
Mink *Itigiaqpak*	One record of mink at Pauline Cove in July 1997
Wolverine *Qavvik*	Regular visitor to the island; all observations are of single visitors
Lynx *Niutuyiq*	One record of a lynx seen at Pauline Cove in May 2010

Adapted from Cooley et al. (2012)

- Wolverine Carcass Collection (WMAC (NS), 2008)
  Between 2004 and 2007, hunters across the ISR submitted carcasses of harvested wolverines to their local HTC for measurement, stomach content analysis, and parasite and disease analysis. Results from the 04/05 season suggest that the harvest is sustainable. No giardia, cryptosporidiosis, or coccidia were detected.

- Ivvavik Wildlife Observations (Parks Canada, 2008)
  Parks Canada staff, researchers, and park visitors record incidental observations of wildlife populations in Aulavik, Ivvavik, and Tuktut Nogait National Parks.

- Harvest Monitoring: Inuvialuit Harvest Study (IRC, 2017, 2018, 2019a)
  Annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included furbearer harvest monitoring. The ISR Community-Based Monitoring Program was revised after 2014 to focus on harvest. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information, including harvest locations, through monthly interviews with active harvesters. CRTs submitted their results online to the ISR Platform. Results were summarized for each community in annual newsletters. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

There are no comprehensive studies that focus exclusively on furbearers on the Yukon North Slope. Instead, the knowledge base is spread across various species-specific research projects, status reports, management documents, traditional knowledge, and traditional use reports. The importance of furbearers in Inuvialuit culture, history, and land-use is well-documented. Scientific research on the Yukon North Slope has furthered the understanding of some species, such as wolves, wolverine and foxes, but not all furbearers.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- *Inuit Land Use and Occupancy Project* (Freeman, 1976)
  As part of the Inuit Land Use and Occupancy Project report, traditional use of the Beaufort Sea and Yukon North Slope was mapped across three time periods: the whaling and fur trade prior to 1930, the period between 1930 and 1955 when the fur trade became well-established in the Mackenzie Delta, and the period between 1955 and 1974, which was characterized by the development of the DEW Line and establishment of Inuvik. Traditional use was documented on 1:500,000 scale maps and shows harvest areas for a variety of species, including furbearers.

- *Yukon North Slope Inuvialuit Oral History* (Nagy, 1994)
  Researchers accompanied Inuvialuit land-users on field trips across the Yukon North Slope and Herschel Island to describe the history of the landscape and the Inuvialuit relationship with the land. The project discusses the lifestyle changes that accompanied major social shifts in the region, such as the development of the DEW Line and describes the traditional reliance on the Yukon North Slope for sustenance and economic support. Includes discussions of hunting and trapping for furbearers.

- *Inuvialuit Use of the Beaufort Sea and its Resources, 1960-2000* (Usher 2002)
  Comprehensive surveys of Inuvialuit harvesters were conducted as part of three different studies: The Area Economic Surveys (1960s), Inuit Land Use and Occupancy Project (1970s) and the Inuvialuit Harvest Study (1990s). These studies include a description of the level of furbearer harvest in the region.

- *Unikkaaqatigiit Inuit Perspectives on Climate Change* (Nickels et al. 2005)
  In response to rapid environmental change in the arctic, the Inuit Tapiriit Kanatami, the Nasivvik Centre for Inuit Health and Changing Environments at Laval University, and the Ajunnginiq Centre at the National Aboriginal Health Organization cooperated with regional Inuit communities to conduct a series of workshops discussing environmental change and its impacts on Inuit land-users. These workshops were held between 2002 and 2005, and included the ISR communities of Aklavik, Inuvik, Tuktoyaktuk, Paulatuk, and Ulukhaktok (known then as Holman Island). Aklavik residents identified climate change impacts on the hunting and trapping of furbearers.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b)
  In 2015, 40 Inuvialuit community members were interviewed in the community of Aklavik to describe their traditional use of the Yukon North Slope. Interviewees were asked to map

traditional use within their "living memory." In total, 2,091 features were mapped on 1:125,000-scale maps. This includes mapped locations and travel routes for furbearer harvest, and a discussion on the history, importance, and methods for harvesting furbearers.

- *Inuvialuit Traditional Knowledge of Wildlife Habitat on the Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2018a)
  Aklavik Inuvialuit participated in workshops and interviews to create an Indigenous classification of habitat types on the Yukon North Slope and describe the habitat requirements of key focal species. Furbearers were not one of the primary focuses, however denning locations for species such as arctic fox, wolverine, and wolf were mapped for internal use as part of this project.

Research

- Seasonal muskrat habitat use in the Mackenzie Delta (Jelinski, 1989)
  Research in the Mackenzie Delta shows muskrat burrows are closer to shallow water, gentle slopes, and greater cover. In the winter, muskrat move to deeper water, possibly to forage on submerged macrophytes and roots.

- Arctic fox and red fox den surveys (Gallant et al., 2012)
  40 years of den surveys on the Yukon North Slope and Herschel Island do not show evidence of red fox range expansion nor competitive exclusion of arctic foxes in the region.

- Den site selection by arctic and red foxes (Gallant et al., 2013)
  Research on the Yukon North Slope and Herschel Island shows that red foxes select dens sites based on accessibility to spring prey populations, while access to shelter is the most important factor in arctic fox den selection. This may result in negative impacts for arctic foxes that are excluded from prey-rich environments.

- Wolf ecology in the Porcupine Caribou Herd range (Hayes et al., 2016)
  Tundra dwelling wolves in the study area are migratory, following the Porcupine Caribou Herd. Taiga dwelling wolves are territorial, feeding on caribou when available, but relying on moose and sheep year-round. A predation rate model found that wolves were not the primary factor in limiting Porcupine Caribou Herd size in the study area.

- Detecting persistent snow at the wolverine den-site scale (Magoun et al., 2017)
  Persistent spring snow cover has previously been considered obligatory for wolverine denning success. Aerial surveys of known wolverine dens in the Rocky Mountains of the United States and on the Alaskan tundra assessed the level of snow present at den sites. There was considerably less persistent snow at the Alaskan den sites than the Rocky Mountain den sites in late May. The lack of snow found at Alaskan den sites suggests a need for further research on the relationship between denning wolverines and persistent spring snowpack.

- Distribution and occupancy of wolverines in northwest Alaska (Poley et al., 2018)
  Research on the spring distribution and occupancy of wolverines in the National Petroleum Reserve- Alaska focused on gathering baseline information to track changes over time. Wolverine occupancy was more likely in drier, well-drained habitats. Wolverines were also more likely to select more rugged or variable terrain. Terrain variability rather than elevation was suggested to be of greater importance in wolverine habitat selection.

- Muskrat habitat site selection (Chanda K. Turner et al., 2020)
  In the Mackenzie Delta, muskrats are more likely to occur in lakes with longer perimeters, higher amounts of forage biomass, and sediment characteristics that support macrophyte growth. The latter two of these characteristics are influenced by spring flood regimes, suggesting that climate change impacts may alter habitat suitability in the region.

References

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

Aubry, K. B., Mckelvey, K. S., & Copeland, J. P. (2007). Distribution and Broadscale Habitat Relations of the Wolverine in the Contiguous United States. *Journal of Wildlife Management*, *71*(7), 2147. https://doi.org/10.2193/2006-548

Bergstrom, B. J., Arias, L. C., Davidson, A. D., Ferguson, A. W., Randa, L. A., & Sheffield, S. R. (2014). License to Kill: Reforming Federal Wildlife Control to Restore Biodiversity and Ecosystem Function. *Conservation Letters*, *7*(2), 131–142. https://doi.org/10.1111/conl.12045

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. (2014). *COSEWIC Assessment and Status Report Wolverine Gulo gulo in Canada*. Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Devineau, O., Shenk, T. M., White, G. C., Doherty, P. F., Lukacs, P. M., & Kahn, R. H. (2010). Evaluating the Canada lynx reintroduction programme in Colorado: Patterns in mortality. *Journal of Applied Ecology*, *47*(3), 524–531. https://doi.org/10.1111/j.1365-2664.2010.01805.x

Freeman, M. M. R. (Ed.). (1976). *Inuit Land Use and Occupancy Project Report*. Retrieved from http://publications.gc.ca/site/eng/9.850125/publication.html

Gallant, D., Reid, D. G., Slough, B. G., & Berteaux, D. (2013). Natal den selection by sympatric arctic and red foxes on Herschel Island, Yukon, Canada. *Polar Biology*, *37*(3), 333–345. https://doi.org/10.1007/s00300-013-1434-1

Gallant, D., Slough, B. G., Reid, D. G., & Berteaux, D. (2012). Arctic fox versus red fox in the warming Arctic: Four decades of den surveys in north Yukon. *Polar Biology*, *35*(9), 1421–1431. https://doi.org/10.1007/s00300-012-1181-8

Government of Yukon. (2012). *Yukon Wolf Conservation and Management Plan*.

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

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

Hornseth, M. L., Walpole, A. A., Walton, L. R., Bowman, J., Ray, J. C., Fortin, M. J. E., & Murray, D. L. (2014). Habitat loss, not fragmentation, drives occurrence patterns of Canada lynx at the southern range periphery. *PLoS ONE*, *9*(11). https://doi.org/10.1371/journal.pone.0113511

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. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

IRC. (2019b). Inuvialuit Harvesters Assistance Program. Retrieved June 24, 2019, from Inuvialuit Regional Corporation website: https://www.irc.inuvialuit.com/program/inuvialuit-harvesters-assistance-program

Jelinski, D. E. (1989). Seasonal differences in habitat use and fat reserves in an arctic muskrat population. *Canadian Journal of Zoology*, *67*(2), 305–313. https://doi.org/10.1139/z89-045

Lofroth, E. C., & Ott, P. K. (2007). Assessment of the Sustainability of Wolverine Harvest in British Columbia, Canada. *Journal of Wildlife Management*, *71*(7), 2193. https://doi.org/10.2193/2007-095

Magoun, A. J., Robards, M. D., Packila, M. L., & Glass, T. W. (2017). Detecting snow at the den-site scale in wolverine denning habitat. *Wildlife Society Bulletin*, *41*(2), 381–387. https://doi.org/10.1002/wsb.765

McLennan, D. S., Bell, T., Berteaux, D., Chen, W., Copland, L., Fraser, R. H., … Zhang, Y. (2012). Recent climate-related terrestrial biodiversity research in Canada's Arctic national parks: Review, summary, and management implications. *Biodiversity*, *13*(3–4), 157–173. https://doi.org/10.1080/14888386.2012.720818

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

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

Nickels, S., Furgal, C., Buell, M., & Moquin, H. (2005). *Unikkaaqatigiit-Putting the Human Face on Climate Change: Perspecitives from Inuit in Canada*. Ottawa, ON: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.

Parks Canada. (2008). *Annual Report of Research and Monitoring in National Parks of the Western Arctic: 2008*.

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

Poley, L. G., Magoun, A. J., Robards, M. D., & Klimstra, R. L. (2018). Distribution and occupancy of wolverines on tundra, northwestern Alaska. *Journal of Wildlife Management*, *82*(5), 991–1002. https://doi.org/10.1002/jwmg.21439

Sime, C. A. (2012). Montana gray wolf conservation and management plan : 2005 annual report /. *Montana Gray Wolf Conservation and Management Plan : 2005 Annual Report /*. https://doi.org/10.5962/bhl.title.55041

Treves, A., Langenberg, J. A., López-Bao, J. V., & Rabenhorst, M. F. (2017). Gray wolf mortality patterns in Wisconsin from 1979 to 2012. *Journal of Mammalogy*, *98*(1), 17–32. https://doi.org/10.1093/jmammal/gyw145

Turner, C.K. (2018). *Springtime in the Delta: the sociocultural role of muskrats and drivers of their distribution in a changing Arctic delta*.

Turner, Chanda K., Lantz, T. C., & Fisher, J. T. (2020). Muskrat distributions in a changing Arctic delta are explained by patch composition and configuration. *Arctic Science*, *6*(2), 77–94. https://doi.org/10.1139/as-2018-0017

Usher, P. J. (2002). Inuvialuit Use of the Beaufort Sea and its Resources, 1960-2000. *Arctic*, *55*(December

2001), 18–28.

Vuntut Gwitchin Government, & Yukon Government. (2009). *North Yukon Regional Land Use Plan*.

WMAC (NS). (2008). *Research Funded Through the Inuvialuit Final Agreement 2005-2008*. 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). (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).

Wildlife Management Advisory Council
North Slope

Yukon North Slope Wildlife Conservation and Management Plan 2021

Companion Report 13: Dall's Sheep / Imnaiq

Publication Information

Cover photo:	Jay Frandsen, ©Parks Canada/Jay Frandsen, 2018
Copyright:	2021 Wildlife Management Advisory Council (North Slope)
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 13: Dall's Sheep / Imnaiq

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 four 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: Dall's Sheep / Imnaiq

This companion report provides information on the conservation requirements for Dall's sheep 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 Dall's sheep, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for Dall's sheep on the Yukon North Slope

1. Conservation of key habitat types and locations used by Dall's sheep, including mineral licks, lambing cliffs, and winter ranges.
2. Management of disturbance so that human activities do not reduce the ability of the range to support sheep, while recognizing harvest rights and ecotourism potential.
3. Monitoring of sheep populations and habitat use so that management measures that protect important sheep areas and habitat types can be adapted to the effects of climate change.

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

Dall's Sheep on the Yukon North Slope

Dall's Sheep (Imnaiq, *Ovis dalli dalli*) is one of two subspecies of thinhorn sheep. The other subspecies is Stone's sheep, found in the far south of the Yukon and British Columbia. Fannin's sheep, a hybrid of Dall's and Stone's sheep, is found in central Yukon (Environment Yukon, 2019).

Dall's sheep live in two separated regions of the Yukon North Slope: the British mountains west of the Firth River; and the Northern Richardson Mountains in the southeast of the region. Both of these sheep ranges are transboundary. In the British Mountains, sheep habitat extends into the Brooks Range in Alaska. The Northern Richardson Mountains Dall's sheep range extends into other land claims jurisdictions in Yukon and NWT. Within the Inuvialuit Settlement Region (ISR), Dall's sheep are only found on the Yukon North Slope.

Sheep are spotted along rocky ridges by Inuvialuit in summer and fall when people are hunting and travelling through these mountainous areas (WMAC (NS) & Aklavik HTC, 2018a). In summer sheep may be in the mountains or on slopes and valleys, close to mineral licks. They select areas near or on cliffs at lambing time. Rugged terrain and cliffs allow sheep to escape from predators. These windblown areas have less snow, making it easier for the sheep to access food. Dall's sheep generally return to the same winter, lambing, and summer areas year after year.

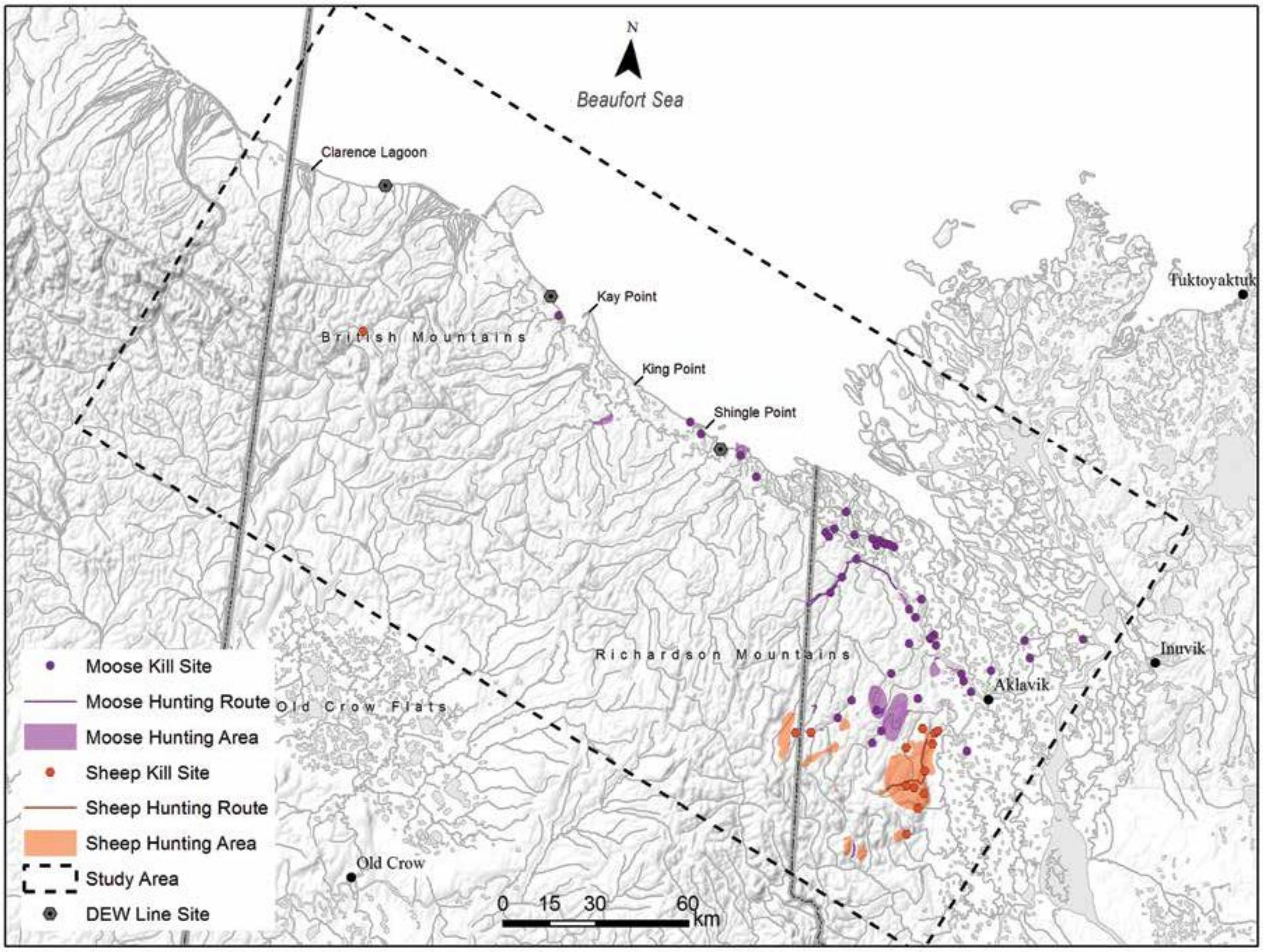
Traditional Use

The Yukon North Slope Inuvialuit Traditional Use Study (WMAC (NS) & Aklavik HTC, 2018b) provides documentation of past and current sheep harvest locations on the Yukon North Slope (Map 13– 1).

Aklavik Inuvialuit travel by snowmobile to the Northern Richardson Mountains to hunt Dall's sheep and other animals. The Black Mountain (Mt. Goodenough) area southwest of Aklavik in the NWT is an important harvesting area (Lambert Koizumi, Carey, Branigan, & Callaghan, 2011; WMAC (NS) & Aklavik HTC, 2018b). In the 1940s and 1950s sheep were harvested in the British Mountains in what is now Ivvavik National Park, but there is currently no harvest in this area (WMAC (NS), 2012).

> We always go up there when I was young. When we stayed at Qargialuk [Ptarmigan Bay] also at Itqiliqpik [Whale Bay]. We go hunt sheep when is long days after Christmas. When my dad get sheep and had enough for food, [then] we come back.
>
> *(1990 interview with Fred Inglangasuk, recorded by M. Nagy. From WMAC (NS) & Aklavik HTC, 2018b, p. 64)*

Map 13– 1. Moose and Dall's sheep harvest locations identified in Inuvialuit traditional use interviews



The interviewers asked Inuvialuit land users to identify hunting routes and areas used within living memory. Source: WMAC (NS) and Aklavik HTC (2018b), Map 8.

A 1991 dietary survey showed that sheep were not a major part of the diet of Aklavik Inuvialuit (Wein & Freeman, 1992). Of the 36 households surveyed, only 4 reported eating sheep at least once over the previous year.

Sheep are harvested in fall, winter, and spring, mainly using skidoos (ICC, TCC, & ACC, 2006). On average, 2 sheep were harvested annually by Aklavik Inuvialuit over the 10-year period from 1988 to 1997, as reported through the Inuvialuit Harvest Study (Inuvialuit Harvest Study, 2003, Table 21). Total harvest by Aklavik Inuvialuit from 2001 to 2010 ranged between 0 and 4 sheep per year (WMAC (NS), 2012). The average harvest

> **Importance of sheep**
>
> Meat from the Dall sheep is still a highly prized food. However, because of their distant range and low numbers, few people hunt them. There is still one hunter that gets them for their horns. These were traditionally used for making tools such as fishhooks and ulu handles, as you can boil and actually shape the horn. People also use it for carving.
>
> Excerpt from *Inuvialuit Settlement Region Traditional Knowledge Report* (ICC et al., 2006), p. 11-69

was also 2 sheep per year (ranging from 0 to 4 sheep) over the 3-year period from 2016 to 2018 (IRC, 2019). These numbers include any sheep harvested in the Northern Richardson Mountains in the NWT to the south of Aklavik, in the Gwich'in Settlement Area.

Habitat for Dall's Sheep

> Mostly the sheep would be in the high mountains—less snow—and [in] the springtime they would be heading down to the valley where there would be all the green grass. That's where they find the food, up in the high hills, but in the summertime where we are staying in the coastline because [of] the fresh tundra. Down the coastline it's all low ground so they [move down] more than on hills so it would be easy for them.
>
> *Inuvialuit Settlement Region Traditional Knowledge Report* (ICC et al., 2006), p. 11-67

Suitable Dall's sheep habitats have steep, rocky areas that provide escape terrain, interspersed with alpine, meadow or mountain slope habitats that provide forage. During winter they are limited to winter ranges, such as exposed areas on wind-blown slopes, that provide both escape terrain and available forage. Dall's sheep need a diversity of habitat features:

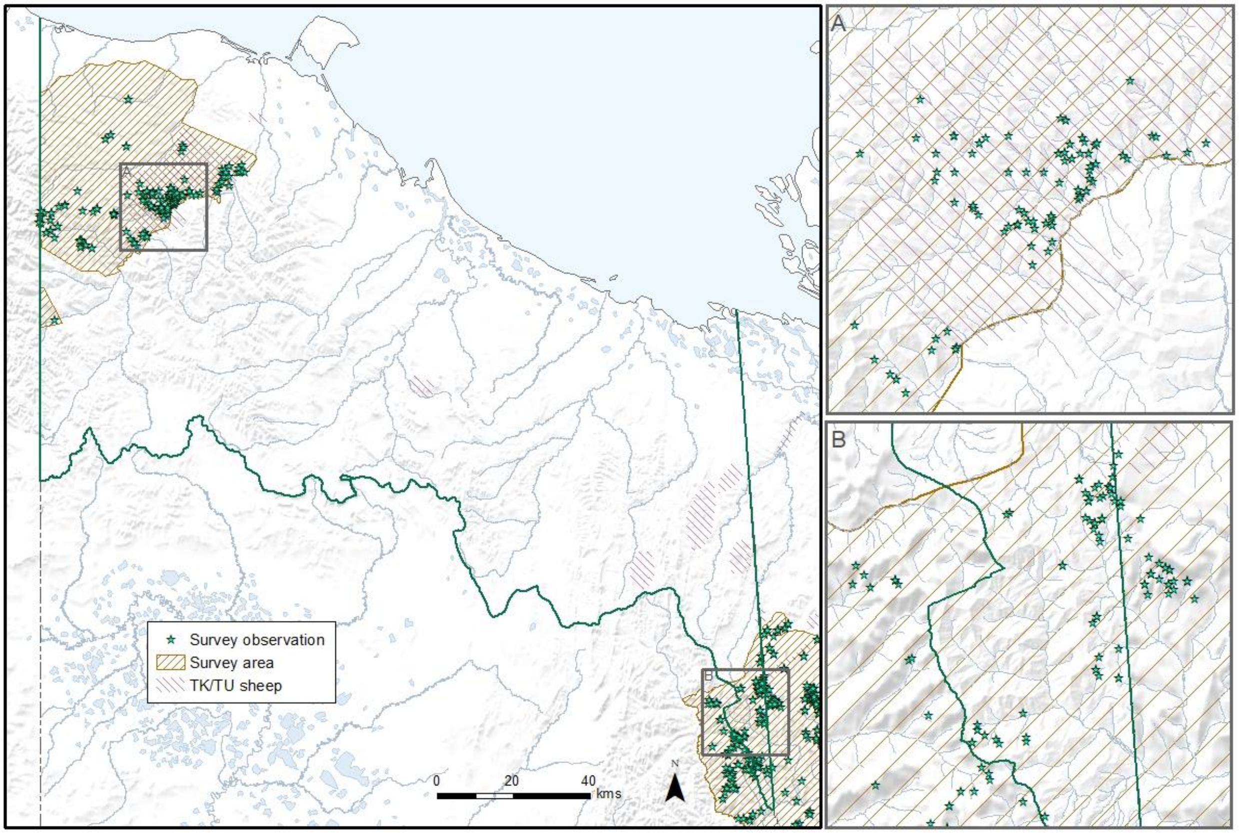
- Alpine ecosystems with a sufficient amount of food;
- Escape terrain;
- Birthing and resting areas;
- Mineral licks; and
- Unobstructed corridors for moving through the landscape over the seasons (Jex et al., 2016).

High quality winter range is particularly essential and may be the factor that limits populations (Barker, 2012). Dall's sheep are vulnerable to extreme weather events such as winter rain-on-snow and prolonged periods of cold spring rain (BCCDC, 2017; Jex et al., 2016; Lambert Koizumi et al., 2011).

Mineral licks are areas of highly mineralized soils that sheep (and other animals) consume to replenish important minerals, including sodium, magnesium and calcium (WMAC (NS), 2012). Dall's sheep herds typically have mineral licks they use frequently in the spring and summer. Lactating ewes appear to use the licks more than males or non-lactating ewes, likely reflecting the increased demands of milk production (Nichols & Bunnell, 1999).

Participants in the study documenting Inuvialuit traditional knowledge of Yukon North Slope wildlife habitat (WMAC (NS) & Aklavik HTC, 2018a) described sheep habitat in mountainous areas in the eastern and western edges of the Yukon North Slope (Map 13– 2). Sheep are generally seen in the summer and fall when land users are travelling through sheep habitat.

Map 13– 2. Dall's sheep: observations of their locations and areas that they frequent, based on surveys and Inuvialuit traditional knowledge



This map is from the Plan (WMAC (NS), 2022, Appendix 1). It is compiled from surveys in Ivvavik National Park and in the Northern Richardson Mountains, and Inuvialuit observations of areas where sheep are seen or hunted. Data sources: observations by Inuvialuit (WMAC (NS) & Aklavik HTC, 2018a) and survey data (Environment Yukon and Parks Canada).

Northern Richardson Mountains

Lambert Koizumi & Derocher (2019), looked at seasonal habitat use by Dall's sheep in the Northern Richardson Mountains. Habitat use by rams differed from habitat use by ewes over the seasons, with ewes and rams showing preferences for different slope aspects and different types of terrain. Choice of habitat appears to be influenced by two main factors: the quality and abundance of available food; and the risks from grizzly bear and wolf predation. Ewes and rams select different habitats at different times of the year. For example, ewes selected steep, rugged terrain suitable for escaping from predators during lambing and summer seasons, even though this terrain has poorer forage than the habitat types favoured by rams in those seasons. The highest densities of sheep occur in the Black Mountain area but concentrations also occur in other areas including the southeast most portion of the Inuvialuit Settlement Region in the Richardson Mountains.

British Mountains

The area between the Firth and Malcolm rivers is important sheep habitat throughout the year and sheep are often found in the Firth River canyon. Tors (rocky knobs on tops of hills), a landscape feature west of the Firth River, provide escape terrain in high alpine grazing areas in much of this area. The rugged high mountains located near the border with Alaska contain other important habitats. Dall's sheep are also occasionally found in other small, isolated pockets within the region. Mineral licks are found alongside Sheep Creek and likely occur in other areas within Dall's sheep range in the park.

Dall's Sheep Populations

Species Conservation Status

Table 13– 1. Dall's sheep conservation status: Canada, Yukon, and global

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 has been done; Dall's sheep is on the mid-priority list of terrestrial mammal species that are candidates for assessment (list date: Mar. 2020).	(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	S4: Apparently Secure*	(Canadian Endangered Species Conservation Council, 2016)(Yukon, 2020)
NatureServe	Global	G5: Secure*	(NatureServe, n.d.-b)

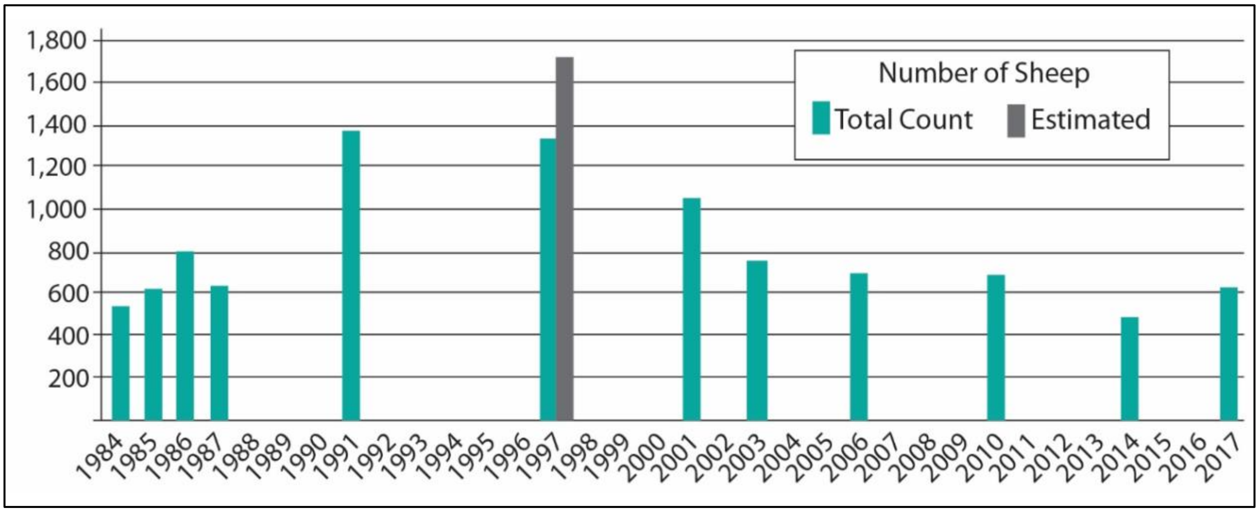
*Following the ranking system developed by NatureServe, an international network of conservation data centres (NatureServe, n.d.-a). G=Global; N=National; S=Subnational

Northern Richardson Mountains

The range of Dall's sheep in the Northern Richardson Mountains includes a relatively small area at the southeast edge of the Yukon North Slope. The range extends east to the NWT and south in the Yukon.

The number of Dall's sheep that range in the Northern Richardson Mountains increased in the 1980s and 1990s, and then rapidly declined from about 1,700 sheep in the 1990s to about 700 sheep in the early 2000s (Figure 13– 1). Predation by grizzly bears and wolves, climate change impacts, and harvest pressure are potential causes of the decline (Davison, Russell, & Belanger, 2018).

Figure 13– 1. Dall's sheep population size: aerial survey results, Northern Richardson Mountains, 1984 to 2017



Source: Davison et al. (2018), Figure 4

Dall's sheep in the Northern Richardson Mountains are at the northern edge of their range and are isolated from other populations. There is likely limited genetic mixing between different populations, particularly at the northern edge of the range. This may reduce the population's resilience to negative effects. The population is vulnerable to a range of factors, including adverse weather conditions, predation, and harvest (Lambert Koizumi & Derocher, 2019; WMAC (NS), 2012; Working Group for Northern Richardson Mountains Dall's Sheep, 2008).

Mapping the home ranges of several Dall's sheep and their main predators, grizzly bears and wolves, showed that the home range of the wolves coincided with most of the Dall's sheep range; and within the core area of Dall's sheep distribution, the overlap with grizzly bears was larger than with wolves (Lambert Koizumi & Derocher, 2010). In the areas most used by Dall's sheep, encounters with grizzly bears are likely more common than encounters with wolves.

British Mountains

Dall's sheep in the British Mountains are located in Ivvavik National Park. Before the park was created, a placer mine operated on Sheep Creek, from 1979 to 1986 (Parks Canada, 2017). Mining activity was a source of disturbance and displacement of the sheep from mineral licks (WMAC (NS), 2012). Dall's sheep are now an attraction for park visitors rafting the Firth River and staying at Imniarvik Fly-in Base Camp.

In Ivvavik National Park, incidental observations have been recorded since 1973, and aerial surveys for Dall's sheep have been conducted sporadically since 1984. Surveys are often conducted in subsequent years to better understand both summer and winter ranges. Given the number of years between surveys, population trends of Dall's sheep are currently unknown. However, the latest survey (winter 2019) did indicate a stable population, due to the age and sex composition.

Winter surveys were conducted in 2002 and 2019, and found between 71 and 188 sheep, mainly west of the Firth River. Total observations can be lower in winter surveys compared to summer ones due to the fact that Dall's sheep are often found on snow, making the observation challenging. The sheep that overwinter at the western edge of the Yukon North Slope are likely part of the larger population that extends through the Brooks Range in Alaska (Parks Canada, 2002). Summer surveys occurred in 1984, 1986, 2001, and 2017, and 84 to 221 total Dall's sheep were observed.

During June 2001 and March 2002 surveys and again in summer 2017 and winter 2019, Parks Canada determined the population size, structure, and types of habitat used by Dall's sheep in Ivvavik National Park (Parks Canada, 2001, 2002; WMAC (NS), 2003). Habitat was assessed by helicopter and sheep sightings were recorded and mapped. The surveys located lambing cliffs and key winter habitat. The summer 2017 survey found 221 Dall's sheep, including 139 adults and 32 yearlings. The winter 2019 survey found 188 Dall's sheep, of which 153 were adults. The age and sex composition of both these surveys indicated a stable population. The 2019 winter survey was also carried out to confirm winter range location and habitat use (WMAC (NS), 2019).

Dall's sheep numbers declined in the 1990s in the Brooks Range in Alaska, adjacent to the western edge of the Yukon North Slope (Battle & Stantorf, 2018). The 1985 estimate for the eastern Brooks Range was 12,000 sheep. The current number is not known, but the population is believed to have stabilized at a lower level. Annual surveys are conducted to detect trends (Battle & Stantorf, 2018).

Population Dynamics and Management

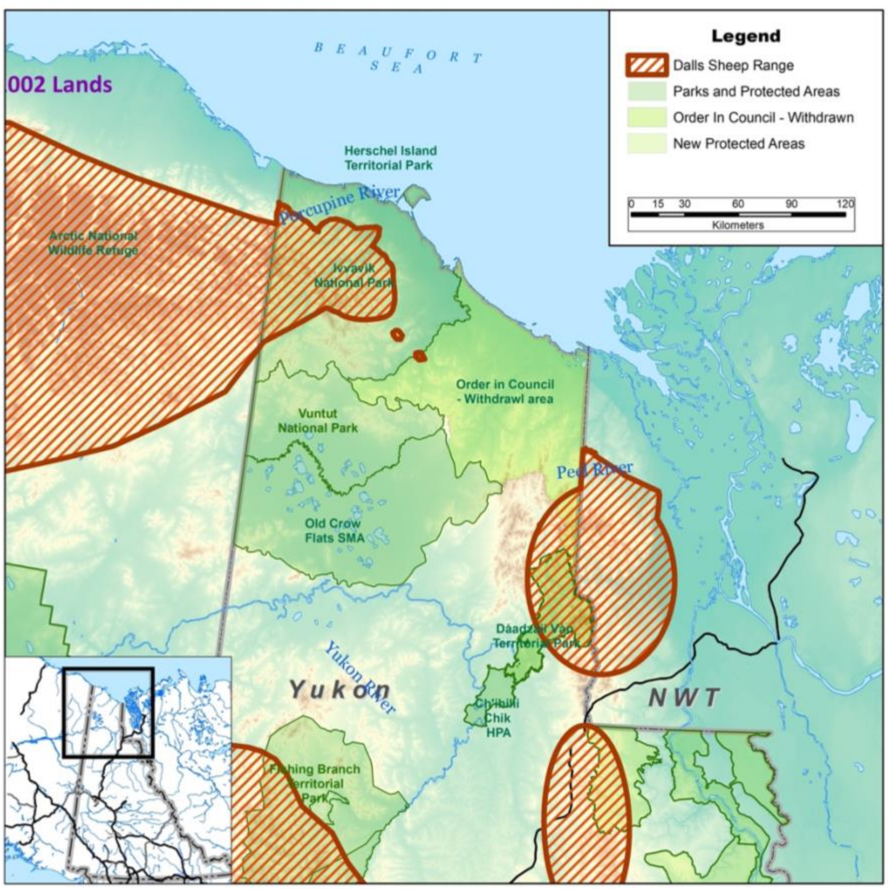
Inuvialuit harvesters have exclusive rights to harvest Dall's sheep in Ivvavik National Park. They have a preferential right to harvest sheep on the Eastern Yukon North Slope (WMAC (NS), 2008). There are no restrictions (such as quotas) placed on Inuvialuit sheep harvest on the Yukon North Slope. Sheep hunting by non-Inuvialuit Yukon residents is not permitted within the Yukon North Slope portion of the range of the Northern Richardson Mountains sheep population, but a limited hunt is permitted in Game Management Subzones south of the Yukon North Slope (Yukon Government, 2019b).

Sheep may be limited by availability of winter range (Parks Canada, 2002) and/or other factors, such as high mortality rates. Predation is important in sheep population dynamics as is habitat selection (Lambert Koizumi & Derocher, 2019). A study in Alaska indicated that causes of mortality vary from mountain range to mountain range. In addition to predation and habitat limitations, they include disease, accidents such as falling or drowning, and adverse weather conditions (ADF&G, 2017). Overharvest has been a cause of Dall's sheep declines in the past (Jex et al., 2016). Harvest of the Northern Richardson Mountains population in the 1970s was considered unsustainable (Lambert Koizumi et al., 2011). Although the harvest pressure is currently low on Dall's sheep on the Yukon North Slope, both populations are at the edge of larger ranges that extend into other jurisdictions and they are harvested elsewhere.

Transboundary Considerations

Dall's sheep live only in the mountainous regions of northwestern North America—in Alaska, Yukon, western NWT, and the far north of British Columbia (Map 13– 3). The total number of Dall's sheep is not known, but may be as high as 100,000 animals (Jex et al., 2016). International cooperation is facilitated through the Wild Sheep Working Group, made up of government and Indigenous organization representatives from jurisdictions over the range of wild sheep in North America (Jex et al., 2016).

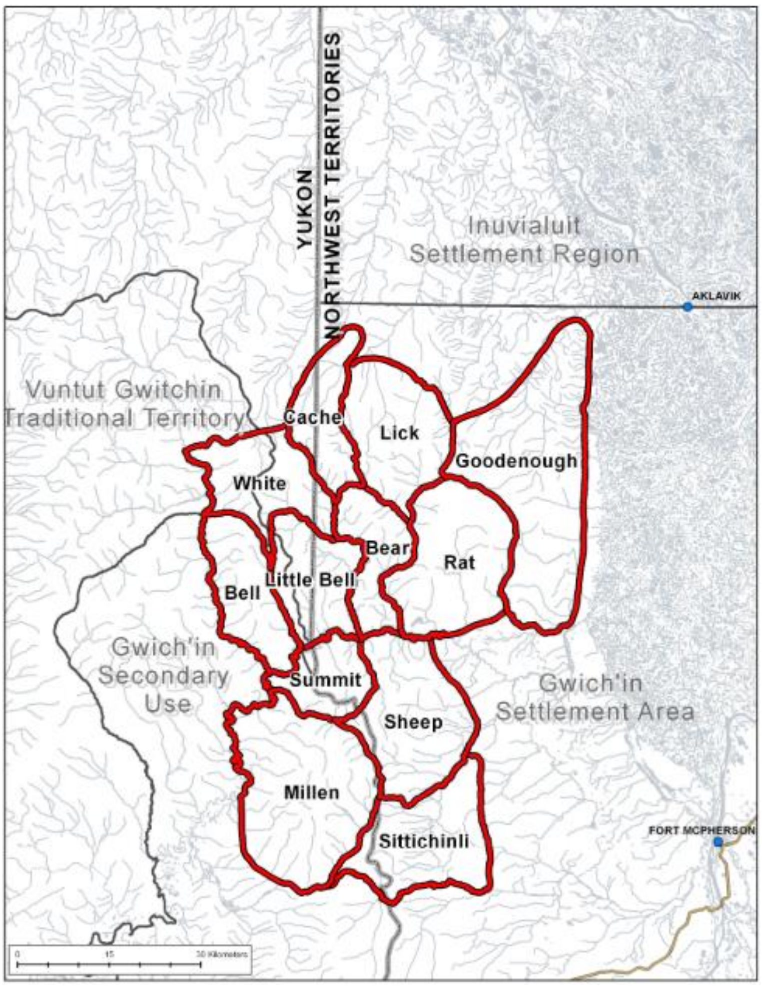
Map 13– 3. Dall's sheep range in regions adjacent to the Yukon North Slope



Dall's sheep range on the Yukon North Slope and nearby ranges in Alaska, Northwest Territories, southern Yukon. Map source: Yukon Department of Environment unpublished data, 2020.

The range of the Northern Richardson Mountains Dall's sheep population crosses territorial and land claims boundaries (Map 13– 4). Management of the population over its entire range is addressed in the draft *Management Plan for Dall's Sheep In the Northern Richardson Mountains* (Working Group for Northern Richardson Mountains Dall's Sheep, 2008).

Map 13– 4 Dall's sheep aerial count blocks in the Northern Richardson Mountains, showing territorial and land claim boundaries



Working Group for Northern Richardson Mountains Dall's Sheep (2008), Figure 2; figure data provided by the Gwich'in Renewable Resources Board.

Observations, Concerns, and Threats

Impacts of Climate Change

Climate change may have varied effects on Dall's sheep. Warmer weather and longer growing seasons mean that more forage may be available in spring. However, changes to vegetation communities, including an increase in shrubs, may reduce the quality of forage. Changes in weather patterns, such as more frequent ice-on-snow events that limit access to foraging, are likely to be harmful to sheep populations. In particular, warmer climates over the range of this northern species may increase the incidence and variety of parasites. There are also many indirect climate change effects, including changes to the distribution and habitat use of sheep predators and other ungulates, changing patterns of human use of the environment, and increased spread of pathogens.

Dall's sheep may be particularly vulnerable to changes in snow conditions, especially during peak snow cover in late winter (Boelman et al., 2019). Snow cover properties, including depth, distribution, and how hard the snowpack is, affect Dall sheep's feeding efficiency, ease of travel through snowy areas, and predation rates. The Western Brooks Range Dall's sheep population in Alaska experienced a rapid, weather-related decline in 2013. The snowpack that year was about three times the average, leading to significant mortality (ADF&G, 2017). Alaskan research on how snow properties affect Dall's sheep movement (Sivy, Nolin, Cosgrove, & Prugh, 2018) concluded that sheep age and the density of the top layer of snow were the most important factors in how much the sheep sank into snow when walking. A study that looked at how to integrate snow science and wildlife ecology (Boelman et al., 2019) recommended development of a suite of snow measurements to improve tracking the effect of changing snow on Dall's sheep and other wildlife.

Lamb recruitment and climate

Models based on sheep survey results and climate data over the entire range of Dall's sheep indicate that spring snow cover has a strong influence on lamb recruitment—more so than temperature or the amount of precipitation. Better lamb recruitment is associated with higher snowline elevations, earlier snow-melt, and fewer snow-covered days, especially in the northern part of Dall sheep's range. This suggests that northern sheep populations are more sensitive to changes in snow conditions than sheep living further south. This is particularly relevant for the Yukon North Slope because its sheep populations are at the far northern edge of the species' range (see Map 13– 3). Most climate models are forecasting earlier springs for the Yukon North Slope (earlier snow melt and green up).

Van De Kerk et al. (2018), Van De Kerk et al. (2020), Severson et al. (in press)

Survival rates of lambs and adults have been examined through analyses combining available information on Dall's sheep from across their range (Van de Kerk et al., 2020). Lamb survival was linked most closely with plant productivity (using an index from satellite imagery), and higher plant productivity in the summer was associated with higher lamb recruitment. Adult sheep survival was lower in years with more freeze-thaw events, a climate phenomenon that affects sheep ability to access forage and one that is predicted to increase into the future.

Impacts from Human Activities

Sheep are easily disturbed by aircraft flights (particularly rotary wing aircraft) and by humans close by on the ground, although they can become habituated to human presence. Industrial development, including mineral exploration, is a potential source of disturbance on sheep ranges. Sheep were displaced from important mineral licks in Sheep Creek due to placer mining, but have resumed using these since the cessation of mining activity (WMAC (NS), 2012).

When disturbed by aircraft, sheep stop activities such as foraging or resting and become vigilant (Frid, 2003; Laberge Environmental Services, 2002). Sheep stand and scan the surroundings and often flee the perceived danger by walking or running, anywhere from a few steps to over a kilometre. Yukon research showed that sheep do not resume their previous activity for up to 45 minutes after an aircraft is out of sound range (Frid, 2003). This reaction to disturbance is damaging because of the energy cost to the animal. If disturbances are frequent, body weight and reproductive success can be lowered. Research also showed that, although the sheep may react less over the course of a day with multiple overflights, they do not become habituated over the longer term. They react to disturbance as strongly on the first flight on subsequent days as they did to the first flight on the first day. Research also showed that helicopters disturb sheep more than fixed wing aircraft (Frid, 2003).

Disease and Parasites

Elders and harvesters have reported that Northern Richardson Mountains Dall's sheep are generally healthy, with few parasites (Lambert Koizumi et al., 2011, based on Shaw et al., 2005, a Dall's sheep local knowledge report published by the Gwich'in Renewable Resource Board). The emergence of new parasites due to climate change, however, is a concern for the long-term health of Dall's sheep populations (Lambert Koizumi et al., 2011). The types of parasites infecting wild sheep, their abundance, and their impacts on the health of sheep, are all highly sensitive to climate and climate change (Kutz et al., 2012).

Gastrointestinal parasites are common in Northern Richardson Mountains sheep, generally at low levels of infection (Lambert Koizumi et al., 2011). These parasites can have impacts on sheep populations if the parasites become more abundant. For example, intense infections in ewes of a common nematode parasite of Dall's sheep (*Marshallagia marshalli*) are associated with poorer body condition and lower pregnancy rates (Kutz et al., 2012).

Dall's sheep are susceptible to pathogens transmitted from other wildlife or domestic animals (Jex et al., 2016). As wildlife species ranges expand or shift, new parasites, bacteria and viruses may be spread between species.

The most significant disease threat to both thinhorn and bighorn sheep are pathogens that lead to respiratory disease (BCCDC, 2017; Jex et al., 2016). Pneumonia caused by bacterial infection has led to outbreaks of disease with significant mortality in bighorn sheep populations (BCCDC, 2017), but health assessments indicate that thinhorn sheep have had less exposure to the pathogens causing respiratory disease (Jex et al., 2016). However, the bacterium *Mycoplasma ovipneumoniae* (M. ovi), was detected in 2018 in Dall's sheep in Alaska (ADF&G, 2019). M. ovi is one of the most frequent causes of outbreaks of pneumonia in bighorn sheep (BCCDC, 2017). Nevertheless, the strain of M. ovi found in Alaska is different from the M. ovi affecting southern wildlife, and to date there is no evidence that this strain causes pneumonia. Testing for these bacteria in sheep is ongoing to ensure it does not become an additional source of mortality to the Dall's sheep populations on the Yukon North Slope.

The Orf virus (*Parapoxvirus*), which results in lesions, can be transmitted between sheep and goats, and between wildlife and man. Research shows that most of the wild ungulates in Alaska can carry and be affected by this virus (Tryland, Beckmen, Burek-Huntington, Breines, & Klein, 2018). Orf has been detected in muskox on the Yukon North Slope and likely occurs in a number of northern species, both domestic and wild.

Research in the early 2000s addressed concerns that a lungworm common in muskoxen east of the Mackenzie River (*Umingmakstrongylus pallikuukensis*) might infect Northern Richardson Mountains Dall's sheep if the muskoxen's range were to expand west of the Mackenzie (WMAC (NS), 2005). The results showed that this parasite is not able to transfer from muskoxen to Dall's sheep. However, another type of lungworm (*Protostrongylus stilesi*) that has been found in muskoxen on the Yukon North Slope has been detected in Northern Richardson Mountain sheep (Lambert Koizumi et al., 2011). Sheep are considered to be the original carrier of this lungworm.

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.

Dall's Sheep Conservation and Management

- *Management Plan for Dall's Sheep in the Northern Richardson Mountains* (Working Group for Northern Richardson Mountains Dall's Sheep, 2008)
  Plan partners include the Aklavik HTC and Inuvialuit Game Council, Gwich'in and Vuntut Gwitchin governments and organizations, the Yukon Fish and Wildlife Management Board, and Yukon and NWT governments. The Working Group recommended that a cooperative management plan should also be developed for the Southern Richardson Mountains.

This recommended draft plan includes actions for harvest monitoring and regulation (for beneficiaries and for other hunting) and plans for surveys and additional monitoring that are based on the size and trend of the sheep population. The plan contains recommendations and action items on community-based monitoring and research, including on population dynamics, predation, disease, and parasites. Other actions focus on monitoring changing conditions, mapping seasonal habitats, and managing effects of access and disturbance on sheep range use, while recognizing harvest rights and interest in tourism opportunities.

Dall's sheep management goals for the Northern Richardson Mountains

1. Ensure long-term conservation by making sure human use of sheep is sustainable and that other activities do not diminish sheep numbers or reduce the ability of the land to support sheep in the future.
2. Provide for traditional and other uses of sheep that benefit all people.

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016)

  Identifies the eastern Yukon North Slope (Special Designated Lands Site 725DE) as important for Dall's sheep for winter range, lambing areas, and migration corridors; mineral lick sites are in the Northern Richardson Mountains.

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

  Conservation and management of Dall's sheep 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" (Parks Canada, 2018).

- *Science-based management guidelines for Thinhorn Sheep in Yukon* (Environment Yukon, 2019a)

  These update the 1996 sheep guidelines for Yukon (Yukon Renewable Resources, 1996).

- *Northern Yukon Regional Land Use Plan* (Vuntut Gwitchin Government & Yukon Government, 2009)

  The planning area includes part of the range of the Northern Richardson Mountains population of Dall's sheep. A best management practice is to "avoid sensitive sheep habitats and key areas, with emphasis on winter range avoidance."

- *Thinhorn Sheep: Conservation Challenges and Management Strategies for the 21st Century* (Jex et al., 2016)

  This assessment and plan was produced by the Wild Sheep Working Group of the Western Association of Fish and Wildlife Agencies (of the US, Canada, and Mexico). It includes objectives and strategies for thinhorn sheep (Dall's and Stone sheep) management throughout their range in northwestern North America. The focus is on developing common, collaborative management and monitoring approaches and standardized guidelines for use across jurisdictions. Habitat conservation is considered a cornerstone of thinhorn sheep conservation and management.

Research and Monitoring Programs

➢ Sheep surveys

Aerial surveys of Dall's sheep ranges provide information on populations and habitat use.

- Surveys in the Northern Richardson Mountains in Yukon and NWT (Davison et al., 2018; Lambert Koizumi et al., 2011) (**Error! Reference source not found.**) have been conducted periodically from 1984 to 2017. See Figure 13– 1 for a summary of results.
- Surveys in the British Mountains were conducted in Ivvavik National Park in 1984, 1986, 2001, and 2017 (summer) and in 2002 and 2019 (winter) (Antoniuk, 1989; WMAC (NS), 2019; WMAC (NS), 2005; Parks Canada, 2002; Parks Canada, 2020).

➢ Harvest monitoring: Inuvialuit Harvest Study (IRC, 2017, 2018, 2019)

Annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included Dall's sheep harvest monitoring. The ISR Community-Based Monitoring Program was revised after 2014 to focus on harvest. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information, including harvest locations, through annual interviews with active harvesters. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

There are different knowledge sources for each of the two regions where Dall's sheep occur on the Yukon North Slope. Sheep surveys, traditional knowledge, research, and consultations for a management plan provide information on Dall's sheep in the Northern Richardson Mountains. Observations and surveys in Ivvavik National Park provide information on Dall's sheep in the British Mountains. Recent research in Alaska and Canada provides insight into the effects of changes in snow conditions on Dall's sheep and the risks to Dall's sheep from disease and parasites.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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. The results were used in developing the Plan and are described and referenced throughout this chapter.

Assessments and Syntheses of Survey Results

- *Thinhorn Sheep: Conservation Challenges and Management Strategies for the 21st Century* (Jex et al., 2016)
  This international plan and assessment reviews knowledge about Dall's sheep throughout the species' range.

- Status of Dall's Sheep (*Ovis dalli dalli*) in the Northern Richardson Mountains (Lambert Koizumi et al., 2011)
  This status report includes information from surveys, research, and Inuvialuit and Gwich'in traditional knowledge about Dall's sheep in the Northern Richardson Mountains.

Research

- Research on grizzly and wolf predation and Dall's sheep habitat use in the Northern Richardson Mountains Dall's sheep (Lambert Koizumi & Derocher, 2010, 2019)
  Research included satellite tracking to establish home ranges of Dall's sheep, wolves, and grizzly bears, analysis of predators' diets, and seasonal habitat selection by rams and ewes. Results show the import role of predation in Dall's sheep use of different habitat types (see the section on Habitat for Dall's Sheep).

- Research on disease and parasites
  - *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 sheep. 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.

Recent research on disease and parasites in Dall's sheep includes Alaskan research on the Orf virus in wildlife (Tryland et al., 2018) and detection of M. ovi infection in Dall's sheep (Environment Yukon unpublished data, ADF&G, 2019).

References

ADF&G. (2017). Dall's Sheep News: Research and management update, winter 2017. In *Dall's Sheep News*. Alaska Department of Fish and Game.

ADF&G. (2019). Mycoplasma ovipneumoniae (M. ovi) in Alaska Wildlife: Answers to Frequently Asked Questions. Retrieved June 11, 2019, from Alaska Department of Fish and Game website: http://www.adfg.alaska.gov/index.cfm?adfg=hottopics.movi

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

Antoniuk, G. (1989). *Northern Yukon National Park Dall's sheep survey*.

Barker, O. (2012). *Late Winter Habitat Selection By Sheep in the Dawson Region*. Yukon Environment.

Battle, D. C., & Stantorf, C. J. (2018). *Dall Sheep Management Report and Plan, Game Management Unit 14C*. (July 2016).

BCCDC. (2017). BC Conservation Data Centre: Conservation Status Report - Ovis dalli dalli, Dall's Sheep. Retrieved from http://a100.gov.bc.ca/pub/eswp/esr.do;jsessionid=1L4gSQpFT14Qsr1VF63y3ZQ8XF4TsspGj2GyM1mpWX8s1PqnymQy!-714317157?id=18422

Boelman, N. T., Liston, G. E., Gurarie, E., Meddens, A. J. H., Mahoney, P. J., Kirchner, P. B., … Vierling, L. A. (2019). Integrating snow science and wildlife ecology in Arctic-boreal North America. *Environmental Research Letters*, *14*(1). https://doi.org/10.1088/1748-9326/aaeec1

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

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/

Davison, T., Russell, K., & Belanger, E. (2018). *Survey of Dall's Sheep in the Northern Richardson Mountains: June, 2017*. Retrieved from Government of the Northwest Territories website: https://www.enr.gov.nt.ca/sites/enr/files/resources/274_manuscript_survey_of_dalls_sheep_in_the_northern_richardson_mountains_june_2017.pdf

Environment Yukon. (2019). *Science-based Guidelines for Management of Thinhorn Sheep in Yukon (MR-19-01)*. Retrieved from https://yukon.ca/sites/yukon.ca/files/env/env-science-based-guidelines-management-thinhorn-sheep-yukon.pdf

Frid, A. (2003). Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. *Biological Conservation*, *110*(3), 387–399. https://doi.org/10.1016/S0006-3207(02)00236-7

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. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

Jex, B. A., Ayotte, J. B., Bleich, V. C., Brewer, C. E., Bruning, D. L., Hegel, T. M., … Wagner, M. W. (2016). *Thinhorn Sheep: Conservation Challenges and Management Strategies for the 21st Century*. Boise, Idaho: Wild Sheep Working Group, Western Association of Fish and Wildlife Agencies.

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

Laberge Environmental Services. (2002). *Flying in Sheep Country: How to minimize disturbance from aircraft*. Whitehorse, Yukon: Mining Environment Research Group.

Lambert Koizumi, C., Carey, J., Branigan, M., & Callaghan, K. (2011). *Status of Dall's Sheep (Ovis dalli dalli) in the Northern Richardson Mountains*. Yukon Environment.

Lambert Koizumi, C., & Derocher, A. (2010). Spatial overlap of Dall sheep, Grizzly bears and wolves in the Richardson mountains, Canada. *Galemys: Boletín Informativo de La Sociedad Española Para La Conservación y Estudio de Los Mamíferos*, *22*(1), 31–42.

Lambert Koizumi, C., & Derocher, A. E. (2019). Predation risk and space use of a declining Dall sheep (Ovis dalli dalli) population. *PLoS ONE*, *14*(4), 1–16. https://doi.org/10.1371/journal.pone.0215519

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

Nichols, L., & Bunnell. (1999). Natural history of thinhorn sheep. In R. Vladez & P. R. Krausman (Eds.), *Mountain sheep of North America* (pp. 23–77). University of Arizona Press, Tucson, Arizona, USA.

Parks Canada. (2001). *Annual Report of Research and Monitoring in National Parks of the Western Arctic: 2001*.

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

Parks Canada. (2017). Ivvavik National Park: History and Culture. Retrieved April 25, 2020, from https://www.pc.gc.ca/en/pn-np/yt/ivvavik/decouvrir-discover/natcul2

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

Sivy, K. J., Nolin, A. W., Cosgrove, C. L., & Prugh, L. R. (2018). Critical snow density threshold for Dall's sheep (Ovis dalli dalli). *Canadian Journal of Zoology*, *96*(10), 1170–1177. https://doi.org/10.1139/cjz-2017-0259

Tryland, M., Beckmen, K. B., Burek-Huntington, K. A., Breines, E. M., & Klein, J. (2018). Orf virus infection in Alaskan mountain goats, Dall's sheep, muskoxen, caribou and Sitka black-tailed deer. *Acta*

Veterinaria Scandinavica, *60*(1), 1–11. https://doi.org/10.1186/s13028-018-0366-8

Van de Kerk, M., Arthur, S., Bertram, M., Borg, B., Herriges, J., Lawler, J., … Prugh, L. (2020). Environmental Influences on Dall's Sheep Survival. *Journal of Wildlife Management*, *84*(6), 1127–1138. https://doi.org/10.1002/jwmg.21873

Van De Kerk, M., Verbyla, D., Nolin, A. W., Sivy, K. J., & Prugh, L. (2018). Range-wide variation in the effect of spring snow phenology on Dall sheep population dynamics. *Environmental Research Letters*, *13*(7). https://doi.org/10.1088/1748-9326/aace64

Vuntut Gwitchin Government, & Yukon Government. (2009). *North Yukon Regional Land Use Plan*.

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). (2003). *Wildlife Management Advisory Council (North Slope) Term Report 2001–2003*. Retrieved from http://www.wmacns.ca/

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). (2008). *Harvesting rights on the North Slope (fact sheet)*. 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). (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. (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).

Working Group for Northern Richardson Mountains Dall's Sheep. (2008). *Management Plan for Dall's Sheep In the Northern Richardson Mountains: Recommended Draft Plan*.

Yukon. (2020). Yukon Wildlife: Dall's Sheep. Retrieved March 9, 2020, from https://yukon.ca/en/dalls-sheep

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

Yukon Renewable Resources. (1996). *Sheep Management Guidelines*.

Wildlife Management Advisory Council
North Slope

Yukon North Slope
Wildlife Conservation and Management Plan
2021

Companion Report 14: Muskox / Umingmak

Publication Information

Cover photo: Jay Frandsen, ©Parks Canada/Jay Frandsen, 2019

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 14: Muskox / Umingmak

Table of Contents

Maps

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 four 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: Muskox / Umingmak

This companion report provides information on the conservation requirements for muskox 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 muskox, programs and measures for conservation and management, and selected studies and research relevant to the Yukon North Slope.

Conservation requirements for muskox on the Yukon North Slope

1. Conservation of a diverse landscape of lowlands and hills with moist vegetation, from sedge swamps to windblown ridges.
2. Investigation of potential interactions in seasonal habitat use by muskox and caribou to evaluate effects of the reintroduced muskox population on caribou.
3. Research and monitoring to help understand the status and vulnerability of this small muskox population.

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

Muskox on the Yukon North Slope

Muskox (Umingmak, *Ovibos moschatus*) crossed the Bering land bridge to North America about 200,000 years ago and survived the ice age, alongside caribou, residing in ice-free Beringia. After the ice age ended, they remained and extended their range in the Yukon and Alaska and beyond but eventually declined in the 1800s and early 1900s to the edge of extinction. Muskox disappeared from the Yukon and Alaska North Slope in the mid 1800s (WMAC (NS), 2012). There is little information on past populations and use of muskox in this region, though northern people have an ancient relationship with muskox, including harvesting for their meat, hide, hair, and horns (WMAC (NS), 2020). Records of local knowledge from Alaska and the discovery of remains of muskox provide evidence of their presence (Lent, 1998).

Thirty-one muskox were brought from Greenland to Nunivak Island, Alaska in the 1930s. This herd grew to over 700 animals by the late 1960s (Alaska Department of Fish and Game, n.d.; WMAC (NS), 2020). Two groups totalling 64 muskox from the Nunivak herd were released in 1969 and 1970 in two areas in and adjacent to the Arctic National Wildlife Refuge in Alaska. This reintroduced population has slowly increased and extended its range. Groups of muskox began to be seen on the Yukon North Slope in the 1980s with the first breeding group established around 1985. The range now extends east to the Mackenzie River and south into Vuntut National Park (WMAC (NS), 2017). There are approximately 400 muskox currently residing as part of the Yukon North Slope population including in the Richardson Mountains, although survey work is ongoing and the estimate will be confirmed in 2022 (M. Suitor, personal communication, August 11, 2021).

Muskox move among feeding areas within their range, but they are not migratory animals. Bulls may travel considerable distances during summer (WMAC (NS), 2012) with sightings occurring in the Peel watershed on an almost annual basis now. Calving is from mid-April to mid-May, with cows normally giving birth to one calf each year (Aklavik HTC, Aklavik Community Corporation, WMAC (NWT), FJMC, & Joint Secretariat, 2016).

Traditional Use

The relationship between northern people and muskox (Umingmak, the bearded one) is ancient. Historically, the animals were hunted with dogs, using bow and arrow. Not only were muskox harvested for meat, but their thick hair and hide was used for sleeping robes and their horns were used to make tools. The utilization of muskox by northern people has waxed and waned, driven by changing economic and cultural realities and opportunities (for further context, see the Traditional Use companion report) (WMAC (NS), 2020).

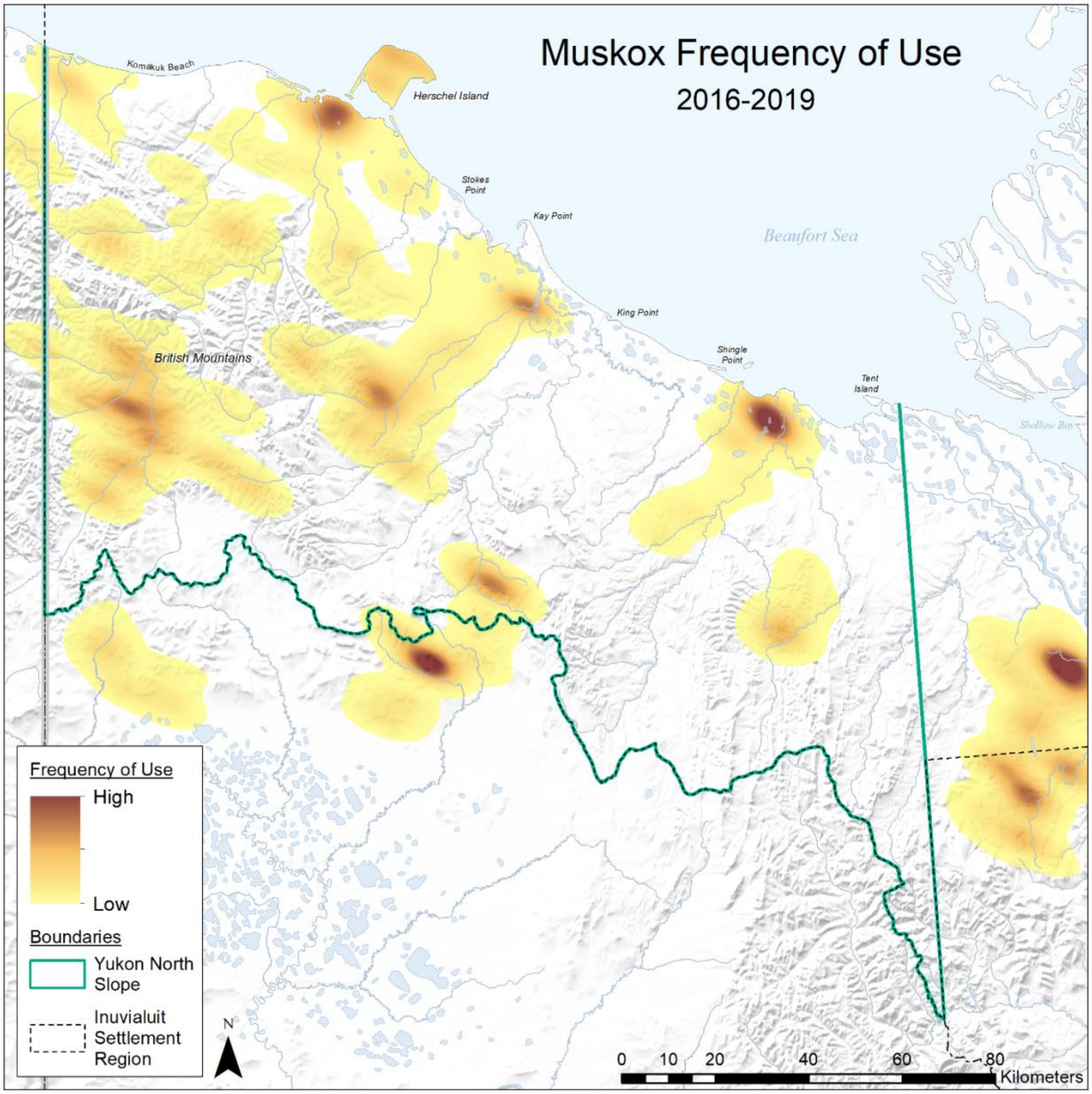
Muskox remain an important source of meat and other resources for many Arctic communities. The underhair of the muskox, called qiviut, may be the finest wool in the world: finer and softer than cashmere, stronger and warmer than sheep wool (WMAC (NS), 2020).

Muskox were extirpated from the Yukon North Slope for more than a century, severing the relationship between the Inuvialuit who use the Yukon North Slope and this species. Currently, there is some harvesting and use of muskox but little reliance on this species for traditional use. The *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016, p. 110) refers to muskox as a "Traditional Use Food source. Also used for tools, bedding, and clothing." Aklavik Inuvialuit hunters reported harvesting an average of 6 muskox annually from 2016 to 2018 (IRC, 2019). Other Inuvialuit may access and harvest from the YNS muskox population in addition to Gwich'in harvesters. The *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b), while noting that muskox are harvested, does not have location-specific information on this species. Other sources indicate that harvesting of muskox primarily takes place in the Richardson Mountains (M. Suitor, personal communication, March 30, 2021).

Habitat for Muskox

Muskox are widely distributed (Map 14- 1) on the Yukon North Slope.

Map 14- 1. Muskox observations, based on Inuvialuit traditional knowledge and surveys



This map is from the Plan (WMAC (NS), 2022, Appendix 1) and shows the distribution of satellite locations collected from 25 collared muskox monitored 2016-2019 (Carter, 2020). The darker (brown) areas indicate the highest density of locations and therefore the most intensely used areas.

Muskox have different habitat needs over the seasons. In most regions where muskox diets have been studied, sedge and willow are consistently common components (Carter, 2020). In summer they make use of a range of habitats, including river valleys and meadows, and in these areas they eat sedges and willows along with a diversity of arctic shrubs, grasses and leafy plants (WMAC (NS), 2020). In fall they also spread into shrubbier areas to feed on willows. In winter they favour hillsides and ridges that have strong winds to blow away the snow, making food more accessible (WMAC (NS), 2012). In areas of deep snow, taller shrubs like willow are important (WMAC (NS), 2020). Recent research has identified that muskox strongly prefer riparian herb-willow, hydric sedge fen and some low-medium shrub ecotypes year-round (Carter, 2020).

Muskox habitat use and diet on the Yukon North Slope

An earlier study of muskox with radio collars was completed between 1999 and 2005. That study involved an analysis that compared where muskox were located relative to available land.

Muskox:

- Use areas to the west of Babbage more than to the east;
- Favour low elevation areas;
- In late winter, prefer areas with moist vegetation;
- In spring, prefer wet graminoid/low shrub and low shrub tundra vegetation types and avoid moist cotton-grass tussock;
- In summer, are highly selective for the moist non-tussock sedge land class;
- In fall, prefer shrub thickets and wet barrens.

Their main food sources, based on fecal analyses, are willow, cotton-grass, sedges, and horsetail.

Source: *Yukon North Slope and Richardson Mountains Muskox Research Plan* (WMAC (NS), 2019b), based on Cooley and McDonald, 2010

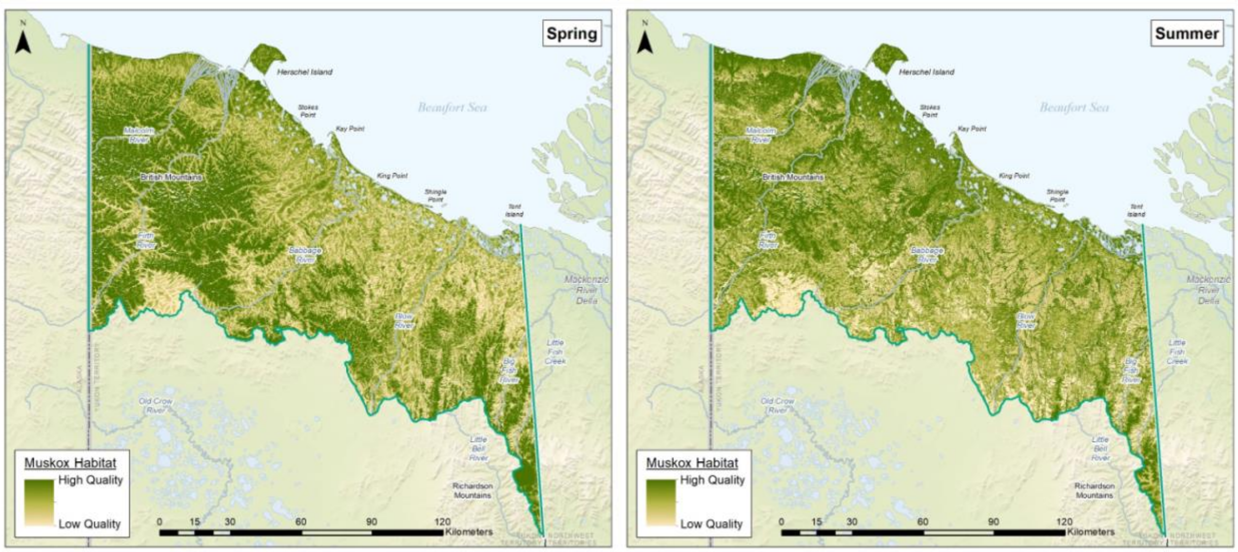
Habitat Model

Models predicting muskox spring and summer habitats were developed using the locations of 25 satellite-collared animals that were monitored from 2016 to 2019. A large portion of muskox groups across the Yukon North Slope included a collared animal that was monitored. The habitat models (resource selection functions) evaluated the relative habitat use of muskox, as indicated by the animal locations, to the relative availability of different kinds of ecosystems across the Yukon North Slope.

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.

In the spring, the analysis found that muskox are more likely to use drier habitats, such as those that occur in the foothills and mountains of Ivvavik National Park and the southern portions of the eastern Yukon North Slope. During summer, preferred habitats are broadly distributed and include habitats across the Yukon North Slope including on the coastal plains (Map 14- 2).

Map 14- 2. Predicted muskox habitat during spring (May 1 – June 30) and summer (July 1 – August 31) based on the locations of satellite collared muskox

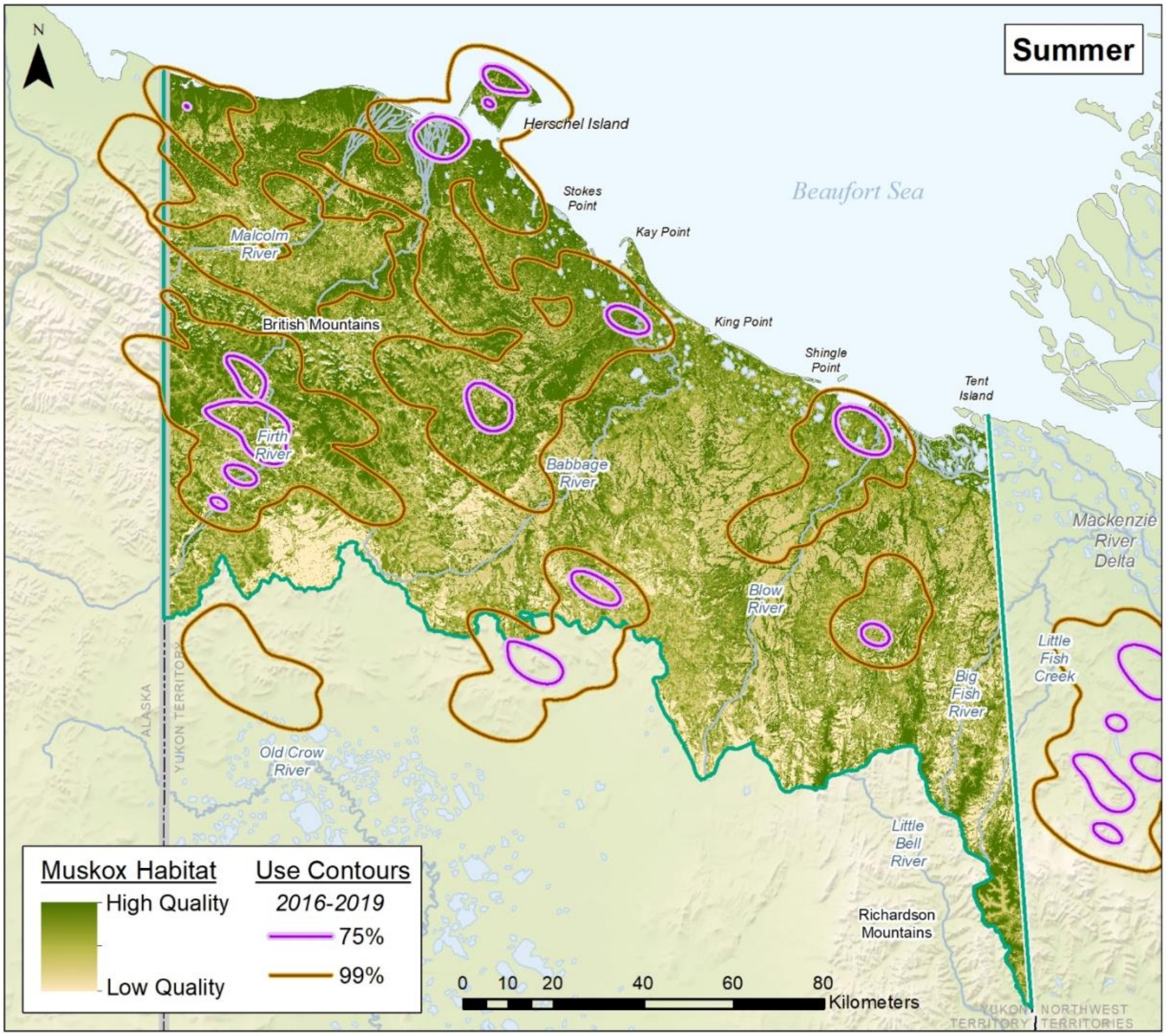


This map shows the results of a Resource Selection Function habitat model based on the GPS collar locations of 25 muskox monitored between 2016 and 2019. The predicted distribution and relative quality of spring and summer habitats are shown, with darker green colors where the model predicts there is a higher probability of muskox use of the area, compared to lighter beige areas that are predicted to have a lower probability of muskox use.

Habitat Occupancy: Comparing Predicted Habitat Distribution with Observations

The habitat models presented in the previous section predict areas that may be preferred muskox habitats, but they do not identify where muskox are actually found. Map 14- 3 shows the summer habitat model as well as the distribution of muskox based on satellite collar locations of 25 animals monitored between 2016 and 2019. This map suggests that much of the higher quality muskox habitats in the western portion of the Yukon North Slope receive some use by muskox, based on the 99% frequency of use contours. The eastern North Slope shows both a pattern of relatively lower amounts of higher quality habitat and a more restricted distribution of muskox. Additionally, the highest levels of use as indicated by the 75% use contours (where 75% of all the locations occur) suggests that the majority of time, muskox use very limited areas that are widely distributed across the Yukon North Slope.

Map 14- 3. Muskox habitat use contours, 75% and 99% based on GPS collar locations



This map shows distribution of satellite locations collected from 25 collared muskox (monitored 2016-2019) layered over predicted summer habitats. The distribution of muskox is based on collar data in which most muskox groups had a collared individual. The distribution is shown as circles with the smaller magenta circles showing where animals spent 75% of their time and the brown circles showing where animals spent 99% of their time. The habitat model shows darker green colors where the model predicts there is a higher probability of muskox using that area, as compared to lighter beige areas that are predicted to have a lower probability of muskox use. Areas outside the brown circles indicate areas where relatively few muskox currently occur. Some of these areas include potentially suitable habitat for muskox, areas that the population may expand or shift into in the future.

Muskox Populations

Species Conservation Status

Table 14- 1. Muskox 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	N3N4: Vulnerable to Apparently Secure*; 2015 status	(Canadian Endangered Species Conservation Council, 2016)
Yukon	Yukon	S1S2: Critically Imperiled to Imperiled*	(Yukon Government, n.d.)
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, n.d.-a). G=Global; N=National; S=Subnational.

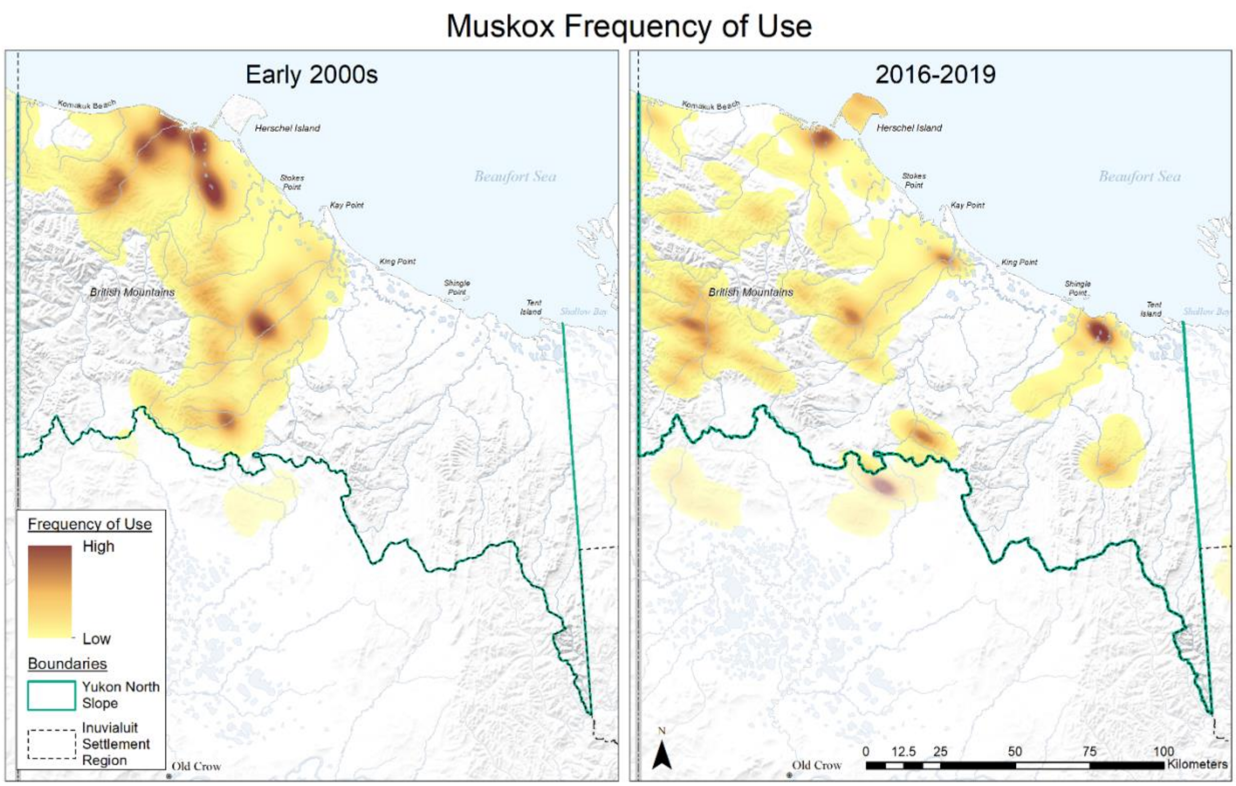
Population Trends on the Yukon North Slope

Groups of muskox began to be seen on the Yukon North Slope in the mid-1980s. The first mixed sex and age group was observed in 1985, indicating a breeding herd. Although their range has expanded since then, the population remains relatively small. In 2019, 2020 and 2021, summer composition surveys in the Yukon and adjacent portion of the NWT west of the Mackenzie Delta have found 373, 336, and 319 muskox respectively. These numbers are minimum counts and are part of a larger effort to produce a population estimate in 2022 with confidence intervals (Environment Yukon, unpublished data, 2020 and M. Suitor, personal communication, August 11, 2021). The population has likely increased by about 50% since the early 2000s. A population count in July 2002 recorded 145 muskox between the Alaska border and Shingle Point (WMAC (NS), n.d.). Recent surveys (2013 to 2020) show high calf productivity, indicating that the population is increasing (Environment Yukon unpublished data, 2020)

Most information about this population is based on aerial survey data (WMAC (NS), 2019b), monitoring collared muskox and community observations (WMAC (NS), n.d.). Pre-calving surveys, conducted in March or April, provide the most accurate population counts. Summer surveys, conducted periodically since 1986, allow muskox to be accurately aged and sexed, resulting in estimates of population productivity, recruitment, and age/class structure. In addition to allowing managers the ability to easily monitor the population, collars provide information on home range sizes, movement rates, and use of different habitat types.

Satellite collar monitoring is on-going, automatically recording locations year-around to learn more about where muskox are found at different times of the year (WMAC (NS), 2020). Monitoring of collared animals shows a more dispersed population from those monitored in the early 2000s (14 animals) to those monitored in the late 2000s (25 animals), although it is worth noting that collars are more representatively distributed amongst all muskox groups now than in the past. Muskox have become more common throughout Ivvavik National Park while densities along the coastal plain have reduced, have become common in places like Herschel Island, Shingle Point and the Barn Mountains (Map 14- 4). Though not shown on Map 14-4, the distribution in the Richardson Mountains has not increased dramatically although the number of groups and size of those groups have increased in time.

Map 14- 4. Frequency of use distributions of muskox, based on the locations of collared animals



Monitoring of 14 animals in early 2000s and 24 animals in late 2000s (2016-2019). The darker (brown) areas indicate the highest density of locations and therefore the most intensely used areas, and lighter areas show less-intensely used areas. While the two maps give a relative sense of density between periods, a direct comparison of densities between the two periods isn't appropriate as total numbers have fluctuated in time.

Predation by grizzly bears, health related issues, and relatively poor long term productivity, rather than a shortage of good habitat, likely keep Yukon North Slope muskox numbers low (WMAC (NS), 2019b). An objective of the muskox research plan is to determine the potential for population increase. This entails understanding the factors that currently limit this population and the roles of harvest and of grizzly bear predation in muskox population dynamics.

> Aklavik Inuvialuit land users have observed that bears are not preying on moose as much and that they have been seen following muskox.
>
> Source: *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2018a)

Population Trends in Northern Alaska

Muskox in Northern Alaska are monitored through precalving surveys, a long-term collar program, and through testing for diseases, parasites, and mineral deficiencies. Studies indicate that forage abundance may not be limiting, but that low trace nutrient content of forage during winter may be affecting muskox health and reproduction (Harper & McCarthy, 2017). A decline in muskox abundance from 2007 to 2011 may have been in part an increase in grizzly bear predation (Arthur & Del Vecchio, 2017). Increased impact from infectious disease is an additional potential cause of the decline (Afema et al., 2017). More recently the Alaskan North Slope population has increased at a similar rate to Yukon North Slope muskox although muskox continue to be rare in the Arctic National Wildlife Refuge, instead occupying habitats west of there (M. Suitor, personal communication, August 17, 2021). A history of population fluctuations in Alaska indicates that muskox numbers can climb quickly and crash quickly within a small population range (WMAC (NS), 2017).

Muskox and grizzly bear predation in Northern Alaska

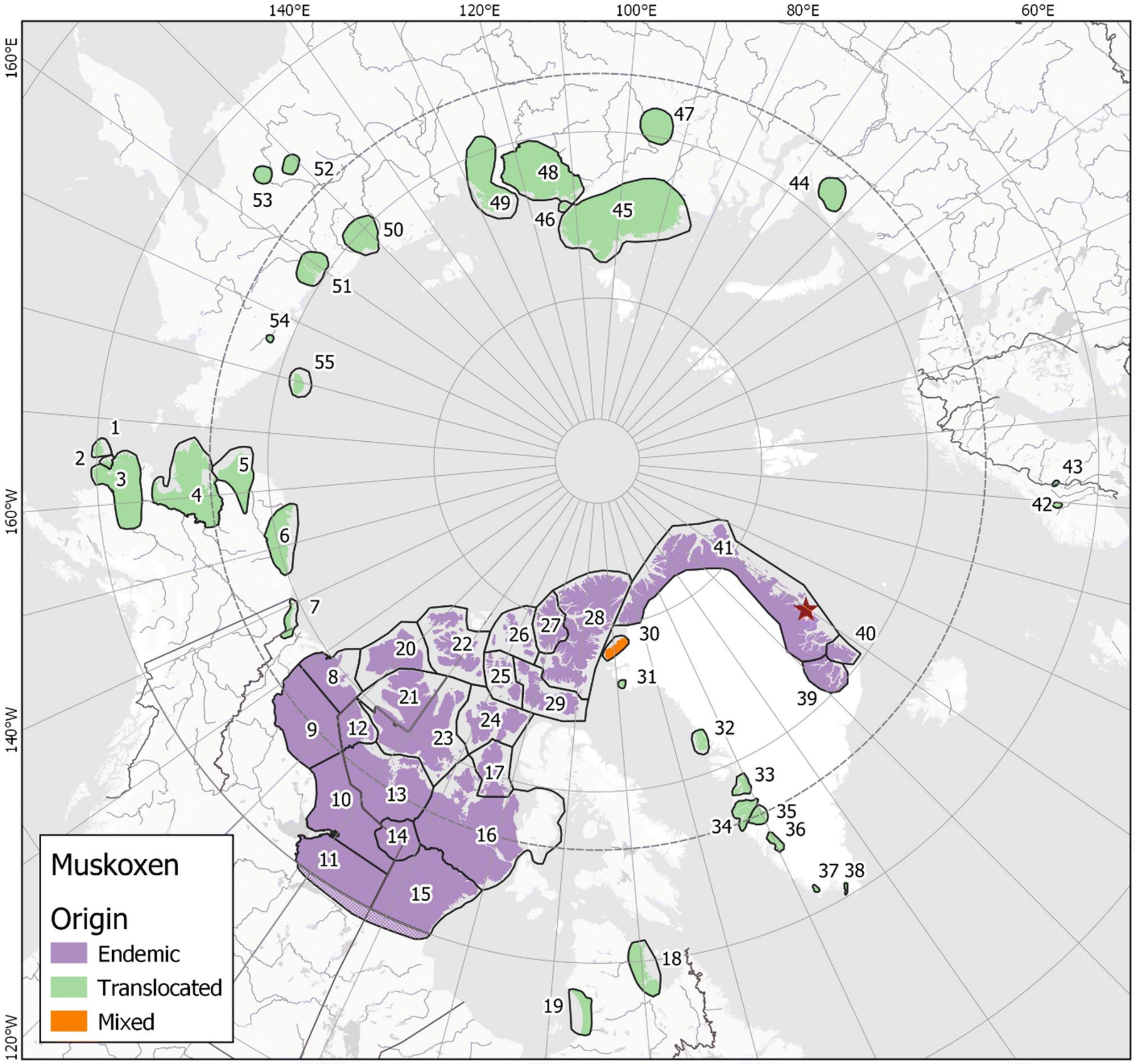
In Northern Alaska, counts indicated a steady decline in muskox from 2007 to 2011. Predation by grizzly bears was the most common cause of deaths during those years. Grizzlies killed muskox mainly in late winter and spring when little other food is available to the bears. There is no evidence that bear abundance changed over this period, but the abundance of moose and caribou declined in the area, suggesting that bears may have switched to muskox as a food source. Another factor in increased grizzly predation may have been the low levels of copper, which weaken animals and make them more prone to predation (Arthur & Del Vecchio, 2017).

Muskox Populations Around the Arctic

Globally, muskox have seen dramatic declines in recent years. Although relatively small in size, the North Slope population will likely continue to play an important role in conserving the species globally.

A review of global muskox populations (Cuyler et al., 2019) provides an overview of origin and distribution of muskox. The 55 endemic or translocated populations are divided into two subspecies: *Ovibos moschatus moschatus* (barren-ground muskox) and *Ovibos moschatus wardi* (white-faced muskox). Genetic studies confirm that these are separate subspecies. The *wardi* subspecies is endemic to the High Arctic islands and Eastern Greenland. Muskox of this subspecies from Eastern Greenland were the original animals introduced to other areas. The Yukon and Alaskan mainland populations are of the *wardi* subspecies, as are the three populations of muskox on Banks Island, Victoria Island, and Melville Island. The populations on the NWT mainland, including the Inuvik area population, are the *moschatus* subspecies. Global abundance is about 170,000 muskox, with several of the larger populations in decline. Factors influencing muskox populations are further discussed in the section on Observations, Concerns, and Threats.

Map 14- 5. Global overview of distribution and origin of muskox populations



Translocated includes introduced and re-introduced. Mixed is translocation to an area with endemic muskox. The star marks Zackenberg Research Station in Greenland. Source: Cuyler et al. (2019)

Population Management

Muskox management has focused on population monitoring, managing harvest opportunities, and addressing questions about how muskox and caribou interact (see section on Effects of Muskox on other Wildlife).

Inuvialuit harvesters have exclusive rights to harvest muskox in Ivvavik and Herschel Island-Qikiqtaruk Parks. They have a preferential right to harvest muskox on the Eastern Yukon North Slope (WMAC (NS), 2008). Muskox is closed to recreational hunting (Yukon Government, 2019) throughout the Yukon. Muskox may also be harvested by Gwich'in beneficiaries in the

Richardson Mountains and by other First Nations when muskox are present in their Traditional Territories.

There are currently no restrictions (such as quotas) placed on Inuvialuit muskox harvest on the Yukon North Slope. However, the muskox management framework includes strategic directions to consider introducing measures to manage muskox harvest in all or part of the population's range, based on population assessments and other factors (WMAC (NS), 2017).

Transboundary Considerations

The muskox population originated through range expansion from Alaska. Until the population crash of muskox in the Arctic National Wildlife Refuge in the mid to late 2000s, WMAC (NS) coordinated international management of the population with Alaska. Muskox in the far west of the Yukon North Slope could act as a seed population to repopulate the former Alaskan range in the future (WMAC (NS), 2017), and recent studies have shown that some groups do spend time in the Refuge (M. Suitor, personal communication, August 17, 2021).

The current range of the approximately 400 muskox that use the Yukon North Slope includes the Yukon coastal plain, extending east to the Mackenzie River, and the northern Barn Mountains and Richardson Mountains in NWT and Yukon. The population's range includes parts of the Inuvialuit Settlement Region (ISR), Gwich'in Settlement Area, and Vuntut Gwitchin Traditional Territory. Muskox range over three parks: Herschel Island–Qikiqtaruk Territorial Park, Ivvavik National Park, and Vuntut National Park.

Observations, Concerns, and Threats

Overview of Threats to Muskox

Muskox population declines have been linked to health issues caused by diseases and parasites, and muskox are prone to die-offs from extreme weather events. Populations in other Arctic regions have declined recently. An improved understanding of pressures on the small Yukon North Slope muskox population will aid in managing the population to maintain its viability.

Overharvest was a contributor to past muskox declines across the Arctic.

Table 14- 2 summarizes some key characteristics of muskox that make them either vulnerable or resilient to change. This table is based on proceedings of an international symposium on muskox health, ecology, and sustainability (Kutz et al., 2017).

Table 14- 2. Vulnerability and resilience of muskox to changing climate and ecological conditions: Key points from the *Muskox Health Ecology Symposium 2016*

	What makes muskox vulnerable?	What makes muskox resilient?
Climate change	• Small, isolated populations that are not highly mobile • Limited ability to respond to extreme weather events, especially heat extremes • Low genetic diversity may limit adaptability to rapid ecosystem changes and emerging pathogens	• Have survived past shifts in climate • Can adapt to new kinds of food and feeding behaviour • Have low metabolism and large fat stores that allow them to survive temporary food crises
Infectious diseases and parasites	• Poor immune response--susceptible to new pathogens • Herd behavior may facilitate spread of pathogens • Heat stress may increase susceptibility	• Isolation of populations may act as a barrier to disease transmission • Historical evidence suggests they have survived similar events in the past
Interspecies interactions	• Decline of other food sources for people may increase harvest pressure on muskox • Encroachment of other herbivores may increase food competition, predator levels, and pathogens	• Isolated populations and wide distribution offer broad-scale species protection • Good at defense against traditional predators and can modify behaviour in response to other species

Source: Kutz et al. (2017), summarized from Table 3

Climate Change

Extreme weather events like heavy snowfalls and rain-on-snow events are natural occurrences that are predicted to happen more frequently and to greater extremes with climate change. Climate trends can also affect muskox access to food. For example, several years with deeper than average snow was linked to the decline of muskox on Bathurst Island in Nunavut (Cuyler et al., 2019). Adverse conditions can prevent muskox from accessing food or make feeding require more energy, which can lead to increased mortality or reproductive failure.

Climate change may also have positive effects on muskox populations, as increases in the length of the growing season and longer snow-free periods may improve food availability (Cuyler et al., 2019; Stern & Gaden, 2015).

The Yukon North Slope is undergoing enhanced vegetation growth as a result of changing climate conditions in the region, which may have a positive influence on muskox demographics. However, these benefits are confounded by other negative aspects of climate change such as changing snow depths and densities.

Parasites and Diseases

Parasites and diseases can affect muskox health, population dynamics, and the quantity and safety of meat for consumption by people (Kutz et al., 2012). The impact of disease on muskox populations is linked to past shifts in the climate and current rapid Arctic climate change. Muskox survived past major climate changes when many other species did not. But widely fluctuating muskox populations in the past have led to low genetic variability, which affects their ability to respond to infectious disease (Cuyler et al., 2019). Current climate warming is leading to shifts in ranges of some parasites and disease vectors, and the introduction of some wildlife diseases not previously seen in the Arctic (Kutz et al., 2012). Changes in vegetation, and related changes in nutrition may lower resistance to disease (Cuyler et al., 2019). Outbreaks of disease have coincided with sharp muskox population declines in Canada and Norway.

Banks Island and Victoria Island muskox populations declined by over 50% between 2000 and 2014 (Kutz et al., 2016). The decline coincided with range expansions of lungworms, likely due to changes in ecological conditions, and emergence of a disease-causing bacterium that was not previously known in Arctic wildlife. Monitoring showed overall deterioration in body condition, additional viral and bacterial infections, and increased signs of stress, indicating that there were likely multiple causes of the rapid population decline.

Orf virus

The Orf virus can be transmitted from one ungulate wildlife species, or livestock, to other ungulate species. It has different effects on Dall's sheep, mountain goats, deer, and muskox. The virus causes lesions on the eyes, nose, lips, muzzle, and legs of muskox. Orf is common in domestic animals globally; there have been severe outbreaks of this viral disease in captive muskox in Alaska and in free-ranging muskox in Norway. There were increased reports of Orf-type lesions on Banks Island muskox when that population was declining. The Orf virus is known to occur in Alaskan muskox populations and, as of 2020, it appears to be widespread in the Yukon North Slope muskox population. Orf is thought to be extremely rare in caribou.

Sources: Tryland et al. (2018), Kutz et al (2016), M. Suitor, personal communication, March 30, 2021

Effects of Muskox on other Wildlife

Caribou

Inuvialuit land users have raised concerns about how muskox affect caribou since the species first began to appear in the Yukon in the 1980s. The concern is partly about whether caribou avoid muskox or flee from them, but also about the potential for competition between the two species for food and habitat, and whether muskox damage vegetation that is important for caribou. These concerns are being investigated through research and monitoring with community involvement, as set out in the *Yukon North Slope and Richardson Mountains Muskox Research Plan* (WMAC (NS), 2019b).

As part of this effort, Carter (2020) examined the overlap and interactions between collared muskox and collared caribou on the Yukon North Slope. Habitat models for spring and summer were developed for both species (see muskox habitat models, Map 14-2). The analyses showed that the two species select different kinds of habitats, with caribou favoring tussock habitats that are avoided by muskox but both favoring rock-lichen, wetland and floodplain habitats. Individual animals encountered each other less than 1% of the time.

Muskox and caribou

Eight interviewees (of 27 total) noted concern that increasing muskox populations were affecting caribou habitat. These observations focused on changes to the vegetation in areas with large muskox populations and on caribou's general avoidance of muskox. Interviewees noted that habitat in areas with large muskox populations has decreased in quality, particularly on Herschel Island. Interviewees also stated that caribou avoid muskox, either the animals themselves or the smell of areas with large muskox populations. Three interviewees suggested that the increased muskox population is contributing to the changing migration routes of caribou.

Excerpt from *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2018a), pp. 25-26

Carter (2020) also evaluated whether muskox impact vegetation biomass and community structure, and found little evidence of this. Muskox presence was associated with higher lichen, graminoid and willow biomass suggesting muskox select for areas with higher forage availability. Based on the results of this work, Carter (2020) suggests there is little evidence that muskox were competing for vegetation or modified significant quantities of vegetation used by caribou during her study period (2016-2019).

Predators

Grizzly bear predation on muskox

Responses also suggest that grizzly bears increasingly follow muskox herds. Four interviewees gave detailed accounts of grizzly bears travelling to areas with large muskox populations, particularly in the spring when access to and from the Herschel Island muskox population is easier and muskox are having their young.

Excerpt from *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & Aklavik HTC, 2018a), p. 33

Muskox, as a relatively new prey species, may also affect predator-prey interactions. For example, there are indications that grizzly bears in Alaska and the Yukon are taking advantage of this new source of food (Arthur & Del Vecchio, 2017; M. Suitor, personal communication, August 17, 2021).

Muskox abundance may also affect wolves on the Yukon North Slope. Wolves follow caribou annual migrations, roaming widely across the herd's range.

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.

Muskox Conservation and Management

- *Framework for the Management of Yukon North Slope Muskox* (WMAC (NS), 2017)

  This plan provides guidance for muskox management on the Yukon North Slope. The guiding principle is conservation of the muskox population, as established for all wildlife across the ISR. Management goals are to:

  1. Provide opportunities for Inuvialuit hunters to harvest muskox while maintaining a healthy, productive, and sustainable population;
  2. Minimize any detrimental effects that muskox may have on caribou and caribou habitat and harvesting;
  3. Cooperate and share information about muskox among users to develop and implement management and research programs.

> In developing this research plan, there was a strong desire expressed for muskox research that responds to community concerns and includes basic monitoring that can contribute to management decisions. Communication, education and outreach emerged as an overarching theme that should guide all research being undertaken on Yukon North Slope muskox.
>
> From *Yukon North Slope and Richardson Mountains Muskox Research Plan* (WMAC (NS), 2019b), p. 6

- *Aklavik Inuvialuit Community Conservation Plan* (Aklavik HTC et al., 2016)

  Identifies the eastern Yukon North Slope, Ivvavik National Park, and Herschel Island–Qikiqtaruk Territorial Park (Special Designated Lands Sites 725DE, 727E, and 730E, respectively), as muskox year-round habitat. The plan also notes that there is an interest in knowing more about muskox diets and the relationship between muskox and caribou.

- Park plans (Herschel Island-Qikiqtaruk Management Plan Review Committee, 2018; Parks Canada, 2018)

  Conservation and management of muskox is part of Ivvavik Park's strategy "to protect and conserve natural ecosystems, habitat, wildlife, cultural resources and Inuvialuit practices, based on the best available scientific and traditional knowledge" (Parks Canada, 2018). Both parks record observations of muskox and participate in monitoring and research on muskox.

Research and Monitoring Programs

- *Yukon North Slope and Richardson Mountains Muskox Research Plan* (WMAC (NS), 2019b)
  The research plan is designed to accompany the *Framework for Co-management of Yukon North Slope Muskox* (WMAC (NS), 2017). The geographic scope of the plan crosses boundaries, encompassing the range of muskox across the Yukon North Slope and in the Richardson Mountains to the south and east. Partners and collaborators for developing and implementing the plan include Inuvialuit and Gwich'in organizations, co-management boards, government agencies, and other researchers. To aid in defining research priorities, a gap analysis was conducted, and a workshop was hosted by the WMAC (NS) and Aklavik HTC in 2017. Research planning is organized around three primary themes: 1) population dynamics; 2) habitat use and movement; 3) muskox-caribou interactions; and one secondary theme: health and genetics. Research objectives and actions are presented for each theme.
- *Muskox (Ovibos moschatus) Habitat Associations and Interactions with Caribou (Rangifer tarandus)* (Carter, 2020)
  This thesis is an ecological assessment of competition potential and habitat segregation between muskox and caribou. Satellite collar data from muskox and caribou were used to analyze their spatial and habitat overlap through range overlap, encounter rates, and resource selection functions. Range overlap was at its highest in the spring and summer months, but less than 1% of collared caribou encountered a muskox during that period. Habitat overlap was minimized through differential selection of elevation, distance to water, and abundant tussock habitat. Ground-based vegetation sampling was used to characterize fine-scale muskox-vegetation associations. Positive associations were found between muskox use and lichen, willow, and graminoid abundance and presence, and research found the relationship between muskox use and vegetation is mostly driven by selection rather than by herbivory (i.e., muskox likely are not changing vegetation on the landscape but rather responding and moving to areas with selected vegetation). Collectively, this research reveals that in the Yukon North Slope and Richardson Mountains, the reintroduced and expanding population of muskox has low encounter rates and differential habitat use with caribou.
- Ongoing monitoring and research on Yukon North Slope muskox (summarized in WMAC (NS) annual and term reports (e.g., WMAC (NS), 2019a))
  Monitoring of muskox on the Yukon North Slope is led by the Yukon Government, in collaboration with the Gwich'in Renewable Resources Board, the Government of the NWT, and Parks Canada. Research and monitoring are guided by the research plan described above (WMAC (NS), 2019b). Muskox surveys to track abundance and collect information on the composition of the herd are carried out annually. Enough muskox are now equipped

with radio collars to enable locating groups of muskox across the population's distribution. Recent or current research projects in collaboration with university researchers include research on muskox genetics, diet, health, and population dynamics. Research to better understand community concerns and solutions for managing muskox is currently getting underway, working with Aklavik. Efforts are also underway to enhance the value of muskox in the community, through harvest activities and workshops with knowledgeable harvesters.

- Muskox Expert Network of the Circumpolar Biodiversity Monitoring Program (MOXNET) (Conservation of Arctic Flora and Fauna, n.d.)
  This circumpolar expert network collaborates and shares information on muskox populations around the circumpolar Arctic. The network helps to advance understanding of muskox ecology and develop and improve monitoring methods (Cuyler et al., 2019; Kutz et al., 2017).

- Harvest monitoring: Inuvialuit Harvest Study (IHS) (IRC, 2017, 2018, 2019)
  Annual harvest monitoring in the ISR was led by the Inuvialuit Game Council and the Inuvialuit Regional Corporation. This program included muskox harvest monitoring. The ISR Community-Based Monitoring Program was revised after 2014 to focus on harvest. Aklavik Inuvialuit Community Resource Technicians (CRTs) collected harvest information, including harvest locations, through annual interviews with active harvesters. This program built on previous harvest monitoring methods and data (Inuvialuit Harvest Study, 2003).

Selected Studies and Research Relevant to the Yukon North Slope

Because muskox on the North Slope is a reintroduced species, the knowledge base around this population is relatively recent. Research on muskox ecology, health, and causes of mortality has been conducted in Alaska and the Yukon. Knowledge about global muskox populations, including their vulnerability and adaptability to rapidly changing Arctic climate and ecosystem conditions, has been synthesized through initiatives of the Circumpolar Biodiversity Monitoring Program.

This section is an annotated listing of selected reports, scientific papers, and other resources that provide support to the *Yukon North Slope Wildlife Conservation and Management Plan* and highlight issues and research directions that will be important to consider during its implementation.

Traditional Knowledge Studies

There is little documented traditional knowledge about muskox on the Yukon North Slope. The species was not present in the region from some time in the 1800s until the 1980s and it is not known how abundant muskox were prior to their extirpation in the 1800s. However, the muskox management framework and research plan were developed through extensive consultation with the community of Aklavik, and incorporate Inuvialuit knowledge and concerns about muskox on the Yukon North Slope.

- *Yukon North Slope Inuvialuit Traditional Use Study* (WMAC (NS) & Aklavik HTC, 2018b) and *Inuvialuit Traditional Knowledge of Wildlife Habitat, Yukon North Slope* (WMAC (NS) & 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. The results were used in developing the Plan. The studies include references to muskox sightings and observations about interactions with caribou, but muskox are not included in the mapped data.

Assessments and Syntheses of Monitoring and Research Findings

The reports listed below summarize knowledge about muskox, identify strengths and gaps in the knowledge base, and include recommendations.

- *Muskox Health Ecology Symposium 2016: Gathering to Share Knowledge on Umingmak in a Time of Rapid Change* (Kutz et al., 2020) This report summarizes the 2016 Muskox Health Ecology Symposium, the first international conference on muskox in almost 30 years. Information was shared on muskox health, ecology, and sustainability.

- *Yukon North Slope and Richardson Mountains Muskox Research Plan* gap analysis (WMAC (NS), 2019b)
  The gap analysis conducted to inform the research plan is based on a review of relevant scientific literature, reports, presentations, and management tools. Results of this review are included in the plan (Table 1 and Appendix 2).

- *Summary of Wildlife-Related Research on the Coastal Plain of the Arctic National Wildlife Refuge, Alaska, 2002–17* (Pearce et al., 2018)
  This US government report includes a summary of the history of Alaskan muskox on the eastern Alaskan North Slope, a review of muskox biology and ecology in the area, and discussion of monitoring results and research on predation, disease, parasites, and nutrition.

- Muskox status, recent variation, and uncertain future (Cuyler et al., 2019)
  This review of global muskox populations includes information on muskox biology; the history, status, and trends of the 55 muskox populations around the circumpolar Arctic; and factors influencing muskox health and population dynamics.

- *Muskox Health Ecology Symposium 2016* (Kutz et al., 2017)
  The report from this international symposium summarizes presentations and discussions on muskox health, ecology, and sustainability. Contents include knowledge about causes of recent declines, gaps in knowledge about resilience of muskox to changes in climate and ecological conditions, and muskox diseases and parasites.
- *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 muskox. 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

Afema, J. A., Beckmen, K. B., Arthur, S. M., Huntington, K. B., & Mazet, J. A. K. (2017). Disease complexity in a declining Alaskan muskox (Ovibos moschatus) population. *Journal of Wildlife Diseases*, *53*(2), 311–329. https://doi.org/10.7589/2016-02-035

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

Alaska Department of Fish and Game. (n.d.). Muskox (Ovibos moschatus): Species Profile. Retrieved from http://www.adfg.alaska.gov/index.cfm?adfg=muskox.main

Arthur, S. M., & Del Vecchio, P. A. (2017). Effects of grizzly bear predation on muskoxen in northeastern Alaska. *Ursus*, *28*(1), 81–91. https://doi.org/10.2192/URSUS-D-16-00023.1

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

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

Conservation of Arctic Flora and Fauna. (n.d.). CBMP Muskox Expert Network. Retrieved April 28, 2020, from https://www.caff.is/terrestrial/terrestrial-expert-networks/muskox

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/

Cuyler, C., Rowell, J., Adamczewski, J., Anderson, M., Blake, J., Bretten, T., … Ytrehus, B. (2019). Muskox status, recent variation, and uncertain future. *Ambio*. https://doi.org/10.1007/s13280-019-01205-x

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.

Harper, P., & McCarthy, L. A. (2017). *Muskox Management Report of Survey- Inventory Activities , 1 July 2012 – 30 June 2014*. Alaska Department of Fish and Game.

Herschel Island-Qikiqtaruk Management Plan Review Committee. (2018). *Herschel Island-Qikqtaruk Territorial Park Management Plan June 12, 2018*.

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

IRC. (2017). *Inuvialuit Harvest Study: Annual Newsletter January-December 2016 (Issue #02, Spring 2017)*. Inuvialuit Regional Corporation.

IRC. (2018). *Inuvialuit Harvest Study: Annual Newsletter January-December 2017 (Issue #03, Spring 2018)*. Inuvialuit Regional Corporation.

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

Kutz, S., Checkley, S., Davison, T., Elkin, B., Di Francesco, J., Forde, T., … Wynne-Edwards, K. (2016). No

Smoking Guns: Emerging diseases and general ill-health coincide with rapid declines of muskox populations on Banks and Victoria Islands, NWT and Nunavut, Canada. In *Muskox Health Symposium Abstracts, p. 14*.

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

Kutz, S., Rowell, J., Adamczewski, J., Gunn, A., Cuyler, C., Aleuy, O. A., … Mavrot, F. (2017). Muskox Health Ecology Symposium 2016: Gathering to Share Knowledge on Uningmak in a Time of Rapid Change. *Arctic*, *70*(2), 225–236.

Lent, P. C. (1998). Alaska's indigenous muskoxen: a history. *Rangifer*, *18*(5), 133. https://doi.org/10.7557/2.18.3-4.1457

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

Pearce, J. M., Flint, P. L., Atwood, T. C., Douglas, D. C., Adams, L. G., Johnson, H. E., … Latty, C. J. (2018). *Summary of Wildlife-Related Research on the Coastal Plain of the Arctic National Wildlife Refuge, Alaska, 2002–17*. https://doi.org/10.1134/S1063778811030112

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.

Tryland, M., Beckmen, K. B., Burek-Huntington, K. A., Breines, E. M., & Klein, J. (2018). Orf virus infection in Alaskan mountain goats, Dall's sheep, muskoxen, caribou and Sitka black-tailed deer. *Acta Veterinaria Scandinavica*, *60*(1), 1–11. https://doi.org/10.1186/s13028-018-0366-8

WMAC (NS). (2008). *Harvesting rights on the North Slope (fact sheet)*. 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). (2017). *Framework for the Management of Yukon North Slope Muskox*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

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

WMAC (NS). (2019b). *Yukon North Slope and Richardson Mountains Muskox Research Plan*. Whitehorse, YT: Wildlife Management Advisory Council (North Slope).

WMAC (NS). (2020). *Muskox Fact Sheets*. Retrieved from https://wmacns.ca/resources/muskox-fact-sheets/

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

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 Government. (n.d.). Yukon Wildlife: Muskox. Retrieved January 15, 2020, from https://yukon.ca/en/muskox

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