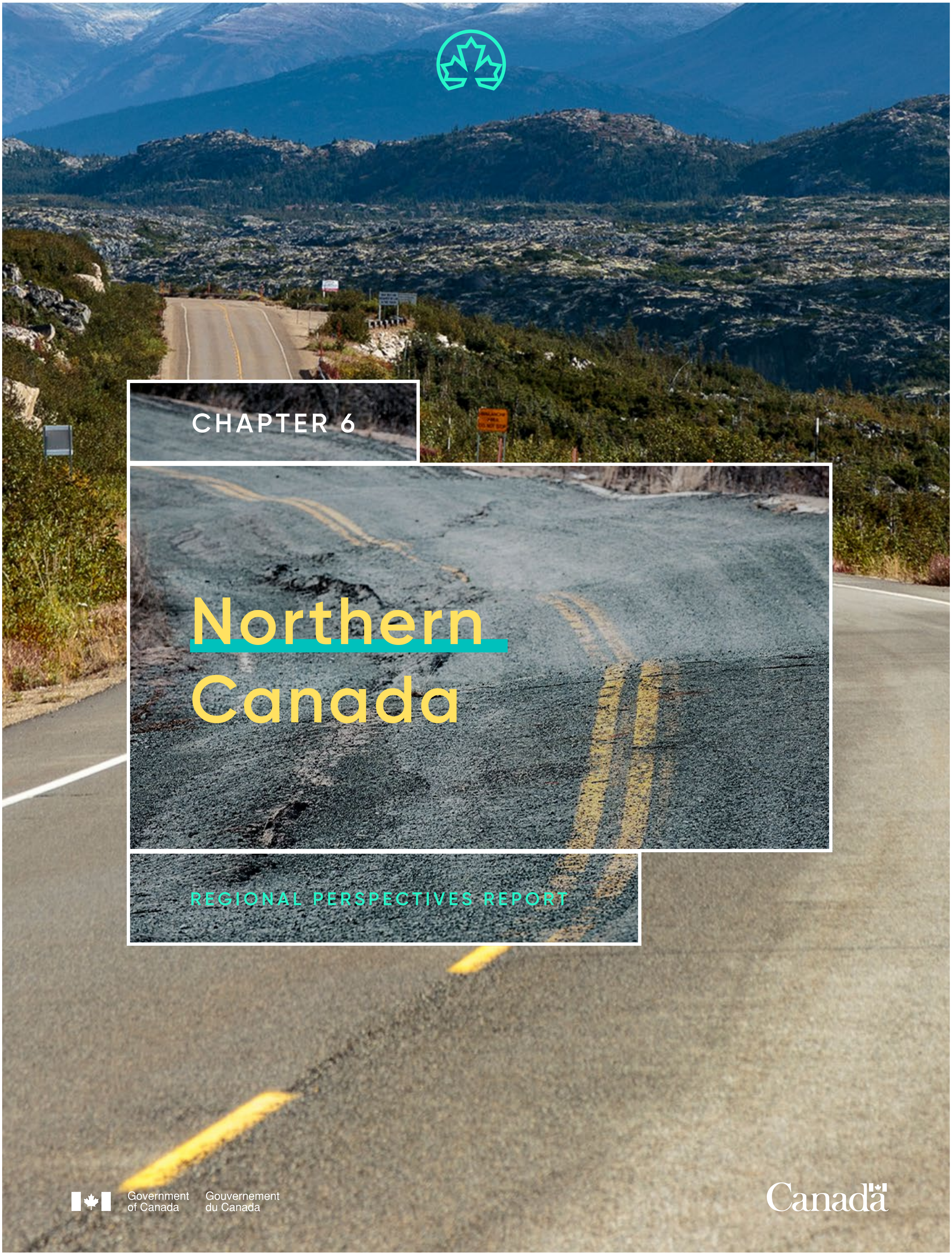


CHAPTER 6

Northern Canada

REGIONAL PERSPECTIVES REPORT

Government of Canada / Gouvernement du Canada

Canada

Coordinating lead author

Bronwyn Hancock, PhD (Yukon University)

Contributing authors

Winston (Barry) Andersen (Nunatsiavut resident)

Fabrice Calmels, PhD (Yukon University)

Joe Collier (Yukon University)

Ashlee Cunsolo, PhD (Labrador Campus, Memorial University)

Sam Darling, PhD (McGill University)

Jackie Dawson, PhD (University of Ottawa)

Gwenn Flowers, PhD (Simon Fraser University)

Mary Gamberg (Gamberg Consulting)

Gwen Healey, PhD (Qaujigiartiit Health Research Centre)

Brian Horton (Yukon University)

Courtney Howard, MD (University of Calgary)

Stephanie Irlbacher-Fox, PhD (Hotıì ts'eeda)

Jill Johnstone, PhD (Yukon University and University of Alaska Fairbanks)

Eric Labrecque (Yukon Energy Corporation, formerly with Yukon University)

Lisa Loseto, PhD (Department of Fisheries and Oceans Canada)

Rachel MacNeill (Hotıì ts'eeda)

Kristeen McTavish (Nunatsiavut Government)

Jacqueline Middleton, PhD (University of Guelph)

Alison Perrin (Yukon University)

Pitseolak Pfeifer (Inuit Solutions)

Jamie Snook, PhD (Torngat Wildlife, Plants and Fisheries Secretariat)

Lindsay Staples (North\West Resources Consulting Group)

Maciej Stetkiewicz (Yukon University)

Carmen Wong, PhD (Parks Canada)

Recommended citation

Hancock, B., Andersen, W.(B.), Calmels, F., Collier, J., Cunsolo, A., Dawson, J., Darling, S., Flowers, G., Gamberg, M., Perrin, A., Healey, G., Horton, B., Howard, C., Irlbacher-Fox, S., Johnstone, J., Labrecque, E., Loseto, L., MacNeill, R., McTavish, K., Middleton, J., Pfeifer, P., Snook, J., Staples, L., Stetkiewicz, M. and Wong, C. (2022). Northern Canada; Chapter 6 *in* Canada in a Changing Climate: Regional Perspectives Report, (eds) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario.

Table of Contents

Key Messages

Climate change is severely impacting northern landscapes and ecosystems (*see* section 6.2)

Climate change is producing severe, and in many cases irreversible, changes to northern landscapes and ecosystems. Northerners are trying to understand the limits of ecosystem resilience and our capacity to adapt to these changes.

Health impacts are intensifying and amplifying inequities in the North (*see* section 6.3)

Climate change is negatively impacting the health of Northerners, amplifying existing inequities and access to healthcare. Locally appropriate, culturally relevant resources and programming, co-created by local communities in partnership with other organizations, are critical to support climate-sensitive physical and mental health outcomes.

Safe travel in the North is threatened by climate change (*see* section 6.4)

Climate change is increasing risks to safe travel in the North, but drawing from different types of knowledge is helping to reduce these risks.

Northerners are leaders and innovators in climate change adaptation (*see* section 6.5)

Innovative approaches to governance, policy and development are addressing social inequities and opening pathways for collaborative and inclusive climate change adaptation.

Recognizing inherent capacity is key to building climate resilience (*see* section 6.6)

Organizations and individuals that recognize and embrace the inherent capacity of northern communities to adapt are key players in the pursuit of climate resilience.

Preface: A message about urgency from the Coordinating Lead Author

Together, the authors and advisors who helped craft this chapter represent decades of lived experience in Canada's North. I would not have been able to complete this chapter without their thoughtful guidance. We are in their debt for the support that they provided.

As the key messages in this chapter demonstrate, northern adaptation to climate change impacts is a lively and complex topic. However, some important messages are not easily conveyed; foremost amongst these is the urgency for action on so many fronts.

I am alarmed by the changes that we are witnessing here, and cannot adequately express the need for urgent action. Northerners are indeed taking action to adapt and are determined to continue doing so. Still, this chapter underscores that building resilience in the North means much more than anticipating the future and changing an existing or planned course of action. Addressing urgent societal issues—such as housing shortages, education, food security and culturally appropriate health and wellness—is deeply intertwined with efforts to build resilience to climate change. I have heard it stated, "How can you worry about climate change when you're hungry?"

At the same time, I fear that adaptation efforts will encounter unmovable limits. The magnitude of projections for temperature increase, sea-level rise, and ice and permafrost loss for the next century will force us to consider the unthinkable—for example, abandoning homes and traditional territories, moratoria on harvesting traditional foods, and travelling exclusively by air rather than on land or sea. Currently, many of these "solutions" are almost taboo—they are too difficult to consider, but they represent possibilities in the coming decades. Northern Indigenous cultures have shown intense resilience over centuries. Holistic knowledge passed through traditional and cultural practices will continue to ensure a level of cultural well-being, but climate change has joined stressors such as social inequity, the legacies of colonialism and environmental issues only partially related to climate change (such as northern contaminants) as a continual and pervasive threat.

The North will be unable to adapt alone. Paying for the costs of climate change is everyone's responsibility; they cannot be borne solely by Northerners. Similarly, there is an urgent need to improve access to the knowledge, solutions, innovation and creativity of Canadian and international experts who are willing to work alongside us as equal partners. I urge Canadians to use the key messages in this chapter to compel urgent adaptation action, but I also call for bold conversations that acknowledge social inequity and the limits of adaptation.

Our North depends on it.

Bronwyn Hancock, PhD

6.1 Introduction

In a region where much of society is deeply tied to the natural environment, changes to the land have the potential to deeply impact the people who live there and who depend upon the land. Many Northerners report that their livelihoods, culture, relationships with the land, and mental health and well-being are being impacted by environmental changes (Kuzyk and Candlish, 2019; Meredith et al., 2019; Bell and Brown, 2018; Stern and Gaden, 2015; Berry et al., 2014), including climate change (*see* Figure 6.1). While the adaptive capacity of Northerners, especially Indigenous Northerners, has allowed them to be resilient to change for generations (Pfeifer, 2020), the pace of change to which we must adapt has accelerated and is outpacing existing adaptive capacity (Ford et al., 2014).

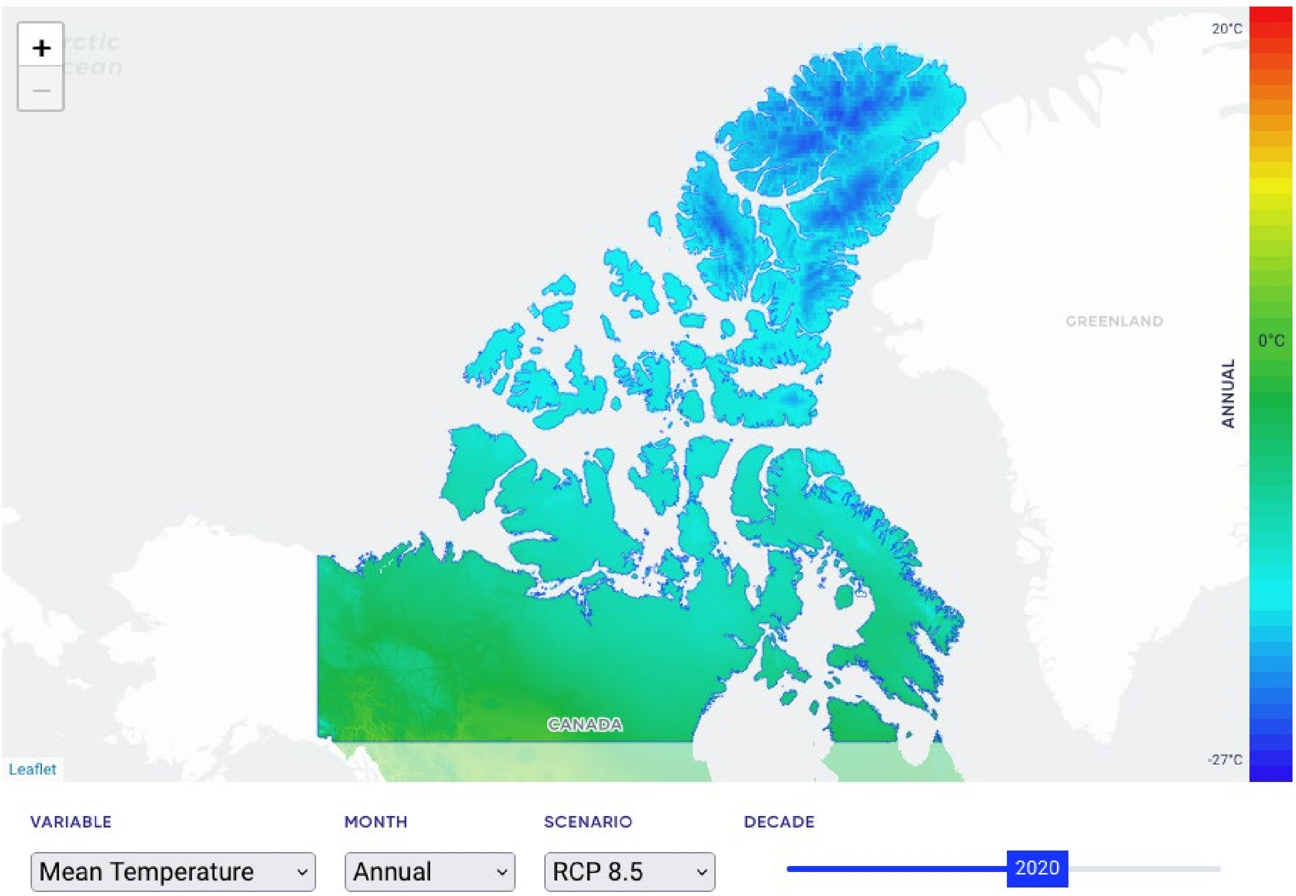


Figure 6.1: Interactive regional map of Northern Canada that draws from climatedata.ca and visualizes various climate variables from 1980 to under three different emissions scenarios: RCP 2.6 (low), RCP 4.5 (medium) and RCP 8.5 (high). Source: climatedata.ca

Canada's status as an Arctic nation elevates the importance of understanding climate change impacts and adaptation. In its report identifying the top climate risks facing Canada, the Council of Canadian Academies identified climate risks to northern communities as being among the top risks for the country (Council of Canadian Academies, 2019). Meanwhile, the development of the Arctic and Northern Policy Framework demonstrates Canada's emphasis on the North as an area of policy focus (Crown Indigenous Relations and Northern Affairs Canada, 2019).

In addition to climate change, the impacts of colonialism and power differentials in Canadian governance and society affect the capacity of Northerners to adapt to change (Council of Canadian Academies, 2019). Indigenous and non-Indigenous Northerners are working within both historical and contemporary treaties, as well as outside of treaties, to overcome this history and to build community resilience. Efforts to support reconciliation guide the decision making of many northern academic institutions and governments (e.g., Wong et al., 2020). In many cases, hunting programs for youth, on-the-land camps, community-centered infrastructure projects and other measures move northern societies towards reconciliation. These measures also improve relationships between community members and strengthen connection to culture, thereby building climate resilience, but such outcomes are rarely direct goals of the activities implemented.

The lived experience of Northerners and the knowledge held over generations as a result of that lived experience, including Indigenous Knowledge and local knowledge, feature prominently in this chapter and are the basis upon which adaptive capacity is built (*see* Box 6.1). While there is regional nuance in the messages conveyed in Box 6.1, the sentiments expressed are common throughout the North. This chapter has attempted to include a diverse range of knowledge, while recognizing that further work in this regard is a necessity, and acknowledging that the scientific framing of this report is not entirely compatible with the holistic and applied intentions expressed below.

Box 6.1: Excerpt from "Inuit, *namiipita?* Climate Change Research and Policy: Beyond Canada's Diversity and Equity Problem"

"Why, in spite of so much research and policy focus on climate change in the Arctic, are we, Inuit, still consultants or fillers in an otherwise Western-driven enterprise to "monitor" climate developments in Inuit Nunangat? The in-situ capacity that Inuit have developed over millennia to observe, analyze, apply and adapt to the changing northern environment is overlooked in the scientific race to research and document environmental transformations taking place in our homelands. We need to turn to a pragmatic approach in the climate change fight—one that starts locally and it presupposes challenging ongoing policy concerns with how to "validate" Inuit knowledge and science. This involves stepping out of the traditional research paradigm and instead directing substantive resources towards the inclusion of Inuit as fully-fledged, distinct researchers and decision-makers.

Inuit are part of the northern ecosystem; thus, a perspective is needed that speaks to the interdisciplinary and holistic nature of *Qaujimajatuqangit* (Inuit traditional knowledge) and way of being of people in this part of the world. Given that the Inuit are at the centre of the looming environmental crisis, they should also be at the center of the way forward, for everybody's sake.

To be fair, there are attempts to incorporate Indigenous epistemologies and methodologies in research, including university-driven community research projects. By and large though, the lead stays outside of the Arctic, with Inuit merely being consulted on research areas that mainly relate to community development or, at best, being called on to contribute what has been called “traditional ecological knowledge” where research gaps exist.

Inuit participation in climate change and other environmental assessment processes will result in increased applied research capacity, sustainable northern economic development as per Inuit *Qaujimajatuqangit* approaches and an opportunity for our community members to feel re-empowered to reclaim their role as the original stewards and guardians of *Sila* (a spiritual power related to weather), bestowed on us by *Anirnirq* (Great Spirit) and passed on through our *Innait* (elders) and *atarniit* (ancestors).

Arctic warming is certainly a hot topic. For the Inuit in particular, it is a burning issue, as it concerns our homelands, and yet we are left out of the national and global climate change conversation. Gathering evidence to inform policymaking in support of slowing down climate change fits into to a northern research and policy capacity-building paradigm that many of us in the south are used to. The urgency of Arctic change compels an alternative applied and solution-focused paradigm. The capacity is there, but it is a distinct, Inuit-specific capacity; the evidence is there, but it has been gathered and documented in a way that has not historically sat well with the exclusive understanding of science that drives evidence-based policymaking. If we, as a society, are to understand and design pragmatic solutions to climate change, the Inuit need to be at the forefront of the research and decision-making process. Their homelands are most affected, and so are they as a people. Their capacity and evidence does not need to be legitimized, but rather to be seen as a unique asset in approaching climate change in an integrated, applied, holistic manner—one that would mark a different way of investing research resources and of thinking through the complexity of the Arctic ecosystem: land, water, animals, and people. Inuit, *namiipita* (where are you)?”

Source: Pfeifer, 2020, 265–269.

The history of Indigenous-northern settler relations is a critical factor in understanding adaptive capacity in the North, and does not follow a simple timeline. In the Eastern Arctic, contact between Inuit and settlers goes back to the 1500s (Inuit Tapiriit Kanatami, 2004). Even before oppressive policies were introduced, settlers introduced viruses, at times intentionally, and overharvested key species. These actions ravaged many Indigenous populations in this early contact period (Truth and Reconciliation Commission of Canada, 2015a; Inuit Tapiriit Kanatami, 2004). By contrast, contact between Yukon First Nations and settler populations happened much later, after oppressive policies and the Indian Act were entrenched elsewhere in early-Confederation Canada. Throughout the North, Christian religious bodies and the Northwest Mounted Police (later the Royal Canadian Mounted Police) played a prominent role in deploying and implementing policies with the explicit intention of eradicating traditional practices and assimilating Indigenous people into “Western” ways (Coates, 2020).

Northern Indigenous voices were almost entirely absent from any policy development until well into the 1970s (Truth and Reconciliation Commission of Canada, 2015a; 2015b). Instrumental work accomplished during this time period included the James Bay and Northern Quebec Agreement (James Bay Northern Quebec Agreement, 1975), Together Today for Our Children Tomorrow (Yukon Native Brotherhood, 1973), The Dene Declaration (Indian Brotherhood of Northwest Territories, 1975) and the Mackenzie Valley Pipeline Inquiry (Berger, 1976). Since this time, Indigenous populations have been able to begin influencing the policies that had been so detrimental to their People, but this still required Indigenous leaders to largely adopt Western governance approaches. Decades also elapsed before the practice of taking Indigenous people from their homes to attend residential schools was ended in 1996 (Reimer et al., 2010). The first Indigenous Self Governments began to form in the early 1990s (Government of Canada, 1995), but they are not universal among northern Indigenous populations today.

It cannot be understated how deeply past and present-day settler policies have harmed Indigenous Northerners (Truth and Reconciliation Commission of Canada, 2015a; 2015b). This reality is present in every conversation, regardless of the specific subject matter. As such, it is exceedingly difficult to situate how climate change impacts and adaptation actions relate to other issues and priorities. Nonetheless, climate change is clearly a priority. Changes already observed are alarming to both Indigenous and non-Indigenous Northerners, and the projected pace and magnitude of anticipated change pose daunting challenges for all of us. Indigenous Knowledge approaches clearly demonstrate that strictly applying a reductionist "Western science" worldview is unlikely to lead to lasting solutions being adopted by northern communities (e.g., Council of Yukon First Nations and Assembly of First Nations, 2019; Inuit Tapiriit Kanatami, 2019a). Applying Indigenous worldviews allows us to move beyond linear "cause-and-effect" thinking towards more holistic approaches to building community resilience. This is the northern reality.

Within the context described above, this chapter was developed by a northern organization, featuring contributions made primarily by northern authors across Canada. This approach provides those living and working in the North with the opportunity to identify and write about climate change impacts and adaptation as they are being perceived, lived, studied and experienced in northern Canada. Contributing authors brought a range of knowledge types and areas of expertise, and have experience in the diverse environments in which we live, and the issues with which we live.

Like other chapters in this report, the Northern Canada chapter uses a "Key Messages" approach. The development of the key messages and the identification of the contributing authors and case stories featured in the chapter were guided by an advisory committee through an iterative, consensus-based approach. The advisory committee was made up of Northerners from across the Territorial North, Inuit Nunangat and northern Manitoba. Like our contributing authors, this chapter's advisors are diverse in their expertise and lived experience, and they worked together to identify issues relevant across our northern home. The broad, engaged approach used to develop this chapter reflects the existing collaborative spirit that is required in order to understand and respond to the impacts of climate change in Canada's North. The advisory committee met five times—four times virtually, and once in person—to create a long list of topic areas, and then to refine this to a manageable list of draft key messages. This was followed by an effort to recruit authors (ideally who live in the North, and are able to incorporate Indigenous perspectives into their writing). The Coordinating Lead Author and supporting team at Yukon University edited and revised the content, with further contributions from the authors, in order to complete this chapter. The result is a chapter that does not cover all northern climate change adaptation topics, but rather attempts to capture what our advisors consider, based on their experience and expert opinion, to be high priorities for the North.

The key messages in this chapter range from biophysical impacts—including novel disturbances and accelerated rates of change—to impacts on people and culture, through an exploration of holistic health and wellness, public health and safety, and capacity and innovation. These key messages are intended to illustrate the connection between northern society and cultures, and changes to northern landscapes. The complexity of types and degrees of connection to the land and sea, cascading impacts, and appropriate adaptation responses increase with each key message. Rather than attempt to provide an exhaustive list of impacts and adaptations associated with the key messages presented here, we have used examples and case stories to illustrate the central themes of each key message.

6.1.1 What is "*North*"?

The question of how to apply a definition of "North" to our country is a long-standing one (Graham, 1990); as a result, many definitions exist and for numerous different applications (*see* Figure 6.2). For example, the southern limit of discontinuous permafrost, or the northern limit of the treeline, have been used to delineate "North". Various indices of nordicity (e.g., Hamelin, 1979; Burns et al., 1975) have been developed to inform policy, while territorial or settlement region boundaries have been used to reflect jurisdictional governance (e.g., Inuit Nunangat, the Inuit homeland in Canada; (Inuit Tapiriit Kanatami, 2019b)). In Canada's Changing Climate Report, "the North" is used to refer to the three territories (i.e., the Northwest Territories, Yukon and Nunavut), while "northern Canada" is used to refer to the region north of latitude 60˚ (Bush and Lemmen, 2019).

Figure 6.2: Interactive map illustrating different definitions of “North”. Data source: Courtesy of Stephanie Saal, Yukon University.

This chapter takes the approach that “North” is defined by identity; therefore, the key messages presented in this chapter are relevant to those living both inside and outside of more typical definitions of “North.” For example, Indigenous Peoples with traditional territories that extend south of territorial borders may identify with key messages presented in this chapter, as may the residents of Inuit Nunangat or remote communities south of 60°N latitude, such as Churchill, Manitoba. A people-oriented definition of “North” allows this chapter to explore the societal impacts of climate change and adaptation responses, and includes those who self-identify as Northerners.

While great diversity exists across Canada’s northern region, some commonalities are shared. The North is dotted with small communities, many of which are only accessible by air, sea or winter road, including all communities in Nunavut, Nunavik and Nunatsiavut. While the population of northern Canada is low (Statistics Canada, 2017), populations across the North are growing faster than other parts of Canada. The primary driver in the eastern region of the North is natural growth (where there is a young population with growing families), while migration becomes a larger driver in the western region of the North (Statistics Canada, 2018). Many residents live in urban centres within each region, and the proportion of the population made up of Indigenous Peoples generally increases from west to east across northern Canada (*see* Table 6.1).

Table 6.1: Population of Northern Canadian communities

REGION/ TERRITORY	PROPORTION OF POPULATION SELF-IDENTIFYING AS INDIGENOUS	URBAN CENTRE	PERCENTAGE OF POPULATION WITHIN THE URBAN CENTRE
Yukon	20%	Whitehorse	70%
Northwest Territories	51%	Yellowknife	49.5%
Nunavut	85%	Iqaluit	20%
Nunavik	90%	Kuuijuaq	20%
Nunatsiavut	90%	Nain	44%

Source: Statistics Canada, 2018, 2017.

Communities in northern Canada have a mix of land-based and wage-based economies. Land-based activities are often associated with subsistence activities and cultural practices, while wage-based economies are often associated with resource development and governance. The knowledge economy of Canada's North is also growing, as a result of post-secondary education, innovation and entrepreneurship. Throughout Northern Canada, there is expanding local access to post-secondary education, including the launch of Yukon University in May 2020, the transition of Aurora College towards being a polytechnic university, the strategic partnership between Nunavut Arctic College and Memorial University, and the creation of the Labrador Campus of Memorial University. Investment in infrastructure for post-secondary education in Yukon and innovative programming such as the Dechinta Centre for Research and Learning in Northwest Territories form a part of Canada's financial support for the North (Government of Canada, 2021; 2019a). Inuit Tapiriit Kanatami (ITK), the national representational organization formed to protect and advance the rights and interests of Inuit in Canada, also identified the establishment of a university in Inuit Nunangat as a core component of its National Strategy on Inuit Education (Inuit Tapiriit Kanatami, 2017; 2011).

6.2 Climate change is severely impacting northern landscapes and ecosystems

Climate change is producing severe, and in many cases irreversible, changes to northern landscapes and ecosystems.

Climate change impacts include changing snow and ice conditions, shrubs invading the tundra, shifts in species distribution, increased extreme weather events, and changing disturbance regimes, such as pests and wildfires that are impacting northern ecosystems in unpredictable ways. Northerners are trying to understand the limits of ecosystem resilience and our capacity to adapt to these changes.

6.2.1 Impacts on the cryosphere

Permafrost, glaciers, snow, and lake and sea ice form the literal and figurative foundation for habitat and human society throughout the North. Changes to seasonal and long-term melt or thaw cycles in any part of the cryosphere—frozen elements of our environment, including ice, snow and permafrost—can trigger a cascade of changes in soil or aquatic ecosystem structure, biological productivity and geomorphology that make ecological, economic and social systems vulnerable to long-term and sometimes irreversible changes.

6.2.1.1 Permafrost

Canada's Changing Climate Report (Bush and Lemmen, 2019) documented increases in ground temperature and active layer thickness in all monitoring sites across the North. Temperature trends show that the temperature of cold permafrost (i.e., below -2˚C) in High Arctic locations (which includes most of Canada's northern Arctic Archipelago) has increased more rapidly than the temperature of warm permafrost (i.e., above -2˚C) in locations such as the Central Mackenzie Valley (*see* Table 6.2; Derksen et al., 2019). These differences are due, in part, to the fact that air temperature increases and changing precipitation patterns are reflected more quickly in ground temperature records at higher latitudes, compared to in warm permafrost at lower latitudes, where there is often a mix of liquid and frozen water. A large amount of the energy from increased air temperatures goes into melting solid ice to liquid water without there being a measurable change in the ground temperature (Derksen et al., 2019). There is no established process for measuring (Oldenborger and LeBlanc, 2018) or modelling (Nicolsky and Romanovsky, 2018) liquid water content in warm permafrost; this means that large, unmeasured changes in surface conditions can be taking place even when there is a limited trend in permafrost temperature or active layer thickness. Pan-northern permafrost modelling approaches rely on remotely sensed data and are steadily improving as new mapping and vegetation products become available (Melton et al., 2019), although challenges remain with regard to how these models represent permafrost processes. In addition, many adaptation actions—particularly those relating to community infrastructure—require site-specific characterization of ground-thermal regime, excess ice content, and surficial geology, even in a context of a more detailed synoptic understanding of permafrost changes (Canadian Standards Association Group, 2019). There is a continued need for methodological improvements to characterize permafrost, and data consolidation efforts are being made to maximize use of the limited data.

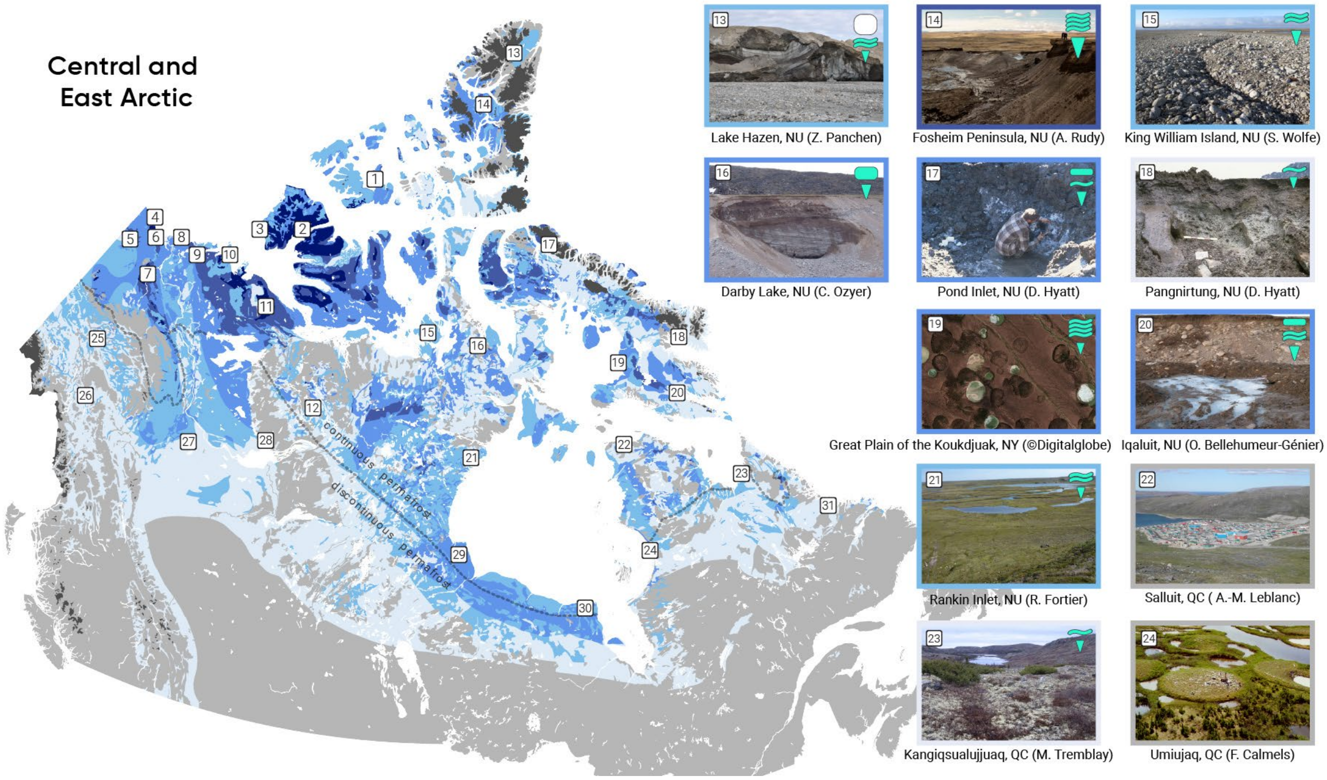
Table 6.2: Changes in permafrost temperature for selected sites across northern Canada

REGION	SITES	INCREASE PER DECADE (°C)	
		ENTIRE RECORD	SINCE 2000
Central Mackenzie Valley	Norman Wells, Wrigley	Up to 0.1	< 0.1 to 0.2
Northern Mackenzie	Norris Ck, KC-07	NA	0.5 to 0.9
Baffin Island	Pond, Arctic Bay, Pangnirtung	NA	0.5 to 0.7
High Arctic	Resolute, Eureka	NA	0.4 to 0.7
High Arctic	Alert	0.5 (15 m), 0.3 to 0.4 (24 m)	1.2 (15 m), 0.7 to 0.9 (24 m)
Northern Quebec (Nunavik)	Akulivik, Salluit, Quaqtaq, Puvirnituq, Tasiujaq, Umiujaq (11–20 m)	0.7 to 1.0	0.5 to 0.9

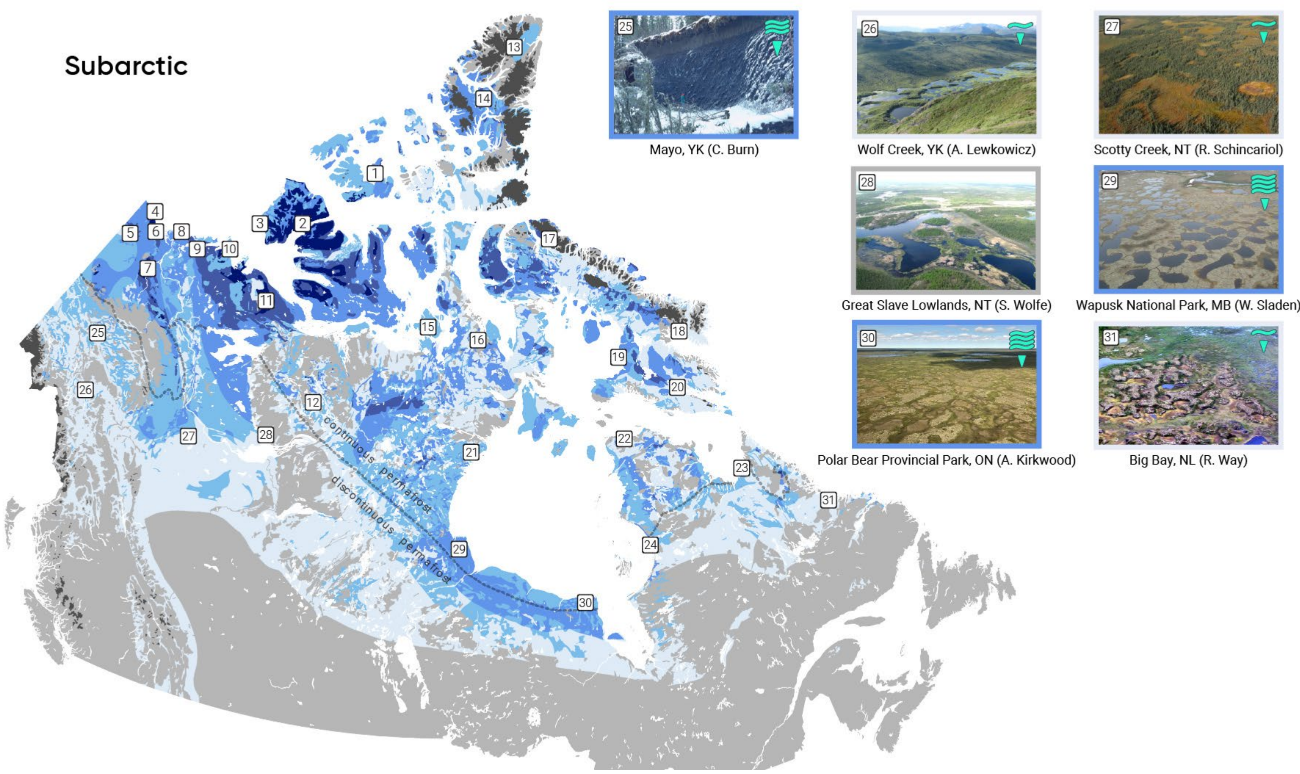
Source: Table 5.1 from Derksen et al., 2019.

Thawing permafrost in Canada's North, particularly in the discontinuous and sporadic permafrost zones (*see* Figure 6.3), is causing subsidence and uneven landscapes. Spring melt of accumulated snowpack contributes a large portion of the total amount of water within most northern drainage basins. Permafrost, particularly in the continuous permafrost zone, can prevent this water from entering groundwater systems, allowing it to flow overland and to accumulate in lakes, rivers, wetlands and muskeg (Prowse et al., 2006). In permafrost lowlands, soil thawing has led to rapid drainage of lakes or wetlands, with consequences for downstream drainage and wildlife habitat (Carpino et al., 2018; Lantz, 2017; Lantz and Turner, 2015) with potential implications for communities in these regions.

Central and East Arctic



Subarctic



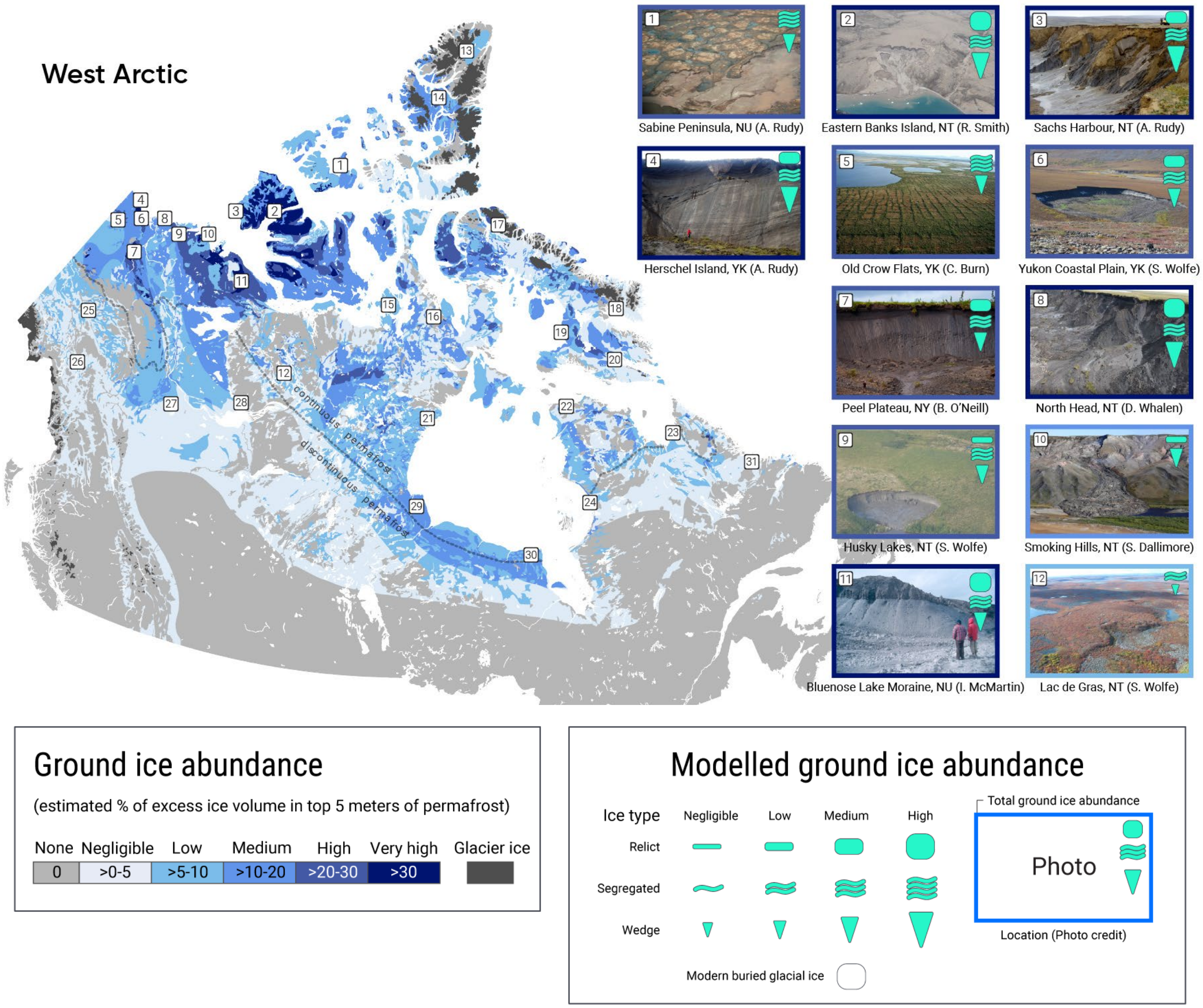


Figure 6.3: This figure highlights the associations between modelled and observed ground ice abundance in the top five meters of permafrost in Northern Canada. It includes photographs from 31 sites across Canada's permafrost regions, illustrating the range of permafrost landscapes and thermokarst–topographic depressions created as a result of thawing ground ice–terrains associated with different ground ice types and abundance. The different ground ice types referred to in the figure include: segregated (i.e., relatively thin and discrete ice lenses or layers that form due to annual downward migration of water), relict (i.e., larger bodies or layers of ice preserved in permafrost by persistent cold-climate conditions) and wedge (i.e., ice that develops when low winter temperatures cause the ground to contract under stress and crack). Source: Adapted from Wolfe et al., 2021.

Permafrost is known to contain contaminants such as heavy metals. As permafrost thaws, these contaminants are being released into groundwater, lakes and rivers, and then can be ingested or absorbed by animals (Miner et al., 2021), impacting the health of these animals and the people who harvest them (*see* Section 6.2.2; Furgal and Prowse, 2008; Warren et al., 2005; Wrona et al., 2005). Access to clean water is also affected by permafrost thaw—partly by increased contaminants, and also by increased sedimentation as permafrost-rich riverbanks erode more quickly (Anisimov, 2007).

The ability to predict rates of thaw is limited due to the lack of available data and an incomplete understanding of the underlying processes (Holloway and Lewkowicz, 2019). Some maps provide a broad overview of expected or actual permafrost conditions (O'Neill et al., 2019; Bonnaventure et al., 2012; Heginbottom et al., 1995), but are of limited utility for decision making at a local scale. In contrast, site-specific studies (e.g., Calmels et al., 2015) and hazard maps (*see* Figure 6.4) are useful at a local level, but are not available for all northern communities (Calmels et al., 2016; Allard and L'Hérault, 2010). Research networks, such as Arctic Development and Adaptation to Permafrost in Transition (Arctic Development and Adaptation to Permafrost in Transition, n.d.) and PermafrostNet (Brown et al., 2020), are working with local experts to add to the knowledge base and to develop standard data collection protocols for both local and pan-northern scales (*see* Section 6.5.4).

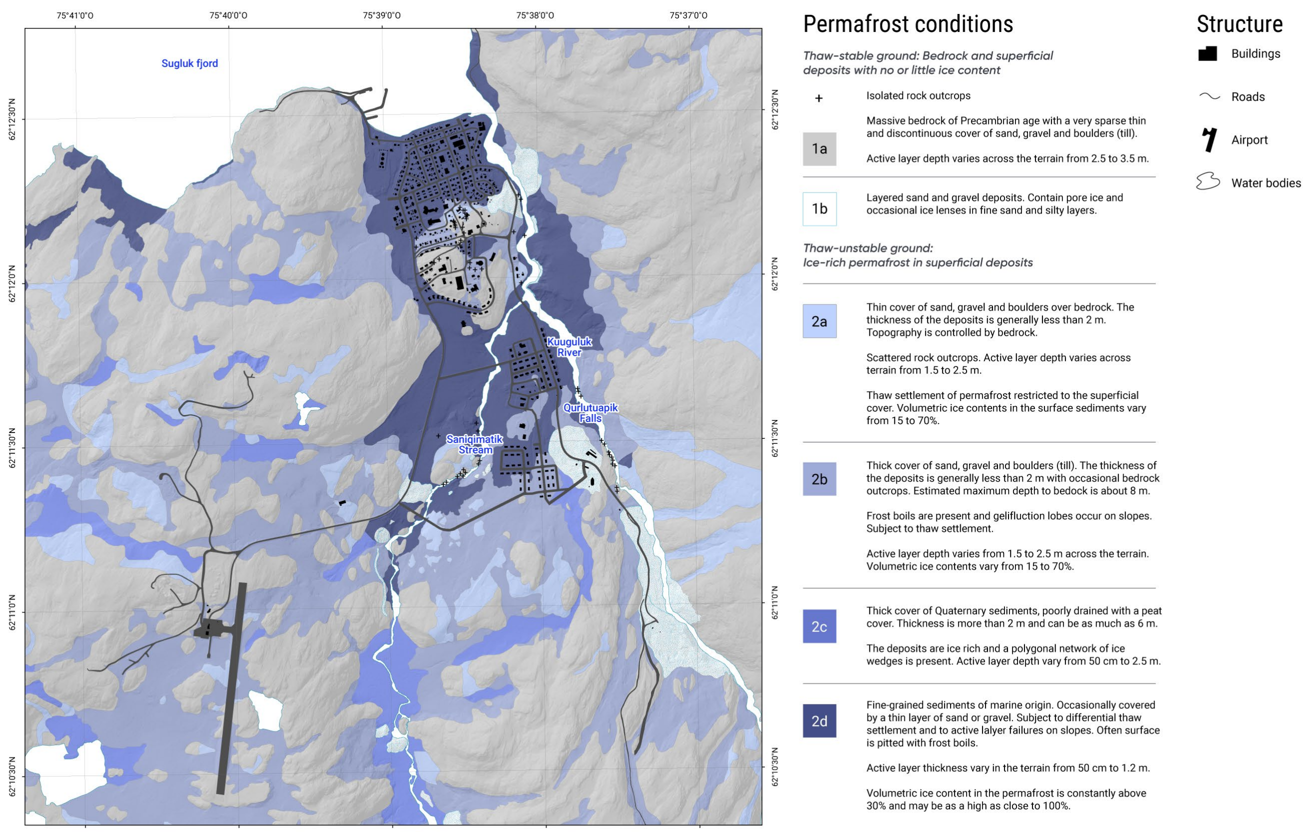


Figure 6.4: Landscape geohazard map for Salluit, Nunavik, summarizing permafrost thaw hazards at the local level. This map was used to inform planning and development in the community and at its airport.
Source: Adapted from Allard et al., 2020.

6.2.1.2 Glaciers

Canada's glaciers in Nunavut, Northwest Territories, Yukon, British Columbia and Alberta (*see* Figure 6.3) are rapidly losing mass due to climate change, and this trend is projected to continue (Bush and Lemmen, 2019). Canada's Arctic glaciers will likely persist for several centuries (Huss and Hock, 2018; Bliss et al., 2014; Radić and Hock, 2014); however, Canada's western sub-Arctic glaciers are expected to be gone by the end of this century (Clarke et al., 2015).

Glaciers are important to culture and feature in oral traditions as sentient and responsive elements of the socio-biophysical system (Cruikshank, 2007). The impacts of melting glaciers due to climate change are being felt throughout river basins in northern Canada. Changing streamflow affects downstream ecosystems as well as Northerners who depend on lake and river systems for subsistence. Glaciers in the Canadian Arctic are poised to become the leading contributor to sea-level rise among all glacierized regions (outside of the Greenland and Antarctic ice sheets) by the end of the century (Hock et al., 2019; Radić and Hock, 2014).

Calving and the retreat of high Arctic glaciers have resulted in some fjords being free of floating glacier tongues for the first time in over 3,000 years (Sharp et al., 2014). Melting glaciers bring uncertainty about the future availability of fresh water, and the impacts on downstream hydroelectric power generation in the Yukon, and on flooding frequency and magnitude throughout glacierized basins in the North (Derksen et al., 2019).

6.2.1.3 Sea ice

Decreases in sea ice thickness and cover (Derksen et al., 2019; Meredith et al., 2019; Meier et al., 2014) have impacted Arctic and marine ecosystems (Arctic Monitoring and Assessment Programme, 2017). The most pronounced physical changes include a 40% decrease in fall sea ice extent and concentration in the last 20 years (Niemi et al., 2019), and a loss of sea ice volume coupled with a dramatic decrease in multi-year sea ice (Perovich et al., 2019; Kwok, 2018). Spring sea ice extent and concentration remain relatively stable, but this ice is thin and young, which is very different from what was present in previous decades (Perovich et al., 2019).

6.2.2 Impacts on marine ecosystems

In natural systems, the impacts of sea ice and glacier melt affect the environmental conditions for many species (Bhatia et al., 2021; Niemi et al., 2019). In addition to the direct impacts of the loss of sea ice as a platform for habitats, climate change is having indirect impacts on environmental stressors such as coastal erosion and slumping (the downward movement of rock debris) (Couture et al., 2018), ocean acidity (Niemi et al., 2019; Qi et al., 2017) and productivity (Bhatia et al., 2021). Understanding of ecosystem responses to these stressors has rapidly developed—aided significantly by collaboration among Indigenous and non-Indigenous knowledge holders (Williams et al., 2020). There is increasing evidence to indicate a mix of positive, negative impacts, as well as non-impacts on species (*see* Figure 6.5). In addition, there is significant sub-regional complexity in marine ecosystem response highlighting the connectivity to physical and biologic systems that are still not fully understood (Niemi et al., 2019).

Overall, the increased ice-free season has supported more primary productivity as light is able to penetrate the water column for a longer period of time (Renaut et al. 2018). However, there is evidence that lack of nutrients limits primary productivity at some locations (Blais et al, 2017, Bergeron and Tremblay, 2014). Some species are resilient to shifts in timing of phytoplankton blooms, and have an ability to shift to other food sources or to spend more time feeding in ocean waters. For example, Arctic char, Greenland halibut, seals and beluga are able to shift to consuming prey such as capelin that are, in turn, consuming phytoplankton rather than sea ice algae (Yurkowski et al. 2018). The impact of these changes in diet continues to be an active area of study. Switching to other prey that may not offer the same level of nutrients may compromise health, while expending additional energy searching for new prey or diving to deeper depths may be problematic (Choy et al., 2019, 2020, Loseto et al., 2018).

Indigenous Knowledge and community-based observations have contributed to an improved intra-annual and interannual understanding of Arctic marine systems, particularly in near-shore coastal environments. For example, collaborative studies have identified hotspots of productivity, have helped to demonstrate the importance of transition zones between water bodies for key species such as Arctic cod, and have led to further research into species such as Pacific salmon entering the Beaufort Sea, and orcas entering many Arctic waters (Niemi et al., 2019). Still, there are many uncertainties regarding the impacts of climate change on commercial and subsistence harvests (*see* Figure 6.5), requiring ongoing research to address knowledge gaps.

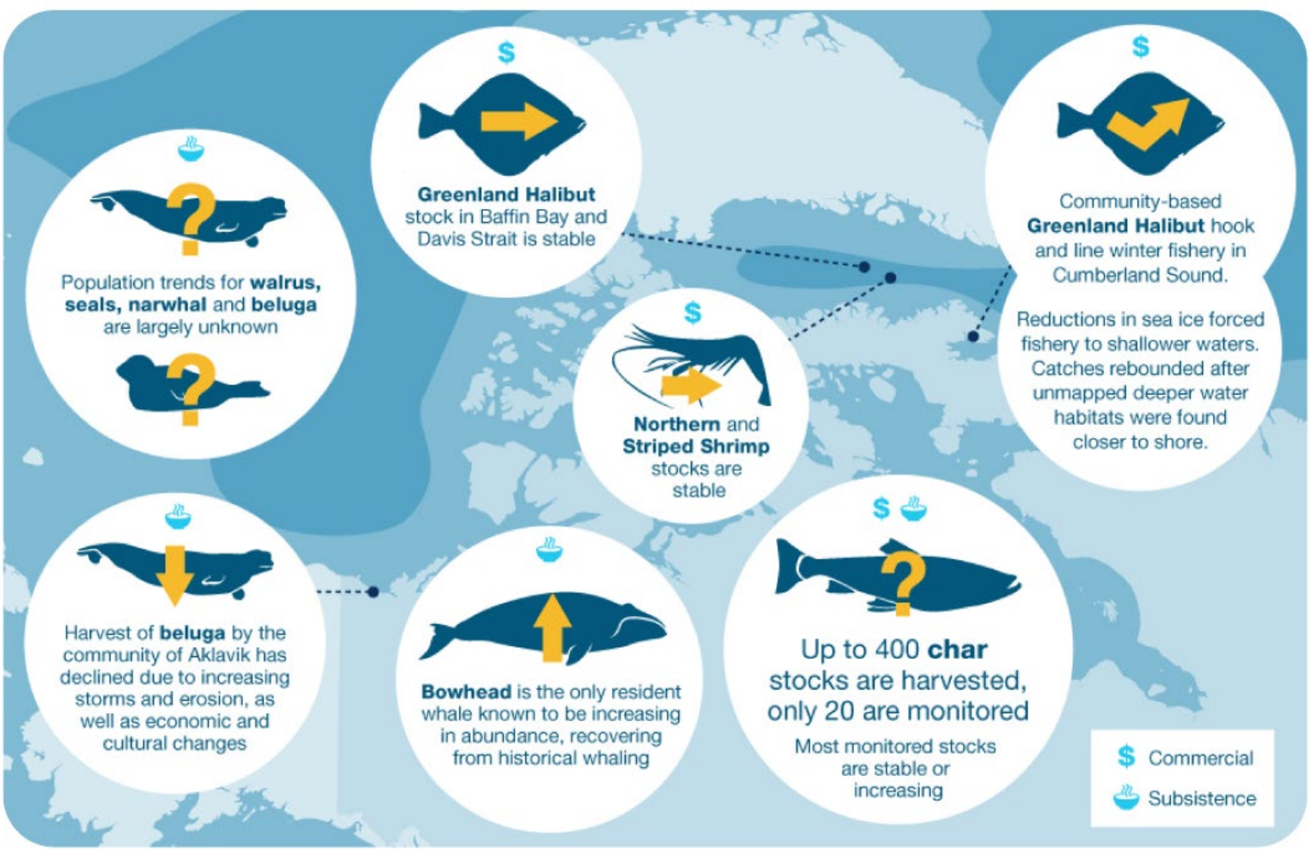


Figure 6.5: Climate change impacts and trends in several key species that are harvested for subsistence or commercial purposes in the North. Source: Department of Fisheries and Oceans Canada, 2019a.

The creation of Tuvaijuittuq Marine Protected Area along the northern coast of Ellesmere Island is expected to help provide habitat protection in the summer for numerous ice-dependent species, including polar bear, walrus and seals (Newton et al., 2021; Department of Fisheries and Oceans Canada, 2019b). The oldest, thickest ice remaining in the Arctic is found in this region, and this is expected to be the last ice area as climate change impacts continue. This marine protected area also represents a significant achievement in terms of embracing collaborative management, with co-governance shared among Indigenous, Territorial and Federal authorities (Department of Fisheries and Oceans Canada, 2019b).

6.2.3 Impacts on vegetation

In addition to physical changes in landscapes due to permafrost thaw, warmer or drier conditions are are leading to an increase in disturbance agents, including forest pests and wildfire. Along the boreal forest-tundra ecotone (the transition area between two plant communities), forest insects are now able to survive warmer winters, resulting in a range of impacts. For example, in 2015, the spruce budworm (*Choristoneura fumiferana*) caused unprecedented spruce defoliation in the Mackenzie Delta (Olesinski and Brett, 2015). Canada's northwest boreal forest has seen increased fire frequency and severity (Meredith et al., 2019, Natural Resources Canada 2017), with wildfires increasing due to climate change and other stressors (*see* the Sector Impacts and Adaptation chapter of the National Issues Report; Coogan et al., 2019). The area burned and the number of large fires in northern Canada have increased over the last half-century (Hanes et al., 2018). Wildfires are projected to increase in frequency and severity, and to become more widespread across Canada, including in the North (Coogan et al., 2020; Coogan et al., 2019; Hu et al., 2015). How these changes impact local and regional vegetation is a function of ecosystem resistance, resilience and vulnerability (*see* Box 6.2).

Box 6.2: Ecosystem resistance, resilience and vulnerability

Ecological systems are dynamic and change over time, often in response to disturbances. For example, a wetland may become flooded temporarily due to heavy spring rainfall, or it may become drier when thawing permafrost allows increased drainage through formerly frozen soil. Alternatively, if soils remain dry for a long period after a fire, a wetland could become a completely different system. Such disturbances happen at large and small scales in virtually all ecosystems. The responses to these changes will depend on both the ability of the ecosystem to remain the same when disturbed (resistance) and the ability of the ecosystem to respond to change, absorb damage and recover quickly (resilience). Northern ecosystems are most resilient to disturbances and environmental conditions within the historic range of variability and previous adaptation (*see* Figure 6.6a; Johnstone et al., 2016; Seidl et al., 2016; Keane et al., 2009). Resilient ecosystems may respond quickly or slowly; the key element is the ability of the system to recover its essential structure or function following a disturbance or change (Holling, 1973). If collapse is triggered by disturbance, there may be a chaotic period followed by eventual re-establishment of the previous state, or a new pathway may emerge in response to the many “chance” circumstances during the chaotic period (*see* Figure 6.6b; Holling, 2011).

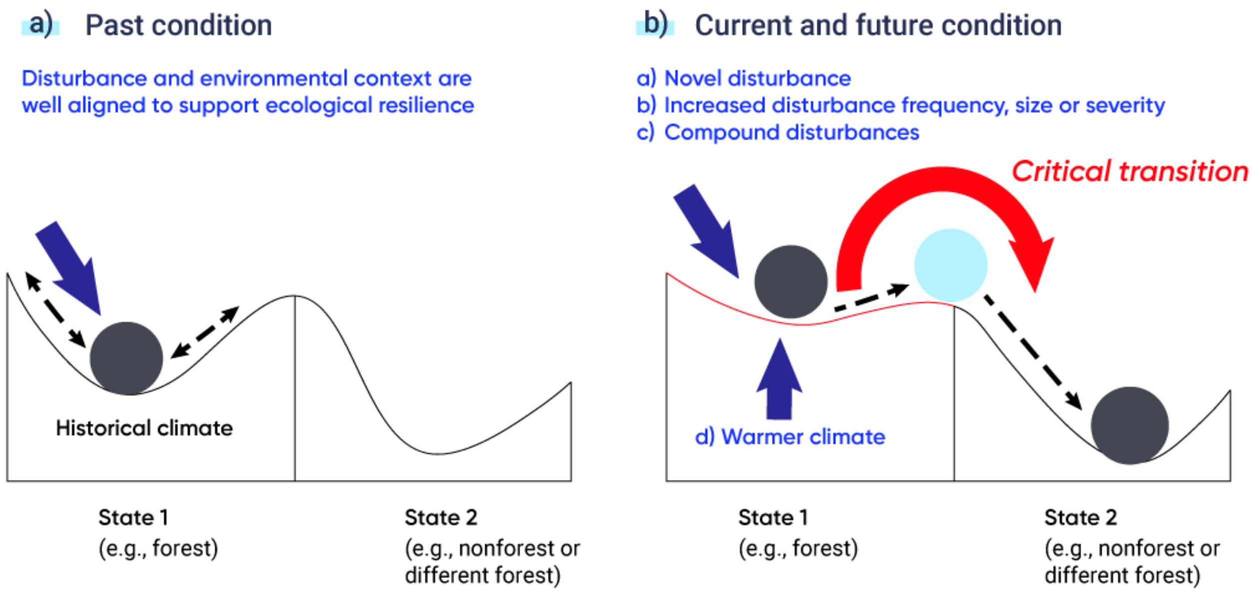


Figure 6.6: Conceptual representation of an ecosystem (portrayed by a black ball) within a theoretical landscape of alternative ecosystem states (portrayed by valleys separated by peaks). a) The ecosystem is resilient to disturbances lying within the historical range of variability and previous adaptation, indicated by disturbances that may move the system, but not cause it to shift to another state. b) The ecosystem is likely to shift to a different state in response to hypothesized mechanisms that move the ecosystem beyond its historical range of variability and previous adaptation, and trigger a shift to a different ecosystem state. Source: Adapted from Johnstone et al., 2016.

Climate change is directly impacting vegetation, with substantial areas of tundra and northern boreal forest in northern and eastern Canada showing increased vegetation productivity (*see* Figure 6.7; Keenan and Riley, 2018; Sulla-Menashe et al., 2018; Ju and Masek, 2016). Local knowledge and Indigenous Knowledge, remote sensing and scientific monitoring indicate that much of the greening of the tundra is due to expansion of woody shrubs (shrubification), such as alder and tall willows, in areas that formerly supported vegetation of much lower stature (Dän Keyi Renewable Resources Council, 2019; Myers-Smith et al., 2019; 2011; Lantz et al., 2013;). Shrubification is causing a shift from tundra to shrubland that will not be reversed without a return to previous climate conditions (Mekonnen et al., 2021); this is one of the largest manifestations of change observed widely across northern Canada (Tremblay et al., 2012; Fraser et al., 2011, Hill and Henry, 2011; Myers-Smith et al., 2011; Thorpe et al., 2002).

Disturbances such as wildfire and insect infestations are influenced by many factors, which interact with climate to cause changes to northern ecosystems (Johnstone et al., 2016). Many ecosystems may be initially resistant to change, given that feedbacks associated with long-lived vegetation help to maintain environmental conditions and ecological functions that support ecological stability even when the climate is changing (Chapin et al., 2004). However, when vegetation is killed or reduced through a disturbance, these feedbacks are disrupted and rapid change can occur (*see* Figure 6.6). For example, stand-replacing wildfires initiate new phases of forest regeneration where seedlings may be much more sensitive to climate conditions than in an established stand where canopy trees substantially alter the local microclimate (Baltzer et al., 2021; Davis et al., 2019; Johnstone et al., 2010). Climate change will also directly affect the type and severity of disturbances that occur, since factors such as fire behaviour, insect pest biology and permafrost thaw are all sensitive to changes in seasonal weather conditions (Turetsky et al., 2017).

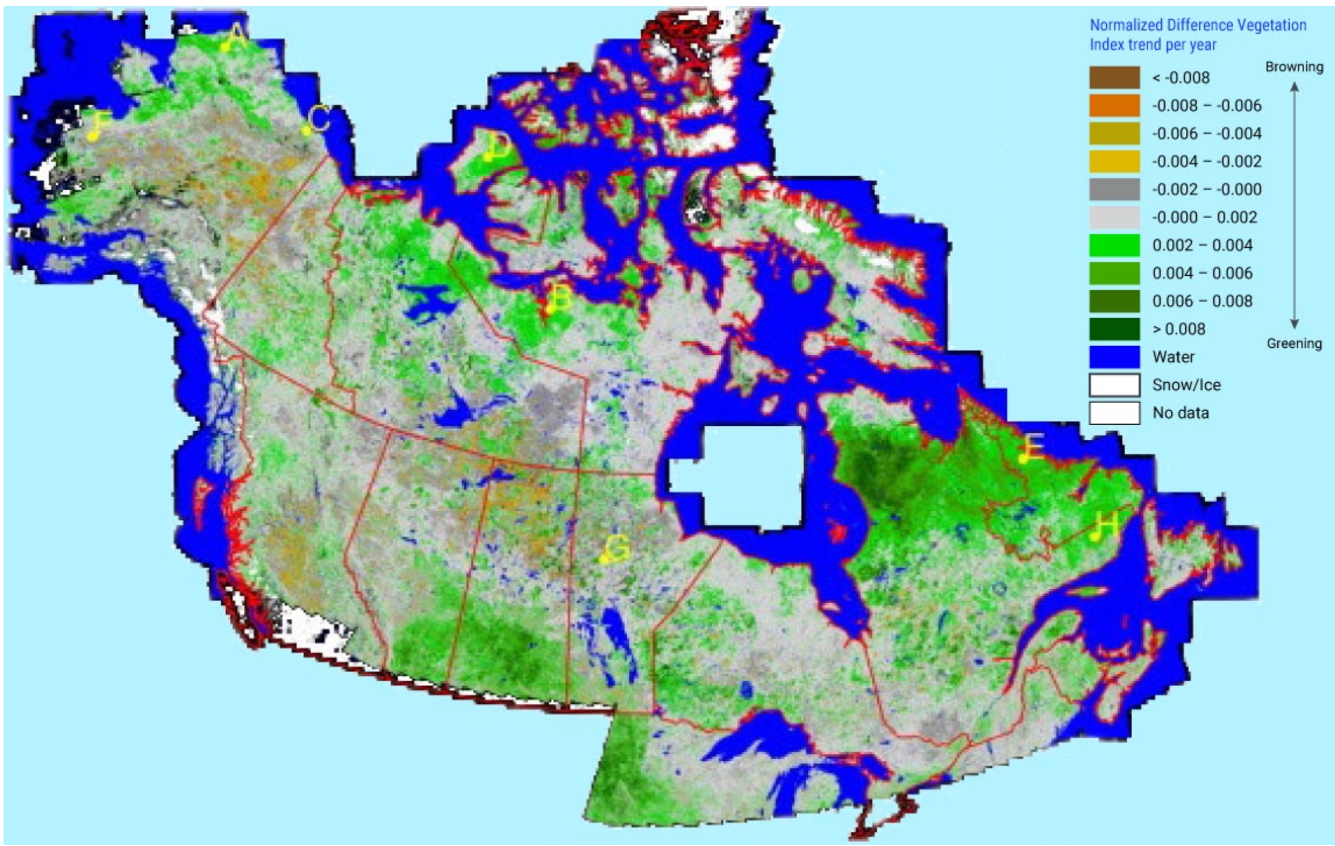


Figure 6.7: Landsat-based maps showing greenness trends through the use of the Normalized Difference Vegetation Index (NDVI), which estimates the density of greenery in an area using the difference between visible and near-infrared reflectance of vegetation. Where there were not enough valid observations to derive greenness trends, all thematic layers were set to “no data.” Letters A to H represent ground validation sites. Source: Adapted from Ju and Masek, 2016.

In contrast to the tundra, much of the boreal forest shows little change in vegetation greenness with regionalized areas of declining productivity (*see* Figure 6.7, Ju and Masek, 2016; Goetz et al., 2005). In some cases, “browning” trends in the boreal forest reflect the impacts of disturbances such as logging and wildfires (Bonney et al., 2018). However, in the northern parts of the boreal forest, there is evidence from tree rings that warming may cause increased drought stress and reduced tree growth (Walker et al., 2015).

6.2.4 Impacts on terrestrial animals

The frequency of extreme weather events, including anomalous warming events during the winter and during rain-on-snow events, has increased across the Arctic (Cohen et al., 2015). Rain-on-snow events cause an impenetrable layer of ice over the ground, which can lead to starvation and population crashes for ungulates (hooved animals) across the Arctic, such as the death of 20,000 muskoxen on Banks Island in 2003 (Rennert et al., 2009).

Currently, many of Canada's caribou populations are in decline due to habitat disturbance. Increasingly, climate change is acting to magnify the disruption of habitat, particularly for woodland caribou (Stewart et al., 2020; Mallory and Boyce, 2017; Gunn et al., 2009). Migratory herds of barren-ground caribou vary substantially in their responses to climate change and habitat disturbance, with most showing negative responses due to difficulty foraging during winter following tundra fire or rain-on-snow events (Schmelzer et al., 2020; Lewis et al., 2019) and some showing positive effects due to increased reproduction success during warmer spring, and improved body condition following warmer winters (Gagnon et al., 2020; Mallory and Boyce, 2017; Wheeler et al., 2017; Gunn et al., 2009). Impacts on caribou are not always gradual, with catastrophic die-off events being associated with extreme precipitation (e.g., rain-on-snow) (Miller and Gunn, 2003). Such observed impacts likely represent the beginning of substantial reorganization of ecological communities in the North in response to climate change (Reid et al., 2013; Post et al., 2009). Traditional caribou harvest practices are severely impacted when caribou migratory routes shift away from historical locations (Douglas et al. 2014). While management practices have evolved to better include Indigenous perspectives, decisions regarding caribou harvest and habitat remain an important, and often contentious, policy issue (Vuntut Gwitchin Government, 2020; The Committee on the Status of Endangered Wildlife in Canada, 2017; Cuerrier and the Elders of Kangiqsualujjuaq, 2012).

In some habitats in the central Canadian Arctic, vegetation productivity has increased (*see* Figure 6.7), although this is not occurring in other habitat types (Rickbeil et al., 2018). Although caribou may benefit in some years from increased vegetation productivity (Mallory et al., 2018), earlier greening of vegetation associated with earlier starts to spring weather, may decrease the quality of forage available to animals during key reproductive periods (Barboza et al., 2018; Post and Stenseth, 1999).

Climate change has created the conditions for new species to inhabit northern Canada, primarily by expanding their northern ranges (Chen et al., 2011). Some newcomer species are responding to new habitat resulting from shrubification of the tundra (Myers-Smith et al., 2011). These include the American Robin (*Turdus migratorius*) and Wilson's Warbler (*Cardellina pusilla*), which have expanded their breeding range northward by 100 to 350 km in northern Labrador (Whitaker, 2017), as well as the North American beaver (*Castor canadensis*), which has been colonizing the treeless tundra on the Beaufort Coastal Plain in parts of the Yukon and Alaska (Tape et al., 2018; Jung et al., 2016).

In Nunavik, Indigenous Knowledge indicates that beavers have been moving further north, blocking rivers that Arctic char depend on for reproduction (Inuit Circumpolar Council, 2018). Because there is limited Indigenous Knowledge about beaver harvesting in the area, local trappers and hunters are being forced to learn new techniques to manage beaver, and are unsure of the impact that beavers are having on Arctic char (Shah et al., 2018). Workshops, surveys and interviews indicate widespread Indigenous observation of new wildlife, birds, insects and fish entering regions, as well as an in-depth understanding of the health of existing species (Knotsch and Lamouche, 2010; Nickels et al., 2005; Krupnik and Jolly, 2002).

New assemblages of species result in novel interactions. It is expected that southern migrants will displace some northern species, particularly those experiencing a range retraction due to diminishing cold habitat (Marcot et al., 2015). Some new species will have more impact than others—for example, beavers are a keystone species and significantly reshape landscape hydrology by building dams. The resulting ponds can increase the thawing of permafrost, thus enhancing the impacts of climatic warming (Tape et al., 2018).

6.2.5 Cascading impacts

New forms of disturbance can induce positive feedbacks that amplify warming and other climate-induced impacts. For example, following a wildfire, ground-cover changes locally amplify warming temperatures, contributing to shrubification of the tundra and permafrost thaw, while also releasing carbon that contributes to additional warming (Jones et al., 2015; Lantz et al., 2013). Negative feedbacks also occur. For example, moisture availability is higher in warm spring conditions, but can produce precipitation in the form of snow, thus increasing albedo and slowing melt (Fletcher et al., 2012; Qu and Hall, 2007). Furthermore, a cascade of disturbances can occur whereby one novel disturbance creates the conditions for another novel disturbance. For instance, increased moisture and humidity across the Northwest Territories in 2017–2018 may have increased pathogens in forests of the Northwest Territories (Olesinki and Brett, 2018).

The impacts of both new and existing disturbances may compromise ecosystem resilience (Johnstone et al., 2016). For instance, wildfires that burn under typical conditions are unlikely to severely disrupt the natural cycles of forest succession, as most boreal tree species have adapted to ensure regeneration after fire. However, increased fire activity may cause stands to burn at young ages before trees are old enough to generate seeds. Such events, especially when they occur in combination with unusually dry or warm years, can trigger regeneration failures and cause shifts to non-forested states (Whitman et al., 2019, 2018). While tundra systems may be less vulnerable to disturbance-induced changes, large fires do occur in tundra environments (Mack et al., 2011), and increased fire activity may result if temperatures cross climate thresholds that have regulated fire activity in the past (Young et al., 2017).

6.3 Health impacts are intensifying and amplifying inequities in the North

Climate change is negatively impacting the health of Northerners, amplifying existing inequities and access to healthcare.

Not all climate change impacts on health are direct. Physical health impacts include disrupted access to country foods, increased exposure to contaminants and wildfire smoke, and increased travel hazards. Mental health challenges arise from changing land access, disruptions to cultural activities and knowledge sharing opportunities, shifting place-based identities, and loss of important species, plants, or ecosystems. Locally appropriate, culturally relevant resources and programming, co-created by local communities in partnership with other organizations, are critical to support climate-sensitive physical and mental health outcomes. Such resources and programs must include connection to place and promote increased time on the land to enhance wellness and decrease the strain on limited healthcare resources.

6.3.1 Introduction

In northern Canada, people often live in close proximity to their environment, relying on the land to support their livelihoods, well-being and, particularly in Indigenous contexts, their culture and identity (Richmond and Ross, 2009; Kirmayer et al., 2008). This means that even subtle alterations in climate and the environment can disrupt peoples' lives and connection to place, ultimately affecting their mental and emotional health. Rising temperatures, decreased sea ice extent and stability, disruptions to food and water resources, and changes to wildlife and plants are impacting livelihoods, cultural practices and knowledge sharing.

Northerners are also concerned about physical health impacts related to the release of naturally occurring contaminants from the melting cryosphere and from increased exposure to wildfire smoke. While the body of literature related to the actual risks for northern Canadians is limited, the perception of risk is high.

6.3.2 Mental health

Mental health is a major public health and health system priority in northern Canada, particularly among Indigenous Peoples, who face significant health disparities and have limited access to mental health services (*see* the Climate Change and Indigenous Peoples' Health in Canada chapter of the Health of Canadians in a Changing Climate Report). The sources of mental health challenges are complex, stemming from intergenerational trauma triggered by forced relocation, land dispossession and residential schools (Inuit Tapiriit Kanatami, 2016; Cunsolo Willox et al., 2014; Kirmayer et al., 2008), as well as inequities in accessing culturally safe care.

Climate change has emerged as an additional direct and indirect stressor on mental health (Clayton et al. 2017; Cunsolo Willox et al., 2013a, b, 2012). For example, increasingly unpredictable weather conditions, combined with sea ice loss and other climate change impacts across northern Canada and Inuit Nunangat, are compounding and exacerbating existing mental health challenges for Indigenous Northerners. This is creating new mental health stressors by diminishing the ability of Indigenous Northerners to safely engage in land-based activities and maintain connections to their ancestral lands and cultures (Durkalec et al., 2015; Harper et al., 2015; Healey, 2015; Petrasek MacDonald et al., 2015; Cunsolo Willox et al., 2013a, b; Petrasek MacDonald et al., 2013). These disruptions to beloved lands, waters, plants and animals are having diverse emotional and mental impacts, as several Inuit-led and community-driven studies have identified (*see* Case Story 6.1).

Case Story 6.1: *Attutauniujuk Nunami/Lament for the Land* Documentary

Attutauniujuk Nunami/Lament for the Land originated out of a community-based, community-led initiative to examine connections between climate change and Inuit mental health in Nunatsiavut (the Inuit Mental Health and Adaptation to Climate Change project). It represents a joint partnership of the five Inuit communities of Nunatsiavut, with coordination in each of the five regions provided by a local research coordinator. A total of 120 interviews conducted with community members and health professionals resulted in a film that highlights the voices of Inuit in Nunatsiavut as they describe the impacts of climate on mental health, and associated adaptations (Cunsolo Willox et al., 2013c). *Attutauniujuk Nunami/Lament for the Land* highlights the ways in which people and place are intimately connected, and the grief and sadness, as well as the hope and strength that emerge in times of change.

Learn more by seeing *Lament for the Land*, 2022.

Decreased time on the land due to changing environmental and weather conditions has been linked to strong emotional reactions such as: anger, fear and sadness; interpersonal distress; possible increased drug and alcohol use; triggering and magnification of previous traumas; potential for increased risk of suicide; challenges to people's identities rooted in place; and a greater burden on healthcare staff for mental health needs during times of limited mobility and reduced land access (Middleton et al. 2020a, b; Bunce et al., 2016; Durkalec et al., 2015; Harper et al., 2015; Ostapchuk et al., 2015; Wolf et al., 2015; Cunsolo Willox et al., 2013a, b; Petrasek MacDonald et al., 2013; Cunsolo Willox et al., 2012). For example, health workers in Rigolet, Nunatsiavut, report that the stress of not being able to be on the land carries over to the familial environment, resonates through the community, and anecdotally results in increased substance use (Cunsolo Willox et al., 2013b).

Reduced opportunities for sharing skills and knowledge, and for subsistence harvesting and subsequent food sharing, are also impacting the social bonds and cohesion within communities (Bunce et al., 2016; Cunsolo Willox et al., 2013b; Pufall et al., 2011). Current and anticipated environmental loss due to climate change is eliciting strong emotional responses. These include: stress, distress and despair (Ellis and Albrecht, 2017; Harper et al., 2015; Ostapchuk et al., 2015; Cunsolo Willox et al. 2013a, b; Cunsolo Willox et al., 2012); solastalgia (emotional and existential stress connected to changing or disrupted environments and connections to place) (Albrecht, 2012); and ecological anxiety and ecological grief (i.e., grief and anxiety in response to physical ecological loss, disruptions to knowledge and cultural systems, and shifting place-based identities (Cunsolo et al., 2020; Cunsolo and Ellis, 2018).

Climate-sensitive mental health impacts require specific and multi-faceted responses to match the diverse psychosocial impacts that are occurring. Such responses may also have co-benefits for other mental health stressors. When support is provided to enhance mental healthcare resources for northern communities, this helps to ensure that residents have access to appropriate therapy and counselling, while education and training for healthcare staff and patients would raise awareness of the mental health impacts resulting from climate change, such as ecological grief (Cunsolo et al. 2020; Middleton et al. 2020b; Cunsolo and Ellis, 2018; Clayton et al., 2017). To address the broader socio-environmental determinants of mental health, many mental health adaptations need to take place outside of the formal healthcare setting. This may include, but is not limited to, community programming that facilitates social cohesion and connection to culture, and provides individuals and communities with a sense of self-efficacy, and opportunities for meaningful action to reclaim their stories in a changing climate (Clayton et al., 2017). Where possible, programming can aim to maintain and enhance peoples' connection to place (Clayton et al., 2017), while also having mental health resources that are not dependent on land or weather conditions, such as climate-resilient culture camps, and thus can be accessed outside of challenges imposed by climate change (Cunsolo Willox et al., 2013b).

6.3.3 Food insecurity

Food insecurity risks for Arctic peoples are increasing as a result of climate change impacts, which are compounded by the impacts of development and economic structures (Meredith et al., 2019). Canada's highest rates of food insecurity are all in the North, with recent studies identifying a regional prevalence of household food insecurity that ranges from 16.9% in the Yukon (Tarasuk and Mitchell, 2020) to 59.5% in Nunatsiavut (Furgal et al., 2017). All dimensions of food insecurity—availability, access, quality, use and stability—are impacted by climate change and its associated environmental changes, which affects virtually all aspects of wellness, including physical and mental health (*see* Food Safety and Security chapter of the Health of Canadians in a Changing Climate Report).

Northern food systems are both complex and distinct. Indigenous and non-Indigenous Northerners continue to rely on what can be generally described as a dual food system made up of both market foods (imported foods purchased at stores through the market economy) and country or wild foods (foods hunted, harvested or gathered from the land, sometimes referred to as traditional foods) (Hansen et al., 2018). Market and country foods have distinct and sometimes interacting mechanisms of food availability, processing, distribution, access and disposal. Adverse and anomalous weather events—such as increasing precipitation, severe winds and prolonged fog—affect the availability and accessibility of all foods. Higher numbers of foggy and windy days negatively affect the transportation of market foods into communities, both by air and marine shipping. These climate-related delays have reduced the availability and quality of market foods in communities, while also contributing to increased costs (Human Rights Watch, 2020; Cunsolo Willox et al., 2012). The same conditions make travel on the land, water and ice more difficult for hunters and harvesters, restricting the accessibility of country foods, the amount of time spent on the land, and the transmission of cultural knowledge. Activities on the land allow people to provide for their families and are essential for Indigenous food security and sovereignty. They are also central to the health and well-being of Arctic residents.

Addressing the negative impacts of climate change on food security is facilitated by policies and programming that encourage and facilitate the practice of land-based activities, as well as participation in market economies (Wilson et al., 2020). Community freezer programs provide access to equipment, training and knowledge that support hunter access to, and safety on, the land, water and ice, while enabling the distribution of country foods within communities (*see* Case Story 6.2). In both Nain and Hopedale, the Department of Health and Social Development of the Nunatsiavut Government operate *Nigivik* ("A place where we eat" in Inuttitut, a dialect of Inuktitut) programs. Often offered in partnership with community freezer and youth programs, *Nigivik* programs offer accessible and flexible cooking spaces and activities that focus on teaching cooking and other food skills to community members of all ages. To address the changing availability of country foods, *Nigivik* emphasizes the importance of both country foods and market foods for health, while teaching skills such as traditional methods of food preservation and contemporary canning, both of which can increase year-round accessibility of country foods (The OKâlaKatiget Society, 2017).

Case Story 6.2: Community freezer programs in Nunatsiavut

Designed to support access to country food, community freezer programs act as a central community repository of country foods that are redistributed throughout communities in Nunatsiavut (Organ et al., 2014). Such programs increase access to country foods and reduce the risk of travel in a changing climate. They also have important co-benefits, including increasing mental wellness and the transmission of cultural knowledge.

Community freezer programs (*see* Figure 6.8) are tailored to meet the needs of each Nunatsiavut community, and are a contemporary formalization of the Inuit value of sharing. In addition to increasing access to a diversity of country foods, many community freezer programs include initiatives to address other challenges to country food access and food security. In Nain, the community freezer program includes a fuel and hunting resources program, where harvesters are provided with essential supplies in return for sharing a portion of their catch with the freezer. Harvesters borrow fishing rods, GPS and InReach units, camping equipment and other essential safety gear that they may not otherwise be able to access. This addresses barriers to harvesting created by increasingly expensive costs of equipment, as well as the risks to individual safety posed by the increasing unpredictability of travel on the land and ice. In several communities, community freezer programs also operate youth and mentorship initiatives, where experienced hunters are hired to take youth out on harvesting trips. These programs train youth in essential harvesting and food security skills and knowledge, while also providing harvested foods to the freezer programs or directly to Elders in the community.

Hopedale Community Freezer Program quick facts

47 to 88

The number of people using the improved program nearly doubled within a year (2014–2015).

93%

of survey respondents called the program important for meeting their food needs.

Usage spikes in January and February

Residents of Hopedale find the program particularly helpful for securing wild food in the early months of winter.

Preserves culture

Survey respondents noted that the program preserves the culture of eating wild food.

Only source of wild food for some

40% of respondents say the freezer program is their only way to access wild food.

Statistics pulled from the 2017–2018 Hopedale Community Freezer Program Evaluation Report.

Figure 6.8: Infographic of quick facts about the Community Freezer Program in Hopedale, Nunatsiavut. Source: Adapted from Food First NL, n.d.

In most communities, community freezers and programs like *Nigivik* contribute to a suite of initiatives that together support adapting to climate change. Although not all were developed as climate change adaptation programs, these initiatives offer co-benefits that include building individual and community climate resilience. Community and regional-scale programs are also complemented by a number of overarching policy initiatives, including the National Inuit Climate Change Strategy (Inuit Tapiriit Kanatami, 2019a) and the Nunatsiavut Food Security Strategy/Imappivut Marine Plan, currently being developed by the Nunatsiavut Government. In the development of these and other strategies, considerations of health and food security are embedded to ensure that associated policies and programs are intersectoral and grounded in Inuit values and ways of life to promote wellness and resilience. Importantly, such strategies recognize and empower inherent capacity (*see* Section 6.6) and draw on both Inuit knowledge and scientific evidence to put people at the core of resilience.

6.3.4 Health concerns related to contaminants

There is evidence that environmental changes caused by warming temperatures result in an increased release of contaminants into the environment, with potential impacts on human and environmental health. Thawing permafrost, and melting glaciers and sea ice can release stored contaminants into the Arctic environment (Obbard et al., 2014). For example, it is estimated that 793 million kilograms of mercury could be released from thawing permafrost in the Northern Hemisphere permafrost regions over the next century (Schuster et al., 2018). Elemental mercury is transformed by aquatic algae into methylmercury, which is more toxic and bioavailable, and is the predominant form of mercury found in fish and the marine environment (Miner et al., 2021). Projected increases in algal growth in Arctic lakes, occurring concurrently with mercury being released from thawing permafrost, will likely result in increased methylmercury in the aquatic environment. Thawing permafrost and decreased snow cover may enhance the release of radioactive radon-222 from the soil, resulting in increased environmental levels of lead-210 and polonium-210, which are both toxic radioactive substances (Arctic Monitoring and Assessment Programme, 2010). Radionuclides and mercury may also be redistributed from natural events such as wildfires, which are projected to increase in frequency and intensity with climate change (Wang et al., 2017).

The threat of increased release of contaminants in the Arctic has serious consequences for the Arctic environment and wildlife populations, with subsequent health impacts on humans when consuming wild foods (including land animals, birds, fish and sea mammals and foraged foods) with elevated levels of contaminants. Precautionary measures include the issuance of advisories by provincial or territorial health authorities related to the consumption of foods linked with health risks. For example, a health advisory in Nunavut recommends that women of child-bearing years avoid eating ringed seal liver due to high concentrations of mercury. Concerns around consuming contaminated country foods could result in increased reliance on market foods, which can be less nutritious, more costly and a potential maladaptation (Rosol et al., 2016; Berry et al. 2014).

6.3.5 Health risks from wildfires

While there is little synthesis of knowledge from which to create a wildfire-associated risk framework in Canada (Johnston et al., 2020), many Indigenous communities in Canada are at higher risk from wildfire because of their remote locations and close proximity to forests (Christianson, 2015). From a human health perspective, wildfires may result in death, trauma and major burns (Cameron et al., 2009), post-traumatic stress disorder symptoms (Papanikolaou et al. 2011; McDermott et al., 2005) and mental health problems (*see* Sector Impacts and Adaptation chapter of the National Issues Report; Coogan et al., 2019). Smoke distribution can be significant far beyond the immediate vicinity of a fire (Reid et al., 2016), compromising air quality even for distant populations (Henderson and Johnston, 2012).

Recent extreme wildfire events include the 2014 fire season in the Northwest Territories, where drought conditions resulted in 3.4 million hectares of land being affected by 385 separate fires. The cost of fighting those wildfires was $56.1 million—almost eight times greater than the territory's annual firefighting budget at the time (Dodd et al., 2018). The fires caused evacuations from communities throughout the territory, serious health consequences and respiratory distress, and ongoing fear and anxiety among Indigenous and non-Indigenous Northerners. Many people reported mental, emotional and spiritual tolls, and having feelings of isolation as a result of staying indoors in compliance with public health advice or due to forced evacuation, and because of loss of time on the land (Dodd et al., 2018). People also reported feeling anticipatory stress and grief about possible future wildfires and further impacts to place and environment, communities, physical health, food security, and mental and emotional health (Dodd et al., 2018).

6.4 Safe travel in the North is threatened by climate change

Climate change is increasing risks to safe travel in the North, but drawing from different types of knowledge is helping to reduce these risks.

Decreasing ice cover, as well as changing landscapes and weather patterns, are impacting travel in the North. In some cases, adoption of new technology can increase vulnerability by placing reliance on things such as cellphone or satellite connectivity, or electronic vehicle components. Northern residents have developed innovative solutions that are specific to the needs in the region. The tools used to exchange knowledge of local conditions are helping Northerners to better prepare for conditions that are outside the range of previous experience.

6.4.1 Introduction

Northerners recognize that changing environmental conditions and weather patterns are resulting in increased risk to safe travel on the land, ice and water, and by air. While climate change affects physical trails or routes through, for example, loss of ice or permafrost thaw, key factors that enable access to the land include maintaining confidence in Indigenous Knowledge, access to equipment (ranging from reliable vehicles to radios and cell phones) and risk tolerance (Ford et al., 2019; Harper et al., 2015). The loss of access to land-based activities negatively impacts physical and mental health, and adaptation measures are an effective way to improve resilience (*see* Rural and Remote Communities chapter of the National Issues Report; Durkalec et al., 2015). Travel-related climate change impacts increase risks to human life, impact property and wellness, and put pressure on search and rescue operations that sometimes have limited equipment and training appropriate to changing conditions (Ford and Clark, 2019). While boats, all-terrain vehicles (such as quads/4-wheelers and side-by-side vehicles), snowmobiles, trucks and other means of transportation all form integral parts of life in the North, increased risks from climate change are leading Northerners to assess their own risk tolerance and to develop strategies to limit risks.

6.4.2 New dangers threaten Northern knowledge of safe travel

Travel in northern regions is part of life (*see* Case Story 6.3). In areas where communities are small and distributed over large areas, travel to access the land, services and education and to conduct business is essential. In some regions, both ice-based and land-based trails are necessary for travelling between communities (Durkalec et al., 2015; Ford et al., 2013; Aporta, 2011). For many Northerners, hunting and travelling on the land and water play a vital role in ensuring food security and maintaining cultural identity (Cunsolo Willox et al., 2013a; Laidler et al., 2008). Land-based and water-based recreation and traditional pursuits, often in remote areas, occur through all seasons. Air travel is also critical to northern communities that rely on aviation for the transportation of people and essential goods and services, and for accessing health care (Government of Canada, 2017). However, travel-associated risks driven by changes in climate, like reduced ice thickness, shifting ice freeze-up and break-up dates, thawing permafrost, unpredictability of weather patterns and extreme events are impacting both perceived and actual safety of all modes of northern travel (Ford et al., 2019).

Case Story 6.3: Perspective on risks to public safety in Makkovik, Nunatsiavut

The following is an excerpt from Winston (Barry) Andersen, a resident of Makkovik, Nunatsiavut, who serves in search and rescue operations, describing his experience with changing climate and how it has impacted public safety in his community:

> "[I] spent all my life working, travelling, gathering, cutting firewood, picking berries, hunting and fishing in Nunatsiavut. For sustenance purposes only. Never fished or trapped commercially. Trap fur-bearing animals for my personal use… I have travelled northern Labrador from Makkovik area to Nain area and inland from Nain to the Quebec border by snowmobile hunting caribou. I have also travelled from Makkovik area to Nain by boat during the summer months both personally and for work as a guide for DFO [Department of Fisheries and Oceans]. With the RCMP, [I] was a guide in the Makkovik, Hopedale and Postville areas. On my first trip to Nain via snowmobile, I was 16 years old and travelled with my father and uncles, learning from them along the way by observing and some lecturing while on the land, or simply sitting in a tent and listening to the elders talking about the weather signs, ice and snow conditions. I travelled from Makkovik to Davis Inlet and inland to Border Beacon in winter and spring, caribou hunting.
>
> Over the last 30 years, I have experienced a major change in the weather patterns. This is also observed by my father and many other elders in my community. Once predictable weather patterns during all seasons are now very unpredictable. In the Makkovik area, the prevailing winds in the spring and summer would be variable. Mornings would be calm, mostly westerly winds during the daylight hours and calm in the evenings. Summer would see long stretches of clear weather with thunderstorms intermittently. Fall would see more northerly winds causing sea swells to rise. The elders would always say in late August or early September it was time for the "liner gale": a strong storm with either northerly or northwest winds and rain that lasted for about three days. After this storm was over, things would settle down. More storms would follow, but they were not as intense. In the winter, the prevailing winds were from the west with cold temperatures.
>
> Today, we see more extreme variable weather causing problems for hunters, trappers, fishermen and travellers generally. In the springtime, we are seeing the sea ice break up earlier. Sometimes now in mid-May the ice is not safe to travel on by snowmobile. In the winter months, the sea ice is also not as stable as it once was along the Labrador coast. Freeze-up is later into December and early January as opposed to early December in years past. Strong winds at sea rises sea swells breaking the ice and disrupting snowmobile travel by leaving open water in areas where the snowmobile trails should be. Sea ice in sheltered bays is static and doesn't move around with the tides as it does at the head lands where the ice can break loose and flow south in the Labrador Current. Simply going out on the sea ice to hunt seal at the sina [the edge of the ice, similar to a polynya] can be dangerous. If the sea swell rises and you are not aware, the ice you are on can break off and begin to drift away. Nobody has been lost due to this, but snowmobiles have been lost in the past due to this kind of event. In the past, heavy slob (snow and water mixed) at sea formed by drifting snow into the ocean and cold temperatures would be six to eight feet thick. This would dampen the sea swells before it reached close to shore. It was a barrier of sorts that gave us some protection. With today's warmer climate, we do not see this effect very often. These variable and extreme weather patterns cause serious safety concerns for users of the land. Many people have gone missing or were stranded for long periods of time due to unforeseen weather and poor snow/ice conditions, or in summer, very high winds and large sea swells."
>
> – Winston (Barry) Anderson, personal communication, 2018

The dangers involved with travelling on the land are linked to the ability of northern Canadians to be food secure and to earn their livelihoods, while the inability to participate in cultural activities severely impacts mental health and wellness (Cunsolo Willox et al., 2013a; Laidler et al., 2008). For example, unsafe sea ice conditions near a coastal Nunavut community may prevent a parent and child from travelling to harvest seal, reducing their access to country foods and the income potential associated with skins, clothing and arts products derived from the animal. The parent also loses their opportunity to share knowledge with their child. In some cases, changes to the land and water, including ice, are resulting in personal injury and damage to, or loss of, equipment like snowmobiles; in the worst cases, they are leading to loss of life.

Arctic communities are experiencing the impacts of sea ice loss in ways that are not always documented in academic literature (Ford et al. 2016; Cuerrier et al., 2015; Wenzel, 2009). These include greater risks for travel across sea ice and open waters, as well as increased marine traffic as a result of better navigability and a longer open-water season. Reduced ability to anticipate suitable sea ice conditions make travel slower, more complex and less safe (Ford et al., 2019; Bell et al., 2014, Nickels et al., 2005). Increased open-water conditions have resulted in rougher water, more fog, difficulty accessing certain safe harbours due to rapid coastal erosion, and movement of sediment (formerly protected by sea ice and permafrost) (Nickels et al., 2005).

Declines in Arctic sea ice have resulted in an increase in navigability and open-water season length for marine traffic (*see* International Dimensions chapter of the National Issues Report; Melia et al., 2016; Pizzolato et al, 2014; Smith and Stephenson, 2013; Stephenson et al., 2013). Since 1990, the distance travelled by ships through the Canadian Arctic has increased threefold (Dawson et al., 2018), with the largest increases attributed to bulk carriers, passenger ships (cruise ships) and pleasure craft (yachts). In addition to climate change impacts, non-climatic factors—such as global economic trends; demand for natural resources related to mining, fisheries, trade, and tourism; demographics; construction demand; and commodity price variability (Pelletier and Guy, 2012)—also influence ship traffic in Arctic waters.

The largest increase in ship traffic has occurred in the eastern Canadian Arctic around Baffin Island, Hudson Strait and the southern route of the Northwest Passage (Dawson et al., 2018). Several communities have experienced significant increases in ship traffic over the past decade, including Pond Inlet, Baker Lake, Cambridge Bay and Chesterfield where there have been recent or ongoing mining and tourism activities (Dawson et al., 2018). It is important to note, however, that factors such as lack of infrastructure and modern bathymetry charts, harsh weather conditions, remoteness and lack of broadband communications will still limit the potential for long-term growth of shipping in the Canadian Arctic in the near-term future (*see* International Dimensions chapter of the National Issues Report; Farré et al., 2014; Smith and Stephenson, 2013).

Combining Indigenous Knowledge, local knowledge and technology can help to reduce challenges and dangers associated with travelling by sea in the face of a changing climate. Innovative examples of this include SIKU.org, an Indigenous Knowledge Social Network that provides an online platform with specific provisions for securing and protecting Indigenous Knowledge, while helping to inform travel decisions and monitor environmental observations (Arctic Eider Society, 2019). Another example is SmartICE (*see* Figure 6.9; SmartIce, 2022) a northern social enterprise that provides employment opportunities related to data gathering and instrument development and production, along with an online platform for presenting data and augmenting Inuit knowledge, all while also helping to strengthen Inuit culture and support intergenerational teaching (Bell et al., 2014). These tools often work together. For example, SmartIce feeds directly into SIKU.org. The Floe Edge Service is a Web-based portal providing community members with access to satellite imagery of ice conditions, which is updated three to five times per week (Laidler et al., 2011). Each of these examples provides easy access to a range of information sources so that travel plans can be made with better foreknowledge of local conditions and can be adjusted accordingly.

Figure 6.9: SmartICE is a community-based social enterprise offering climate change adaptation tools and services that integrate Inuit knowledge of sea ice with monitoring technology. This is a photo of SmartICE researchers Samuel Dicker (left) and Rex Holwell (right). Photo courtesy of SmartICE and Hamlin Lampe, 2022.

Other adaptation actions reducing risk to travel on land, water and ice include enhanced surveillance and early warning systems that alert community members to incoming adverse conditions, the bolstering of local search and rescue operations to respond in emergency situations, and enhanced emergency preparedness education (Ford et al., 2014). In multiple Nunavik communities, hunters, Parks Canada, and the Kativik regional government have invested in developing a new VHF radio network that has improved the ability of community members to share information about on-the-land conditions and travel plans (Anselmi, 2019). An Indigenous-led initiative is installing weather stations in multiple communities along the Labrador coast. The active stations at Rigolet, North West River, Red Bay and Postville, as well as future planned stations, will help to fill the gaps in weather monitoring data for the area and to improve the accuracy of weather reports, which can be a matter of life and death to northern Canadians in the area (Careen, 2019). Growing these networks and subsidizing the cost of personal radios are important aspects of addressing real and perceived risks of northern travel (Shah et al., 2018).

While new technologies are often regarded as adaptation solutions, their adoption can sometimes exacerbate or compound travel risk in northern regions. For example, the use of electronic technology in snowmobiles and small watercraft engines increases the risk of water-induced damage and reduces reparability in the field. New four-stroke engine snowmobiles with electric starters are not typically equipped with backup starters due to high compression. Thus, a problem in an electrical relay or computer module can leave a traveller stranded (Andersen, 2018).

Ice roads (roads entirely on ice) and winter roads (roads on both ice and land) are important conduits for importing materials and supplies to some northern communities and mines, but shorter winter seasons and changes to lake and river freeze-up and break-up dates can impact operating season and stability (Pendakur, 2016; Andrey et al., 2014). The operating season length of an ice road has an immediate economic impact on the mines and communities relying on them. Supplies that cannot be moved on the ice road may have to wait to be transported by barge (where available) or by air (at significant cost). Ice roads are particularly vulnerable to climate changes such as temperature swings in excess of 18˚C, the number of consecutive days above 0˚C, the amount of snow on the ground as of January 1st and the number of extreme cold events during the operational season (Perrin et al., 2015). These changes necessitate adaptation actions, which include the use of new technologies and construction techniques, as well as increased maintenance and monitoring (Pendakur, 2016).

Ice bridges (e.g., seasonal crossings over a frozen river to connect all-season roads) are also key to some northern highways. The Dempster Highway, which stretches for 740 km from Dawson City, Yukon, to Inuvik, Northwest Territories, crosses several streams and includes crossings of the Peel and Mackenzie Rivers, which operate as ferry crossings in the summer and ice bridges in the winter. To mitigate the shortening of the ice bridge season, the Government of the Northwest Territories has constructed several permanent bridges over stream crossings. Ice spray, a technique that sprays river water into the air over the river during freeze-up, applied at the Mackenzie River crossing helps to develop thicker ice earlier in the season, and ground-penetrating radar is used to measure ice thickness and to identify thin sections (Government of Northwest Territories, 2008).

Operational and policy changes have been implemented to consider changing winter road conditions in the Northwest Territories. For example, the Northwest Territories Housing Corporation began awarding contracts to suppliers one month earlier to allow for adjusted transport schedules, including load adjustments in response to road weight limitations (Government of Northwest Territories, 2008). Residents living north of the Peel and Mackenzie Rivers also stockpile additional supplies and fuel in anticipation of a longer period of road closure between the ferry and ice-bridge seasons, but not everyone can afford the up-front cost of purchasing enough supplies to span this period. Climate change also affects the viability of permanent, all-season roads in the North, and is increasingly being incorporated into long term planning and management processes (*see* Case Story 6.4).

Case Story 6.4: Improving the climate resilience of the Dempster Highway

Engineers and maintenance personnel typically use planning tools, such as functional plans, to provide high-level summaries of anticipated maintenance, safety, and engineering needs and associated costs. In an innovative project, Yukon Government's Department of Highways and Public Works developed a functional plan with a 25-year outlook for the Dempster Highway that explicitly considers climate change impacts on geohazards as an integrated part of the plan (Associated Engineering, 2018; Calmels et al., 2018).

The Dempster Highway, which is the only highway linking Yukon and the Northwest Territories, is experiencing climate change-related impacts, including permafrost thaw, flooding and active layer detachments following extreme precipitation (*see* Figure 6.10). Snow drifting, washouts due to flooding, retrogressive thaw slumps, culvert failures and subsidence due to the melting of ground ice are key concerns that the Highways and Public Works Department is attempting to anticipate and address in the context of climate change. Highways and Public Works considered projected changes to hydrology, as well as detailed characterization of permafrost thaw vulnerability, as inputs to their functional plan. This approach builds consideration of climate change directly into a commonly used planning tool and exemplifies an innovative approach to ensuring that a full suite of risks are being considered in maintenance and engineering decisions for the highway.

Figure 6.10: Photo of the Dempster Highway following a heavy rainfall event in August 2022. Photo courtesy of Meredith Caspell.

Climate change is likely to have varied impacts on aviation in northern Canada, including more frequent and lengthier weather-related delays, increased clear-air turbulence and modified flight times due to increased winds (Storer et al., 2019; Williams and Joshi, 2013). Andy Williams, a bush pilot who has been flying over the ice fields in Kluane National Park since the 1970s, reports that the region has experienced “incredible amounts of change,” including changes to snow conditions necessary for take-offs and landings (Hossack, 2018).

Limited local weather information contributes to the delay and cancellation of flights—for example, in 2015, approximately 29 % of Nunavut’s medical emergency evacuations were cancelled or delayed due to lack of reliable weather reporting (Government of Canada, 2017). Coverage by automated weather observation systems, which provide continuous, real-time information about weather conditions, is limited across the North, as the construction and networking of stations are costly (Hatt, 2016). Initiatives such as the Meteorological Service of Canada’s Collaborative Monitoring Initiative are helping to improve access to data to ensure that it can be used in forecasting, and are working to increase understanding of weather and climate systems (Zucconi and Karn, 2019; Hatt, 2016).

The ability to safely travel on the land relies on many factors, not all of which are climate-related. For example, social determinants, such as knowledge of routes and expected conditions, access to well-maintained equipment, and time to wait out a storm, all contribute to travel safety regardless of conditions (Clark et al., 2016a). While climate change is impacting seasonality of trail use, there is conflicting evidence regarding whether useable seasons are actually shorter. In addition, non-climate factors can also play a role in travel safety. For example, the cost of safety equipment and reduced transmission of land skills to younger generations were dominant factors affecting search and rescue operations along Canada’s Arctic Coast between 2013 and 2014 (Ford et al., 2019).

6.5 Northerners are leaders and innovators in climate change adaptation

Innovative approaches to governance, policy and development are addressing social inequities and opening pathways for collaborative and inclusive climate change adaptation.

Northerners are exerting greater influence over decision-making and the building of climate change resilience through the development of innovative policy approaches and pragmatic infrastructure management. Central themes in successful adaptation initiatives include drawing from Indigenous Knowledge and a culture of self-sufficiency and local problem solving. Within the unique governance environment in northern Canada, where many Indigenous communities are self-governing, Indigenous-specific policy spaces are foundational to good governance and are laying the groundwork for innovative approaches to planning and decision making. While economic opportunities may enhance resilience and provide additional adaptation options, modern governance approaches can provide the basis for cautious and careful exploration of the costs and benefits related to these emerging opportunities and their potential impacts on northern people, societies and cultures, and environments.

6.5.1 Devolution and Indigenous self-determination

The implementation of modern treaties and the devolution of some aspects of governance by the federal government have led to greater self-determination, and the ability of Indigenous and non-Indigenous Northerners to play a greater role in leading decision making, including that associated with climate change adaptation actions (Alcantara et al., 2012). While not typically conceived of as a climate change adaptation action, devolution in northern regions (i.e., the delegation of certain federal decision-making authorities to the territorial governments) has resulted in regional governments having greater authority over actions in their regions, thereby improving the resilience of smaller governments because they are better able to respond to the needs of their members, and also increasing their ability to plan for anticipated changes (Coates and Broderstad, 2020).

Increasing the inclusion of local communities and Indigenous Peoples in decision making, and strengthening governance mechanisms to support the goals of self-determination, have helped community development to succeed in the face of increased socioeconomic growth (Ritsema et al., 2015). Progress towards more meaningful inclusion of Indigenous worldviews contributes to more consideration of the holistic interrelationships between nature and society (*see* Case Story 6.5)—expanding the opportunity to consider and build resilience to climate change impacts.

Case Story 6.5: Excerpt from "Indigenous Governance as an Adaptive Climate Change Strategy"

Indigenous Peoples provide critical insights into how climate change results in immediate and important implications for humans (Alam, 2018). However, using Indigenous experiences as evidence for climate change often is where the conversation stops.

In academia, where much of the thinking on climate change adaptation originates, much has been made of Indigenous responses to climate change framed as "resilience" (i.e., "Don't worry, Indigenous Peoples will bounce back"; Ramos-Castillo et al., 2017) or "ecological grief" (i.e., "Worry, Indigenous Peoples cannot bounce back and this grief amplifies other social ills"; Cunsolo, 2012). Such analyses provide compelling evidence for action, yet also paint a picture of peoples at the margins of power.

The only legitimate and probably sustainable climate change adaptation strategy for Indigenous Peoples starts with their continuing to know and understand their lands through being on and living with their lands, even if power over land management or weather eludes them. Like many of the pressures faced by Indigenous Peoples, their climate change adaptation options are subject to settler colonial, societal and institutional control. The best climate change adaptation strategy is for governments (and voters) to support Indigenous governance of climate change strategies for their communities and territories, ensuring the provision of resources needed to accomplish targeted outcomes and goals.

Using the power and authority over their lands and people, recognized through negotiated rights-based agreements and/or rooted in cosmologies that understand Indigenous Peoples as part of their lands, many

Indigenous governments have undertaken targeted, culturally based land connection initiatives. These range from building land-based camps for uses from eco-tourism to healing, to major annual seasonal journeys through their traditional territories, as ways to reconnect youth to their people and identities. These land-based acts are generative of identity and relationship, and are essential for closing the various gaps and healing the individual and collective harms resulting from ongoing colonial impacts. Labelled by Indigenous scholars as "grounded normativity" (Coulthard and Simpson, 2016), simply put, it is the ability for Indigenous people to engage in cultural resurgences and forms of culturally based being as the basis for their social and political norms.

A fundamental requirement for enacting Indigenous governance as an adaptive climate change strategy is for settler colonial society to get out of the way: to respect Indigenous land relationships, to honour Treaties through fulfilling legal obligations, to restore governance authorities and to institute specific actions for restoring respectful societal relations, as recommended by Truth and Reconciliation Commission of Canada, 2015 (Truth and Reconciliation Commission of Canada, 2015b). Climate change adaptation on these terms would support Indigenous Peoples to lead us all in adapting to climate change on the lands that they have managed since time immemorial.

Source: Irlbacher-Fox and MacNeill, 2020.

6.5.2 Impact assessment and co-management

Co-management boards and decision-making bodies engaged in impact assessment in many jurisdictions in northern Canada have created a network of knowledge holders and practitioners who are well-versed in interpreting Indigenous Knowledge, science and other forms of information that enhance decision-making processes. Co-management (*see* Box 6.3) and shared approaches to impact assessment facilitate culturally appropriate environmental protection in the hope of maximizing both socioeconomic and environmental resilience, including resilience necessitated by the impacts of climate change.

Box 6.3: What is co-management?

Co-management arrangements in Canada, as established under modern-day land claim agreements (for example, the *Nunavut Land Claims Agreement Act* and the *Western Arctic (Inuvialuit) Claims Settlement Act*), are formal and legally-based cooperative institutional arrangements among provincial, territorial and federal governments, Indigenous authorities and, in some cases, local "user" communities. There is significant regional variability regarding precisely how power is shared among the parties at a co-management table, and how well formal agreements are implemented and followed, with some describing co-management as cooperative management due to region-specific interpretation of how power sharing is being implemented (Clark and Joe-Strack, 2017). However, co-management partners are generally required to give equal weight to Indigenous Knowledge and science in their recommendations and decisions affecting wildlife management (Minister of Justice, 1993; Minister of Indian Affairs and Northern Development, 1984). Within the context of climate change, co-management boards draw on diverse experience and expertise related to research, decision making and policy as they relate to protecting animals, plants and fish that are particularly vulnerable to climate change. Through this collaborative structure, co-management boards provide a "shared space" where all levels of government agree to work together in specific geographic areas; outside of those areas, each organization retains its respective powers and jurisdictions (Snook et al., 2018).

At the regional scale, a key strategy for maintaining ecosystem and social resilience encompasses conservation and resource management efforts that maintain large natural landscapes with a diverse array of habitat types and connectivity. Key adaptive measures that are already being implemented include the following: continuing and improving co-management and adaptive management by local, territorial, federal and international partners; recognizing spatial and temporal variability in species response to climate change; implementing monitoring programs with clear goals; reducing cumulative impacts of increased human activity; and recognizing the limits of current protected species legislation (Laidre et al., 2015). These efforts allow for managing potentially impactful activities in ways that reduce changes in vulnerable ecosystems and maintaining mechanisms of resilience that give rise to healthy, dynamic landscapes (Chapin et al., 2006; Walker et al., 2004).

Similarly, strategic-level mechanisms (e.g., regional impact assessments, regional land use plans) are critical for addressing complex issues, such as the assessment of climate change impacts, including cumulative impacts, which extend beyond the individual project level. For example, the North Yukon Regional Land Use Plan undertook a scenario modelling approach that examined potential impacts from climate change and energy sector activity on caribou habitat (Francis and Hamm, 2011).

Few strategic-level or regional-level assessments address the cumulative impacts of climate change in Canada (Blakley et al., 2020), let alone for the North. A range of issues must be considered to ensure that these processes are effective, and that they include the concerns of Indigenous communities in the North about strategic-level issues leading to a loss of power or control in their relationship with the federal government (Fidler and Noble, 2013). Regional land-use plans are a mechanism that is implemented more frequently, but generally speaking, such plans do not address cumulative impacts of climate change. The above example of the North Yukon Plan is notable in that it attempted to incorporate cumulative impacts and climate change considerations in its development process. Similarly, the Strategic Environmental Assessment in Baffin Bay and Davis Strait, the final report of the Nunavut Impact Review Board, examined development scenarios in the context of cumulative impacts and climate change considerations. Importantly, the report notes that "this assessment has made significant progress with the respect for and treatment of Inuit knowledge and experience" (Nunavut Impact Review Board, 2019, p iii).

Monitoring is a key enabler in both impact assessment and strategic-level assessment. Initiatives to consolidate access to data (e.g., the open data portal launched by the Government of Yukon, 2020) and the Northwest Territories Cumulative Impact Monitoring Program (Northwest Territories Cumulative Impact Monitoring Program, 2015) are examples of initiatives that improve the accessibility to, and effectiveness of, public data. Increasingly, co-management institutions require innovative and streamlined processes to stay informed about the rate and types of changes in habitat conditions (Lenton, 2012; Chapin et al., 2010;

Beaufort Sea Partnership, 2009). This information is used to re-assess and establish habitat protections early enough to be effective (Chapin et al., 2010; Beaufort Sea Partnership, 2009).

Co-management arrangements need up-to-date information and expanded knowledge on ecosystems in Canada's North, and on how they are responding to climate change (Staples, 2013). For example, when species that were previously considered incidental or invasive become frequent visitors or residents (*see* Section 6.2), the current understanding of ecosystem integrity is challenged and the functioning of Arctic marine food webs must be reassessed (Staples, 2013). Indigenous Knowledge and local knowledge from subsistence users and communities, and input from regional institutions that monitor and report on ecological and sociological changes, will be important for co-management arrangements to continue their work in ensuring ecosystems in Canada's North are resilient in the face of climate change. Expanding the mandate of co-management agreements may also be required in order to maintain their effectiveness in the face of climate change (Popp et al., 2018; Snook et al., 2018; White, 2018).

Co-management boards are also leading efforts to ensure that Indigenous Knowledge and local knowledge informs decision making. This is distinct from including Indigenous membership. The observations and knowledge of Indigenous Peoples and local people provide current information that can identify subtle changes in species health and ecological conditions (Gearheard et al., 2011; Berkes et al., 2007), which can help to inform responsive management practices (*see* Case Story 6.6). In this way, co-management boards play an active role in facilitating dialogues that incorporate both Indigenous Knowledge and science related to climate change adaptation and changes to food systems, livelihoods and well-being, and serve as platforms for adaptation actions. Co-management boards help to ensure that the voices, knowledge and science of the region are meaningfully included in climate policy analysis, and that adaptation initiatives continue to be enhanced through co-learning, cooperation and the implementation of co-management recommendations and decisions.

Case Story 6.6: Co-management approaches to polar bear management

Canada is home to thirteen of the world's nineteen polar bear sub-populations. It collaborates internationally with other nations with large polar bear populations. Polar bears (*Ursus maritimus*, "*nanuq*" in Inuktitut) are a keystone species and have received increasing attention within the context of climate change and environmental shifts. This species is designated as a species of "special concern" by the Committee on the Status of Endangered Wildlife in Canada, with a predicted decline over the next three decades due to a reduction in seasonal ice coverage (The Committee on the Status of Endangered Wildlife in Canada, 2018).

Shorter ice seasons and less stable ice conditions already affect harvesters' access to polar bears (Joint Secretariat, 2015; Hovelsrud et al., 2011). This has led to adjustments in the length of the period within which hunters are permitted to harvest an animal. As a result, co-management partners must balance the demand for fewer licenses held for longer periods of time with reduced hunting opportunities for all harvesters. In some instances, these types of changes require a re-assessment of long-standing regulated harvest seasons.

Within Canada, there are multiple levels and structures of government that collaborate on polar bear management, including the Government of Canada, the provinces and territories, the national Polar Bear Technical Committee, the Polar Bear Administrative Committee, and a network of co-management boards in Inuit Nunangat that were established through negotiated land claim agreements. These boards are undertaking research, leading dialogues and making decisions at the local level in Inuvialuit, Nunavut, Nunavik and Nunatsiavut. These collaborative efforts are making substantive contributions to knowledge about polar bears and are also helping to integrate Inuit *Qaujimajatuqangit* into decision making and recommendations. Inuit *Qaujimajatuqangit* is defined as "all aspects of traditional Inuit culture including values, worldview, language, social organization, knowledge, life skills, perceptions and expectations" (Government of Nunavut, 1999). For example, in 2010, the Government of Nunavut started publishing supplemental Inuit *Qaujimajatuqangit* that supported and influenced dialogues about polar bears (Kotierk, 2010a,b). Nunatsiavut and Inuvialuit followed suit in 2015 (Joint Secretariat, 2015; York et al., 2015), as did Nunavik in 2018 (Nunavik Marine Regional Wildlife Board, 2018). Through the generous sharing of their knowledge, Inuit enhance polar bear management within Inuit communities, national organizations and internationally (Clark et al., 2013).

6.5.3 Energy security and community resilience

Much of the electricity infrastructure in northern Canada was built when considerations of climate change and other factors were not as prominent as they are today. Currently, energy security for Canada's northern communities is an area in which economic development, innovations in policy and governance, applied research, and community capacity development are contributing to resilience (Bizikova et al., 2008). As ageing energy infrastructure is replaced, and increasing value is placed on limiting negative socioeconomic and environmental impacts, governments, industry and communities are beginning to turn to new approaches for energy production (Natural Resources Canada, 2018). Today, electricity is primarily generated through a combination of hydroelectric power and diesel generation, with the growing use of solar energy and other alternatives like liquefied natural gas and biomass (Canada Energy Regulator, 2019). Wind and geothermal power generation are also being explored.

Capacity-building initiatives to increase energy security and resilience include training programs and project funding. Examples include the 20/20 Catalyst Program, a three-month program designed to build leadership skills and project management capacity of Indigenous community members, and the Arctic Community Energy Planning and Implementation Toolkit, a publicly available resource for northern communities developing and implementing community energy plans and project (Indigenous Clean Energy Social Enterprise, 2019; Cox et al., 2019). Increasingly, communities are recognizing the impact that local energy coordinators can have in developing tools and projects by creating capacity to pursue funding for and to coordinate community-oriented projects and programs associated with energy security (Denton et al., 2015). Applying these approaches to energy projects allows northern communities to harness local knowledge and social capital, incorporate unique circumstances, values and challenges on a community scale, and build resilience to climate change within their energy systems while providing environmental, health, social and resilience benefits.

In Aklavik, Northwest Territories, the efficiency of variable speed generators in a range of northern operating conditions and loads is being tested as a way to optimize the use of diesel that is normally brought to the community by sea lift, acknowledging that diesel power is likely to remain an important resource for remote communities (Yukon Research Centre, 2019; Mercer et al., 2018). In some Nunatsiavut communities, energy plans have prioritized the efficient use of diesel for heat and power generation as a familiar, reliable and predictable energy source that provides employment benefits. This highlights how adaptation and resilience are improved by investing in existing infrastructure, while acknowledging that emission reduction benefits are sometimes outweighed by the benefit of maintaining a known technology (Mercer et al., 2018).

In parts of the North, hydropower is already an important source of electricity. Increasing streamflow associated with climate change may prove to be beneficial for hydropower generation. However, increasing flow variability and changes to the timing of peak and low flows can add uncertainty and challenges for sustained power production (Gaudard et al., 2013). By understanding how changes to streamflow may occur on different timescales, hydropower corporations can better adapt their short-term operations to ensure that they meet energy demands in the coming year, and can improve their long-term planning. Streamflow forecasting tools, such as those being used by the Yukon Energy Corporation, can help decision-makers understand how changes to streamflow may occur on different timescales (Samuel et al., 2019).

Within communities, synergies often exist between climate change resiliency and community-led projects. In Inuvik, Northwest Territories, a 5-kW grid-tied solar photovoltaic system was installed in 2017 for the Inuvialuit Community Economic Development Organization's community freezer project as part of a four-day solar energy workshop (Inuvialuit Regional Corporation, 2017). The workshop increased the community's food security and technical capacity related to renewable energy, while also supporting traditional hunting practices and contributing to the community's transition towards energy independence (Arctic Energy Alliance, 2020). In this example, local practices and knowledge were supported and utilized through the development of working relationships between local, regional and national organizations to improve the local community's food and energy security.

The development of responsive energy policy also offers another example of how policy innovation can support climate change adaptation, low-carbon resilience and energy security. While northern energy policies and regulations have historically been applied territory- or province-wide, independent power producer and net metering policies have allowed individual communities to lead their own energy projects (Karanasios and Parker, 2016). The governments of the Yukon and the Northwest Territories have both developed policies that incentivize communities and entrepreneurs to produce energy via renewable energy sources and to feed it back into electrical grids with compensation (*see* Case Story 6.7; Government of Northwest Territories, 2018; Government of Yukon, 2018). The Government of Nunavut launched a net metering policy in 2018 and is currently developing an independent power producer policy for the territory (Quliq Energy Corporation, 2020, 2018). In Nunavik, Pituvik Landholding Corporation has signed a Power Purchase Agreement with Hydro Quebec for the construction of a 7.5-MW hydropower plant (Innergex Renewable Energy, 2019). When developed effectively, energy policy can improve community resilience by enabling leadership and adaptation at the community level.

Case Story 6.7: The Old Crow Solar Array

The Vuntut Gwitchin First Nation wanted to improve energy security and reduce reliance on diesel needed to fuel generators, which was being flown into the community of Old Crow, Yukon's northernmost community. However, there was uncertainty regarding the technical constraints of the existing electricity infrastructure. Conflicting reports from consultants and companies created uncertainty about the possibility of including solar power in existing infrastructure owned by ATCO Electric Yukon. The Vuntut Gwitchin Government approached Yukon University's Northern Energy Innovation research team to receive technical assistance from an independent third party. With the participation of both ATCO Electric Yukon and Vuntut Gwitchin Government, the team conducted a power system impact study of Old Crow's electrical grid to determine if and how the renewable resource could be integrated into the system to provide a stable and reliable energy source. The study provided a basis for Vuntut Gwitchin Government to move ahead and implement its vision for greater energy security and low-carbon resilience (Arctic Council Secretariat, 2022).

Concurrently, the Yukon Government developed an independent power producer policy that allows communities to generate electricity and sell it to existing grids (Government of Yukon, 2018). The community of Old Crow can now operate without the use of diesel for 95 to 100 non-consecutive days of the year. While the Vuntut Gwitchin Government purchased the capital assets for the solar energy plant, ATCO continues to ensure that the energy produced by the solar panels is stored in batteries, and properly and safely utilized to provide a consistent and reliable energy source. The success of this project was enabled through a coordinated and collaborative effort by the private sector, governments and academia.

6.5.4 Community responses to biophysical change

It has been estimated that climate change impacts on public infrastructure in the Northwest Territories will cost $1.3 billion over the next 75 years (Northwest Territories Association of Communities, 2018), providing a general understanding of the anticipated costs of climate-induced damage and advantages of applying adaptation actions. The Canadian Climate Institute is currently conducting a pan-northern analysis to estimate the financial impacts of permafrost thaw on infrastructure (Clark et al., 2022).

Recognizing the urgency of permafrost thaw-related infrastructure issues, the Standards Council of Canada's Northern Infrastructure Standards Initiative (NISI) has initiated work to prepare a guide for hazard mapping. NISI and the *Bureau de normalisation du Québec* (BNQ) have made northern-specific guidance available for moderating the effect of permafrost on foundations (Standards Council of Canada, 2014a), managing snow loads (Standards Council of Canada, 2014b), thermosyphon foundation design (*see* Figure 6.11; Standards Council of Canada, 2014c), community drainage design (Standards Council of Canada, 2015) and geotechnical site investigation (*Bureau de normalisation du Québec*, 2017). These tools assist decision-makers, but the costs of implementing the recommended measures and accessing qualified experts are barriers to their implementation. To encourage uptake of these resources, NISI has partnered with northern organizations to develop posters and "101-style" videos that summarize each standard and provide the key points for community infrastructure managers (Standards Council of Canada, 2020a). Northern organizations are playing a more prominent role in the review and revision of existing standards, and creation of new ones. However, standards to quantify permafrost vulnerability to thaw are not broadly established or practiced (*see* Section 2.1.2; Arctic Development and Adaptation to Permafrost in Transition, n.d.).

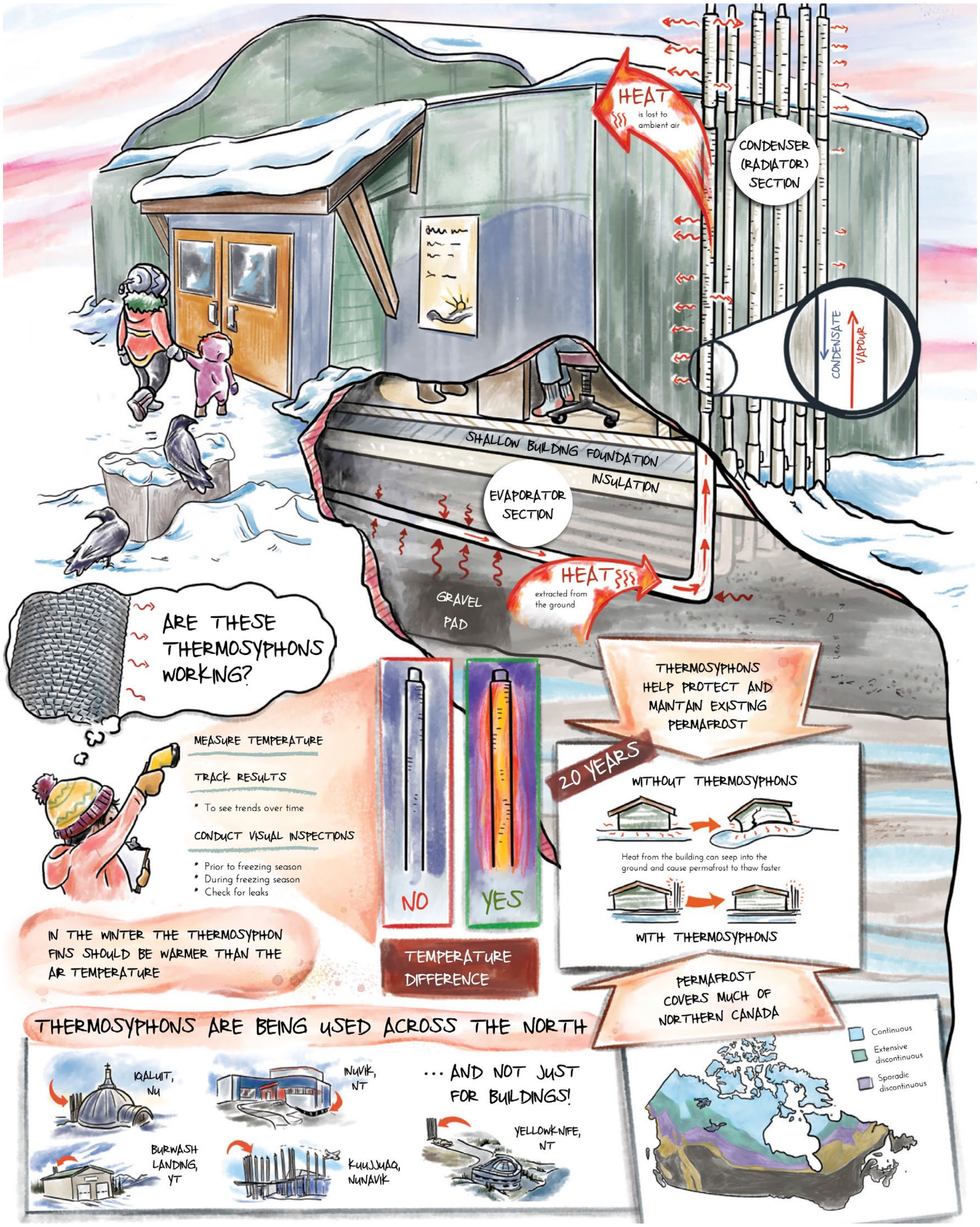


Figure 6.11: Infographic illustrating how thermosiphon foundation systems function, which ultimately aim to stop heat from a building from damaging the permafrost located beneath it. Source: Standards Council of Canada, 2020b.

Flooding is another common hazard in northern communities, which were often established adjacent to rivers and lakes in order to facilitate transportation. While overall seasonal and annual precipitation has increased—a trend projected to continue (*see* Changes in Temperature and Precipitation Across Canada chapter of Canada's Changing Climate Report)—trends and projections indicate decreased maximum snow water equivalent in much of the North (Mudryk et al., 2018). As a result, flood events resulting from high snowmelt runoff are declining in some large rivers. However, more intense precipitation may generate higher flow conditions in smaller rivers in the future, which would impact transportation infrastructure between communities. Many communities in northern Canada are also at risk of flooding from ice jams. These can occur in both winter and spring, and can cause extreme damage to communities and infrastructure along rivers, as well as impacting aquatic life (Beltaos, 2008). Extreme rainfall and rain-on-snow events may result in higher flows when ice is still present (Burn et al., 2016; Buttle et al., 2016), often leading to ice jams. In some cases, climate change has been associated with conditions leading to ice-jam flooding (Turcotte et al., 2019; Janowicz, 2017). In other cases, climate change has been linked to a possible reduction in the likelihood or severity of ice jams (Das et al., 2017; Burn et al., 2016). Given the complex processes leading to ice jam floods (e.g., Turcotte et al., 2019), local knowledge and Indigenous Knowledge, environmental monitoring and site-specific studies will improve understanding of how climate change is influencing the frequency and severity of ice-jam flooding.

One approach to reducing flood risk for northern communities involves the construction of engineered structures to reduce the amount of flood water to which an area is vulnerable (Burrell et al., 2015). The engineered dykes constructed in Dawson City, Yukon following a record flood event in May 1979 (Janowicz, 2010) are a good example of this; however, such initiatives are often reactionary responses. Moreover, inadequate designs (e.g., Beltaos and Doyle, 1996) or maintenance protocols may lead to a false impression of security. Beyond engineered structures, most flood reduction efforts are related to evaluating risks, like geohazard or flood mapping initiatives (Yukon Government, 2015), or integrating climate change modelling into flood hazard assessment (Beltaos, 2019; Lindenschmidt et al., 2016). These projects help communities understand risk to inform development, planning and emergency measures (Moudrak and Feltmate, 2017; Burrell et al., 2015), but may not address the risk itself. Clear documentation of how flood-related risks were accounted for is rarely available, with a lack of regulation and transparency regarding risk disclosure acting as barriers to implementation of flood risk management (Clark et al., 2022).

Risks of wildfire are projected to increase as a result of climate change (Erni et al., 2019; Kirchmeier-Young et al., 2017). FireSmart®—a process that involves thinning and brushing to reduce vegetation that could fuel fires in tree stands adjacent to residential areas—is a proven protective measure to limit the severity of fires in northern boreal forest systems (Schroeder, 2010). FireSmart® prescriptions have not yet been applied in all communities in the Northwest Territories and Yukon. Some northern communities are also investing in biomass harvesting as a means to manage and thin forests surrounding residential areas, while providing a source of energy for heating and developing new local economies (Yukon Government, 2016; Government of Northwest Territories, 2012).

6.5.5 Integrated planning for marine traffic

While increased ship traffic may bring economic benefits to Arctic regions (Christensen et al., 2018), community members across the Canadian Arctic have identified increased shipping as an area of concern that requires collaborative research and governance, including in the development of adaptation options to address both the direct (e.g., sea ice decline) and indirect (e.g., increased ship traffic) impacts of climate change on marine transportation (Dawson et al., 2020). Adaptation options include the development of infrastructure like safe harbours, navigational aids and their supporting systems, increased charting, and increased emergency response capacity and tools (related to search and rescue capabilities, as well as environmental impacts).

The development of low-impact corridors is emerging as a collaborative approach to moderating impacts and adapting travel through Canada's Arctic waters. Low-impact corridors, which can be developed using a co-management or collaborative approach, recognize areas of environmental and cultural significance by identifying voluntary maritime routes along which infrastructure, navigational support and emergency response services are clustered (Levitt, 2019), minimizing marine traffic in other areas. The use of local knowledge and Indigenous Knowledge to identify preferred corridors, areas to avoid, restrictions by season, modification of vessel operation and charting required provides an opportunity for meaningful inclusion of northern voices in the development of such corridors (Dawson et al., 2020) and represents an innovative approach to adaptation planning in a sector undergoing rapid change.

Other commercial interests, such as increased Arctic shipping and offshore oil and gas development, will also require co-management partners to develop innovative approaches for assessing and managing environmental risk (Arctic Monitoring and Assessment Programme, 2008; Inuit Circumpolar Council, 2008). Risk assessment methodologies will become important tools for understanding high-consequence, low-probability events, such as blow-outs and spills associated with offshore drilling and shipping (Arctic Council, 2009). These methodologies will be used to evaluate development scenarios and resolve differences among co-management partners. In addition, due to increasing traffic from growth in fisheries, tourism and heightened interest in exploration, there is a growing demand for search and rescue support in the Canadian Arctic, which puts stress on both human and financial resources (Clark et al., 2016b; Dawson et al., 2014; Arctic Monitoring and Assessment Programme, 2008).

6.6 Recognizing inherent capacity is key to building climate resilience

Organizations and individuals that recognize and embrace the inherent capacity of northern communities to adapt are key players in the pursuit of climate resilience.

Strong connections to the land, social structures that uphold community, and political environments that enable shared decision-making enhance existing resilience. While innovative research and decision-making partnerships signal a shift in leadership in northern Canada, the existing capacity of Indigenous Northerners based on millennia of observations and adaptation actions too often remains overlooked.

6.6.1 Describing northern capacity

In academic discussions, capacity can be understood in many ways, including as capability and competence (Howlett and Ramesh, 2016; Araral et al., 2015). The concept plays a substantial role in northern Canada, where the term “capacity” appears regularly in both popular media and political discourse. In the northern context, capacity discussions often focus on community, governance and the ability to adapt to climate change at the local scale (Darling et al., 2018; Simon, 2017; Graham, 2016; Irlbacher-Fox and Gibson, 2010), in addition to financial aspects. Other factors that impact capacity within communities include social justice issues, political mandates and institutional fragmentation (Ford and Furgal, 2009; Keskitalo, 2009; Bizikova et al., 2007).

The literature on capacity related to climate change focuses mainly on adaptive capacity—the ability of a community or group to adapt or adjust in light of changes to the environment (Ford et al., 2015; Engle, 2011; de Loë and Plummer, 2010). Vital components of adaptive capacity include the Indigenous Knowledge and local knowledge held by many northerners (Pearce et al., 2015), social structures that encourage resource sharing and mutual aid (Ayers and Forsyth, 2009), and a political landscape that encourages co-management (Armitage et al., 2011; Dale and Armitage, 2011). It is widely appreciated that Arctic communities have high rates of adaptive capacity and resilience (Ford et al., 2015; de Loë and Plummer, 2010). However, the ongoing impacts on Indigenous Peoples from colonization, including marginalization, power differentials in Canadian society and loss of land, negatively affect that capacity (Council of Canadian Academies, 2019; Ramos-Castillo et al 2017).

This context is also plagued by overarching questions related to colonialism, responsible conduct of research, lack of infrastructure, and conflicting mandates or priorities (Ford et al., 2015; Cameron, 2012; Glaas et al., 2010; Berkes and Jolly, 2001). The impacts of climate change, combined with the above-mentioned pressures, have the potential to affect adaptive capacity and adaptation success, especially among Indigenous populations (Council of Canadian Academies, 2019). The linkages between local and higher-level governance systems can facilitate or impede adaptation through the distribution of resources, including social services, resource rights and regulatory frameworks (Ford et al., 2015; Keskitalo, 2009; Smit and Wandel, 2006). There is also inadequate financial capacity to respond to climate change impacts through adaptation actions, and this lack of capacity can limit adaptation options in northern Canada. For example, climate change poses further challenges to Canada's ability to fund, build and operate the country's infrastructure, especially in northern Canada (Clark et al., 2022).

In the North, increases in capacity can often be directly linked back to the work of small innovative groups and sometimes even to particular individuals. Increasingly, northern leaders are being invited to participate in the development of national standards like the Northern Infrastructure Standardization Initiative, convened by the Standards Council of Canada (*see* Section 6.5.1). Northern and Indigenous representation in major research initiatives, such as ArcticNet, PermafrostNet and the Canadian Mountain Network has also increased. Northern expertise is being directly sought and included in national policy research (e.g., Council of Canadian Academies, 2019; Crown-Indigenous Relations and Northern Affairs Canada, 2019; Environment and Climate Change Canada, 2016). Governments have recognized that northern representation and continued capacity investment in a wide range of social and economic areas is required to maintain and improve climate resilience (Crown-Indigenous Relations and Northern Affairs Canada, 2019).

6.6.2 Research

Innovative models for research collaboration are becoming increasingly prevalent across the North, as are calls challenging the scientific community to transform the way it conducts research and engages with Indigenous communities in a time of reconciliation (Wong et al., 2020). Indigenous organizations and governments are developing research strategies to ensure that research is governed, conducted, resourced and shared in ways aligning with Indigenous priorities and values. This includes, for example, the National Inuit Strategy on Research (Inuit Tapiriit Kanatami, 2018). At the same time, educational and research institutions across the North are growing their capacity to lead research activities and train the next generation of northern researchers. Northern institutions are playing a growing role in national research networks, changing approaches to funding, governance, partnerships, and training for research in the North. Importantly, these shifts are allowing Northerners to ask and answer research questions that are relevant to them, to build adaptive capacity and resilience, and to identify adaptation options (*see* Case Story 6.8).

Case Story 6.8: The Qaujigiartiit Health Research Centre

In Nunavut, the Qaujigiartiit Health Research Centre (QHRC) promotes the concept that research can be used as a tool for action—when one understands the scope and breadth of an issue, one is better-equipped to take action. The *Piliriqatigiinniq* Partnership Model for Community Health Research (ᐱᓕᕆᖃᑎᒌᓐᓂᒃᑯᑦ ᓄᓇᓕᓐᓂ ᐋᓐᓂᐊᖃᙱᑦᑐᓕᕆᓂᕐᒧᑦ ᖃᐅᔨᓴᕐᓂᖅ) was developed by the QHRC in the formative years of the Research Centre. It was created in response to a community-identified need for health research that explores topics of concern to Nunavummiut, the people who reside in Nunavut, and is collected, analyzed and disseminated in a holistic and collaborative way. The *Piliriqatigiinniq* Partnership Model is built upon the principle that anyone and everyone can be involved in health research in some capacity, because multi-disciplinary collaboration strengthens research projects, provides added perspective to data analysis, and contributes to greater dissemination and implementation of findings across sectors.

The multi-disciplinary *Piliriqatigiinniq* Partnership Model contributes to building capacity in multiple sectors across Nunavut. It also reinforces the vision for health research that acknowledges the importance of both Western science models and Inuit *Qaujimajatuqangit* (Inuit traditional knowledge) in understanding and addressing health concerns of the Nunavummiut, contributes to the generation of meaningful knowledge, and ultimately supports progress towards improving the health of the Nunavummiut through research. The *Piliriqatigiinniq* Partnership Model is used as a guide for the development of each health research project implemented at the QHRC. This model is a reminder to look beyond the scope of what is defined as "health" and "research" to include knowledge holders and stakeholders from other disciplines and walks of life.

For more information, see Qaujigiartiit Health Research Centre (2019).

The Inuit Health Survey is a powerful example of research designed and led by Northerners that enhances health research capacity among Inuit and contributes to improved well-being. First conducted during the International Polar Year in 2007–2008 and led by McGill University (Centre for Indigenous Peoples' Nutrition and Environment, n.d.), the survey was groundbreaking as it generated Inuit-specific health data that had not previously been gathered on such a scale. Since the implementation of that survey, Inuit organizations have been promoting the significance of thorough and regionally specific data for understanding Inuit health and for making evidence-based decisions, while at the same time advancing Inuit self-determination in research.

In 2018, ITK announced the creation of the *Qanuippitaa?* National Inuit Health Survey (QNIHS) (Inuit Tapiriit Kanatami, n.d.). QNIHS is the first national health survey led by Inuit, with the objective of providing high quality, Inuit-determined and Inuit-owned data to monitor change, identify strengths and gaps, and inform decision making, leading to improved health and wellness among Inuit in Canada. The regional Inuit organizations are developing and implementing the QNIHS in Nunatsiavut, Nunavik, Nunavut and the Inuvialuit Settlement Region, in collaboration with ITK. Governance structures are being created within each region to ensure that all aspects of the survey are constructed with the input and priorities of Inuit individuals, families and communities from across Inuit Nunangat. The QNIHS will also include an urban component, implemented in partnership with organizations mandated to provide services for urban Inuit populations. An urban Inuit survey will take place in Ottawa for the first survey cycle and may be expanded to other urban centres in subsequent cycles.

As the QNIHS is Inuit-led, it uses a holistic health framework that is inclusive of physical, emotional and mental wellness; environmental health; and Inuit social determinants of health. These important and diverse health and well-being indicators will be monitored every five years (Inuit Tapiriit Kanatami, n.d.). Collecting Inuit-owned health data on an ongoing basis and in a way that is designed by, and appropriate for, Inuit will provide regional governments and organizations with evidence to inform policy and programming decisions. Importantly, a major focus of the design of the program is creating innovative training and capacity enhancement approaches, to ensure that the QNIHS process enhances health research capacity across Inuit Nunangat (Inuit Tapiriit Kanatami, n.d.).

Citizen science is also an emerging pathway to advance collaborative approaches to adaptation and policy development (Kythreotis et al., 2019). Citizen science elevates the role of individuals and community members in such a way that local knowledge and Indigenous Knowledge can be more directly applied in identifying and implementing solutions. Examples include the wildlife observations project of the Dan Keyi Renewable Resources Council (Dän Keyi Renewable Resources Council, 2019) and SIKU, the Indigenous Knowledge Social Network (Arctic Eider Society, 2019). Distinguishing impacts caused by climate change and other forms of human and natural disturbance allows for better prediction of what parts of a landscape or ecosystem are most likely to shift under current and anticipated future environmental changes (Folke et al., 2004).

In recognition of the linkages between Indigenous self-determination, community health and resilience, and citizen concern over climate and environmental change, research networks and funding bodies have been modernizing their structures to provide greater opportunities for community-based research. In the fall of 2018, the Social Sciences and Humanities Research Council of Canada held a special call for Indigenous Research Capacity and Reconciliation Connection Grants (Social Sciences and Humanities Research Council, 2018). Indigenous organizations were eligible award holders, to apply and manage research funds awarded under the program. ArcticNet, a research network that studies the impacts of climate change in the Canadian Arctic, has devoted funding to a North by North program and invested in research coordination capacity through northern and Inuit organizations in each of the territories, as well as in Nunatsiavut and Nunavik (Reedman, 2020). North by North is also awarding research funds directly to communities. These initiatives have opened the door for more in-depth consideration about who the key actors are in northern research and what role they can play in contemporary research collaboration (*see* Case Story 6.9). They have established greater connections between research and action, improved research coordination and engaged diverse stakeholders in identifying solutions for addressing fundamental issues of community resilience (Canadian Mountain Network Yukon Initiating Group, 2017).

Case Story 6.9: *Ikaarvik*: Barriers to Bridges

Ikaarvik is the Inuktitut word for bridge and the intention of the Barriers to Bridges program that *Ikaarvik* operates. *Ikaarvik* aims to build bridges between research communities and northern communities by promoting youth involvement in research. *Ikaarvik* gives youth the opportunities, confidence, and experience to explore how Inuit Knowledge and science can be combined to address northern issues. The program empowers youth to work with their communities in identifying local research priorities and to build relationships with researchers, government, and industry to address those priorities. By focusing on youth, *Ikaarvik* is ensuring that future Inuit leaders will be familiar and comfortable with both Inuit Knowledge and scientific research processes, thus enabling Inuit to have a strong voice in determining research priorities in their communities across the North.

Video 6.1: Ikaarvik: Barriers to Bridges is a program that works with Arctic youth to bridge between research and their communities. Source: Ocean Wise, 2019. https://www.youtube.com/watch?v=cVXGM6hkbRY

6.6.3 Northern development and resilience

While much of the dialogue around climate change impacts and adaptation focuses on limiting the impacts of undesirable changes on the environment, society and culture, climate change impacts also present new economic opportunities. Northern development, in part facilitated by climate change through impacts such as longer ice-free seasons and the appearance of new commercially viable harvest species, may bring socioeconomic benefits to the North. However, there are concerns about how these benefits are distributed and whether local communities are positively impacted (Ford and Furgal, 2009). Such economic growth has potential to impact society and culture in ways that are often difficult to assess, anticipate and disentangle from concurrent change.

While there is potential for increased economic activity and Arctic shipping, made possible from longer ice free season, there are associated environmental risks (*see* International Dimensions chapter of the National Issues Report; Arctic Council, 2009). Increased access to mining is providing economic opportunities, but is also associated with remediation concerns evidenced by a long history of abandoned mines in the North (Sandlos and Keeling, 2016; Caine and Krogman, 2010). Extractive industries also tend to experience boom and bust periods. Increased drug and alcohol abuse, housing problems and transiency are often associated with the boom part of the cycle, while out-migration and poverty are often associated with the bust (Southcott, 2015).

With respect to Arctic fisheries, increases in some fish stocks and improved access due to a longer open-water season are leading to interest in commercializing fisheries that either did not exist in the past or were limited to subsistence use. The appearance of new fish species in Arctic waters, such as sockeye salmon in the Beaufort Sea (Niemi et al., 2019; Irvine et al., 2009; Babaluk et al., 2000) will also lead to new demands for commercial fishing. In response to growth in Arctic fisheries, co-management partners will need to establish sustainable harvest levels for these stocks in Arctic waters, especially for newly arrived species and where historical data are limited (Staples, 2013). Commercial harvesting is also adding stress on fish and wildlife that are directly and indirectly impacted by climate change (Government of Canada, 2019b).

Some regions in the North are identifying strategies that consider economic benefit, resilience and adaptation while integrating cultural values, Indigenous livelihoods and local modern economies. The Nunatsiavut Government's Department of Education and Economic Development Division runs a char fishery social enterprise whereby Inuit fishers are allocated licenses by the Nunatsiavut Government and all the fish is landed and processed at the fish plant in Nain. Every year, the Division provides a financial contribution to the Torngat Fish Producers Co-operative, a local Indigenous-led business, to purchase between 10,000 and 15,000 pounds of processed Arctic char, which is then distributed to communities through the community freezer programs (Torngat Fish Producers Cooperative, 2022). In addition to contributing to food security, this program supports the local fishery and processing enterprise, providing employment to local fishers and plant workers in their home communities. Notably, the community freezer programs also trade a portion of their char for cod from NunatuKavut Community Council, contributing to diet diversity and building regional economic collaborations.

It is not easy to prevent the negative impacts on northern communities that are inevitably associated with the socioeconomic opportunities resulting from climate change. However, it is possible to build sustainable resource industries in ways that benefit local communities and also provide the resources needed to build social resiliency and health and well-being (Southcott, 2015). Modern treaties, self-government, devolution and co-management, rigorous environmental and socioeconomic assessments and regulations, as well as corporate responsibility are, and will continue to be, crucial requirements for advancing resiliency (Southcott, 2015).

6.7 Moving forward

While much is being done in northern Canada to adapt to our changing climate, there is a continued need to understand the prevalence, rate and magnitude of climate change impacts on both our natural environment and our society to enable responsive adaptation action. Some of the emerging issues identified below warrant additional research or identify gaps in policy or adaptation responses that impair resilience. They also present opportunities for leadership in a thriving North.

While the key messages in this chapter are broad in nature, there are several common themes related to gaps in knowledge and emerging issues. These include: data availability; building resilience to multiple stressors; recognition of health, well-being and societal impacts; responsive decision making and co-governance; placing value on Indigenous Knowledge and inherent capacity; and understanding limits to adaptation.

6.7.1 Lack of data

In virtually every topic covered in this chapter, a lack of data hampers our understanding of existing climate change impacts, which in turn limits or influences the nature and effectiveness of adaptation action. Data to support understanding of how human systems and the biophysical environment are responding to climate change is lacking—for example, how new migrant species will interact with existing resident species, or how native species will vary their responses to climate change impacts. Cascading changes, feedbacks and new types of disturbances are emerging, but rarely is there sufficient data to understand these changes or to project them in advance.

Integrative approaches that consider Western and Indigenous Knowledge help to expand what is regarded as "data." Many observations and solutions are already present in ways that governments and decision-makers have historically not appreciated or acted upon. Holistic understanding improves in locations where collaboration between Indigenous Knowledge holders and scientists has been successful. However, there are still large areas, such as non-coastal areas of the Arctic Ocean where both Indigenous Knowledge and Western scientific approaches are unable to provide complete understanding of natural systems and how they are changing (Niemi, 2019).

In many community settings, signs of climate change impacts can be missed. For example, the frequency of grading of a gravel road over degrading permafrost or the number of times a house on such permafrost is levelled can give important information of how permafrost thaw is impacting a community. Likewise, climate change-related impacts on travel safety are rarely documented in ways that can be used to support adaptation action or even comprehensive assessments of the scope of the issue. Details regarding delayed flights or the number of local search and rescue operations due to unusual weather or ice conditions, for example, are rarely captured beyond anecdotal evidence; also, in cases where records are kept locally, they have yet to be examined across northern Canada (The Standing Senate Committee on Fisheries and Oceans, 2018; Clark et al., 2016b). Developing tools, approaches and capacity to support the added effort to document and share this information as "data" for subsequent analysis could help address the issues related to a lack of data, but this will take significant and sustained effort.

6.7.2 Building resilience to multiple stressors

The impacts of climate change on the biophysical environment are often strongly influenced by non-climate-related pressures, including those resulting from northern development, changing demographics, long-range transport of chemicals and pollutants, and a diverse range of other impacts on the environment. It is recognized that measures that build resilience are necessary regardless of whether climate change is the dominant cause of disturbance or only one contributor. Changes to the biophysical environment are not limited to the Arctic, and investigating impacts of northern environmental changes on other regions of the world (e.g., the relationship between Arctic sea ice loss and mid-latitude weather) is emerging as an important issue of study (IPCC, 2019).

Communities are regularly taking action to build resilience, both in response to the impacts of climate change and in response to other, non-climate-related stressors. This is done even in the absence of quantitative data regarding projected changes (Meredith et al., 2019). Reflection on lived experience and reliance on the dominant knowledge system of the community are heavily used in most local- and regional-level decisions. Northern communities often make projections based on their understanding of changes that have already occurred and on what make them resilient. Instead of asking why a change is occurring, they are focused on taking tangible actions that will create base levels of resilience. For example, trail projects help maintain access to harvest sites and are often completed without fully examining whether a newly built or reconstructed trail will remain resilient to future conditions. The immediate benefits of rebuilding a trail can improve resilience in the short term even if further adaptation is needed later (Pearce et al., 2015). Meanwhile, improvements to housing, social programming, education, community infrastructure and the reinvigoration of cultural practices improve resilience regardless of what outside forces are impacting them. There is an important need to research, fund and support mechanisms for social resilience.

6.7.3 Recognition of health, well-being and societal impacts of climate change

There is a growing body of literature, much of it created in partnership with northern communities and individuals, identifying ecological grief as an emerging mental health issue (e.g., Cunsolo et al., 2020; Cunsolo and Ellis, 2018). Recognition of compounding mental health concerns, including those associated with ecological grief, is leading to a call to address broader socioeconomic determinants of mental health through increased care and support, both within and outside of the healthcare system.

Concerns associated with physical human health impacts resulting from climate change, or perceived to be associated with climate change, are also growing. This includes concerns related to contaminant exposure (e.g., through the consumption of wild foods that, in turn, are exposed to contaminants as a result of thawing permafrost), food insecurity and health impacts of wildfire smoke (Rautio et al., 2020, Creed et al., 2018, Dodd et al., 2018). There is also increasing recognition of the impacts of northern development on mental, physical, and emotional health and well-being in communities. For example, close to 50 Indigenous communities in Northwest Territories are downstream of oilsands production in Alberta (McCreadie, 2014). There are broad calls for continued work to understand these impacts and the ways that they are compounded by climate change, and to carefully examine the costs and benefits of development on community health and social resilience (Assembly of First Nations, 2019; Inuit Tapiriit Kanatami 2019a). In recognition of the urgency of work to address Arctic health and well-being in the face of climate change impacts, the Lancet medical journal has convened the Lancet Commission on Arctic Health (Adams et al., 2019). Findings from the Lancet Commission are expected in 2022.

6.7.4 Need for responsive decision making and co-governance

There are growing calls for cautious and careful exploration of the costs and benefits related to emerging opportunities and their potential impacts on northern societies and cultures. Citizen science is evolving as an approach to advancing collaborative approaches to climate change adaptation, and co-management boards are proving themselves to be effective in responsive, collaborative decision making (*see* Section 6.5.2). However, northern development is testing the capacity of co-management boards and communities, while the ability to channel Indigenous Knowledge, environmental monitoring and environmental change information to those boards for integration into management decisions is becoming increasingly important in the pursuit of equity among the rights-holders involved in decision making (Arngna'naaq et al., 2020). Continued work is warranted to ensure that Indigenous Knowledge and Western knowledge are both drawn upon to inform responsive co-management decisions, and pathways to ensure that this happens effectively must be developed, tested, implemented and shared across the North. In addition, climate change impacts cannot be viewed in isolation from other stressors, but there is no trusted body with a mandate to review, understand, and recommend actions to address cumulative impacts. Efforts to understand cumulative impacts can become polarizing when they do not fit well within existing planning or environmental review processes (*see* Section 6.5.2; Blakley and Franks, 2021).

Meanwhile, new northern leadership in research is shifting and refocusing the research questions that are being posed and investigated; this in turn is creating opportunities for new forms of collaborative research, including Indigenous-led research following Indigenous research methodologies. Establishing greater connections between research and action, improving research coordination within and outside of Canada's North, and engaging diverse stakeholders and rights-holders in identifying solutions for addressing fundamental issues of community resilience and adaptation are all pressing issues in northern Canada.

6.7.5 Recognition of Indigenous Knowledge and inherent capacity

With an increasing reliance on co-management boards and decision-making tables, there is increasing need to value both Indigenous Knowledge and knowledge from land users in informing responsive co-management practices. Future adaptation initiatives will continue to be enhanced through co-learning, cooperation and the implementation of co-management recommendations and decisions (Abram et al., 2019).

There are growing calls to stop seeking "validation" of Indigenous Knowledge using Western science approaches, but rather to recognize Indigenous Knowledge as a distinct and equally valued knowledge system. Northerners are expressing concerns about adequate recognition of Indigenous Knowledge in evidence-based policy making and decision making, and are voicing a continued call for the inclusion of Indigenous Knowledge holders and other Northerners in national policy dialogues. There is a desire to see the inherent capacity present in Northerners, especially Indigenous Northerners, as a key tool in climate change adaptation and sustained northern resilience (Copper Jack et al., 2020).

6.7.6 Understanding the limits of adaptation

While most of the adaptation and resilience work in the North is carried out with the goal of maintaining and improving quality of life, the magnitude, spatial extent and pace of change will create conditions where, in some cases, there are no economically or socially viable adaptation solutions. This is particularly true under a high emissions future (RCP 8.5; IPCC, 2019). Even in cases where a technological solution such as reinforcement of infrastructure may provide protection, the spatial extent of the impacts, coupled with the small population and limited scale of economic activity in the North, limit the likelihood that such a solution could be implemented (Council of Yukon First Nations and Assembly of First Nations, 2019, Inuit Tapiriit

Kanatami, 2019a). In addition, cultural connections to place are very strong in most Northern communities; this means that a solution considered appropriate in other locations, like relocation following a climate-related disaster, may be unacceptable in a Northern context.

Even in places where drastic action such as relocation is being undertaken (Moses, 2018), Northern conversations of the “acceptability of policy or system change” (IPCC, 2018) are deeply intertwined with the issues of reconciliation and equity, and the resolution of social justice issues. Exploring the acceptability of topics such as planned relocation requires time, empathetic dialogue, and a commitment to respectful exploration of many options before decisions are finalized (Arngna'naaq et al., 2020; Inuit Tapiriit Kanatami 2018). There is no “step by step” approach for how to advance consideration of topics that society considers unacceptable now. Despite a growing need for sensitive but realistic exploration of the limits to which maintaining and improving current practice is sustainable, past practices by researchers and governments can act as a barrier to taking urgent action. Many Indigenous leaders and organizations are providing guidance that can help facilitate reconciliation and support collaborative work to initiate what promise to be important but very challenging conversations (e.g., Wong et al., 2020, Inuit Tapiriit Kanatami, 2019a, McGregor, 2018).

6.8 Conclusion

The 2019 report of an expert panel convened by the Council of Canadian Academies recognized climate risks to northern communities, as well as risks to Indigenous ways of life, as among the top climate risks facing Canada. The panel recognized “the centrality of Arctic issues and sovereignty to national and international affairs, [elevating] the risks to Arctic areas to the national level” (Council of Canadian Academies, 2019). Addressing climate change risks and impacts through adaptation is important to more than just the northern communities themselves. Northern leadership and innovation will help to maintain resilience, while also serving the interests of Canada’s Arctic sovereignty and identity. Successful adaptation in the North will help Canada demonstrate leadership among Arctic nations.

As recognition of the broad significance of adaptation to climate change in northern Canada is growing across the country, the conversation around northern adaptation is shifting from a focus on biophysical impacts to one that examines complex issues such as mental health, socioeconomic equity and the inherent right to practice traditional ways of life. Climate change impacts are felt in almost every aspect of northern environments and populations, and often amplify existing socioeconomic issues present in Canada’s North. While there is an absence of economic analysis on the direct and indirect costs of climate change impacts and adaptation in the region, it is clear that costs will be substantial and cannot be borne by Northerners alone. Questions around who will bear those costs, and how, remain.

While adaptation actions like those profiled in this chapter are underway across Canada’s North, and are in many cases being led by northern governments and communities, there is a growing sense that the rate of change in northern Canada is outpacing the capacity to adapt. Permanent changes to parts of the northern environment are either occurring or expected to occur, and these have irreversible impacts on the generations-long ability of people to support themselves from the land, and ways that people interact with the land, and practice traditional and chosen ways of life. The Indigenous Peoples of the North have already endured over a century of cultural disruption and will not simply abandon traditional practices and values. While climate change impacts reach beyond many previously experienced conditions, trust in traditional teachings is providing sources of resilience that are not well represented in Western knowledge systems.

In much of the discourse about adaptation in Canada, there is an expression of the urgent need to act and not to allow insufficient data or uncertainty regarding the nature or magnitude of impacts to delay that action. However, there is an absence in this discourse about the limits of adaptation and a lack of recognition of how to identify situations in which it may not be possible to adapt. Permanent change to the migration pattern of a species that has been relied upon for millennia, or continued infrastructure damage to a community caused by permafrost thaw may not be solvable through adaptation action—instead, a new way of being in the absence of that traditional food or a relocation of key community infrastructure may be warranted. In the discourse about climate change impacts in northern Canada, the limits of adaptation are often neglected, as is the timing of when to begin exploring the need for a new way of being. It is time for these conversations to begin.

References

Abram, N., Gattuso, J.-P., Prakash, A., Cheng, L., Chidichimo, M.P., Crate, S., Enomoto, S., Garschagen, M., Gruber, N., Harper, S., Holland, E., Kudela, R.M., Rice, J., Steffen, K. and von Schuckmann, K. (2019). Framing and Context of the Report, Chapter 1 *in* IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N.M. Weyer. Cambridge University Press, Cambridge, United Kingdom and New York, New York, United States. Retrieved May 2022, from <https://www.ipcc.ch/site/assets/uploads/sites/3/2022/03/03_SROCC_Ch01_FINAL.pdf>

Adams, L., Dorough, D.S., Chatwood, S., Erasmus, B., Eriksen, H., Ford, S., Sosin, A., Virginia, R.A., and Cloutier, S.W. (2019). Shared Vision. The Lancet Commission on Arctic Health Urgently Accelerating Indigenous Health and Well-Being. Retrieved January 2022, from <https://sites.google.com/dartmouth.edu/lancetarctic/shared-vision-statement>

Alcantara, C., Cameron, K., and Kennedy, S. (2012). Assessing Devolution in the Canadian North: A Case Study of the Yukon Territory. *Arctic*, *65*(3), 328–338. Retrieved January 2022, from <https://doi.org/10.14430/arctic4220>

Arctic Development and Adaptation to Permafrost in Transition (ADAPT) (n.d.). Homepage. Retrieved June 2021, from <http://www.cen.ulaval.ca/adapt/index.php>

Arngna'naaq, K., Bourassa. H., Couturier, D., Kaluraq, K., and Panchyshyn, K. (2020). Realizing Indigenous Law in Co-Management. Jane Glassco Northern Fellowship. Retrieved January 2022, from <https://gordonfoundation.ca/wp-content/uploads/2020/04/JGNF_2018-2019_Realizing-Indigenous-Law-in-Co-Management.pdf>

Alam, H. (2018). Indigenous communities see effects of climate change up close, conference told. Edmonton Journal. Retrieved June 2021, from <https://edmontonjournal.com/news/local-news/indigenous-communities-see-effects-of-climate-change-up-close-conference-told>

Albrecht, G. (2012). Psychoterratic conditions in a scientific and technological world, *in* Ecopsychology: Science, Totems, and the Technological Species, (Eds.) P. H. Kahn and P. H. Hasbach. The MIT Press, Cambridge, Massachusetts, United States, 241–264. Retrieved June 2021, from <https://researchrepository.murdoch.edu.au/id/eprint/36235/>

Allard, M. and L'Hérault, E. (2010). *L'impact des changements climatiques sur la problématique de la fonte du pergélisol au village de Salluit. Rapport d'étape: Cartographie du potentiel de construction de la vallée de Salluit selon les conditions de pergélisol et les pentes.* Report to the ministère des Affaires municipales, des Régions et de l'Occupation du territoire (MAMROT), Centre d'études Nordiques, 25 p.

Allard, M., Chiasson, A., B. St-Amour, A., Mathon-Dufour, V., Aubé-Michaud, S., L'Hérault, E., Bilodeau, S. and Deslauriers, C. (2020). Geotechnical characterization and permafrost mapping project in the Inuit communities of Nunavik. Final report. Québec, Centre d'études nordiques, Université Laval. Retrieved May 2022, from <https://bit.ly/CEN_MAMH_Caracterisation_pergelisol_Nunavik>

Anderson, W. (2018). Personal communication with Winston (Barry) Anderson, resident of Makkovik, Nunatsiavut who serves in search and rescue operations.

Andrey, J., Kertland, P. and Warren, F.J. (2014). Water and Transportation Infrastructure, chapter 8 *in* Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation; (Eds.) F.J. Warren and D.S. Lemmen, government of Canada, Ottawa, ON, 233–252. Retrieved May 2022, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2014/pdf/Chapter8-Infrastructure_Eng.pdf>

Anisimov, O. (2007). Potential feedback of thawing permafrost to the global climate system through methane emission. *Environmental Research Letters*, *2*, 045016. Retrieved June 2021, from <https://doi.org/10.1088/1748-9326/2/4/045016>

Aporta, C. (2011). Shifting perspectives on shifting ice: Documenting and representing Inuit use of the sea ice. *The Canadian Geographer, 55*(1), 6–19. Retrieved June 2021, from <https://doi.org/10.1111/j.1541-0064.2010.00340.x>

Araral, E., Pelizzo, R., Burkhanov, A., Chen, Y., Janenova, S. and Collins, N. (2015). Capacity and Autonomy: An Exploration of Fukuyama's Governance Hypothesis, Part IV *in* Varieties of Governance - Studies in the Political Economy of Public Policy, (Eds.) G. Capano, M. Howlett, and M. Ramesh. Palgrave Macmillan, London, 173–193. Retrieved June 2021, from <https://doi.org/10.1057/9781137477972_8>

Arctic Council (2009). Arctic Marine Shipping Assessment 2009 Report. Protection of the Arctic Marine Environment. Retrieved May 2022, from <https://oaarchive.arctic-council.org/bitstream/handle/11374/54/AMSA_2009_Report_2nd_print.pdf?sequence=1&isAllowed=y>

Arctic Council Secretariat (2022). Powered by Nature: The Old Crow Solar Project. Retrieved March 2022, from <https://arctic-council.org/news/the-old-crow-solar-project/>

Arctic Energy Alliance (2020). 2018-19 Annual Report. Retrieved June 2021, from <https://aea.nt.ca/news/2018-19-annual-report/>

Arctic Monitoring and Assessment Programme (2008). Arctic Oil and Gas 2007. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. Retrieved May 2022, from <https://www.amap.no/documents/download/1017/inline>

Arctic Monitoring and Assessment Programme (2010). AMAP Assessment 2009: Radioactivity in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. Retrieved May 2022, from <https://www.amap.no/documents/download/1164/inline>

Arctic Monitoring and Assessment Programme (2017). Snow, Water, Ice and Permafrost in the Arctic Summary for Policy-makers. Arctic Monitoring and Assessment Programme (AMAP), Oslo Norway, 20 p. Retrieved May 2022, from <https://www.amap.no/documents/download/2888/inline>

Arctic Eider Society (2019). SIKU: The Indigenous Knowledge Social Network. Retrieved April 2022, from <https://siku.org/#/press-kit>

Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E. and Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change*, *21*(3), 995–1004. Retrieved June 2021, from <https://doi.org/10.1016/j.gloenvcha.2011.04.006>

Anselmi, E. (2019). New VHF radio system connects Puvirnituq hunters; Communications system allows accessible alternative to HF radio. Nunatsiaq News. Retrieved June 2021, from <https://nunatsiaq.com/stories/article/new-vhf-radio-system-connects-puvirnituq-hunters/>

Assembly of First Nations (2019). Declaring a First Nations Climate Emergency. Assembly of First Nations Annual General Assembly. Resolution 05/2019, Fredericton, New Brunswick. Retrieved January, 2022 from <https://www.afn.ca/wp-content/uploads/2019/08/19-05-Declaring-a-First-Nations-Climate-Emergency.pdf>

Associated Engineering (2018). Functional Plan for the Dempster Highway considers changing climate to protect this critical transportation link. Retrieved June 2021, from <https://www.ae.ca/ae-today/latest-updates/details/blog/2018/10/28/functional-plan-for-the-dempster-highway-considers-changing-climate-to-protect-this-critical-transportation-link>

Ayers, J. and Forsyth, T. (2009). Community-Based Adaptation to Climate Change. *Environment: Science and Policy for Sustainable Development*, *51*(4), 22–31. Retrieved June 2021, from <https://doi.org/10.3200/ENV.51.4.22-31>

Babaluk, J. A., Reist, J. D., Johnson, J. D. and Johnson, L. (2000). First records of sockeye (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha*) from Banks Island and other records of Pacific salmon in Northwest Territories, Canada. *Arctic*, *53*(2), 161–164. Retrieved February 2022, from <https://doi.org/10.14430/arctic846>

Baltzer, J.L, Day, N.J., Walker, X.J., Greene, D., Mack, M.C., Alexander, H.D., Arseneault, D.,Barnes, J., Bergeron, Y., Boucher, Y., Bourgeau-Chavez, L., Brown, C.D., Carrière, S., Howard, B.H., Gauthier, S., Parisien, M-A., Reid, K.A., Rogers, B.M., Roland, C., Sirois, L., Stehn, S., Thompson, D.K., Turetsky, M.R., Veraverbeke, S., Whitman, E., Yang, J. and Johnstone, J.F. (2021). Increasing fire and the decline of fire adapted black spruce in the boreal forest. *Proceedings of the National Academy of Sciences*, *118*(45), e2024872118. Retrieved February 2022, from <https://doi.org/10.1073/pnas.2024872118>

Barboza, P. S., Van Someren, L. L., Gustine, D. D. and Bret-Harte, M. S. (2018). The nitrogen window for arctic herbivores: Plant phenology and protein gain of migratory caribou (*Rangifer tarandus*). *Ecosphere*, *9*(1), e02073. Retrieved June 2021, from <https://doi.org/10.1002/ecs2.2073>

Beaufort Sea Partnership (2009). Integrated Ocean Management Plan (IOMP) for the Beaufort Sea: 2009 and beyond. Beaufort Sea Planning Office, Inuvik, Northwest Territories. Retrieved May 2022, from <http://www.beaufortseapartnership.ca/wp-content/uploads/2015/04/integrated-ocean-management-plan-for-the-beaufort-sea-2009-and-beyond.pdf>

Bell, T., Briggs, R., Bachmayer, R. and Li, S. (2014). Augmenting Inuit knowledge for safe sea-ice travel—The SmartICE information system. 2014 Oceans - St. John's, St. John's, Newfoundland, 1–9. Retrieved June 2021, from <https://doi.org/10.1109/OCEANS.2014.7003290>

Bell, T. and Brown, T.M. (2018). From Science to Policy in the Eastern Canadian Arctic: An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization: Synthesis and Recommendations. ArcticNet, Québec City, 48 p.

Beltaos, S. and Doyle, P. (1996). Ice Jam Mitigation Using Setback Dykes: Coldwater River at Merritt, B.C. *Journal of Cold Regions Engineering: 10*:4.
Retrieved June 2021, from <https://doi.org/10.1061/(ASCE)0887-381X(1996)10:4(190)>

Beltaos, S. (2008). Progress in the study and management of river ice jams. *Cold Regions Science and Technology*, *51*(1), 2–19. Retrieved June 2021, from <https://doi.org/10.1016/j.coldregions.2007.09.001>

Beltaos, S. (2019). Numerical prediction of ice-jam profiles in lower Athabasca River. *Canadian Journal of Civil Engineering*, *46*(8), 722–731. Retrieved June 2021, from <https://doi.org/10.1139/cjce-2018-0542>

Berger, T. R. (1976). The Mackenzie Valley Pipeline Inquiry. Queen's Law Journal (LJ), 3, 3.

Bergeron, M., and Tremblay, J.-É. (2014). Shifts in biological productivity inferred from nutrient drawdown in the southern Beaufort Sea (2003–2011) and northern Baffin Bay (1997–2011), Canadian Arctic. *Geophysical Research Letters*. 41: 3979–3987. Retrieved February 2022, from <https://doi.org/10.1002/2014GL059649>

Berkes, F. and Jolly, D. (2001). Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology, 5*(2), 18. Retrieved February 2022, from <https://doi.org/10.5751/ES-00342-050218>

Berkes, F., Berkes, M. K. and Fast, H. (2007). Collaborative Integrated Management in Canada's North: The Role of Local and Traditional Knowledge and Community-Based Monitoring. *Coastal Management*, *35*(1), 143–162. Retrieved June 2021, from <https://doi.org/10.1080/08920750600970487>

Berry, P., Kaila-Lea, C., Fleury, M. D. and Parker, S. (2014). Human Health, Chapter 7 *in* Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, (Eds.) F.J. Warren and D.S. Lemmen. Government of Canada, Ottawa, Ontario, 191–232. Retrieved May 2022, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2014/pdf/Chapter7-Human-Health_Eng.pdf>

Bhatia, M.P., Waterman, S., Burgess, D.O., Williams, P.L., Bundy, R.M., Mellett, T., Roberts, M., and Bertrand, E.M. 2021. Glaciers and Nutrients in the Canadian Arctic Archipelago Marine System. *Global Biogeochemical Cycles, 35*, 8. Retrieved May 2022, from <https://doi.org/10.1029/2021GB006976>

Bizikova, L., Robinson, J. and Cohen, S. (2007). Linking climate change and sustainable development at the local level. *Climate Policy*, *7*(4), 271–277. Retrieved June 2021, from <https://doi.org/10.1080/14693062.2007.9685655>

Bizikova, L., Neale, T. and Burton, I. (2008). Canadian Communities' Guidebook for Adaptation to Climate Change. Including an approach to generate mitigation co-benefits in the context of sustainable development. First Edition. Environment Canada and University of British Columbia, Vancouver, British Columbia. Retrieved May 2022, from <https://publications.gc.ca/collections/collection_2017/eccc/En56-226-2008-eng.pdf>

Blais, M., Ardyna, M., Gosselin, M., Dumont, D., Bélanger, S., Tremblay, J.-É., Gratton, Y., Marchese, C., and Poulin, M. (2017). Contrasting interannual changes in phytoplankton productivity and community structure in the coastal Canadian Arctic Ocean. *Limnology and Oceanography, 62*: 2480–2497. Retrieved February 2022, from <https://doi.org/10.1002/lno.10581>

Blakley, J.E., Franks, D. M. (Eds.) (2021). Handbook of Cumulative Impact Assessment. Cheltenham, UK: Edward Elgar Publishing. Retrieved April 2022, from <https://doi.org/10.4337/9781783474028>

Blakley, J., Noble, B., Vella, K., Marty, J., Nwanekezie, K., and Fedoroff, K. (2020). Lessons Learned, Best Practices and Critical Gaps in Regional Environmental Assessment: A Synthesis of Canadian and International Literature. Prepared for the Social Sciences and Humanities Research Council of Canada and the Impact Assessment Agency of Canada, University of Saskatchewan. Retrieved October 2020, from <https://research-groups.usask.ca/blakley/current-projects/regional-assessment.php>

Bliss, A., Hock, R. and Radić, V. (2014). Global response of glacier runoff to twenty-first century climate change. *Journal of Geophysical Research: Earth Surface, 119*(4), 717–730. Retrieved February 2022, from <https://doi.org/10.1002/2013JF002931>

Bonnaventure, P.P., Lewkowicz, A.G., Kremer, M. and Sawada, M.C. (2012). A Permafrost Probability Model for the Southern Yukon and Northern British Columbia, Canada. *Permafrost and Periglacial Processes*, *23*(1), 52–68. Retrieved June 2021, from <https://doi.org/10.1002/ppp.1733>

Bonney, M.T., Danby, R.K. and Treitz, P.M. (2018). Landscape variability of vegetation change across the forest to tundra transition of central Canada. *Remote Sensing of Environment*, *217*, 18–29. Retrieved June 2021, from <https://doi.org/10.1016/j.rse.2018.08.002>

Brown, N., Gruber, S., Pulsifer, P. and Stewart-Jones, E. (2020) Permafrost Data Workshop 2020: Final Report. NSERC PermafrostNet, Natural Sciences and Engineering Research Council of Canada (NSERC), Ottawa, Canada. Retrieved April 2022, from <doi.org/10.22215/pn/10120001>

Bunce, A., Ford, J., Harper, S., Edge, V. and IHACC Research Team (2016). Vulnerability and adaptive capacity of Inuit women to climate change: A case study from Iqaluit, Nunavut. *Natural Hazards*, *83*(3), 1419–1441. Retrieved June 2021, from <https://doi.org/10.1007/s11069-016-2398-6>

Bureau de normalisation du Québec (2017). Geotechnical Site Investigations for Building Foundations in Permafrost Zones. National Standard of Canada, CAN/BNQ 2501–500, 15, 83. Retrieved April 2022, from <https://www.bnq.qc.ca/fr/normalisation/genie-civil-et-infrastructures-urbaines/etudes-geotechniques-pour-les-fondations-de-batiments-construites-dans-les-zones-de-pergelisol.html>

Burn, D. H., Whitfield, P. H. and Sharif, M. (2016). Identification of changes in floods and flood regimes in Canada using a peaks over threshold approach. *Hydrological Processes*, *30*(18), 3303–3314. Retrieved June 2021, from <https://doi.org/10.1002/hyp.10861>

Burns, B. M., Richardson, F. A. and Hall, C. N. H. (1975). A Nordicity Index. *The Musk Ox*, *17*, 41.

Burrell, B. C., Huokuna, M., Beltaos, S., Kovachis, N., Turcotte, B. and Jasek, M. (2015). Flood Hazard and Risk Delineation of Ice-Related Floods: Present Status and Outlook. CGU HS Committee on River Ice Processes and the Environment. Retrieved June 2021, from <https://www.researchgate.net/profile/Spyros_Beltaos/publication/308688387_Flood_Hazard_and_Risk_Delineation_of_Ice-Related_Floods_Present_Status_and_Outlook/links/57eae42a08ae5d93a4815aff.pdf>

Bush, E. and Lemmen, D. S. (Eds.) (2019). Canada's Changing Climate Report. Government of Canada; Government of Canada, Ottawa, Ontario, 444 p. Retrieved February 2022, from <https://changingclimate.ca/CCCR2019/>

Buttle, J. M., Allen, D. M., Caissie, D., Davison, B., Hayashi, M., Peters, D. L., Pomeroy, J. W., Simonovic, S., St-Hilaire, A. and Whitfield, P. H. (2016). Flood processes in Canada: Regional and special aspects. *Canadian Water Resources Journal*, *41*(1–2), 7–30. Retrieved June 2021, from <https://doi.org/10.1080/07011784.2015.1131629>

Caine, K. and Krogman, N. (2010). Powerful or Just Plain Power-Full? A Power Analysis of Impact and Benefit Agreements in Canada's North. *Organization and Environment*, *23*, 76–98. Retrieved June 2021, from <https://doi.org/10.1177/1086026609358969>

Calmels, F., Laurent, C., Brown, R., Pivot, F. and Ireland, M. (2015). How Permafrost Thaw May Impact Food Security of Jean Marie River First Nation, NWT. 7th Canadian Permafrost Conference, Québec, Quebec, Canada. Retrieved May 2022, from <https://www.researchgate.net/publication/282328455_How_Permafrost_Thaw_May_Impact_Food_Security_of_Jean_Marie_River_First_Nation_NWT>

Calmels, F., Horton, B., Roy, L., Lipovsky, P. and Benkert, B. (2016). Assessment of Risk to Infrastructure from Permafrost Degradation and a Changing Climate, Ross River. Northern Climate Exchange, Yukon Research Centre. Yukon College. Retrieved May 2022, from <https://emrlibrary.gov.yk.ca/ebooks/Northern%20Research%20Institute/assessment-risk-infrastructure.pdf>

Calmels, F., Roy, L.P., Grandmont, K. and Pugh, R. (2018). A summary of climate- and geohazard-related vulnerabilities for the Dempster Highway corridor. Yukon Research Centre, Yukon College, 204 p.

Cameron, E. S. (2012). Securing Indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. *Global Environmental Change, 22*(1), 103–114. Retrieved February 2022, from <https://doi.org/10.1016/j.gloenvcha.2011.11.004>

Cameron, P., Mitra, B., Fitzgerald, M., Scheinkestel, C., Stripp, A., Batey, C., Niggemeyer, L., Truesdale, M., Holman, P., Mehra, R., Wasiak, J. and Cleland, H. (2009). Black Saturday: The immediate impact of the February 2009 bushfires in Victoria, Australia. *The Medical Journal of Australia*, *191*, 11–16. Retrieved June 2021, from <https://doi.org/10.5694/j.1326-5377.2009.tb02666.x>

Canada Energy Regulator (2019). Canada's Energy Future 2019: Energy Supply and Demand Projections to 2040. Government of Canada. Retrieved July 2022, from <https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/archive/2019/2019nrgftr-eng.pdf>

Canadian Mountain Network Yukon Initiating Group (2017). Canadian Mountain Network Discussion Paper V20170628. Retrieved June 2021, from <http://www.eco.gov.yk.ca/pdf/Yukon_CMN-IG_2017-06-28.pdf>

Canadian Standards Association [CSA] Group (2019). Technical Guide: Infrastructure in permafrost: A guideline for climate change adaptation. CSA PLUS 4011:19.

Careen, E. (2019). New weather stations set up on Labrador coast. The Telegram. Retrieved June 2021, from <https://www.thetelegram.com/news/provincial/new-weather-stations-set-up-on-labrador-coast-349003/>

Carpino, O., Berg, A., Quinton, W. and Adams, J. (2018). Climate change and permafrost thaw-induced boreal forest loss in northwestern Canada. *Environmental Research Letters*, *13*(8). Retrieved June 2021, from <https://doi.org/10.1088/1748-9326/aad74e>

Centre for Indigenous Peoples' Nutrition and Environment, McGill (n.d). Inuit Health Survey 2007–2008. Retrieved June 2021, from <https://www.mcgill.ca/cine/resources/ihs>

Chapin, F. S., Callaghan, T. V., Bergeron, Y., Fukuda, M., Johnstone, J. F., Juday, G., and Zimov, S. A. (2004). Global Change and the Boreal Forest: Thresholds, Shifting States or Gradual Change? *AMBIO: A Journal of the Human Environment*, *33*(6), 361–365. Retrieved February 2022, from <https://doi.org/10.1579/0044-7447-33.6.361>

Chapin, F. S., Lovecraft, A. L., Zavaleta, E. S., Nelson, J., Robards, M. D., Kofinas, G. P., Trainor, S. F., Peterson, G. D., Huntington, H. P. and Naylor, R. L. (2006). Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. *Proceedings of the National Academy of Sciences*, *103*(45), 16637–16643. Retrieved June 2021, from <https://doi.org/10.1073/pnas.0606955103>

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., Olsson, P., Smith, D. M. S., Walker, B., Young, O. R., Berkes, F., Biggs, R., Grove, J. M., Naylor, R. L., Pinkerton, E., Steffen, W. and Swanson, F. J. (2010). Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution*, *25*(4), 241–249. Retrieved June 2021, from <https://doi.org/10.1016/j.tree.2009.10.008>

Chen, I.-C., Hill, J. K., Ohlemüller, R., Roy, D. B. and Thomas, C. D. (2011). Rapid Range Shifts of Species Associated with High Levels of Climate Warming. *Science*, *333*(6045), 1024. Retrieved June 2021, from <https://doi.org/10.1126/science.1206432>

Choy, E.S., Campbell, K.L., Berenbrink, M., Roth, J.D. and Loseto, L.L. (2019). Body condition impacts blood and muscle oxygen storage capacity of free-living beluga whales (*Delphinapterus leucas*). *Journal of Experimental Biology*, 222(11). Retrieved February 2022, from <https://doi.org/10.1242/jeb.191916>

Choy, E.S., Giraldo, C., Rosenberg, B., Roth, J.D., Ehrman, A.D., Majewski, A., Swanson, H., Power, M., Reist, J.D. and Loseto, L.L. (2020). Variation in the diet of beluga whales in response to changes in prey availability: insights on changes in the Beaufort Sea ecosystem. *Marine Ecology Progress Series*, 647, 195–210. Retrieved February 2022, from <https://doi.org/10.3354/meps13413>

Christianson, A. (2015). Social science research on Indigenous wildfire management in the 21st century and future research needs. *International Journal of Wildland Fire, 24,* 190–200. Retrieved June 2021, from <http://dx.doi.org/10.1071/WF13048>

Christensen, T., Lasserre, F., Dawson, J., Guy, E., and Pelletier, J-F. (2018). Shipping, Chapter 9 *in* Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, 243–260. Retrieved May 2022, from <https://www.amap.no/documents/download/3015/inline>

Clarke, G.K., Jarosch, A.H., Anslow, F.S., Radić, V. and Menounos, B., (2015). Projected deglaciation of western Canada in the twenty-first century. *Nature Geoscience*, 8(5), 372 p. Retrieved February 2022, from <https://doi.org/10.1038/ngeo2407>

Clark, D.A., Meek, C., Cheechoo, J., Clark, S., Lee Foote, A., Lee, D. and York, G. (2013). Polar bears and CITES: A rejoinder to Parsons and Cornick. *Marine Policy*, *38*, 365–368. Retrieved June 2021, from <https://doi.org/10.1016/j.marpol.2012.06.014>

Clark, D.G., Ford, J.D., Berrang-Ford, L., Pearce, T., Kowal, S. and Gough, W.A. (2016a). The role of environmental factors in search and rescue incidents in Nunavut, Canada. *Public Health*, *137*, 44–49. Retrieved June 2021, from <https://doi.org/10.1016/j.puhe.2016.06.003>

Clark, D. G., Ford, J.D., Pearce, T. and Berrang-Ford, L. (2016b). Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada. *Social Science & Medicine*, 169.18–26. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2016.09.026>

Clark, D. and Joe-Strack, J. (2017) Keeping the "co" in co-management of Northern resources. *Northern Public Affairs*, 5(1), 71–74.

Clark, D. G., Coffman, D., Ness, R., Bujold, I. and Beugin, D. (2022). Due North: Facing the costs of climate change for Northern infrastructure. Canadian Climate Institute. Ottawa, ON. Retrieved January, 2022 from <https://climatechoices.ca/wp-content/uploads/2021/09/Infrastructure-English-FINALSep29.pdf>

Clayton, S., Manning, C. M., Krygsman, K. and Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. American Psychological Association and ecoAmerica. Retrieved May 2022, from <https://www.apa.org/news/press/releases/2017/03/mental-health-climate.pdf>

Coates, K.S. and Broderstad, E.G. (2020) Indigenous Peoples of the Arctic: Re-taking Control of the Far North, *in* Coates K., Holroyd C. (Eds.) The Palgrave Handbook of Arctic Policy and Politics. Palgrave Macmillan, Cham. Retrieved January 2022, from <https://doi.org/10.1007/978-3-030-20557-7_2>

Coates, K. (2020). Reflections on the Evolution of Legal Systems in the Canadian North. *Northern Review*, *50*, 235–244. Retrieved April, 2022, from <https://doi.org/10.22584/nr50.2020.012>

Cohen, J., Ye, H. and Jones, J. (2015). Trends and variability in rain-on-snow events. *Geophysical Research Letters*, *42*(17), 7115–7122. Retrieved June 2021, from <https://doi.org/10.1002/2015GL065320>

Copper Jack, J., Gonet, J., Mease, A. and Nowak, K. (2020). Traditional Knowledge underlies One Health. *Science*, *369*(6511), 1576. Retrieved June 2021, from <https://doi.org/10.1126/science.abe2401>

Coogan, S.C.P., Daniels, L.D., Boychuk, D., Burton, P.J., Flannigan, M.D., Gauthier, S., Kafka, V., Park, J.S., and Wotton. B.M. (2020): Fifty years of wildland fire science in Canada. *Canadian Journal of Forest Research*. *51*(2): 283–302. Retrieved May 2022, from <https://doi.org/10.1139/cjfr-2020-0314>

Coogan, S.C.P., Robinne, F.-N., Jain, P. and Flannigan, M.D. (2019). Scientists' warning on wildfire—a Canadian perspective. *Canadian Journal of Forestry Research, 49,* 1015. Retrieved June 2021, from <http://dx.doi.org/10.1139/cjfr-2019-0094>

Coulthard, G. and Simpson, L. (2016). Grounded Normativity / Place-Based Solidarity. *American Quarterly*, *68*, 249–255. Retrieved June 2021, from <https://doi.org/10.1353/aq.2016.0038>

Council of Canadian Academies (2019). Canada's Top Climate Change Risks. The Expert Panel on Climate Change Risks and Adaptation Potential, Ottawa, Ontario. Retrieved May 2022, from <https://cca-reports.ca/wp-content/uploads/2019/07/Report-Canada-top-climate-change-risks.pdf>

Council of Yukon First Nations and Assembly of First Nations (2019). Yukon First Nations Climate Emergency Declaration. Whitehorse, Yukon.

Couture, N. J., Irrgang, A., Pollard, W., Lantuit, H., and Fritz, M. (2018). Coastal erosion of permafrost soils along the Yukon Coastal Plain and fluxes of organic carbon to the Canadian Beaufort Sea. *Journal of Geophysical Research: Biogeosciences*, *123*, 406–422. Retrieved February 2022, from <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JG004166>

Cox, S., Hvistendal, C., Sullivan, G., Henderson, C., Stewart, E., Van Tassel, B., Hermansen, S. and Poelzer, G. (2019). Arctic Sustainable Energy Futures: The Arctic Community Energy Planning and Implementations (ACEPI) Toolkit. Arctic Council and the Sustainable Development Working Group. Retrieved June 2021, from <http://hdl.handle.net/11374/2301>

Creed, I.F., Bergström, A.K., Trick, C.G., Grimm, N.B., Hessen, D.O., Karlsson, J., Kidd, K.A., Kritzberg, E., McKnight, D.M., Freeman, E.C., Senar, O.E., Andersson, A., Ask, J., Berggren, M., Cherif, M., Giesler, R., Hotchkiss, E.R., Kortelainen, P., Palta, M.M., Vrede, T. and Weyhenmeyer, G.A. (2018). Global change-driven effects on dissolved organic matter composition: Implications for food webs of northern lakes. *Global Change Biology, 24*: 3692–3714. Retrieved February 2022, from <https://doi.org/10.1111/gcb.14129>

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). (2019). Canada's Arctic and Northern Policy Framework. Government of Canada. Retrieved June 2021, from <https://www.rcaanc-cirnac.gc.ca/eng/1560523306861/1560523330587>

Cruikshank J. (2007) Do Glaciers Listen? Local knowledge, colonial encounters, and social imagination. UBC Press; 2007, 328 p.

Cuerrier, A., Brunet, N. D., Gérin-Lajoie, J., Downing, A. and Lévesque, E. (2015). The study of Inuit knowledge of climate change in Nunavik, Quebec: a mixed methods approach. *Human ecology, 43*(3), 379–394. Retrieved February 2022, from <https://doi.org/10.1007/s10745-015-9750-4>

Cuerrier and the Elders of Kangiqsualujjuaq (2012). The Zoological Knowledge of the Inuit of Kangiqsualujjuaq, Nunavik. Avataq Cultural Institute, 132 p.

Cunsolo, A. (2012). Climate Change as the Work of Mourning. *Ethics and the Environment*, *17*, 137–164. Retrieved June 2021, from <https://doi.org/10.2979/ethicsenviro.17.2.137>

Cunsolo, A. and Ellis, N. R. (2018). Ecological grief as a mental health response to climate change-related loss. *Nature Climate Change*, *8*(4), 275–281. Retrieved June 2021, from <https://doi.org/10.1038/s41558-018-0092-2>

Cunsolo, A., Harper, S.L., Minor, K., Hayes, K., Williams, K. and Howard, C. (2020). Ecological Grief and Anxiety: The Start of a Healthy Response to Climate Change? [Commentary]. *Lancet Planetary Health, 4*(7), e261. Retrieved June 2021, from <https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(20)30144-3.pdf>

Cunsolo Willox, A., Harper, S.L., Ford, J.D., Landman, K., Houle, K., Edge, V.L., and the Rigolet Inuit Community Government (2012). From this place and of this place: Climate change, sense of place, and health in Nunatsiavut, Canada. Social Science & Medicine *75*(3), 538–547. Retrieved February 2022, from <https://doi.org/10.1016/j.socscimed.2012.03.043>

Cunsolo Willox, A., Harper, S. L., Ford, J. D., Landman, K., Houle, K. and Edge, V. L. (2012). "From this place and of this place:" Climate change, sense of place, and health in Nunatsiavut, Canada. *Social Science and Medicine*, *75*(3), 538–547. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2012.03.043>

Cunsolo Willox, A., Harper, S.L., Edge, V.L., Landman, K., Houle, K. and Ford, J.D. (2013a). The land enriches the soul: On climatic and environmental change, affect, and emotional health and well-being in Rigolet, Nunatsiavut, Canada. *Emotion and Ecology*, *6*, 14–24. Retrieved June 2021, from <https://doi.org/10.1016/j.emospa.2011.08.005>

Cunsolo Willox, A., Harper, S.L., Ford, J.D., Edge, V.L., Landman, K., Houle, K., Blake, S. and Wolfrey, C. (2013b). Climate change and mental health: An exploratory case study from Rigolet, Nunatsiavut, Canada. *Climatic Change*, *121*(2), 255–270. Retrieved June 2021, from <https://doi.org/10.1007/s10584-013-0875-4>

Cunsolo Willox, A., Harper, S.L. and Edge, V.L. (2013c). 'My Word': Storytelling and Digital Media Lab, Rigolet Inuit Community Government. *Qualitative Research, 13*(2), 127–147.

Cunsolo Willox, A., Stephenson, E., Allen, J., Bourque, F., Drossos, A., Elgarøy, S., Kral, M.J., Mauro, I., Moses, J., Pearce, T., MacDonald, J.P. and Wexler, L. (2014). Examining relationships between climate change and mental health in the Circumpolar North. *Regional Environmental Change*, *15*(1), 169–182. Retrieved June 2021, from <https://doi.org/10.1007/s10113-014-0630-z>

Dale, A., and Armitage, D. (2011). Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *The Human Dimensions of Northern Marine Mammal Management in a Time of Rapid Change*, *35*(4), 440–449. Retrieved June 2021, from <https://doi.org/10.1016/j.marpol.2010.10.019>

Dän Keyi Renewable Resources Council [DKRRC]. (2019). Wildlife Observations Project Community Project Summary 201–2017.

Darling, S., Ogden, A. and Hickey, G. (2018). Reviewing Northern Capacity for Impact Assessment in Yukon Territory, Canada, *in* Arctic Yearbook 2018. Northern Research Forum, 162–179. Retrieved February 2022, from <https://www.researchgate.net/publication/328841963_Reviewing_Northern_Capacity_for_Impact_Assessment_in_Yukon_Territory_Canada>

Das, A., Rokaya, P. and Lindenschmidt, K.-E. (2017). Assessing the impacts of climate change on ice jams along the Athabasca River at Fort McMurray, Alberta, Canada. CGU HS Committee on River Ice Processes and the Environment. Retrieved June 2021, from <http://www.cripe.ca/docs/proceedings/19/Das-et-al-2017.pdf>

Davis, K. T., Dobrowski, S. Z., Holden, Z. A., Higuera, P. E. and Abatzoglou, J. T. (2019). Microclimatic buffering in forests of the future: The role of local water balance. *Ecography*, *42*(1), 1–11. Retrieved February 2022, from <https://doi.org/10.1111/ecog.03836>

Dawson, J., Johnston, M. E. and Stewart, E. J. (2014). Governance of Arctic expedition cruise ships in a time of rapid environmental and economic change. *Ocean and Coastal Management*, *89*, 88–99. Retrieved June 2021, from <https://doi.org/10.1016/j.ocecoaman.2013.12.005>

Dawson, J., Pizzolato, L., Howell, S., Copland, L. and Johnston, M. (2018). Temporal and spatial patterns of ship traffic in the Canadian arctic from 1990 to 2015. *Arctic 71*(1), 1–113. Retrieved February 2022, from <https://doi.org/10.14430/arctic4698>

Dawson, J. Carter, N., van Luijk, N., Parker, C., Weber, M., Cook, A., Grey, K. and 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*: 19–36. Retrieved February 2022, from <https://doi.org/10.1016/j.envsci.2019.11.013>

de Loë, R. and Plummer, R. (2010). Climate Change, Adaptive Capacity, and Governance for Drinking Water in Canada. *Adaptive Capacity and Environmental Governance*, 157–178. Retrieved June 2021, from <https://doi.org/10.1007/978-3-642-12194-4_8>

Denton, F., Wilbanks, T.J., Abeysinghe, A.C., Burton, I., Gao, Q., Lemos, M.C., Masui, T., O'Brien, K.L. and Warner, K. (2015). Climate-resilient pathways: Adaptation, mitigation, and sustainable development, Chapter 20 in Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects Contributions of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, (Eds.) C.B. Field, B.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L. White. Cambridge University Press, Cambridge, United Kingdom and New York, New York, United States of America, 1101–1131. Retrieved June 2021, from <https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap20_FINAL.pdf>

Department of Fisheries and Oceans Canada (2019a). Canada's Oceans Now: Arctic Ecosystems 2019. Retrieved June 2022, from <https://waves-vagues.dfo-mpo.gc.ca/Library/40833574.pdf>

Department of Fisheries and Oceans Canada (2019b). Report on the designation of the Tuvaijuittuq Marine Protected Area. Retrieved January 2022, from <https://www.dfo-mpo.gc.ca/oceans/publications/tuvaijuittuq/designation/index-eng.html>

Dodd, W., Scott, P., Howard, C., Scott, C., Rose, C., Cunsolo, A. and Orbinski, J. (2018). Lived experience of a record wildfire season in the Northwest Territories, Canada. *Canadian Journal of Public Health*, *109*(3), 327–337. Retrieved June 2021, from <https://doi.org/10.17269/s41997-018-0070-5>

Douglas, V., Chan, H.M., Wesche, S., Dickson, C., Kassi, N., Netro, L. and Williams, M. (2014). Reconciling traditional knowledge, food security, and climate change: experience from Old Crow, YT, Canada. *Progress in Community Health Partnerships, 8*(1), 21–7. Retrieved April 2022, from <https://muse.jhu.edu/article/545087>

Duchesne, C., Smith, S., Ednie, M. and Bonnaventure, P. (2015). Active layer variability and change in the Mackenzie Valley, Northwest Territories. 68th Canadian Geotechnical Conference and 7th Canadian Conference on Permafrost, Quebec. Retrieved May 2022, from <https://www.researchgate.net/publication/282658355_Active_Layer_Variability_and_Change_in_the_Mackenzie_Valley_Northwest_Territories>

Durkalec, A., Furgal, C., Skinner, M.W. and Sheldon, T. (2015). Climate change influences on environment as a determinant of Indigenous health: Relationships to place, sea ice, and health in an Inuit community. *Social Science and Medicine*, 136–137, 17–26. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2015.04.026>

Ellis, N.R. and Albrecht, G. A. (2017). Climate change threats to family farmers' sense of place and mental wellbeing: A case study from the Western Australian Wheatbelt. *Social Science and Medicine*, *175*, 161–168. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2017.01.009>

Engle, N.L. (2011). Adaptive capacity and its assessment. *Special Issue on the Politics and Policy of Carbon Capture and Storage*, *21*(2), 647–656. Retrieved June 2021, from <https://doi.org/10.1016/j.gloenvcha.2011.01.019>

Environment and Climate Change Canada (2016). Pan-Canadian Framework on Clean Growth and Climate Change: Canada's plan to address climate change and grow the economy. 78 p. Retrieved June 2021, from <http://publications.gc.ca/site/eng/9.828774/publication.html>

Erni, S., Johnston, L., Gauthier, S., Christianson, A., Cardinal, Boulanger, Y. and Eddy, B. (2019). Strategic Assessment of Current and Future Exposure of Wildland Human Interface and Communities to Wildfire in Canada. Natural Resource Canada.

Fidler, C. and Noble, B. (2013) Stakeholder Perceptions of Current Planning, Assessment and Science Initiatives in Canada's Beaufort Sea. *Arctic, 66*(2), 179–190. Retrieved February 2022, from <https://doi.org/10.14430/arctic4289>

Farré, A.B., Stephenson, S., Chen, L., Czub, M., Dai, Y., Demchev, D., Yaroslav, E., Graczyk, P., Grythe, H., Stephen, K., Kivekäs, N., Kumar, N., Liu, N., Matelenok, I., Myksvoll, M., Leary, D., Olsen, J., Pavithran, AP., Petersen, S. and Wighting, J. (2014). Commercial Arctic shipping through the Northeast Passage: routes, resources, governance, technology, and infrastructure. *Polar Geography, 37*, 298-324. Retrieved February 2022, from <https://doi.org/10.1080/1088937X.2014.965769>

Fletcher, C.G., Zhao, H., Kushner, P.J. and Fernandes, R. (2012), Using models and satellite observations to evaluate the strength of snow albedo feedback, *Journal of Geophysical Research.*, 117, D11117. Retrieved February 2022, from <https://doi.org/10.1029/2012JD017724>

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L. and Holling, C. S. (2004). Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. *Annual Review of Ecology, Evolution, and Systematics*, *35*(1), 557–581. Retrieved June 2021, from <https://doi.org/10.1146/annurev.ecolsys.35.021103.105711>

Food First NL (n.d.). Expansion of the Community Freezer Program in Hopedale. Retrieved November 2021, from <https://www.foodfirstnl.ca/expansion-of-the-community-freezer-program-in-hopedale>

Ford, J. D., Cameron, L., Rubis, J., Maillet, M., Nakashima, D., Willox, A.C. and Pearce, T. (2016). Including indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change, 6*(4), 349–353. Retrieved February 2022, from <https://doi.org/10.1038/nclimate2954>

Ford, J. D. and Furgal, C. (2009). Foreword to the special issue: Climate change impacts, adaptation and vulnerability in the Arctic. *Polar Research*, *28*(1), 1–9. Retrieved June 2021, from <https://doi.org/10.1111/j.1751-8369.2009.00103.x>

Ford, J.D., McDowell, G., Shirley, J., Pitre, M., Siewierski, R., Gough, W., Duerden, F., Pearce, T., Adams, P. and Statham, S. (2013). The Dynamic Multiscale Nature of Climate Change Vulnerability: An Inuit Harvesting Example. *Annals of the Association of American Geographers*, *103*(5), 1193–1211. Retrieved June 2021, from <https://doi.org/10.1080/00045608.2013.776880>

Ford, J.D., McDowell, G. and Jones, J. (2014). The state of climate change adaptation in the Arctic. *Environmental Research Letters*, *9*(10), 104005. Retrieved June 2021, from <https://doi.org/10.1088/1748-9326/9/10/104005>

Ford, J.D., McDowell, G. and Pearce, T. (2015). The adaptation challenge in the Arctic. *Nature Climate Change*, *5*(12), 1046–1053. Retrieved June 2021, from <https://doi.org/10.1038/nclimate2723>

Ford, J. and Clark, D. (2019). Preparing for the impacts of climate change along Canada's Arctic coast: The importance of search and rescue, *Marine Policy, 108*, 103662. Retrieved June 2021, from <https://doi.org/10.1016/j.marpol.2019.103662>

Ford, J.D., Clark, D., Pearce, T., Berrang-Ford, L., Copland, L., Dawson, J., New, M., and Harper, S. L. (2019). Changing access to ice, land and water in Arctic communities. *Nature Climate Change, 9*(4), 335–339. Retrieved February 2022, from <https://doi.org/10.1038/s41558-019-0435-7>

Francis, S. and Hamm, J. (2011). Looking Forward: Using Scenario Modeling to Support Regional Land Use Planning in Northern Yukon, Canada. *Ecology and Society*, *16*. Retrieved June 2021, from <https://doi.org/10.5751/ES-04532-160418>

Fraser, F., Olthof, I., Carrière, M., Deschamps, A. and Pouliot, D. (2011). Detecting long-term changes to vegetation in northern Canada using the Landsat satellite image archive. *Environmental Research Letters,* 6, 9. Retrieved February 2022, from <http://dx.doi.org/10.1088/1748-9326/6/4/045502>

Furgal, C. and Prowse, T. D. (2008). Northern Canada, Chapter 3 *in* From Impacts to Adaptation: Canada in a Changing Climate, (Eds.) D.S. Lemmen, F.J. Warren, J.Lacroix and E. Bush. Natural Resources Canada, Government of Canada, Ottawa, Ontario, 57–118. Retrieved May 2022, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/ch3_e.pdf>

Furgal C, McTavish K, Martin R. and IHACC Research Team (2017). The importance of scale in understanding and addressing Arctic food security [Presentation Abstract]. ArcticNet, Arctic Change, International Conference, December 2017, Québec City, Quebec, Canada. Retrieved May 2022, from <http://www.arcticnetmeetings.ca/ac2017/docs/AC2017-Abstracts-2018-02-01.pdf>

Gagnon, CA, Hamel, S, Russell, DE, Powell, T., Andre, J., Svoboda, M.Y., and 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. Retrieved February 2022, from <https://doi.org/10.1111/1365-2664.13558>

Gaudard, L., Gilli, M. and Romerio, F. (2013). Climate Change Impacts on Hydropower Management. *Water Resources Management*, *27*(15), 5143–5156. Retrieved February 2022, from <https://doi.org/10.1007/s11269-013-0458-1>

Gearheard, S., Aporta, C., Aipellee, G. and O'Keefe, K. (2011). The Igliniit project: Inuit hunters document life on the trail to map and monitor arctic change. *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 42–55. Retrieved June 2021, from <https://doi.org/10.1111/j.1541-0064.2010.00344.x>

Glaas, E., Jonsson, A., Hjerpe, M. and Andersson-Sköld, Y. (2010). Managing climate change vulnerabilities: formal institutions and knowledge use as determinants of adaptive capacity at the local level in Sweden. *Local Environment, 15*(6), 525–539. Retrieved June 2021, from <https://doi.org/10.1080/13549839.2010.487525>

Goetz, S.J., Bunn, A.G., Fiske, G.J. and Houghton, R.A. (2005). Satellite-observed photosynthetic trends across boreal North America associated with climate and fire disturbance. *Proceedings of the National Academy of Sciences*, *102*(38), 13521–13525. Retrieved June 2021, from <https://doi.org/10.1073/pnas.0506179102>

Government of Canada (1995). Federal policy guide. Aboriginal self-government: The Government of Canada's approach to implementation of the inherent right and negotiation of Aboriginal self-government. Retrieved May 2022, from <https://www.rcaanc-cirnac.gc.ca/eng/1100100031843/1539869205136>

Government of Canada (2017). Report 6—Civil Aviation Infrastructure in the North—Transport Canada. Office of the Auditor General of Canada. Retrieved June 2021, from <http://www.oag-bvg.gc.ca/internet/English/parl_oag_201705_06_e_42228.html>

Government of Canada (2019a). Budget 2019. Chapter 2: Building a Better Canada. Retrieved June 2021, from <https://www.budget.gc.ca/2019/docs/plan/chap-02-en.html>

Government of Canada (2019b). Canada's Oceans Now; Arctic Ecosystems. Retrieved December 2021, from <https://waves-vagues.dfo-mpo.gc.ca/Library/40833574.pdf>

Government of Canada (2021). Budget 2021. Chapter 3: New Opportunities for Canadians. Retrieved January 2022, from <https://www.budget.gc.ca/2021/report-rapport/p2-en.html>

Government of Northwest Territories (2008). NWT Climate Change Impacts and Adaptations Report. Retrieved May 2022, from <https://www.enr.gov.nt.ca/sites/enr/files/reports/nwt_climate_change_impacts_and_adaptation_report.pdf>

Government of Northwest Territories (2012). Northwest Territories Biomass Energy Strategy 2012–2015. Environment and Natural Resources, Government of Northwest Territories, 1–24. Retrieved June 2021, from <https://www.enr.gov.nt.ca/sites/enr/files/strategies/biomass_energy_strategy_2012-2015.pdf>

Government of Northwest Territories. (2018). 2030 Energy Strategy A Path to More Affordable, Secure and Sustainable Energy in the Northwest Territories. Retrieved May 2022, from <https://www.inf.gov.nt.ca/sites/inf/files/resources/gnwt_inf_7272_energy_strategy_web-eng.pdf>

Government of Nunavut. (1999). Towards an Inuit *Qaujimajatuqangit* policy for Nunavut - A discussion paper. Iqaluit, Nunavut.

Government of Yukon (2018). Yukon's Independent Power Production Policy. Retrieved May 2022, from <https://yukon.ca/sites/yukon.ca/files/emr/emr-yukon-independent-power-production-policy.pdf>

Government of Yukon (2020). Government of Yukon Open Data. Retrieved June 2021, from <https://open.yukon.ca/data/>

Graham, A. (1990). Indexing the Canadian North: Broadening the Definition. *The Northern Review, Yukon College*, *6*, 21–37. Retrieved May 2022, from <https://thenorthernreview.ca/index.php/nr/article/view/255/251>

Graham, W. (2016). The Arctic, North America, and the World: A Political Perspective. *Governing the North American Arctic,* 13–25. Retrieved June 2021, from <https://doi.org/10.1057/9781137493910_1>

Gunn, A., Russell, D., White, R. and Kofinas, G. (2009). Facing a Future of Change: Wild Migratory Caribou and Reindeer. *Arctic*, *62*. Retrieved June 2021, from <https://doi.org/10.14430/arctic145>

Hamelin, L.-E. (1979). Canadian Nordicity: It's Your North, Too. Harvest House, Montréal, 1–13.

Hanes, C.C., Wang, X., Jain, P., Parisien, M.-A., Little, J.M. and Flannigan, M.D. (2018). Fire-regime changes in Canada over the last half century. *Canadian Journal of Forest Research*, *49*(3), 256–269. Retrieved June 2021, from <https://doi.org/10.1139/cjfr-2018-0293>

Hansen, A.M., Ingebrigtson, L. and Edmunds-Potvin, S. (2018). Health and Well-being, Chapter 4 *in* Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, 101-120. Retrieved May 2022, from <https://www.amap.no/documents/download/3015/inline>

Harper, S.L., Edge, V.L., Ford, J., Willox, A.C., Wood, M., McEwen, S.A., IHACC [Indigenous Health Adaptation to Climate Change] Research Team and RICG [Rigolet Inuit Community Government]. (2015). Climate-sensitive health priorities in Nunatsiavut, Canada. *BMC Public Health*, *15*(1), 605. Retrieved June 2021, from <https://doi.org/10.1186/s12889-015-1874-3>

Hatt, K. (2016). Isolated communities and inadequate airstrips: The challenges of airport infrastructure in Northern Canada. *Northern Public Affairs*, *3*(2). Retrieved June 2021, from <http://www.northernpublicaffairs.ca/index/volume-3-issue-2-building-new-partnerships/isolated-communities-and-inadequate-airstrips-the-challenges-of-airport-infrastructure-in-northern-canada/>

Healey, G. (2015). Exploring health-related indicators of climate change in Nunavut. Iqaluit, Nunavut: Qaujigiartiit. Health Research Centre.

Heginbottom, J. A., Dubrauil, M. A. and Harker, P. A. (1995). Canada, Permafrost. National Atlas of Canada (5th Edition, MCR, 4177). Natural Resources Canada. Retrieved May 2022, from <https://open.canada.ca/data/en/dataset/d1e2048b-ccff-5852-aaa5-b861bd55c367>

Henderson, S. and Johnston, F. (2012). Measures of forest fire smoke exposure and their associations with respiratory health outcomes. *Current Opinion in Allergy and Clinical Immunology*, *12*, 221–227. Retrieved June 2021, from <https://doi.org/10.1097/ACI.0b013e328353351f>

Hill, G. B. and Henry, G. H. R. (2011). Responses of High Arctic wet sedge tundra to climate warming since 1980. *Global Change Biology*, *17*(1), 276–287. Retrieved June 2021, from <https://doi.org/10.1111/j.1365-2486.2010.02244.x>

Hock, R., Bliss, A., Marzeion, B.E.N., Giesen, R.H., Hirabayashi, Y., Huss, M., Radic, V., and Slangen, A.B.A. (2019). GlacierMIP – A model intercomparison of global-scale glacier mass-balance models and projections. Journal of Glaciology, 65: 453–467. Retrieved May 2022, from <https://doi.org/10.1017/jog.2019.22>

Holling, B. (2011). Resilience and Life in the Arctic. *Resilience Science*. Retrieved June 2021, from <http://rs.resalliance.org/2011/04/05/resilience-and-life-in-the-arctic/>

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. Retrieved June 2021, from <https://doi.org/10.1146/annurev.es.04.110173.000245>

Hossack, S. (2018). Plane gets stuck in snow on Yukon glacier as region sees “incredible amount of change”. CBC News. Retrieved June 2021, from <https://www.cbc.ca/news/canada/north/yukon-pilot-stuck-glacier-icefield-1.4657619>

Holloway, J. E. and Lewkowicz, A.G. (2019). Half a century of discontinuous permafrost persistence and degradation in western Canada. *Permafrost and Periglacial Processes, 31*(1), 85–96. Retrieved June 2021, from <https://onlinelibrary.wiley.com/doi/abs/10.1002/ppp.2017>

Hovelsrud, G. K., Poppel, B., van Oort, B. and Reist, J. D. (2011). Arctic Societies, Cultures, and Peoples in a Changing Cryosphere. *Ambio*, *40*(Suppl 1), 100–110. PMC. Retrieved June 2021, from <https://doi.org/10.1007/s13280-011-0219-4>

Howlett, M. and Ramesh, M. (2016). Achilles’ heels of governance: Critical capacity deficits and their role in governance failures: The Achilles heel of governance. *Regulation and Governance*, *10(4)*, 301–313. Retrieved June 2021, from <https://doi.org/10.1111/rego.12091>

Hu, F. S., Higura, P. E., Duffy, P., Chipman, M.L., Rocha, A.V., Young, A.M., Kelly, R. and Dietze, M. C. (2015). Arctic tundra fires: Natural variability and responses to climate change. *Frontiers in Ecology and the Environment*, *13*, 369–377. Retrieved February 2022, from <https://doi.org/10.1890/150063>

Human Rights Watch (2020). Canada: Climate Crisis Toll on First Nations’ Food Supply: Government Response Inadequate as Emissions Rise. Retrieved June 2021, from <https://www.hrw.org/news/2020/10/21/canada-climate-crisis-toll-first-nations-food-supply>

Huss, M. and Hock, R. (2018). Global-scale hydrological response to future glacier mass loss. *Nature Climate Change, 8*(2), 135–140. Retrieved February 2022, from <https://doi.org/10.1038/s41558-017-0049-x>

Indian Brotherhood of Northwest Territories (1975). The Dene Declaration: General Assembly, Indian Brotherhood of NWT (i.e., Dene Nation), Fort Simpson, 19 July 1975.

Indigenous Clean Energy Social Enterprise (2019). 20/20 Catalyst Program.

Innergex Renewable Energy (2019). Construction of a hydroelectric generating station for the energy transition in the Inukjuak off-grid system. Retrieved June 2021, from <https://www.innergex.com/wp-content/uploads/2019/05/INE_INNAVIK_PPA_EN.pdf>

IPCC [Intergovernmental Panel on Climate Change] (2018). Annex I: Glossary [(ed.) Matthews, J.B.R.] *in* Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, (Eds.) V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield. Retrieved May 2022, from <https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_AnnexI_Glossary.pdf>

IPCC [Intergovernmental Panel on Climate Change] (2019). Summary for Policymakers *in* IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama and N.M. Weyer. Cambridge University Press, United Kingdom and New York, New York, United States. Retrieved in May 2022, from <https://www.ipcc.ch/site/assets/uploads/sites/3/2022/03/02_SROCC_TS_FINAL.pdf>

Inuit Circumpolar Council [ICC] (2008). The sea ice is our highway: An Inuit perspective on transportation in the Arctic. Inuit Circumpolar Concil - Canada. Retrieved May 2022, from <https://www.inuitcircumpolar.com/project/the-sea-ice-is-our-highway-an-inuit-perspective-on-transportation-in-the-arctic/>

Inuit Circumpolar Council [ICC] (2018). Wildlife Management Summit Report; November 6–8, 2017, Ottawa, Canada. Retrieved June 2021, from <https://iccalaska.org/wp-icc/wp-content/uploads/2018/03/ICC-Wildlife-Management-Summit-Report_Final_for-web.pdf>

Inuit Tapiriit Kanatami (2004). “5000 years of Inuit history and heritage.” National Inuit Organization in Canada. 1–17. Retrieved May 2022, from <https://www.itk.ca/wp-content/uploads/2016/07/5000YearHeritage_0.pdf>

Inuit Tapiriit Kanatami (2011). National Strategy on Inuit Education: First Canadians, Canadians First. Inuit Tapiriit Kanatami, Ottawa, Ontario. Retrieved April 2022, from <https://itk.ca/wp-content/uploads/2011/06/National-Strategy-on-Inuit-Education-2011.pdf>

Inuit Tapiriit Kanatami (2016). National Inuit Suicide Prevention Strategy. Inuit Tapiriit Kanatami, Ottawa, Ontario. Retrieved May 2022, from <https://www.itk.ca/download/12091/>

Inuit Tapiriit Kanatami (2017). National Strategy on Inuit Education – First Canadians, Canadians First [Website]. Retrieved April 2022, from <https://www.itk.ca/amaujaq/>

Inuit Tapiriit Kanatami (2018). National Inuit Strategy on Research. Inuit Tapiriit Kanatami, Ottawa, Ontario. Retrieved May 2022, from <https://www.itk.ca/wp-content/uploads/2018/09/ITK_NISR_Implementation-Plan_Electronic-Version.pdf>

Inuit Tapiriit Kanatami (2019a). National Inuit Climate Change Strategy. Inuit Tapiriit Kanatami, Ottawa, Ontario. Retrieved May 2022, from <https://www.itk.ca/wp-content/uploads/2019/07/ITK_Climate-Change-Strategy_English.pdf>

Inuit Tapiriit Kanatami (2019b). Arctic and Northern Policy Framework: Inuit Nunangat. Inuit Tapiriit Kanatami, Ottawa, Ontario. Retrieved May 2022, from <https://www.itk.ca/wp-content/uploads/2019/09/20190925-arctic-and-northern-policy-framework-inuit-nunangat-final-en.pdf>

Inuit Tapiriit Kanatami (n.d.). Inuit Launch *Qanuippitaa?* National Inuit Health Survey. Retrieved June 2021, from <https://www.itk.ca/inuit-launch-qanuippitaa-national-inuit-health-survey/>

Inuvialuit Regional Corporation (2017). New PV System Installed During ICEDO's Solar Energy Workshop. Retrieved June 2021, from <http://www.irc.inuvialuit.com/news/new-pv-system-installed-during-icedos-solar-energy-workshop>

Irlbacher-Fox, S. and Gibson, G. (2010). Scoping potential for developing northern institutional policy capacity: The 2009 Northern Governance Policy Research Conference. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*, *8*(1). Retrieved February 2022, from <https://journalindigenouswellbeing.co.nz/media/2018/12/8_Irlbacher-Fox.pdf>

Irlbacher-Fox, S. and MacNeill, R. (2020). Indigenous Governance is an Adaptive Climate Change Strategy. *Northern Review, 49*. Retrieved February 2022, from <https://doi.org/10.22584/nr49.2020.019>

Irvine, J. R., Macdonald, R. W., Brown, R. J., Godbout, L., Reist, J. D. and Carmack, E. C. (2009). Salmon in the Arctic and How They Avoid Lethal Low Temperatures. *North Pacific Anadromous Fish Commission*, *Bulletin 5*, 39–50. Retrieved February 2022, from <https://www.researchgate.net/publication/228476851_Salmon_in_the_Arctic_and_how_they_avoid_lethal_low_temperatures>

James Bay and Northern Quebec Agreement (JBNQA). (1975). Agreement between the Grand Council of the Crees (Of Quebec), The Northern Quebec Inuit Association, the *Gouvernement du Québec*, the *Société d'Énergie de la Baie James*, the *Société de Développement de la Baie James*, the *Commission Hydroélectrique de Québec (Hydro-Québec)*, and the Government of Canada. Dated December 12, 1975.

Janowicz, J. (2010). Observed trends in the river ice regimes of northwest Canada. *Hydrology Research*, *41*, 462. Retrieved June 2021, from <https://doi.org/10.2166/nh.2010.145>

Janowicz, J. R. (2017). Impacts of Climate Warming on River Ice Break-up and Snowmelt Freshet Processes on the Porcupine River in Northern Yukon. *CGU HS Committee on River Ice Processes and the Environment.* Retrieved June 2021, from <http://cripe.ca/docs/proceedings/19/Janowicz-2017.pdf>

Johnston, L.M., Wang, X., Erni, S., Taylor, S.W., McFayden, C.B., Oliver, J.A., Stockdale, C., Christianson, A., Boulanger, Y., Gauthier, S., Arseneault, D., Wotton, B.M., Parisien, M.-A. and Flannigan, M.D. (2020). Wildland fire risk research in Canada. *Environmental Reviews, 28*, 164–186. Retrieved June 2021, from <https://dx.doi.org/10.1139/er-2019-0046>

Johnstone, J.F., McIntire, E.J.B., Pedersen, E.J., King, G. and Pisaric, M.J.F. (2010). A sensitive slope: Estimating landscape patterns of forest resilience in a changing climate. *Ecosphere*, *1*(6), 1–21. Retrieved June 2021, from <https://doi.org/10.1890/ES10-00102.1>

Johnstone, J.F., Allen, C.D., Franklin, J.F., Frelich, L.E., Harvey, B.J., Higuera, P.E., Mack, M.C., Meentemeyer, R.K., Metz, M.R., Perry, G.L., Schoennagel, T. and Turner, M.G. (2016). Changing disturbance regimes, ecological memory, and forest resilience. *Frontiers in Ecology and the Environment*, *14*(7), 369–378. Retrieved June 2021, from <https://doi.org/10.1002/fee.1311>

Joint Secretariat. (2015). Inuvialuit and *Nanuq*: A Polar Bear Traditional Knowledge Study. Joint Secretariat, Inuvialuit Settlement Region, 304 p. Retrieved May 2022, from <https://wmacns.ca/documents/18/394_polar-bear-tk-report-low-res.pdf>

Jones, B.M., Grosse, G., Arp, C.D., Miller, E., Liu, L., Hayes, D.J. and Larsen, C.F. (2015). Recent Arctic tundra fire initiates widespread thermokarst development. *Scientific Reports*, *5*(1), 15865. Retrieved June 2021, from <https://doi.org/10.1038/srep15865>

Ju, J. and Masek, J. G. (2016). The vegetation greenness trend in Canada and US Alaska from 1984–2012 Landsat data. *Remote Sensing of Environment*, *176*, 1–16. Retrieved June 2021, from <https://doi.org/10.1016/j.rse.2016.01.001>

Jung, T., Frandsen, J., Gordon, D. and Mossop, D. (2016). Colonization of the Beaufort Coastal Plain by beaver (*Castor canadensis*): A response to shrubification of the tundra? *Canadian Field Naturalist*, *130*, 132–135. Retrieved June 2021, from <https://doi.org/10.22621/cfn.v130i4.1927>

Karanasios, K. and Parker, P. (2016). Recent Developments in Renewable Energy in Remote Aboriginal Communities, NWT, Canada. *Papers in Canadian Economic Development*, *16*, 1–13. Retrieved June 2021, from <http://dx.doi.org/10.15353/pced.v16i0.68>

Keane, R.E., Hessburg, P.F., Landres, P.B. and Swanson, F.J. (2009). The use of historical range and variability (HRV) in landscape management. *Forest Ecology and Management*, *258*(7), 1025–1037. Retrieved June 2021, from <https://doi.org/10.1016/j.foreco.2009.05.035>

Keenan, T.F. and Riley, W.J. (2018). Greening of the land surface in the world's cold regions consistent with recent warming. *Nature Climate Change*, *8*(9), 825–828. Retrieved June 2021, from <https://doi.org/10.1038/s41558-018-0258-y>

Keskitalo, E.C.H. (2009). Governance in vulnerability assessment: The role of globalizing decision-making networks in determining local vulnerability and adaptive capacity. *Mitigation and Adaptation Strategies for Global Change*, *14*(2), 185–201. Retrieved June 2021, from <https://doi.org/10.1007/s11027-008-9159-0>

Kirchmeier-Young, M.C., Zwiers, F.W., Gillett, N.P. and Cannon, A.J. (2017). Attributing extreme fire risk in Western Canada to human emissions. *Climatic Change 144*, 365–379. Retrieved June 2021, from <https://doi.org/10.1007/s10584-017-2030-0>

Kirmayer, L., Fletcher, C. and Watt, R. (2008). Locating the ecocentric self: Inuit concepts of mental health and illness *in* Healing Traditions: The Mental Health of Aboriginal Peoples in Canada, , (Eds.) L.J. Kirmayer and G.G. Valaskakis. UBC Press, 289–314.

Knotsch, C. and Lamouche, J. (2010). Arctic Biodiversity and Inuit Health. National Aboriginal Health Organization, Ottawa, Ontario. Retrieved June 2021, from <https://ruor.uottawa.ca/bitstream/10393/30205/1/2010_Arctic_Biodiversity.pdf>

Kotierk, M. (2010a). Elder and Hunter Knowledge of Davis Strait Polar Bears, Climate Change, and Inuit Participation. Government of Nunavut. Retrieved May 2022, from <https://www.gov.nu.ca/sites/default/files/davis_strait_traditional_knowledge_report.pdf>

Kotierk, M. (2010b). The Documentation of Inuit and Public Knowledge of Davis Strait Polar Bears, Climate Change, Inuit Knowledge and Environmental Management Using Public Opinion Polls. Retrieved May 2022, from <https://www.gov.nu.ca/sites/default/files/davis_strait_public_opinion_report_2010.pdf>

Krupnik, I. and Jolly, D. (2002). The Earth is Faster Now; Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States (ARCUS), Faibanks, Alaska. Retrieved May 2022, from <https://www.arcus.org/publications/eifn>

Kuzyk, Z.A. and Candlish, L.M. (2019). From Science to Policy in the Greater Hudson Bay Marine Region: An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization. ArcticNet, Québec City, 424 p.

Kwok, R. (2018). Arctic sea ice thickness, volume, and multiyear ice coverage: losses and coupled variability (1958–2018). *Environmental Research Letters, 13*(10), 105005. Retrieved February 2022, from <0.1088/1748-9326/aae3ec>

Kythreotis, A.P., Mantyka-Pringle, C., Mercer, T.G., Whitmarsh, L.E., Corner, A., Paavola, J., Chambers, C., Miller, B.A. and Castree, N. (2019). Citizen Social Science for More Integrative and Effective Climate Action: A Science-Policy Perspective. *Frontiers in Environmental Science*, *7*, 10. Retrieved June 2021, from <https://doi.org/10.3389/fenvs.2019.00010>

Laidler, G.J., Ford, J.D., Gough, W.A., Ikummaq, T., Gagnon, A.S., Kowal, S., Qrunnut, K. and Irngaut, C. (2008). Travelling and hunting in a changing Arctic: Assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic Change*, *94*(3), 363–397. Retrieved June 2021, from <https://doi.org/10.1007/s10584-008-9512-z>

Laidler, G. J., Hirose, T., Kapfer, M., Ikummaq, T., Joamie, E. and Elee, P. (2011). Evaluating the Floe Edge Service: How well can SAR imagery address Inuit community concerns around sea ice change and travel safety? *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 91–107. Retrieved June 2021, from <https://doi.org/10.1111/j.1541-0064.2010.00347.x>

Laidre, K.L., Stern, H., Kovacs, K.M., Lowry, L., Moore, S.E., Regehr, E.V., Ferguson, S.H., Wiig, Ø., Boveng, P., Angliss, R.P., Born, E.W., Litovka, D., Quakenbush, L., Lydersen, C., Vongraven, D. and Ugarte, F. (2015). Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. *Conservation Biology*, *29*(3), 724–737. Retrieved June 2021, from <https://doi.org/10.1111/cobi.12474>

Lament for the Land (2022). Home- Lament for the Land; Lament Productions 2014. RetrievedMarch 2022, from <http://www.lamentfortheland.ca/>

Lantz, T. C., Marsh, P. and Kokelj, S. V. (2013). Recent Shrub Proliferation in the Mackenzie Delta Uplands and Microclimatic Implications. *Ecosystems*, *16*(1), 47–59. Retrieved June 2021, from <https://doi.org/10.1007/s10021-012-9595-2>

Lantz, T.C. and Turner, K.W. (2015). Changes in lake area in response to thermokarst processes and climate in Old Crow Flats, Yukon. *Journal of Geophysical Research: Biogeosciences*, *120*(3), 513–524. Retrieved June 2021, from <https://doi.org/10.1002/2014JG002744>

Lantz, T. (2017). Vegetation Succession and Environmental Conditions following Catastrophic Lake Drainage in Old Crow Flats, Yukon. *Arctic 70*, 177. Retrieved June 2021, from <https://doi.org/10.14430/arctic4646>

Lenton, T.M. (2012). Arctic Climate Tipping Points. *Ambio*, *41*(1), 10–22. Retrieved June 2021, from <https://doi.org/10.1007/s13280-011-0221-x>

Lewis, K. J., Johnson, C. J. and Karim, M. N. (2019). Fire and lichen dynamics in the Taiga Shield of the Northwest Territories and implications for barren-ground caribou winter forage. *Journal of Vegetation Science*, *30*(3), 448–460. Retrieved February 2022, from <https://doi.org/10.1111/jvs.12736>

Lindenschmidt, K.-E., Das, A., Rokaya, P. and Chu, T. (2016). Ice-jam flood risk assessment and mapping. *Hydrological Processes*, *30*(21), 3754–3769. Retrieved June 2021, from <https://doi.org/10.1002/hyp.10853>

Levitt, M. (2019). Nation-Building at Home, Vigilance Beyond: Preparing for the Coming Decades in the Arctic: Report of the Standing Committee on Foreign Affairs and International Development. House of Commons Canada. Retrieved June 2021, from <https://www.ourcommons.ca/Content/Committee/421/FAAE/Reports/RP10411277/faaerp24/faaerp24-e.pdf>

Loseto, L.L., Brewster, J.D., Ostertag, S.K., Snow, K., MacPhee, S.A., McNicholl, D.G., Choy, E.S., Giraldo, C. and Hornby, C.A. (2018). Diet and feeding observations from an unusual beluga harvest in 2014 near Ulukhaktok, Northwest Territories, Canada. *Arctic Science, 4*(3), 421–431. Retrieved February 2022, from <https://doi.org/10.1139/as-2017-0046>

Mack, M. C., Bret-Harte, M. S., Hollingsworth, T. N., Jandt, R. R., Schuur, E.A.G., Shaver, G.R. and Verbyla, D.L. (2011). Carbon loss from an unprecedented Arctic tundra wildfire. *Nature*, *475*(7357), 489–492. Retrieved June 2021, from <https://doi.org/10.1038/nature10283>

Mallory, C.D. and Boyce, M.S. (2017). Observed and predicted effects of climate change on Arctic caribou and reindeer. *Environmental Reviews*, *26*(1), 13–25. Retrieved June 2021, from <https://doi.org/10.1139/er-2017-0032>

Mallory, C., Campbell, M. and Boyce, M. (2018). Climate influences body condition and synchrony of barren-ground caribou abundance in Northern Canada. *Polar Biology*. Retrieved June 2021, from <https://doi.org/10.1007/s00300-017-2248-3>

Marcot, B. G., Jorgenson, M. T., Lawler, J. P., Handel, C. M. and DeGange, A.R. (2015). Projected changes in wildlife habitats in Arctic natural areas of northwest Alaska. *Climatic Change*, *130*, 145–154.

McCreadie, M. (2014). Northern Biographies: Francois Paulette; Buffalo Hunter, Activist, Respected Elder, Hereditary Leader, Dancer, Family Man, Traditionalist, Spiritualist. NWT Literacy Council. Retrieved January, 2022 from <https://www.nwtliteracy.ca/sites/default/files/resources/130556%20NWT%20Literacy%20Northern%20Biography%20WEB_0.pdf>

McDermott, B., Lee, E., Judd, M. and Gibbon, P. (2005). Post-Traumatic Stress Disorder and General Psychopathology in Children and Adolescents Following a Wildfire Disaster. *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie*, *50*, 137–143. Retrieved June 2021, from <https://doi.org/10.1177/070674370505000302>

McGregor. D. (2018). From Decolonized to Reconciliation Research in Canada: Drawing from Indigenous Research Paradigms. *ACME: An International Journal for Critical Geographies, 2018, 17*(3): 810–831. Retrieved January, 2022 from <https://acme-ojs-test.unbc.ca/index.php/acme/article/view/1335/1289>

Meier, W.N., Hovelsrud, G.K., Van Oort, B.E., Key, J.R., Kovacs, K.M., Michel, C., Haas, C., Granskog, M.A., Gerland, S., Perovich, D.K., Makshtas, A., and Reist, J.D. (2014). Arctic sea ice in transformation: A review of recent observed changes and impacts on biology and human activity. *Reviews of Geophysics, 52*(3), 185–217. Retrieved February 2022, from <https://doi.org/10.1002/2013RG000431>

Mekonnen, Z.A., Riley, W.J., Berner, L.T., Bouskill, N.J., Torn, M.S., Iwahana, G., Breen A.L., Myers-Smith, I.H., Criado M.G., Liu, Y., Euskirchen, E.S., Goetz, S.J., Mack, M.N., and Grant R.F. (2021). Arctic tundra shrubification: a review of mechanisms and impacts on ecosystem carbon balance. *Environmental Research Letters*, *16*, 053001. Retrieved January 2022, from <https://iopscience.iop.org/article/10.1088/1748-9326/abf28b>

Melia, N., Haines, K. and Hawkins, E. (2016). Sea ice decline and 21st century trans-Arctic shipping routes. *Geophysical Research Letters 43*(18), 9720 – 9728. Retrieved June 2021, from <https://doi.org/10.1002/2016GL069315>

Melton, J.R., Verseghy, D.L., Sospedra-Alfonso, R. and Gruber, S. (2019). Improving permafrost physics in the coupled Canadian Land Surface Scheme (v.3.6.2) and Canadian Terrestrial Ecosystem Model (v.2.1) (CLASS-CTEM), *Geoscientific Model Development, 12*, 4443–4467. Retrieved June 2021, from <https://doi.org/10.5194/gmd-12-4443-2019>

Meredith, M., Sommerkorn, M., Cassotta, S., Derksen, C., Ekaykin, A., Hollowed, A., Kofinas, G., Mackintosh, A., Melbourne-Thomas, J., Muelbert, M.M.C., Ottersen G., Pritchard, H. and Schuur, E.A.G. (2019). « Polar Regions *in* IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N.M. Weyer. Retrieved June 2021, from <https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/07_SROCC_Ch03_FINAL.pdf>

Mercer, N., Parker, P., Martin, D. and Hudson, A. (2018). SSHRC Engage Executive Summary: 4RIGHT Community Energy Planning in NunatuKavut, Labrador. Retrieved June 2021, from <https://nunatukavut.ca/site/uploads/2019/06/executive-summary-1124.pdf>

Middleton, J., Cunsolo, A., Jones-Bitton, A., Shiwak, A., Wood, M., Pollock, N., Flowers, C. and Harper, S.L. (2020a). “We’re people of the snow”: Weather, climate change and Inuit mental wellness. *Social Science & Medicine*, *262*. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2020.113137>

Middleton, J., Cunsolo, A., Jones-Bitton, A., Wright, C. and Harper S.L. (2020b). Indigenous mental health in a changing climate: A systematic scoping review of the global literature. *Environmental Research Letters*, *15*(5). Retrieved June 2021, from <https://iopscience.iop.org/article/10.1088/1748-9326/ab68a9>

Miller, F.L. and Gunn, A. (2003). Catastrophic Die-Off of Peary Caribou on the Western Queen Elizabeth Islands, Canadian High Arctic. *Arctic, 56*:4. 381–390. Retrieved February 2022, from <https://doi.org/10.14430/arctic635>

Miner, K.R., D'Andrilli, J., Mackelprang, R., Edwards, A., Malaska, M.J., Waldrop, M.P., and Miller, C.E. (2021). Emergent biogeochemical risks from Arctic permafrost degradation. *Nature Climate Change*, *11*, 809–819. Retrieved February 2022, from <https://doi.org/10.1038/s41558-021-01162-y>

Minister of Indian Affairs and Northern Development (1984). « The Western Arctic Claim: The Inuvialuit Final Agreement (Bill C-49) ». Ottawa, Canada. Retrieved May 2022, from <https://publications.gc.ca/collections/collection_2017/aanc-inac/R74-34-1985-eng.pdf>

Minister of Justice (1993). *Nunavut Land Claims Agreement Act* (S.C. 1993, c. 29). Ottawa, Canada. Retrieved May 2022, from <https://laws-lois.justice.gc.ca/eng/acts/n-28.7/index.html>

Moses, A. (2018). Alfred Moses: Tuktoyaktuk Shoreline Relocation Project. Ministers' Statements and Speeches, Government of Northwest Territories. Retrieved April 2022, from <https://www.gov.nt.ca/en/newsroom/news/alfred-moses-tuktoyaktuk-shoreline-relocation-project>

Moudrak, N. and Feltmate, B. (2017). Preventing Disaster Before it Strikes: Developing a Canadian Standard for New Flood-Resilient Residential Communities 20 Best Practices. Intact Centre on Climate Adaptation, University of Waterloo. Retrieved June 2021, from <https://www.intactcentre.ca/wp-content/uploads/2017/09/Preventing-Disaster-Before-It-Strikes.pdf>

Mudryk, L.R., Derksen, C., Howell, S., Laliberté, F., Thackeray, C., Sospedra-Alfonso, R., Vionnet, V., Kushner, P.J. and Brown, R. (2018). Canadian snow and sea ice: historical trends and projections. *The Cryoshpere*. *12*. 1157–1176. Retrieved June 2021, from <https://tc.copernicus.org/articles/12/1157/2018/>

Myers-Smith, I.H., Forbes, B.C., Wilmking, M., Hallinger, M., Lantz, T., Blok, D., Tape, K.D., Macias-Fauria, M., Sass-Klaassen, U., Lévesque, E., Boudreau, S., Ropars, P., Hermanutz, L., Trant, A., Collier, L.S., Weijers, S., Rozema, J., Rayback, S.A., Schmidt, N.M., Schaepman-Strub, G., Wipf, S., Rixen, C., Ménard, C.B., Venn, S., Goetz, S., Andreu-Hayles, S., Elmendorf, S., Ravolainen, V., Welker, J., Grogan, P., Epstein, H.E. and Hik, D.S. (2011). Shrub expansion in tundra ecosystems: Dynamics, impacts and research priorities. *Environmental Research Letters*, *6*(4), 045509. Retrieved June 2021, from <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., Cunliffe, A.M., Assmann, J.J., Boyle, J.S., McLeod, E., McLeod, S., Joe, R., Lennie, P., Arey, D., Gordon, R.R. and Eckert, C.D. (2019). Eighteen years of ecological monitoring reveals multiple lines of evidence for tundra vegetation change. *Ecological Monographs*, *89*(2), e01351. Retrieved June 2021, from <https://doi.org/10.1002/ecm.1351>

Natural Resources Canada (2017). Climate Change and Fire. Government of Canada. Retrieved June 2021, from <https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/climate-change-fire/13155>

Natural Resources Canada (2018). Canada's Energy Transition: Getting to Our Energy Future, Together. Retrieved July 2022, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/CoucilReport_june27_English_Web.pdf>

Newton, R., Pfirman, S., Tremblay, L.B. and DeRepentigny, P. (2021). Defining the "ice shed" of the Arctic Ocean's Last Ice Area and its future evolution. *Earth's Future, 9*, e2021EF001988. Retrieved February 2022, from <https://doi.org/10.1029/2021EF001988>

Nickels, S., Furgal, C., Buell, M. and Moquin, H. (2005). Unikkaaqatigiit – Putting the Human Face on Climate Change: Perspectives from Inuit in Canada. Ottawa: 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.

Niemi, A., Ferguson, S., Hedges, K., Melling, H., Michel, C., Ayles, B., Azetsu-Scott, K., Coupel, P., Deslauriers, D., Devred, E., Doniol-Valcroze, T., Dunmall, K., Eert, J., Galbraith, P., Geoffroy, M., Gilchrist, G., Hennin, H., Howland, K., Kendall, M., Kohlbach, D., Lea, E., Loseto, L., Majewski, A., Marcoux, M., Matthews, C., McNicholl, D., Mosnier, A., Mundy, C.J., Ogloff, W., Perrie, W., Richards, C., Richardson, E., Reist, Virginie Roy, J., Sawatzky, C., Scharffenberg, K., Tallman, R., Tremblay, J-E., Tufts, T., Watt, C., Williams, W., Worden, E., Yurkowski, D. and Zimmerman, S. (2019). State of Canada's Arctic Seas. *Canadian Technical Report of Fisheries and Aquatic Sciences,* 3344, Department of Fisheries and Oceans Canada, xv + 189 p. Retrieved February 2022, from <https://publications.gc.ca/collections/collection_2019/mpo-dfo/Fs97-6-3344-eng.pdf>

Northwest Territories Association of Communities (2018). The Technical Opportunities and Economic Implications of Permafrost Decay on Public Infrastructure in the Northwest Territories. Final Report for the Project Entitled "Technical Opportunities Arising from Permafrost Impacts" Arrangement No: 1213-00-000131.

Northwest Territories Cumulative Impact Monitoring Program. (2015). NWT Cumulative Impact Monitoring Program (NWT IMP). Government of Northwest Territories, Environment and Natural Resources. . Retrieved February 2022, from <https://www.enr.gov.nt.ca/en/services/cumulative-impact-monitoring-program-cimp/about-us>

Nunavik Marine Regional Wildlife Board [NMRWB] (2018). Nunavik Inuit Knowledge and Observations of Polar Bears: Polar bears of the Southern Hudson Bay sub-population. Report prepared for the NMRWB, 73 p. Retrieved June 2021, from <https://nmrwb.ca/wp-content/uploads/2017/05/NMRWB-Nunavik-Inuit-knowledge-and-Observations-of-polar-bears-SHB-subpopulation.pdf>

Nunavut Impact Review Board (2019). Final Report for the Strategic Environmental Assessment in Baffin Bay and Davis Straight. Nunavut Impact Review Board File No. 17SN034. Retrieved May 2022, from <https://www.nirb.ca/portal/pdash.php?appid=125087>

Nicolsky, D. J., and Romanovsky, V. E. (2018). Modeling long-term permafrost degradation. *Journal of Geophysical Research: Earth Surface, 123*(8), 1756-1771. Retrieved May 2022, from <https://doi.org/10.1029/2018JF004655>

Obbard, R.W., Sadri, S., Wong, Y.Q., Khitun, A.A., Baker, I. and Thompson, R.C. (2014). Global warming releases microplastic legacy frozen in Arctic Sea ice. *Earth's Future*, *2*(6), 315–320. Retrieved June 2021, from <https://doi.org/10.1002/2014EF000240>

Oldenborger, G. A., et LeBlanc, A. M. (2018). Monitoring changes in unfrozen water content with electrical resistivity surveys in cold continuous permafrost. *Geophysical Journal International*, 215(2), 965–977. Retrieved May 2022, from <https://doi.org/10.1093/gji/ggy321>

Olesinski, J. and Brett, R. (2015). Northwest Territories Forest Health Report. Northwest Territories Environment and Natural Resources. Retrieved May 2022, from <https://www.enr.gov.nt.ca/en/files/nwt-forest-health-report-2015>

Olesinki, J., and Brett, R., (2018). Northwest Territories Forest Health Report. Government of Northwest Territories. Retrieved May 2022, from <https://www.enr.gov.nt.ca/en/2018-northwest-territories-forest-health-report>

O'Neill, H. B., Wolfe, S.A. and Duchesne, C. (2019). New ground ice maps for Canada using a paleogeographic modelling approach. *The Cryosphere*, *13*(3), 753–773. Retrieved June 2021, from <https://doi.org/10.5194/tc-13-753-2019>

Organ, J., Castleden, H., Furgal, C., Sheldon, T. and Hart, C. (2014). Contemporary programs in support of traditional ways: Inuit perspectives on community freezers as a mechanism to alleviate pressures of wild food access in Nain, Nunatsiavut. *Health & Place, 30*, 251–259. Retrieved June 2021, from <https://doi.org/10.1016/j.healthplace.2014.09.012>

Ostapchuk, J., Harper, S., Cunsolo, A., Edge, V., and Rigolet Inuit Community Government (2015). Exploring Elders' and Seniors' Perceptions of How Climate Change is Impacting Health and Well-being in Rigolet, Nunatsiavut / ᕿᒥᕐᕈᓂᖅ ᐃᓐᓇᐃᑦ ᐊᒻᒪᓗ ᐃᓄᑐᖃᐃᑦ ᐃᓱᒪᔾᔪᓯᖏᓐᓂᒃ ᓇᒍᓚᑦ, ᓄᓇᑦᓯᐊᕗᒻᒥ ᓯᓚᐅᑉ ᐊᓯᔾᔨᐸᒡᓕᐊᓂᖓᓂᒃ ᐊᑦᑐᐃᓂᖃᖅᑎᑦᓗᒍ ᐃᓗᓯᖅᒥᒃ ᐊᒻᒪᓗ ᖃᓄᐃᓐᖏᓂᖏᓐᓂᒃ. *International Journal of Indigenous Health*, *9*, 6. Retrieved June 2021, from <https://doi.org/10.18357/ijih92201214358>

Papanikolaou, V., Adamis, D., Mellon, R. and Prodromitis, G. (2011). Psychological distress following wildfires disaster in a rural part of Greece: A case-control population-based study. *International Journal of Emergency Mental Health*, *13*, 11–26. Retrieved February 2022, from <https://pubmed.ncbi.nlm.nih.gov/21957753/>

Pearce, T., Ford, J., Willox, A.C. and Smit, B. (2015). Inuit Traditional Ecological Knowledge (TEK), Subsistence Hunting and Adaptation to Climate Change in the Canadian Arctic. *Arctic*, *68*(2), 233–245. Retrieved February 2022, from <https://doi.org/10.14430/arctic4475>

Pearce, T., Ford, J., Duerden, F., Furgal, C., Dawson, J., Smit, B (2015). Factors of adaptation–climate change policy responses for Canada's Inuit population, Chapter 10 *in* From Science to Policy in the Western and Central Canadian Arctic: An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization, (Eds.) Stern, G.A. and Gaden, A. ArcticNet, Québec City, Quebec, 432 p.

Pelletier, J.F. and Guy, E. (2012). Évaluation des activités de transport maritime en Arctique Canadien. Cahiers Scientifiques du Transport, *61*, 3–33.

Pendakur, K. (2016). Northern Territories, Chapter 3 *in* Climate risks and adaptation practices for the Canadian transportation sector, (Eds.) K. Palko and D.S. Lemmen, 27–64. Government of Canada, Ottawa, Ontario. Retrieved May 2022, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2016/Chapter-3e.pdf>

Perrin, A., Dion, S., Sawyer, D., Nodelman, J.R., Comer, N., Auld, H., Sparling, E., Harris, M., Nodelman, J.Y.H. and Kinnear, L. (2015). Economic Implications of Climate Change Adaptations for Mine Access Roads in Northern Canada. Northern Climate ExChange, Yukon Research Centre, Yukon College. Retrieved June 2021, from <https://www.yukoncollege.yk.ca/sites/default/files/inline-files/Economic_Implications_TCWR_FINAL_web3.pdf>

Perovich, D., Meier, W., Tschudi, M., Farrell, S., Hendricks, S., Gerland, S., Kaleschke, L., Ricker, R., Tian-Kunze, X., Webster, M. and Wood, K. (2019). Sea Ice. Arctic Report Card: Update for 2019. Retrieved June 2021, from <https://arctic.noaa.gov/Report-Card/Report-Card-2019/ArtMID/7916/ArticleID/841/>

Petrasek MacDonald, J., Ford, J., and Cunsolo Willox, A. (2013). A review of protective factors and causal mechanisms that enhance the mental health of Indigenous Circumpolar youth. *International Journal of Circumpolar Health*, *72*(1), 21775. Retrieved June 2021, from <https://doi.org/10.3402/ijch.v72i0.21775>

Petrasek MacDonald, J., Cunsolo Willox, A., Ford, J. D., Shiwak, I. and Wood, M. (2015). Protective factors for mental health and well-being in a changing climate: Perspectives from Inuit youth in Nunatsiavut, Labrador. *Social Science and Medicine*, *141*, 133–141. Retrieved June 2021, from <https://doi.org/10.1016/j.socscimed.2015.07.017>

Pfeifer, P. (2020). "Inuit, namiipita? Climate Change Research and Policy: Beyond Canada's Diversity and Equity Problem." *The Northern Review, 49*, 265–269. Retrieved February 2022, from <https://doi.org/10.22584/nr49.2020.018>

Pizzolato, L., Howell, S.E., Derksen, C., Dawson, J. and Copland, L. (2014). Changing sea ice conditions and marine transportation activity in Canadian Arctic waters between 1990 and 2012. *Climate Change 123* (2), 161–173. Retrieved June 2021, from <https://doi.org/10.1007/s10584-013-1038-3>

Popp, J. N., Priadka, P., and Kozmik, C. (2018). The rise of moose co-management and integration of Indigenous knowledge. Human Dimensions of Wildlife, 24(2), 159–167. Retrieved May 2022, from <http://dx.doi.org/10.1080/10871209.2019.1545953>

Post, E. and Stenseth, N. Chr. (1999). Climatic variability, plant phenology, and northern ungulates. *Ecology*, *80*(4), 1322–1339. Retrieved June 2021, from <https://doi.org/10.1890/0012-9658(1999)080[1322:CVPPAN]2.0.CO;2>

Post, E., Forchhammer, M. ., Bret-Harte, M.S., Callaghan, T.V., Christensen, T.R., Elberling, B., Fox, A. D., Gilg, O., Hik, D.S., Høye, T.T., Ims, R.A., Jeppesen, E., Klein, D.R., Madsen, J., McGuire, A. D., Rysgaard, S., Schindler, D.E., Stirling, I., Tamstorf, M.P., Tyler, N.J.C., van der Wal, R., Welker, J., Wookey, P.A., Schmidt, N.M. and Aastrup, P. (2009). Ecological Dynamics Across the Arctic Associated with Recent Climate Change. *Science*, *325*(5946), 1355. Retrieved June 2021, from <https://doi.org/10.1126/science.1173113>

Prowse, T.D., Wrona, F.J., Reist, J.D., Hobbie, J.E., Lévesque, L.M.J. and Warwick, V.F. (2006). General Features of the Arctic Relevant to Climate Change in Freshwater Ecosystems. *AMBIO: A Journal of the Human Environment*, *35*(7), 330–338. Retrieved June 2021, from <https://doi.org/10.1579/0044-7447(2006)35[330:GFOTAR]2.0.CO;2>

Pufall, E., Jones, A., Mcewen, S., Lyall, C., Peregrine, A. and Edge, V. (2011). Perception of the Importance of Traditional Country Foods to the Physical, Mental, and Spiritual Health of Labrador Inuit. *Arctic*, *64*. Retrieved June 2021, from <https://doi.org/10.14430/arctic4103>

Qaujigiartiit Health Research Centre (2019): Qaujigiartiit Health Research Centre. Retrieved March 2022, from <https://www.qhrc.ca/>

Qi, D., Chen, L., Chen, B., Gao, Z., Zhong, W., Feely, R.A., Anderson, L.G., Sun, H., Chen, J., Chen, M., Zhan, L., Zhan, Y., and Cai, W.-J. (2017). Increase in acidifying water in the western Arctic Ocean. *Nature Climate Change 7*, 195–199. Retrieved February 2022, from <https://doi.org/10.1038/nclimate3228>

Qu, X. and Hall, A. (2007). What Controls the Strength of Snow-Albedo Feedback? *Journal of Climate, 20*, 3971–3981. Retrieved June 2021, from <https://doi.org/10.1175/JCLI4186.1>

Quliq Energy Corporation (2018). Net Metering Policy. 1–4. Retrieved May 2022, from <https://www.qec.nu.ca/sites/default/files/qec-2017-net_metering_policy_final_eng.pdf>

Quliq Energy Corporation. (2020). Independent Power Producer Program. Retrieved June 2021, from <https://www.qec.nu.ca/customer-care/generating-power/independent-power-producer-program>

Radić, V. and Hock, R. (2014). Glaciers in the Earth's hydrological cycle: assessments of glacier mass and runoff changes on global and regional scales. *Surveys in Geophysics*, *35*(3), 813–837. Retrieved February 2022, from <https://doi.org/10.1007/s10712-013-9262-y>

Ramos-Castillo, A., Castellanos, E.J. and Galloway McLean, K. (2017). Indigenous peoples, local communities and climate change mitigation. *Climatic Change*, *140*(1), 1–4. Retrieved June 2021, from <https://doi.org/10.1007/s10584-016-1873-0>

Rautio, M, Evans, M, Grosbois, G, Power, M. (2020). Omega-3 fatty acids and mercury in the food web of Greiner Lake, *in* Aqhaliat 2019 Report. Polar Knowledge Canada.

Reedman, A. (2020) Research by the North, for the North, in the North. ArcticNet Magazine. ArcticNet. Retrieved July 2022, from <https://arcticnetmagazine.ca/current-volume/north-by-north>

Reid, C., Brauer, M., Johnston, F., Jerrett, M., Balmes, J. and Elliott, C. (2016). Critical Review of Health Impacts of Wildfire Smoke Exposure. *Environmental Health Perspectives*, *124*. Retrieved June 2021, from <https://doi.org/10.1289/ehp.1409277>

Reid, D.G., Berteaux, D. and Laidre K.L. (2013). Mammals, Chapter 3 *in* Arctic Biodiversity Assessment 2013. The Conservation of Arctic Flora and Flauna (CAFF). Retrieved June 2021, from <https://www.arcticbiodiversity.is/index.php/the-report/chapters/mammals>

Reimer, G., Bombay, A., Ellsworth, L., Fryer, S. and Logan, T. (2010). The *Indian residential schools settlement agreement*'s common experience payment and healing: a qualitative study exploring impacts on recipients. Aboriginal Healing Foundation, Ottawa, Ontario. Retrieved May 2022, from <https://www.ahf.ca/downloads/cep-2010-healing.pdf>

Rennert, K.J., Roe, G., Putkonen, J. and 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. Retrieved June 2021, from <https://doi.org/10.1175/2008JCLI2117.1>

Renaut, S., Devred, E., and Babin, M. (2018). Northward expansion and intensification of phytoplankton growth during the early ice-free season in Arctic. *Geophysical Research Letters*, *45*(19), 10590–10598. Retrieved February 2022, from <https://doi.org/10.1029/2018GL078995>

Richmond, C.A.M. and Ross, N.A. (2009). The determinants of First Nation and Inuit health: A critical population health approach. *Health and Place*, *15*(2), 403–411. Retrieved June 2021, from <https://doi.org/10.1016/j.healthplace.2008.07.004>

Rickbeil, G.J.M., Hermosilla, T., Coops, N.C., White, J.C., Wulder, M.A. and Lantz, T.C. (2018). Changing northern vegetation conditions are influencing barren ground caribou (*Rangifer tarandus groenlandicus*) post-calving movement rates. *Journal of Biogeography*, *45*(3), 702–712. Retrieved June 2021, from <https://doi.org/10.1111/jbi.13161>

Ritsema, R., Dawson, J., Jorgensen, M. and Macdougall, B. (2015). "Steering Our Own Ship?" An Assessment of Self-Determination and Self-Governance for Community Development in Nunavut. *The Northern Review, Yukon College*, *41*, 157–180. Retrieved February 2022, from <https://doi.org/10.22584/nr41.2015.007>

Rosol, R., Powell-Hellyer, S. and Chan, H.M. (2016). Impacts of decline harvest of country food on nutrient intake among Inuit in Arctic Canada: Impact of climate change and possible adaptation plan. *International Journal of Circumpolar Health*, *75*(1), 31127. Retrieved June 2021, from <https://doi.org/10.3402/ijch.v75.31127>

Samuel, J., Rousseau, A.N., Abbasnezhadi, K. and Savary, S. (2019). Development and evaluation of a hydrologic data-assimilation scheme for short-range flow and inflow forecasts in a data-sparse high-latitude region using a distributed model and ensemble Kalman filtering. *Advances in Water Resources*, *130*, 198–220. Retrieved February 2022, from <https://doi.org/10.1016/j.advwatres.2019.06.004>

Sandlos, J. and Keeling, A. (2016). Toxic Legacies, Slow Violence, and Environmental Injustice at Giant Mine, Northwest Territories. *The Northern Review, 42*, 7–21. Retrieved February 2022, from <https://doi.org/10.22584/nr42.2016.002>

Schmelzer, I., Lewis, K.P., Jacobs, J.D. and McCarthy, S.M. (2020). Boreal caribou survival in a warming climate, Labrador, Canada 1996–2014. *Global Ecology and Conservation*, *23*. Retrieved June 2021, from <https://doi.org/10.1016/j.gecco.2020.e01038>

Schroeder, D. (2010). Fire behaviour in thinned jack pine: Two case studies of FireSmart treatments in Canada's Northwest Territories. *Advantage, FPInnovations*, *12*(7), 1–12. Retrieved February 2022, from <https://wildfire.fpinnovations.ca/81/FireBehaviourInThinnedJackPine.pdf>

Schuster, P., Schaefer, K., Aiken, G., Antweiler, R., Dewild, J., Gryziec, J., Gusmeroli, A., Hugelius, G., Jararoy, E., Krabbbenhoft, D., Liu, L., Herman-Mercer, N., Mu, C., Roth, D., Schaefer, T., Striegl, R. and Wickland. (2018). Permafrost stores a globally significant amount of mercury. Geophysical Research Letters, 45(3), 1463-147. Retrieved July 2022, from <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL075571>

Seidl, R., Spies, T.A., Peterson, D.L., Stephens, S.L. and Hicke, J.A. (2016). Searching for resilience: Addressing the impacts of changing disturbance regimes on forest ecosystem services. *Journal of Applied Ecology*, *53*(1), 120–129. Retrieved June 2021, from <https://doi.org/10.1111/1365-2664.12511>

Shah, C., Ford, J., Labbé, J. and Flynn, M. (2018). Adaptation Policy & Practice in Nunavut. McGill University.

Sharp, M., Burgess, D. O., Cawkwell, F., Copland, L., Davis, J. A., Dowdeswell, E. K., Dowdeswell, J. A., Gardner, A. S., Mair, D., Wang, L., Williamson, S. N., Wolken, G. J., Wyatt, F. (2014). Remote sensing of recent glacier changes in the Canadian Arctic. In Global land ice measurements from space. *Global Land Ice Measurements from Space*. 205–228. Springer, Berlin, Heidelberg.

Simon, M. (2017). A new shared arctic leadership model. Indigenous and Northern Affairs Canada. Retrieved June 2021, from <https://www.rcaanc-cirnac.gc.ca/eng/1492708558500/1537886544718>

SmartIce (2022): Enabling Resiliency in the Face of Climate Change: SmartICE is an award-winning technological innovation for the North; Retrieved March 2022, from <https://smartice.org/>

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282–292. Retrieved February 2022, from <https://doi.org/10.1016/j.gloenvcha.2006.03.008>

Smith, L. C. and Stephenson, S. R. (2013). New Trans-Arctic shipping routes navigable by midcentury. *Proceedings of the National Academy of Sciences of the United States of America, 110* (13), E1191–E1195. Retrieved June 2021, from <https://doi.org/10.1073/pnas.1214212110>

Snook, J., Cunsolo, A. and Dale, A. (2018). Co-management led research and sharing space on the pathway to Inuit self-determination in research. *Northern Public Affairs*, *6*(1), 52–56. Retrieved April 2022, from <https://www.researchgate.net/profile/Jamie-Snook/publication/328808144_Co-management_led_research_and_sharing_space_on_the_pathway_to_Inuit_self-determination_in_research/links/5be43190a6fdcc3a8dc6ed49/Co-management-led-research-and-sharing-space-on-the-pathway-to-Inuit-self-determination-in-research.pdf>

Southcott, C. (2015). Resource Development and Northern Communities—An Introduction. *The Northern Review, 41,* 3–12. Retrieved February 2022, from <https://doi.org/10.22584/nr41.2015.001>

Social Sciences and Humanities Research Council (SSHRC). (2018). Special Call: Indigenous Research Capacity and Reconciliation—Connection Grants. Retrieved June 2021, from <http://www.sshrc-crsh.gc.ca/funding-financement/programs-programmes/indigenous_research-recherche_autochtone-eng.aspx>

Standards Council of Canada (2014a). Community drainage system planning, design, and maintenance in northern communities (CAN/CSA-S503-15, 15, 83). National Standards of Canada.

Standards Council of Canada (2014b). Managing snow load risks for buildings in Canada's North. (CAN/CSA-S502, 14, 55). National Standards of Canada.

Standards Council of Canada (2014c). Thermosyphon foundations for building in permafrost regions. (CAN/CSA-S500, 14, 44). National Standards of Canada.

Standards Council of Canada (2015). Community drainage system planning, design, and maintenance in northern communities. (CAN/CSA-S503-15, 15, 83). National Standard of Canada.

Standards Council of Canada (2020a). NISI 101 Guides and Videos. NISI Standards and Training Materials. Standards Council of Canada. Retrieved June 2021, from <https://www.scc.ca/en/nisi/nisi-101>

Standards Council of Canada (2020b). Thermosyphon guide. Consulted in August 2022, from <https://www.scc.ca/en/system/files/publications/Thermosyphons_EN_web.pdf>

Staples, L. (2013). Conservation of arctic flora and fauna in a changing ice regime: Implications for co-management *in* Life linked to ice: A guide to sea-ice-associated biodiversity in this time of rapid change, (Eds.) J. Eamer, G.M. Donaldson, A.J. Gaston, K.N. Kosobokova, K.F. Lárusson, I.A. Melnikov, J.D. Reist, E. Richardson, L. Staples and C.H. von Quillfeldt. Conservation of Arctic Flora and Fauna. Retrieved May 2022, from <https://oaarchive.arctic-council.org/bitstream/handle/11374/239/Life_Linked_to_Ice_Oct_2013.pdf?sequence=1&isAllowed=y>

Statistics Canada (2017). Focus on Geography Series, 2016 Census Catalogue no. 98-404-x2016001. Government of Canada, Ontario. Data products, 2016 Census.

Statistics Canada (2018). Population and Demography. Government of Canada. Retrieved June 2021, from <https://www150.statcan.gc.ca/n1/pub/11-402-x/2011000/chap/pop/pop-eng.htm>

Stephenson, S.R., Smith, L.C., Brigham, L.W. and Agnew, J.A. (2013). Projected 21st-century changes to Arctic marine access. *Climatic Change, 118*(3–4), 885–899. Retrieved June 2021, from <https://doi.org/10.1007/s10584-012-0685-0>

Stern, G.A. and Gaden, A. (2015). From Science to Policy in the Western and Central Canadian Arctic: An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization. Synthesis and Recommendations. ArcticNet, Québec City, 40 p.

Stewart, F.E.C., Nowak, J.J., Micheletti, T., McIntire, E.J.B., Schmiegelow, F.K.A. and Cumming, S.G. (2020). Boreal Caribou Can Coexist with Natural but Not Industrial Disturbances. *The Journal of Wildlife Management*, *84*(8), 1–10. Retrieved February 2022, from <https://doi.org/10.1002/jwmg.21937>

Storer, L.N., Williams, P.D. and Gill, P.G. (2019). Aviation Turbulence: Dynamics, Forecasting, and Response to Climate Change. *Pure and Applied Geophysics*, *176*(5), 2081–2095. Retrieved June 2021, from <https://doi.org/10.1007/s00024-018-1822-0>

Streicker, J. (2016). Yukon Climate Change Indicators and Key Findings. Northern Climate ExChange, Yukon Research Centre, Yukon College. Whitehorse, Yukon. Retrieved May 2022, from <https://www.yukonu.ca/sites/default/files/inline-files/Indicator_Report_Final_web.pdf>

Sulla-Menashe, D., Woodcock, C.E. and Friedl, M.A. (2018). Canadian boreal forest greening and browning trends: An analysis of biogeographic patterns and the relative roles of disturbance versus climate drivers. *Environmental Research Letters*, *13*(1), 014007. Retrieved June 2021, from <https://doi.org/10.1088/1748-9326/aa9b88>

Tape, K. D., Jones, B. M., Arp, C. D., Nitze, I. and Grosse, G. (2018). Tundra be dammed: Beaver colonization of the Arctic. *Global Change Biology*, *24*(10), 4478–4488. Retrieved June 2021, from <https://doi.org/10.1111/gcb.14332>

Tarasuk V. and Mitchell A. (2020) Household food insecurity in Canada, 2017-18. Research to identify policy options to reduce food insecurity (PROOF), Toronto Ontario. Retrieved June 2021, from <https://proof.utoronto.ca/wp-content/uploads/2020/03/Household-Food-Insecurity-in-Canada-2017-2018-Full-Reportpdf.pdf>

The Committee on the Status of Endangered Wildlife in Canada [COSEWIC] (2017). Caribou (*Rangifer tarandus*) some populations: COSEWIC assessment and status report 2017. Government of Canada. Retrieved June 2021, from <https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/caribou-some-populations-2017.html#_08>

The Committee on the Status of Endangered Wildlife in Canada [COSEWIC] (2018). Polar Bear (*Ursus maritimus*): COSEWIC assessment and status report 2018. Government of Canada. Retrieved June 2021, from <https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/polar-bear-2018.html>

The OKâlaKatiget Society (2017). OKâlaKatiget Society. Retrieved January, 2022 from <http://www.oksociety.com/>

The Standing Senate Committee on Fisheries and Oceans (2018). Evidence of Tuesday February 13, 2018 (testimony of Dylan Clark as an individual). Senate of Canada, 42nd Parliament, 1st Session (December 3, 2015 - September 11, 2019) Retrieved May 2022, from <https://sencanada.ca/en/Content/Sen/Committee/421/POFO/53810-e>

Thorpe, N., Eyegetok, S. and Hakongak, N. (2002). Nowadays it is not the same: Inuit Quajimajatuqangit, climate and caribou in the Kitikmeot Region of Nunavut, Canada *in* The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change, (Eds.) I. Krupnik and D. Jolly. Arctic Research Consortium of the United States (ARCUS), Fairbanks, Alaska, 198–239. Retrieved May 2022, from <https://www.arcus.org/publications/eifn>

Torncat Fish Producers Cooperative (2022). Fresh Catches from the Labrador Sea. Retrieved March 2022, from <https://www.torngatfishcoop.com/>

Tremblay, B., Lévesque, E. and Boudreau, S. (2012). Recent expansion of erect shrubs in the Low Arctic: Evidence from Eastern Nunavik. *Environmental Research Letters*, *7*(3), 035501. Retrieved June 2021, from <https://doi.org/10.1088/1748-9326/7/3/035501>

Truth and Reconciliation Commission of Canada (2015a). Canada's Residential Schools: The Inuit and Northern Experience: The Final Report of the Truth and Reconciliation Commission of Canada –Volume 2. Retrieved June 2021, from <https://publications.gc.ca/collections/collection_2015/trc/IR4-9-2-2015-eng.pdf>

Truth and Reconciliation Commission of Canada (2015b). Truth and Reconciliation Commission of Canada: Calls to Action. Retrieved June 2021, from <https://publications.gc.ca/collections/collection_2015/trc/IR4-8-2015-eng.pdf>

Turcotte, B., Burrell, B. and Beltaos, S. (2019). The Impact of Climate Change on Breakup Ice Jams in Canada: State of knowledge and research approaches. CGU HS Committee on River Ice Processes and the Environment, 20th Workshop on the Hydraulics of Ice-Covered Rivers, Ottawa, Ontario, Canada, May 14-16, 2019. Retrieved May 2022, from <http://www.cripe.ca/docs/proceedings/20/Turcotte-et-al-2019.pdf>

Turetsky, M.R., Baltzer, J.L., Johnstone, J.F., Mack, M.C., McCann, K. and Schuur, E.A.G. (2017). Losing Legacies, Ecological Release, and Transient Responses: Key Challenges for the Future of Northern Ecosystem Science. *Ecosystems*, *20*(1), 23–30. Retrieved February 2022, from <https://doi.org/10.1007/s10021-016-0055-2>

Vasiliki, D., Hing Man Chan, L., Wesche, S., Dickson, C., Kassi, N., Netro, L. and Williams, M. (2014). Reconciling Traditional Knowledge, Food Security, and Climate Change: Experience From Old Crow, YT, Canada. *Progress in Community Health Partnerships: Research, Education, and Action*, *8*(1), 21–27. Retrieved February 2022, from <10.1353/cpr.2014.0010>

Vuntut Gwitchin Government (2020). Caribou Coordination Newsletter September 2020. Vuntut Gwitchin Government. Retrieved June 2021, from <https://www.vgfn.ca/pdf/2020_09_Caribou_Coordination_Community_Update_FINAL.pdf>

Walker, B., Holling, C.S., Carpenter, S.R. and Kinzig, A.P. (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society*, *9*(2), 5. Retrieved February 2022, from <https://www.ecologyandsociety.org/vol9/iss2/art5/>

Walker, X.J., Mack, M.C. and Johnstone, J.F. (2015). Stable carbon isotope analysis reveals widespread drought stress in boreal black spruce forests. *Global Change Biology*, *21*(8), 3102–3113. Retrieved June 2021, from <https://doi.org/10.1111/gcb.12893>

Wang, X., Parisien, M.-A., Taylor, S.W., Candau, J.-N., Stralberg, D., Marshall, G.A., Little, J.M., Flannigan, M.D. (2017). Projected changes in daily fire spread across Canada over the next century. *Environmental Research Letters*, *12*(2), 025005. Retrieved January 2022, from <https://doi.org/10.1088/1748-9326/aa5835>

Warren, J.A., Berner, J.E. and Curtis, T. (2005). Climate change and human health: Infrastructure impacts to small remote communities in the north. *International Journal of Circumpolar Health*, *64*(5), 487–497. Retrieved June 2021, from <https://doi.org/10.3402/ijch.v64i5.18030>

Wenzel, G. W. (2009). Canadian Inuit subsistence and ecological instability—if the climate changes, must the Inuit? *Polar Research*, *28*(1), 89–99. Retrieved February 2022, from <https://doi.org/10.1111/j.1751-8369.2009.00098.x>

Wheeler, H., Høye, T. and Svenning, J.-C. (2017). Wildlife species benefitting from a greener Arctic are most sensitive to shrub cover at leading range edges. *Global Change Biology*, *24*. Retrieved June 2021, from <https://doi.org/10.1111/gcb.13837>

Whitaker, D. (2017). Expanded Range Limits of Boreal Birds in the Torngat Mountains of Northern Labrador. *The Canadian Field-Naturalist*, *131*, 55. Retrieved June 2021, from <https://doi.org/10.22621/cfn.v131i1.1957>

White, G. (2018). Issues of independence in Northern Aboriginal-state co-management boards. Canadian Public Administration, 61(4), 550–571. Retrieved May 2022, from <https://doi.org/10.1111/capa.12302>

Whitman, E., Parisien, M.-A., Thompson, D. and Flannigan, M. (2018). Topoedaphic and Forest Controls on Post-Fire Vegetation Assemblies Are Modified by Fire History and Burn Severity in the Northwestern Canadian Boreal Forest. *Forests*, *9*, 151. Retrieved June 2021, from <https://doi.org/10.3390/f9030151>

Whitman, E., Parisien, M.-A., Thompson, D.K. and Flannigan, M.D. (2019). Short-interval wildfire and drought overwhelm boreal forest resilience. *Scientific Reports*, *9*(1), 18796. Retrieved June 2021, from <https://doi.org/10.1038/s41598-019-55036-7>

Williams, P.D. and Joshi, M.M. (2013). Intensification of winter transatlantic aviation turbulence in response to climate change. *Nature Climate Change*, *3*(7), 644–648. Retrieved June 2021, from <https://doi.org/10.1038/nclimate1866>

Williams, P.L., Burgess, D.O., Waterman, S., Roberts, M., Bertrand, E.M., and Bhatia, M.P. (2021). Nutrient and Carbon Export From a Tidewater Glacier to the Coastal Ocean in the Canadian Arctic Archipelago. *Journal of Geophysical Research: Biogeosciences, 126*(9). Retrieved May 2022, from <https://doi.org/10.1029/2021JG006289>

Wilson, A., Levkoe, C.Z., Andrée, P., Skinner, K., Spring, A., Wesche, S., and Galloway, T. (2020). Strengthening Sustainable Northern Food Systems: Federal Policy Constraints and Potential Opportunities. *Arctic, 73*(3), 292–31. Retrieved February 2022, from <https://doi.org/10.14430/arctic70869>

Wolf, J., Allice, I. and Bell, T. (2015). Values and Traditional Practices in Adaptation to Climate Change, *in* The Adaptive Challenge of Climate Change, (Eds.) E. Selboe and K. O'Brien. Cambridge University Press; Cambridge Core. 171–193 Retrieved June 2021, from <https://doi.org/10.1017/CBO9781139149389.011>

Wolfe, S.A., O'Neill, H.B. and Duchesne, C. (2021). A ground ice atlas of Canada. Geological Survey of Canada, Open File 8770. Retrieved May 2022, from <https://doi.org/10.4095/328115>

Wong, C., Ballegooyen, K., Ignace, L., Johnson, M.J. (Gùdia), Swanson, H. and Boran, I. (2020). Towards reconciliation: 10 Calls to Action to natural scientists working in Canada. *FACETS. 5*(1): 769–783. Retrieved June 2021, from <https://doi.org/10.1139/facets-2020-0005>

Wrona, F.J., Prowse, T.D., Reist, J.D., Beamish, R., Gibson, J.J., Hobbie, J., Jeppesen, E., King, J., Koeck, G., Korhola, A., Lévesque, L., Macdonald, R., Power, M., Skvortsov, V., Vincent, W., Clark, R., Dempson, B., Lean, D., Lehtonen, H., Perin, S., Pienitz, R., Rautio, M., Smol, J., Tallman, R., and Zhulidov, A. (2005). Freshwater ecosystems and fisheries, Chapter 8 *in* Arctic Climate Impact Assessment, (Eds.) C. Symon, L. Arris and B. Heal. Cambridge University Press, 353–452. Retrieved May 2022, from <https://www.amap.no/documents/download/1089/inline>

York, J.D., Mitchell, J., Nash, T., Snook, J., Felt, L., Taylor, M. and Dowsley, M. (2015). Labrador Polar Bear Traditional Ecological Knowledge Final Report, Torngat Wildlife, Plants and Fisheries Secretariat, Happy Valley-Goose Bay, Newfoundland and Labrador, 133 p. Retrieved May 2022, from <https://www.torngatsecretariat.ca/home/files/cat6/2015-labrador_polar_bear_traditional_ecological_knowledge_final_report.pdf>

Young, A.M., Higuera, P.E., Duffy, P.A. and Hu, F.S. (2017). Climatic thresholds shape northern high-latitude fire regimes and imply vulnerability to future climate change. *Ecography*, *40*(5), 606–617. Retrieved June 2021, from <https://doi.org/10.1111/ecog.02205>

Yukon Government (2015). Yukon Government Climate Change Action Plan December 2015 Progress Report, 52 p. Yukon Government, Department of Environment.

Yukon Government (2016). Yukon Biomass Energy Strategy. Retrieved June 2021, from <https://yukon.ca/sites/yukon.ca/files/emr/emr-yukon-biomass-energy-strategy.pdf>

Yukon Native Brotherhood [YNB]. (1973). Together today for our children tomorrow: A statement of grievances and an approach to settlement by the Yukon Indian People. The Council for Yukon Indians. Retrieved May 2022, from <https://yukon.ca/sites/yukon.ca/files/eco/eco-ar-together-today-for-our-children-tomorrow.pdf>

Yukon Research Centre (2019). Aklavik Variable Speed Generator Analysis. Technical Report. Yukon Research Centre, Yukon College. Whitehorse, Yukon.

Yurkowski, D.J., Hussey, N.E., Ferguson, S.H., and Fisk, A.T. (2018). A temporal shift in trophic diversity among a predator assemblage in a warming Arctic. *Royal Society Open Science, 5*(10), 180259. Retrieved February 2022, from <https://doi.org/10.1098/rsos.180259>

Zucconi, A. and Karn, J. (2019). The MSC's Collaborative Monitoring Initiative & Risk Based Approach to Hydrometric Network Design. Presented at the Prairie Provinces Water Board Workshop November 28, 2019. Retrieved April 2022, from <https://www.ppwb.ca/uploads/media/5df7f6c98ac64/presentation-8-jeffalex-eccc.pdf?v1>