



Canadian Polar Commission
Commission canadienne des affaires polaires

The State of NORTHERN KNOWLEDGE IN CANADA



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This report is a key Canadian contribution towards the Third International Conference on Arctic Research Planning (ICARP III), a transformative priority-setting exercise that will provide a roadmap to guide research-focused organizations across the globe in their Arctic research planning and delivery over the next decade. Please visit <http://icarp.arcticportal.org/> for more information.



Cover:
Debbie Iqaluk, from Resolute Bay, looks for trilobites on Truro Island, Nunavut.
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Mandate of the Canadian Polar Commission

Established in 1991, the Canadian Polar Commission is Canada's primary polar knowledge agency and has responsibility for:

- Monitoring polar knowledge in Canada and around the world;
- Working with Canadian and international institutions to determine scientific and other priorities;
- Encouraging support for Canadian polar research;
- Communicating polar research information to Canadians; and,
- Fostering international cooperation in the advancement of polar knowledge.

In carrying out its mandate the Commission builds and maintains polar knowledge networks, hosts conferences and workshops, publishes information regarding the polar regions, and works closely with other governmental and non-governmental partners to promote and support Canadian polar knowledge.

The Commission serves as Canada's primary point of contact with the circumpolar knowledge community, and is Canada's adhering body to the International Arctic Science Committee (IASC) and the Scientific Committee for Antarctic Research (SCAR). In addition, the Commission maintains liaison with research organizations and institutes throughout the circumpolar world, providing guidance into bi-lateral and multi-lateral scientific projects relevant to Canadian interests.

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Message from the Board of Directors

The Canadian Polar Commission's mandate requires it to monitor and report to Canadians on the state of knowledge of the polar regions. The focus of this report is the Canadian North, comprising Yukon, Northwest Territories, Nunavut, Nunavik in northern Quebec, and Nunatsiavut in northern Newfoundland and Labrador.

The purpose of this report is to inform Canadians, especially those living in Canada's North, of the state of northern research so they can better influence its direction. It will also assist decision-makers in identifying and acting on those key knowledge gaps most critical to Northerners and the Canadian North. This report also provides an opportunity to reflect on the praiseworthy work carried out by our nation's community of northern researchers. Their collective efforts, the calibre of their work, and their accomplishments are a source of national pride.

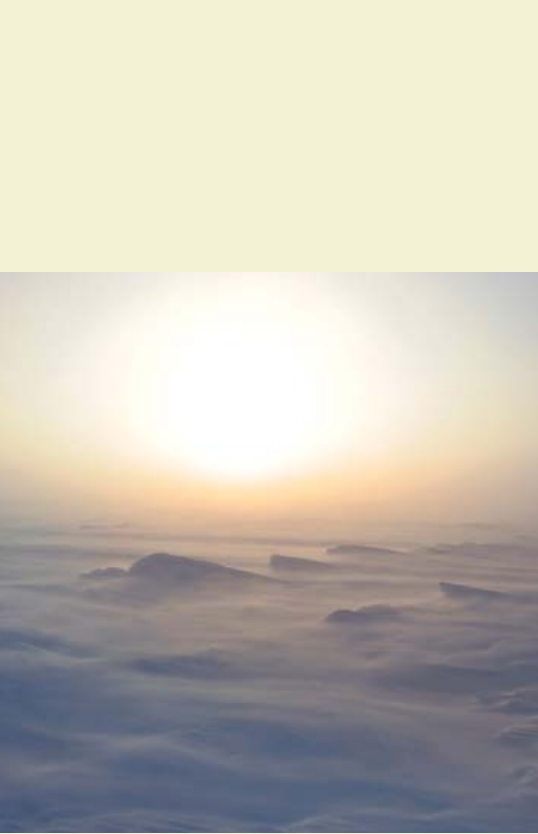
The published research considered in this report is the product of one of the busiest, most fruitful periods of scientific investigation in the history of the Canadian North, the seven-year period starting with International Polar Year in 2007. The knowledge gains of this period raise new questions that will set the course of northern research for years to come. This report examines those gains and some of the pressing knowledge gaps that remain in order to chart that course forward. The timing is opportune, coinciding as it does with a number of other inter-related circumstances each important to the future of northern research in Canada. These include:

- Canada's current leadership of the Arctic Council, the dominant international forum for circumpolar cooperation in northern knowledge creation
- Increasing political and economic empowerment of Northerners—exemplified most recently by the devolution of responsibility for lands and resource management to the Government of the NWT—which is gradually shifting control of the research agenda northward
- Recent \$85 million revitalization of Canada's network of northern research facilities, better equipping them to meet the varied and complex needs of northern research
- Planned opening in 2017 of the Government of Canada's signature deliverable under its integrated Northern Strategy, the world-class Canadian High Arctic Research Station (CHARS) in Cambridge Bay as a catalyst for the next wave of targeted northern research
- Ongoing advances in Aboriginal self-government taking place throughout the region and their positive effects on government policies, including how research is undertaken
- Heightened northern interest on the part of Canadians

Consistent with Canada's Northern Strategy, this report focuses on the need for science and technology to support sound decision-making. As such, "knowledge to action" research is emphasized, consisting of new knowledge that translates readily into improved policies, programs, interventions and services with a near- to mid-term time horizon. Since Northerners have the greatest vested interest in northern research, the focus of this report is also on knowledge gains and opportunities that align with the priorities of Northerners. This knowledge creation value is illustrated in the research project "vignettes" that are highlighted in this report. These vignettes showcase examples of northern collaboration, involvement and leadership, attributes of northern knowledge creation that the Canadian Polar Commission strongly endorses.

In closing, the members of the Board wish to express their gratitude to all those who have contributed over the past 18 months to the creation of this report.





Introduction

Canada's North is undergoing significant change driven by a number of complex factors, some global in nature, others rooted in the dynamics of the region's unique history, and others stemming from the increased empowerment of Aboriginal peoples through settled comprehensive land claims. These changes have overlapping consequences for Northerners, their communities, their cultures, their natural and built environments, the northern economy, and Canada as a nation. This interconnectedness makes it difficult to discuss human health and well-being, for example, without touching on the issues of overcrowded housing, the cost of living, building technologies and the warming of permafrost.

To reflect the interconnected consequences of this change, and in turn, the interdisciplinary responses that are required, the Commission has identified four over-arching functional themes. They are based on a thorough analysis of recurring and inter-related issues and research priorities of Northerners, identified in the literature and by informants, especially those who are based in the North. These themes provide the framework for our analysis and the context for our findings. The four themes are the following:

- **Preparing for large-scale resource development**—which includes employment and training, understanding and mitigating negative impacts, governance, and mapping and surveys
- **Increasing community sustainability**— which includes housing, infrastructure, transportation, energy security, food security, supporting local and regional economies, and health care systems
- **Strengthening resilience**— which includes determinants of health, impacts of socio-economic and cultural change, Inuit suicide, education and cultural preservation, fetal alcohol spectrum disorder, and physical health including tuberculosis, obesity, cancer, and lower respiratory tract infections
- **Understanding environmental change**—which includes the cryosphere, ocean and marine ecosystems, terrestrial ecosystems, pollutants and contaminants, and monitoring

This report views northern research in terms of what is beneficial to the people who live in the region. The institutional barriers to greater local influence over northern research, while relevant, are systemic issues beyond the scope of this report. Public policy focused research also falls largely outside the scope of this report. Research focused on the humanities, including the epistemological study of traditional or indigenous knowledge systems, is significant and vast, and therefore merits a separate, in-depth investigation. The interview, literature review and validation phases of this study have confirmed to us the crucial value of traditional knowledge to northern research, especially in the environmental and social domains. We have attempted to reflect this in corresponding areas of this report.

Finally, a word must be said about the physical sciences which, especially in the Arctic, are foremost in their contribution to the global understanding of climatic change. Other national and international research and policy agencies are evaluating physical science gains and gaps as part of their own far-reaching priority-setting and research planning activities for the polar regions, including the Canadian North. As a consequence, the physical science aspects of this report concentrate primarily on those environmental research questions with more immediate "knowledge to action" potential for Northerners, especially in terms of personal and community well-being.

In closing, Canada is not unique in the world for its heightened interest in northern knowledge creation. Other nations have embraced the challenge. The result is an unprecedented opportunity for global expansion of northern knowledge. For the sake of focus, this report concentrates primarily on those key knowledge gains and gaps specifically relevant to the Canadian North and its people.

How This Study Was Conducted

Our methodology was developed and the study initiated under the guidance of a five-person advisory committee of northern research specialists.¹ This support was supplemented by ongoing consultations with the science advisors of the governments of Yukon, Northwest Territories and Nunavut, as well as other northern experts. The study focuses on knowledge gains primarily during the seven-year period commencing with International Polar Year in 2007. As an initial step, some 114 subject matter experts were engaged in semi-structured interviews, two-thirds of them based in northern Canada. These informants were asked to identify key research gains, gaps and opportunities within their areas of expertise. Their observations were validated and supplemented with peer reviewed and “grey” literature.

The resulting input was analyzed to identify predominant cross-cutting functional themes. The data were screened for key gains, gaps and opportunities, organized by themes areas, then reviewed and prioritized with input from northern research experts in terms of relevance to Northerners and alignment with northern priorities. This report constitutes the Commission's high-level synthesis of the resulting output.

Methodological hurdles include the challenging volume of research implicit in the report's comprehensive scope and time period covered, as well the limited time and staff resources available to undertake this effort. A detailed methodology and subject area summaries will be made available on the Canadian Polar Commission's website as a compendium to this study:

<http://www.polarcom.gc.ca/eng/content/download-northern-knowledge-report>



Natural Resources Canada's Polar Continental Shelf Program

Established in 1958, Natural Resources Canada's Polar Continental Shelf Program (PCSP) assists scientists from around the world to better understand the Arctic by providing Canadian and international research teams with cost-effective, safe and coordinated field logistics and support services.

These services are crucial to working in the Canadian Arctic, where remoteness, a harsh climate, and rapidly changing weather make it challenging to conduct research. With the help of PCSP, however, scientists continue to safely visit and study this region. In doing so, they are expanding our knowledge of and our respect for the Arctic.

Every year, PCSP serves as many as 1100 researchers and students annually. Through its Arctic logistics hub in Resolute and its field equipment hub in Ottawa, PCSP supports 140 projects a year on average in field camps spread across the Arctic. Researchers count on PCSP as a reliable and cost-effective source of research equipment, supplies and support and look to PCSP for expert advice from trained individuals who know the Arctic first-hand.

¹ The Advisory Committee consisted of: Dr. Frances Abele (Chair) – Professor, School of Public Policy and Administration, Carleton University; Jean-Marie Beaulieu – Senior Science Advisor, Canadian Polar Commission; Dr. Carolyn Relf – Director, Yukon Geological Survey; Dr. David J. Scott – Executive Director, Canadian Polar Commission; and Tom Sheldon – Director, Environment Division, Nunatsiavut Government



Findings

Preparing for Large-Scale Resource Development *through knowledge focused on mitigating impacts and maximizing benefits*

Overview

Mineral and oil and gas exploration, development and production will be the primary private sector drivers of Canada's northern economy for the foreseeable future (Huntington, 2007; Prowse & Furgal, 2009; Kativik Regional Government & Makivik Corporation, 2010; The Conference Board of Canada, 2010; Centre for the North, 2011; Rhéaume & Caron-Vuotari, 2013). There are few people across the region whose lives are not already impacted by the mineral and fossil fuel industries. Projected long-term demand for energy, metals and precious gems accompanied by shrinking global reserves will continue to gradually shift competitive advantage to the region's high cost deposits prompting future growth of the North's non-renewable resource sector (Huntington, 2007; Kesler, 2007; Deloitte, 2010; Rhéaume & Caron-Vuotari, 2013). That will further strengthen the economic predominance of the minerals and fossil fuels in the region. Meanwhile, Northerners expect that resource development will provide meaningful economic benefits to their regions, that development will proceed in a sustainable manner and that negative environmental and social consequences be minimized.

Recent Advances and Current Challenges

Employment and Training

- The northern minerals sector is characterized by high wages (Sisco & Stonebridge, 2010) and is a major contributor to the quality of northern life. However, the employment benefits of resource development in the North have been unevenly distributed in favor of those with the requisite skills. The education and skill levels of many Aboriginal Northerners can limit both their employment and advancement prospects in the industry (Fenge, 2009; Sisco & Stonebridge, 2010; Howard et al., 2012). Some ways in which Aboriginal workers can be better engaged, supported and retained have been examined (Martin, 2011; Howard et al., 2012). However, in the face of a persistent northern skills gap (Fenge, 2009; Howard et al., 2012), resource development companies continue to hire significant numbers of workers from southern Canada (Fenge, 2009; CBC News, 2013) while many Aboriginal Northerners remain unemployed or under-employed.

Understanding and Mitigating Impacts

- Some Northerners are concerned about the strain that increased industrial development can place on the environment and on their communities (Centre for the North, 2011). There is a better understanding of some of the socio-economic impacts of northern resource development (e.g. Gibson & Klinck, 2005; Buell, 2006; Bowes-Lyon et al., 2009; Storey, 2010; Haley et al., 2011; Peterson, 2012; Davison & Hawe, 2012). Also, more indicators are available to assist in assessing socio-economic conditions (Duhaime & Caron, 2009). There is also more data regarding the environment, driven in part by regulatory requirements (Centre for the North, 2011) and by such multi-stakeholder research initiatives as ArcticNet's Integrated Regional Impact Studies and the Beaufort Regional Environmental Assessment (BREA). However the extent of resource development in the North is creating a continued need for ever more varied and detailed baseline data to better assess change, to appropriately regulate development, to guide adaptive strategies and minimize negative impacts (Huntington, 2007; Centre for the North, 2011; Christensen et al., 2013).



The NWT Cumulative Impact Monitoring Program
(Aboriginal Affairs and Northern Development Canada): Partners in baseline stream sampling

The NWT Cumulative Impact Monitoring Program collects, analyzes, and disseminates key environmental information, contributing to informed resource management decisions. Designed and guided by Northerners, its study of the health of streams in the Mackenzie River basin between Tulita and Norman Wells, where oil and gas exploration is taking place, includes a water quality and stream health assessment program designed with input from communities, academics, and regulators from the Sahtu Land and Water Board. Elders, as well as other community members, identified traditionally important sites in oil and gas exploration areas. The study, which began in April 2013, is sampling streams throughout the watershed to determine baseline conditions.



Governance

- If the decisions of land management regimes, especially co-management bodies, are to have meaning for Aboriginal Northerners, their regulatory practices, procedures and governance structures must reflect local cultural values. White (2005, 2006), Dowsley (2009) and others have shed light on the functioning of northern co-management boards and the issue of their compatibility with Aboriginal perspectives. We also know more about 'social license to operate' in a mining context and the underlying implications of governance arrangements for industry-community relations (Prno & Slocombe, 2012). However the workings and outputs of the North's regulatory mechanisms need still further attention if approved projects are to proceed with sufficient degrees of social license.

Mapping and Surveys

- Much has been learned through private sector exploration initiatives, the activities of provincial and territorial geosciences offices and the Geological Survey of Canada, and as a consequence of Natural Resources Canada's Geo-mapping for Energy and Minerals (GEM) Program. That federal program, renewed to 2020, has produced some 700 geoscience maps and reports on the Canadian North since 2008 (Natural Resources Canada, 2012). However, the vastness and remoteness of the Canadian North means large tracts remain insufficiently mapped and assessed. This includes the bathymetry of the region's marine shipping channels (Arctic Council, 2009).

Knowledge Gaps and Research Opportunities

Employment and Training: Further knowledge is needed respecting

- models of Aboriginal learning in order to improve academic success and skills acquisition while respecting Aboriginal culture and language; this applies to both young people and adult learners (Rogers & Rowell, 2007; Berger, 2007 & 2009; Ronning & Wiborg, 2008; Aylward, 2009; Higgins, 2011; Lafferty, 2012; Sisco et al., 2012; Ayres, 2012; Ross, 2012). Such research must demonstrate gender-sensitivity where necessary (Ilitaqsiiniq-Nunavut Literacy Council, 2012)
- factors affecting recruitment and retention of Aboriginal employees in the wage economy, especially the large-scale, non-renewable resource industry (Université Laval, 2012; Howard et al., 2012).

Understanding and Mitigating Impacts: Further knowledge is needed respecting

Socio-economic and cultural impacts

- socio-economic and cultural impacts of prolonged major resource development on Aboriginal peoples, their communities and families, including the effects of fly-in/fly-out arrangements (Gibson & Klinck, 2005; Angell & Parkins, 2011; Davison & Hawe, 2012; Schweitzer et al., 2013; Resources and Sustainable Development in the Arctic, 2013a)
- resilience indicators and models in order to improve our understanding of the ways in which impacts are distributed, experienced and mediated (Gibson & Klinck, 2005; Angell & Parkins, 2011). This includes the extent to which resource development activities may contribute to family breakdown, family violence, and addictions (Gibson & Klinck, 2005)
- the needs of communities in order to support the collection of culturally appropriate, community-based socio-economic and environmental data to measure impacts and inform standards, legislation, policies and programs (Hallett, 2005; Angell & Parkins, 2011; Centre for the North, 2011).

Environmental impacts

- how northern ecosystems (including terrestrial, coastal, freshwater, and marine) function, and how environmental and human-induced change will affect those ecosystems, including cumulative effects (Post et al., 2009; Conservation of Arctic Flora and Fauna, 2010; Arctic Monitoring and Assessment Program,

2012; Conservation of Arctic Flora and Fauna, 2013). As well, more data is needed to better understand base-line conditions (Conservation of Arctic Flora and Fauna, 2010; Arctic Monitoring and Assessment Program, 2012)

- climate change impacts on oil and gas exploration, production and delivery to inform adaptive measures and technologies (Prowse & Furgal, 2009). Similarly, further research is needed to adapt mining infrastructure (including tailings retention structures and storage sites) to climate change in both the operational and post-operational phases (Prowse & Furgal, 2009; Pearce et al., 2011).

Governance: Further knowledge is needed respecting

- the dynamics of co-management and other resource governance regimes, including factors that can strengthen or undermine their effectiveness (Caulfield, 2004). The regions' resource management and regulatory boards, many born out of Aboriginal land claims, are still in their formative stages. Research is needed to inform the evolving operations of these governance innovations to ensure the developments they regulate proceed with a sufficient degree of 'social license' (Prno & Slocombe, 2012).
- means for adequately incorporating climate change considerations into the assessment and regulation of large-scale resource development projects (Pearce et al., 2011)
- the development of best practices and templates for negotiating and advocating for appropriate process and content in impact and benefit agreements (IBAs) (Knotsch & Warda, 2009; Southcott & Irlbacher-Fox, 2009). As well, there is a need to identify alternatives to IBAs that have the potential to enhance economic development and social justice for communities (Bradshaw, n.d.).

Mapping and Surveys: There is a need to

- undertake further geological mapping in the Canadian North (including the three territories and northern parts of provinces) to meet modern international exploration standards and land-use planning needs (Benoit, 2012), especially the sedimentary basins of the eastern and western Arctic and Hudson Bay, the Canadian Shield of the central Arctic, and the High Arctic Islands and northern mainland (A. Leclair, Geo-mapping for Energy and Minerals Coordinator, Natural Resources Canada, personal communication, March 4, 2014)
- increase and update hydrographic data and charting to support safe navigation (Wright, 2012). This is particularly important in the face of retreating multi-year Arctic sea ice with its potential implications for increased marine traffic in the Canadian Arctic (Arctic Council, 2009)
- examine Arctic shipping regulations and standards to ensure they are appropriate to the levels of human and environmental risk (Arctic Council, 2009; Chircop, 2009).



ReSDA: Bridging the link between resource development and sustainable communities

ReSDA, a circumpolar social sciences research network, looks at the social impacts of resource developments to help find ways of increasing community benefit from these developments. The network is funded mainly by the Social Sciences and Humanities Research Council of Canada (SSHRC) with financial and in kind support from its many northern partners and researchers.

ReSDA supports the establishment of five regional social science lab facilities with funding from the Canada Foundation for Innovation (CFI). These will assist social science research in the Yukon, Northwest Territories, Nunavut, Nunavik and Labrador through the ReSDA northern partner offices at the Yukon Research Centre, Aurora Research Institute, Nunavut Research Institute, Makivik Corporation and the Labrador Institute. The new labs will provide dedicated resources to build local capacity for research that looks for ways to sustain and improve the health and well being of Canada's northern communities.



Increasing Community Sustainability through knowledge of the material aspects of northern living

Overview

Many of the 99 communities of the Northwest Territories, Yukon, Nunavut, Nunavik and Nunatsiavut are isolated and widely scattered. Approximately half of those communities have a population of five hundred people or less (Statistics Canada, 2011c), and less than half have all-weather road connections with the rest of the country (Government of Yukon et al., 2008; Kativik Regional Government & Makivik Corporation, 2010; Goldhar et al., 2012). The cost of living, cost of public services and construction costs are among the highest in the world.

Although the region is endowed with significant natural resources, distance to and from markets and inadequate transportation infrastructure are significant impediments to the development of those resources. However, remoteness has also been a buffer, especially at the settlement, hamlet and village levels where traditional cultures still predominate and the connection with the land remains relatively intact. It is in these smaller northern communities that the question of sustainability weighs most heavily as they attempt to balance new expectations with traditional values, wage employment with subsistence pursuits, and “splendid isolation” with the paucity of public and commercial services they face. Research can play an important role in helping northern communities, organizations, and governments find the balance needed for secure, sustainable community futures.

Recent Advances and Current Challenges

Affordability

- The high cost of living is central to the sustainability of northern communities (Bolton et al., 2011; Pulla, 2012). This is especially the case in smaller communities where lower median and average wages (Kativik Regional Government & Makivik Corporation, 2010; Statistics Canada, 2011a & b) make affordability an issue of far-reaching consequences (Sisco & Stonebridge, 2010; Kativik Regional Government & Makivik Corporation, 2010; Goldhar et al., 2012). Northerners, especially Aboriginal Northerners, cite the cost of living almost as frequently as climate change as a quality of life concern (DataPath Systems, 2007).

Growing Local and Regional Economies

- Changing markets and historic sectorial declines have altered the economic foundations of a number of northern communities leaving many largely reliant on government employment and transfer payments. The sustainability of others is affected by dependence on a single industry or the general depth of their economic base. These economic weaknesses can be offset in part by the economic and social contribution of subsistence, traditional and not-for-profit activities, with positive synergies noted between wage and traditional economies (Natcher, 2008 & 2009; Southcott & Walker, 2009). The role of entrepreneurship as a generator of employment and diversification is also better understood, as are entrepreneurial barriers unique to the region and some means of overcoming them (Mason et al., 2007, 2008 & 2009; Walker, 2009; Sisco & Stewart, 2009). Some sectors such as the knowledge sector in the Yukon and the northern film industry have been examined to identify how their economic contributions could be strengthened (Outcrop Communications, 2011; Lutra Associates, 2011; Voswinkel, 2012). Some economic development and diversification opportunities have also been examined in Nunatsiavut and Nunavik in the context of community and regional sustainability (Kativik Regional Government & Makivik Corporation, 2010; Goldhar et al., 2012; Rodon & Schott, 2013; Makivik Corporation, 2013). Also notable are major economic planning initiatives currently underway or completed in each of the three territories (Yukon Economic Development, 2006; Nunavut Economic Forum, 2012; NWT Chamber of Commerce et al., 2013). However, additional scholarship is needed to further support economic diversification, job creation, entrepreneurship and social economies at the regional and community

levels and to address the competitive disadvantages faced by communities throughout the region (Petrov, 2008; Abele, 2009a; MacPherson, 2009; Walker, 2009; Olfert & Natcher, 2013; Southcott, in press).

Climate Change and Infrastructure

- Climate change makes infrastructure a critical research issue in Canada's North. This is due to the effects of warming permafrost on soil stability and the consequences for structural integrity (Allard et al., 2012). Much has been learned about the implications of climate change on the built environment, with some progress made and other initiatives underway to assess infrastructure vulnerability, improve infrastructure monitoring and engineering tools and approaches, test and adapt building technologies, develop operations and management guidelines, and adapt building codes and standards to better cope with environmental change (e.g. I. Holubec Consulting, 2008; National Round Table on Energy and the Environment, 2009; Transportation Association of Canada, 2010; BGC Engineering, 2011; Université Laval, 2011; National Research Council, 2011; Allard et al., 2012; Standards Council of Canada, 2012; Morse & Doré [Eds.], 2012; Boucher & Guimond, 2012; CSA Group, 2012; Yukon College, 2012). Much has also been learned about permafrost degradation processes, some of the factors that can aggravate or accelerate degradation, and the associated consequences (e.g. Natural Resources Canada, 2007; Transportation Association of Canada, 2010; Université Laval, 2011; Allard et al., 2012; Coulombe et al., 2012; Boucher & Guimond, 2012). The magnitude of environmental challenge calls for improved climate data and projections as well as more infrastructure vulnerability assessments and ongoing monitoring, and further research to inform engineering approaches, and guidelines and tools to support practitioners (I. Holubec Consulting, 2008; National Round Table on Energy and the Environment, 2009; Prowse et al., 2009; Ford et al., 2010a; Bristow & Gill, 2011; BGC Engineering, 2011; Allard et al., 2012).

Housing

- Residential housing can be viewed from a climate change perspective. But it also presents critical research challenges from the socio-economic, micro-economic, and public and mental health perspectives. This is especially the case in the smaller communities where, due to low incomes and limited housing stock, there can be a substantial reliance on public housing. There has been more documentation of housing conditions (The Bayswater Consulting Group Inc., 2005; Kativik Regional Government & Makivik Corporation, 2010; Minich et al., 2011; Nunavut Housing Corporation, 2012a; Government of Newfoundland and Labrador, 2013) and the relationship between housing and health and social conditions (Kovesi et al., 2007; Verhille et al., 2009; Knotsch & Kinnon, 2011). Inuit in particular face some of the most crowded housing conditions in Canada (Kativik Regional Government & Makivik Corporation, 2010; Knotsch & Kinnon 2011; Sheppard & Hetherington, 2012).

Access to Country Food

- Traditional game meats such as seal, moose, geese and caribou offer relief from imported, store-bought food, especially for First Nations, Métis and Inuit, and particularly in small communities. Subsistence harvesting is also a way of life and a means to transfer culture and community values (Nickels et al., 2006; Schuster et al., 2011). However a dependence on game leaves communities vulnerable to fluctuations in wildlife populations (Meakin & Kurvits, 2009), as is currently the case with the Bathurst, George River and South Baffin caribou herds. Vulnerabilities are heightened by climate change with its unpredictable effects on the wilderness travel conditions faced by hunters and fishers (Ford, 2009; Ford & Pearce, 2010). The culturally induced shift from country foods to store-bought products presents food security issues, especially in light of the cost of imported foods and their varying nutritional content. Some of the implications of the latter, such as nutrition related diseases and conditions have been examined (Kuhnlein et al., 2004; Egeland et al., 2011; Huet et al., 2012; Aboriginal Affairs and Northern Development Canada, 2012a).

Other Food Security Issues

- There is an improved understanding of some of the other factors affecting the food security of Northerners. For example, the Council of Canadian Academies recently completed a major assessment of factors such as country food and market/imported food systems, environmental change, intergenerational well-being, and



Yukon Research Centre: Forecasting hydro security for the future of the Yukon

The Yukon Research Centre is working with Yukon Energy Corporation (YEC) and the Yukon Geological Survey to assess how climate change will affect the Yukon River headwaters. Those headwaters feed the Whitehorse dam, which supplies electricity for much of southern Yukon. The project, which has \$790,000 of shared funding from the YEC and the Natural Sciences and Engineering Research Council of Canada, will gather data from the glaciated headwaters of the Yukon River to help create hydrological and glaciological models that will provide important insights into the hydro security of Yukon. These tools will predict how a changing climate will alter the flow of the Yukon River, and will allow Yukon Energy to operate their hydropower facilities efficiently under different levels of demand for electricity.



governance. Potential long-term health and well-being implications of food insecurity, such as increased incidence of chronic disease were also highlighted (Council of Canadian Academies, 2014). Initiatives such as greenhouses and community freezers have been developed and implemented in some communities in response to food security challenges (Prowse & Furgal, 2009). However, with the varying contextual factors and levels of adaptive capacity within communities and regions (Lambden et al., 2006; Wesche & Chan, 2010; Council of Canadian Academies, 2014), further understanding of food security determinants is needed to inform evidence-based policies, programs and interventions with evaluations to understand their effectiveness (Institute of Nutrition, Metabolism, and Diabetes, 2010; Organ, 2012; Council of Canadian Academies, 2014).

Health Care Systems

- Isolation and a widely dispersed population pose key challenges in the delivery of health care in northern Canada (Romanow, 2002; Yukon Health Care Review Steering Committee, 2008; Nunavut Tunngavik Inc., 2008; Health and Social Services – Government of the Northwest Territories, 2011). Such circumstances can lead to fragmented and uncoordinated health care delivery (Nunavut Tunngavik Inc., 2008; King et al., 2009; Ford et al., 2010b; Cameron, 2011). Low patient thresholds outside the major centres exacerbate these delivery problems and contribute to health care inequities (Marrone, 2007; King et al., 2009; Ford et al., 2010b; Cameron, 2011). The health care practices of some other circumpolar countries have been studied for their relevance to the Canadian North (Young & Chatwood, 2009). Some organizational and delivery alternatives have been examined (Mitton et al., 2011). As well, some e-Health initiatives implemented in the North have been examined, providing better understanding of the ways in which implementation challenges can be overcome and some of the socio-technical barriers to their use (Peddle, 2007; Powers, 2011). However, given the region's wide diversity, disparities in the provision of local services, the high cost of delivery and the fundamental importance of community-based health care, more research is needed at the pan-northern, regional and community levels.

Knowledge Gaps and Research Opportunities

Affordability: Further work is needed respecting

Renewable energy and conservation

- the adaptation and marketing of renewable energy systems and technologies to help reduce the region's dependency on high cost fuel oil, especially in small northern communities. This includes energy-complement technologies and cost-effective energy storage technologies (Energy, Mines and Resources – Yukon Government, 2009; National Energy Board, 2011; Rodon & Schott, 2013)
- the adaptation and marketing of energy efficiency and conservation programs and initiatives to reduce energy consumption (Energy, Mines and Resources – Yukon Government, 2009; A Northern Vision, 2011; Nunavut Housing Corporation, 2012b)
- low-cost, energy-efficient building envelope options and cost-effective cold climate building technologies (Northwest Territories Housing Corporation, 2008; Pulla, 2012)

Transportation

- the full range of life-cycle costs and benefits associated with transportation infrastructure investment by means of quantitative analysis (Bristow & Gill, 2011)
- the best balance of responsibilities between the public and private sectors with respect to developing and maintaining northern transportation systems (Bristow & Gill, 2011)

Municipal service delivery

- best practices for the cost-effective delivery of municipal services in isolated, remote and harsh climates (Government of the Northwest Territories, 2009).

Growing Local and Regional Economies: Further knowledge is needed respecting

Economic development

- the internal development of the regions of Canada's North through a synthesis of existing economic research to better understand the internal dynamics of regional economies (Abele, 2009a)
- northern and Aboriginal entrepreneurship, especially that generated and directed by Aboriginal peoples, in order to inform appropriate policies and programs that can more effectively address barriers to entrepreneurship (Peredo et al., 2004; Walker, 2009; Hindle & Moroz, 2009)
- community-level social capital, networks and conditions to help inform long-term sustainable economic development policies (Olfert & Natcher, 2013)
- cultural preconditions for successful socio-economic development, including the influence of evolving relations between Aboriginal peoples and other northern residents on the northern social economy (Southcott, in press)

Labour force

- the relationship between northern education systems and local/regional labour markets (Ronning & Wiborg, 2008), including longitudinal analyses to track both Aboriginal and other northern students in order to better understand education and mobility including learning-to-work transitions and the pathways of different population groups (Hodgkins, 2013)
- labour force characteristics at the industry and community levels as well as the capacity of multi-stakeholder partnerships to improve training strategies and labour force capacity (Martin, 2011)

Fisheries

- commercial fisheries opportunities, including their identification and how to sustainably develop them (Rompeky & Patterson, 2010)

Tourism

- external and community factors influencing northern tourism as well as the cultural, social, environmental and economic impacts of northern tourism (Stewart et al., 2005)
- the management of tourism in the face of rapid environmental change (Economic Development & Transportation – Government of Nunavut, 2013; Johnston et al., 2013)

Forestry

- ways to build local forest management capacity through participation in research and monitoring (Ogden & Innes, 2009; Energy, Mines and Resources – Yukon Government, 2011), as well as the economic benefits associated with the forestry sector.

Climate Change and Infrastructure: Further knowledge is needed respecting

- the implications of climate change for built environments, by means of improved data collection, modeling and projections, with a view to informing infrastructure planning, design, construction, operations and maintenance, and monitoring (National Round Table on Energy and the Economy, 2009; Prowse et al., 2009; Ford et al., 2010a; BGC Engineering, 2011; Bolton et al., 2011; Bristow & Gill, 2011; Allard et al., 2012)



Ikaarvik: From Barriers to Bridges

The Ikaarvik: From Barriers to Bridges project is a collaboration led by the Vancouver Aquarium and its partners in five Inuit communities in Nunavut's Kitikmeot and Qikiqtaaluk regions, ArctiConnexion, research scientists, zoos, and aquariums that is building partnerships between communities and scientists to study and address issues ranging from food security to socio-economic capacity building. The partners will integrate their different ways of knowing and describing the world to identify each community's research priorities, and then plan, conduct and interpret the research. One example is the Canadian Rangers Ocean Watch (CROW), which trains Inuit to collect oceanographic data on factors such as temperature, salinity, dissolved oxygen and productivity that could have significant food security implications. Through Ikaarvik, the communities will become active partners in the CROW research. Through these partnerships, the communities are empowered to ensure that the knowledge gained will lead to meaningful action on the issues that impact them directly. This project was a winner of the 2013 Arctic Inspiration Prize.



- improved methods for detecting and characterizing permafrost (Allard et al., 2012)
- solid waste management options in a changing northern environment, including their identification and assessment, with a view to determining waste capacity levels, storage impacts, and how permafrost and solid waste interact including the extent of associated impacts (Government of the Northwest Territories, 2009).

Housing: Further knowledge is needed respecting

- the relationship between housing and socio-economic conditions to inform housing and socio-economic policies and programs (Knotsch & Kinnon, 2011; Nunavut Housing Corporation, 2012a)
- factors that will affect housing demand in the future including the demand for various types of accommodation along the housing continuum (Nunavut Housing Corporation, 2012a; Pulla, 2012)
- risks associated with residential construction in small northern communities with a view to strengthening private housing and rental markets (Nunavut Housing Corporation, 2012b).

Food Security: Further knowledge is needed respecting

- environmental, social, cultural and economic factors effecting food security from a multi-disciplinary, community-based perspective, with links to similar regional and pan-northern assessments (Allard et al., 2012; Ford & Pearce, 2012)
- food security implications of climate change (Furgal, 2008; Meakin & Kurvits, 2009) and of the loss of traditional knowledge (Meakin & Kurvits, 2009; Université Laval, 2012; Allard et al., 2012)
- population dynamics and habitat productivity of species that provide significant contributions within the country food system (Université Laval, 2012)
- impact of changing food webs on the occurrence and behaviour of game species (Arctic Monitoring and Assessment Program, 2009b; Donaldson et al., 2010; Conservation of Arctic Flora and Fauna, 2010 & 2013)
- the impact of a warming climate on wildlife diseases that are zoonotic or have an effect on wildlife population health (Prowse & Furgal, 2009; Davidson et al., 2011).

Health Care Systems: Further knowledge is needed respecting

- the state of public health by means of enhanced surveillance (Indian Health Service, 2008; Nunavut Tunngavik Inc., 2008; Young & Chatwood, 2009; Ford et al., 2010b) to better gauge trends, detect public health threats and support planning
- patterns of disease transmission between northern communities to better inform intervention strategies (Parkinson & Evengård, 2009)
- how to enhance the efficacy of e-Health in addressing respiratory diseases in remote communities (Wesche et al., 2011)
- the appropriate distribution of medical services between those provided locally and those accessed from a distance through medical evacuations (Mitton et al., 2011).

Strengthening Resilience

through knowledge focused on individual and cultural well-being

Overview

The North's most important resource is its people. Northerners are resourceful and adaptive, stemming, in the case of its Aboriginal peoples, from deep relationships with the land transmitted across generations in a cumulative manner (Andrews & Buggey, 2008; Aporto, 2010; Berkes, 2012). However, the dislocating forces of northern history, government policy and social, environmental and economic changes have resulted in significant indigenous language loss as well as inequities in physical health, mental well-being, economic opportunity and living conditions. This has weakened cultural foundations (Usborne et al., 2009; Ford, 2009; Bolton et al., 2011) and influenced individual and community resilience, which can be defined as the ability to cope with stress or adversity. The consequences of this demonstrate the close interplay of cultural strength, mental and physical health and socio-economic circumstances. For instance, the suicide rates of Aboriginal Northerners significantly exceed those of other northern residents (Abele, 2009b; Cameron, 2011) as do rates of residential overcrowding, tobacco use, incarceration and unemployment (Latimer & Casey Foss, 2004; Fenge, 2009; Lix et al., 2009; Cameron, 2011; Knotsch & Kinnon, 2011; Sheppard & Hetherington, 2012; Office of the Correctional Investigator, 2013). This multi-dimensional dynamic underlines the value of integrated approaches to fostering human wellness.

Recent Advances and Current Challenges

Health Status and Determinants of Health

- The health status and health inequities between Aboriginal and other northern residents are better understood, as well as some of the social determinants associated with these inequities (Furgal & Seguin, 2006; Parkinson, 2008; King et al., 2009; Gracey & King, 2009; Reading & Wien, 2009; Egeland et al., 2010; Donaldson et al., 2010; Cameron, 2011; National Collaborating Centre for Aboriginal Health, 2012a & b; Peters, 2012; Reading & Halseth, 2013; Halseth, 2013). This includes documentation of higher rates of preterm birth, stillbirth and infant death, notably in Inuit communities (Luo et al., 2010). More baseline data on a range of determinants of Inuit health has also been gathered from the IPY Inuit Health Survey and a similar survey conducted in Nunavik to support the identification of health risks and inform evidence-based and targeted programs and interventions (Ancil [prepared by], 2008; Egeland et al., 2010; Cameron, 2011; Rosol et al., 2011; Huet et al., 2012; Owens et al., 2012; Chan et al., 2012). We also have a better understanding of the relationship between well-being and other factors such as employment opportunities, a sense of local control, and the availability of wildlife (Poppel et al., 2007).

Mental Health and Personal Well-being

- **Effects of socio-economic and cultural change:** There is greater knowledge of the direct and indirect effects of Canada's residential school system on the mental health of succeeding generations of Aboriginal peoples (Wesley-Esquimaux, 2007; Truth and Reconciliation Commission of Canada, 2012). This has been greatly augmented by work of the Truth and Reconciliation Commission of Canada (TRC) which has documented the extent of residential school and intergenerational trauma and is assembling considerable data on the subject. However, further understanding of "residential school syndrome," a form of post-traumatic stress disorder, is needed in support of healing so that families and communities can restore their spiritual, emotional and cultural values in ways that they choose (Robertson, 2006). As well, more is known about the effects of imported institutional norms, values and practices on Aboriginal mental health research and services (Nelson, 2012). This underscores the need for more culturally relevant interventions and systems of mental health delivery.



The Men's Project: Narrowing the Gender Gap

"Why are so many young Inuit men not in school, working or learning traditional skills?" This question, asked by elder Quluqaq Pilakapsi, initiated the development of the Northern Men's Research Project. A collaboration of the Nunavut, NWT, Yukon and Newfoundland and Labrador literacy councils, the purpose of this research project is to better understand the barriers that northern First Nations, Inuit and Métis men face and, most important, what will help them succeed. Locally trained researchers drive the research—from initial engagement and dialogue with community groups, through developing and asking research questions to the interpretation and sharing of results. Using respected community members as researchers facilitates local engagement, creates a positive experience for research participants and ensures the collection of useful data. This empowering process supports the development of relevant and meaningful program and policy recommendations that can work to support northern Aboriginal men's learning, work and well-being.



- **Inuit suicide:** Inuit, especially young males (Hicks, 2007), have among the highest suicide rates in the world (Tester & McNicoll, 2004; Kral et al., 2011; Oliver et al., 2012). Significant work has been done to better understand the determinants of Inuit suicide (Lehti et al., 2009; Hicks, 2009; Chachamovich & Tomlinson, 2013; Chachamovich et al., 2013), and implement and evaluate more Inuit-driven and community-based prevention initiatives (Kral et al., 2009). Still, significant knowledge gaps remain with respect to cultural and gender factors, prevention, treatment, as well as the broader community implications (Hicks, 2009; Sustainable Development Working Group, 2010; Cameron, 2011; Kral, 2012; Chachamovich et al., 2013).
- **Fetal alcohol spectrum disorder:** A report published by the National Collaborating Centre for Aboriginal Health (NCCAH) examined literature regarding the prevalence and incidence of Fetal Alcohol Spectrum Disorder (FASD) and Fetal Alcohol Syndrome (FAS) among Aboriginal peoples in Canada, noting that “the true extent of FAS and FASD among Aboriginal and non-aboriginal populations is not known and thus no assessment of higher prevalence is possible” (Pacey, 2009a). While little is known about the prevalence of FASD in northern correctional facilities, studies based on Canadian data suggest young people with FASD are as much as 19 times more likely to be incarcerated as those without in a given year (Popova et al., 2011). There is a need for more research on FASD and the criminal justice system (Pacey, 2009b; Popova et al., 2011). Several researchers note that FASD in northern communities can only be understood in light of the overall impact of the social determinants of health (Healey & Meadows, 2007; Badry & Wight Felske, 2013a). Salmon and Clarren stress the need to understand northern contexts in light of significant diversity while finding collaborative approaches that allow for knowledge transfer and capacity building amongst researchers and communities (Salmon & Clarren, 2011).

Education and Cultural Preservation

- **Culturally-based learning:** Educational research has added to our knowledge of non-formal, culturally-based learning initiatives for youth and adult learners, especially of the benefits (Driedger, 2009; Tulloch et al., 2012; Ilitaqiniq-Nunavut Literacy Council, 2013). From research conducted in Tuktoyaktuk, NT we also know more about some of the ways in which individuals negotiate between traditional and more formal ways of learning, and some of the factors that can impact learning opportunities (Salokangas & Parlee, 2009). An examination of a crime prevention program in Yellowknife highlighted the effectiveness of culturally-based and resiliency-focused education (Lafferty, 2012).
- **Aboriginal language acquisition:** We have a better understanding of dynamics of indigenous language acquisition and use in the context of a dominant outside language, including the contemporary value and use of traditional and multiple literacies (Balanoff et al., 2006). We know about the importance of establishing baseline skills in an indigenous language and the longitudinal relationship between that and the later acquisition of skills in a second language from research examining the use of Inuktitut along with French or English among Inuit students in Nunavik (Taylor et al., 2008; Usborne et al., 2009). We have a better understanding of the importance of first language instruction and culturally and contextually appropriate subject matter to improve success in formal education (Ayres, 2012).

Physical Health

- **Tuberculosis:** More is known about the state of tuberculosis (TB) in Inuit Nunangat where TB rates are “significantly higher than those of any other Canadian-born population group,” as well as some of the prevention, intervention and education activities that have been implemented in each of the regions (Demmer, 2011; Inuit Tapiriit Kanatami, 2013). While not specific to the North, TB-related research is being carried out to better understand outbreaks (e.g. Walker et al., 2013), to shorten treatment regimens (Inuit Tapiriit Kanatami, 2013) and to support the application of new technologies (e.g. Kirwan & Gilman, 2013). We have improved understanding of the critical problem of treatment adherence as a cause of initial treatment failure and disease relapse (Orr, 2010a), including the role of systemic, personal and societal factors and the need for strategies that focus more attention on the social context (Orr, 2010a & b).

- **Obesity:** We have more knowledge of the prevalence of obesity in Canada's North (Deering et al., 2009; Chateau-Degat et al., 2010; Galloway et al., 2012), where, in the case of Nunavut, the prevalence of severe obesity increased by nearly four times in the 12-year period ending in 2004 (Kellett et al., 2012). The problem of obesity among children and youth and its extent is better understood as a result of surveys in Nunavut and the Northwest Territories (Freeman et al., 2012; Owens et al., 2012). The need for the further development of obesity prevention and management strategies remains (Deering et al., 2009).
- **Cancer:** There is more knowledge respecting the growing rate of cancer in the North among Inuit (Kelly et al., 2008a & b), with lifestyle-associated cancers of the lung, breast and colon being among the most malignant of all diseases among Inuit (Friborg & Melbye, 2008). Some socio-economic characteristics such as housing and income have been identified as potential contributors (Carrière et al., 2012).
- **Lower respiratory tract infections:** Research has advanced our knowledge of the higher rates of hospital admission for lower respiratory tract infections (LRTIs) among Inuit children than among non-Inuit children (Young et al., 2007), and some of the associated risk factors such as overcrowding (Kovesi et al., 2006; Cameron et al., 2008; Banerji et al., 2009 & 2013). The significant costs of hospital admissions associated with LRTIs are also better understood (Banerji et al., 2013). Further work is, however, needed to develop and implement prevention strategies, especially in regions where there is an elevated occurrence (Banerji et al., 2013).

Knowledge Gaps and Research Opportunities

Health Status and Determinants of Health: *Further knowledge is needed respecting*

- the relationship between Aboriginal self-government, community control of health services, and health equity in Canada's North (Young & Chatwood, 2011)
- the social determinants of health among Aboriginal populations living in the North (King et al., 2009; Cameron, 2011; Sheppard & Hetherington, 2012)
- health outcomes from more local knowledge and observations obtained through the collection of long-term data that is comparable temporally and spatially (Furgal & Seguin, 2006)
- the development of more culturally appropriate indicators of health and well-being that reflect the values of Aboriginal peoples, such as the use of local country food (Cameron, 2011; Pauktuutit Inuit Women of Canada et al., 2012)
- the consequences of the shift from traditional foods to imported foods, specifically investigations into correlations and relationships between that and increasing levels of chronic diseases (Donaldson et al., 2010).

Mental Health and Personal Well-being: *Further knowledge is needed respecting*

Effects of socio-economic and cultural change

- the determinants of social and mental health among northern peoples, especially the impact of rapid socio-cultural change (Tester & McNicoll, 2004; Lehti et al., 2009; Kronstal, 2009; Whitbeck, 2010) and changing livelihoods (Bolton et al., 2011)
- interventions that incorporate community values and traditional healing practices (Kronstal, 2009)
- community-based methods for determining the impacts of trauma, especially consequences of the Canadian residential school system. More needs to be known about how residential school trauma is transferred inter-generationally
- ways in which individual and community resilience can be strengthened to support adaptation to change
- the variables that influence intimate partner violence (Moffitt et al., 2013).



Yukon River Inter-Tribal Watershed Council: *Hands Across the Waters*

The Yukon River Inter-Tribal Watershed Council (YRITWC) comprises representatives from over 70 First Nations and Tribes in the Yukon River basin. It assists these groups in protecting and improving the water quality of the Yukon River and all its tributaries. In August 2013, the First Nations (from Yukon and northern British Columbia) and Tribes (from Alaska) at the YRITWC's Biennial Summit approved a Yukon River Watershed Plan designed with exactly that purpose in mind. The plan combines the best of modern science and policy with the traditional knowledge of the Indigenous governments and people of the Yukon River, and includes specific, enforceable objectives and standards to protect the quality and quantity of the water in the river. The Watershed Plan is meant to assure that the Yukon River will continue to sustain the coming generations of all the people, fish, wildlife and plants of the Watershed.



Inuit Suicide

- the social determinants of Inuit suicide from epidemiological, socio-cultural and community-based perspectives (Lehti et al., 2009; Hicks, 2009; Sustainable Development Working Group, 2010; Cameron, 2011)
- the factors behind the higher prevalence of suicide among young Inuit men including research into the cultural and gender specific bases of suicide (Hicks, 2009; Sustainable Development Working Group, 2010; Cameron, 2011; Kral, 2012)
- the development, implementation and evaluation of community-driven and designed prevention interventions (Hicks 2009; Sustainable Development Working Group, 2010; Cameron 2011).

Education and Cultural Integrity

- comparative education research in the circumpolar Arctic (Johansson et al., 2004) and within Canada
- education policies and programs from research that has been co-designed and co-directed by Northerners (Blakesley, 2008; Inuit Tapiriit Kanatami, 2011)
- educational supports needed for Aboriginal student success (Lees et al., 2010), and the empirical evaluation of the impact of those supports (Friesen & Krauth, 2012)
- ways in which the engagement of parents and communities with schools can be increased through more evidence-based strategies (Friesen & Krauth, 2012; Ives et al., 2012)
- educational leadership, especially in the context of self-government agreements (Blakesley, 2008), including the documentation of experiences of Aboriginal educators and the barriers they face, as a basis for developing better training and professional supports (Lees et al., 2010; Blakesley, 2010)
- the development, implementation and evaluation of experiential learning pilot programs (e.g. land-based programs, etc.), especially those which target struggling students (Ives et al., 2012)
- the “causal effect of culturally-based instruction on academic outcomes” (Friesen & Krauth, 2012).

Fetal Alcohol Spectrum Disorder (FASD)

- the extent and prevalence of fetal alcohol spectrum disorder in the North (Pacey, 2009b; Ospina & Dennett, 2013) and ways in which impediments to diagnosis and treatment such as capacity and lack of resources can be overcome (Pacey, 2009b)
- the effectiveness of prevention and treatment programs through evaluations in order to inform future program design, life course trajectories and the associated implications for communities (Pacey, 2009b), and non-stigmatizing prevention therapies and care for women (Badry & Wight Felske, 2013b)
- more accurate estimates of prevalence of FASD in the criminal justice system through further data collection with screening (Popova et al., 2011)
- interventions which could help to rehabilitate offenders with FASD (Pacey, 2009b; Popova et al., 2011).

Physical Health: Knowledge is needed respecting

Tuberculosis

- ways in which health inequities can be reduced as an approach to lowering TB rates in northern populations (Orr, 2010b)
- the development of more culturally and contextually appropriate TB prevention, control and care programs (Inuit Tapiriit Kanatami, 2013), especially those focused on personal, family and socio-economic barriers to TB treatment adherence (Volmink & Garner, 2007; Orr, 2010b; Kulmann & Richmond, 2011).

Obesity

- health outcomes through cohort studies that examine obesity (Galloway et al., 2012).

Cancer

- the impacts of contaminants on the incidence of cancer especially through the collection of more comprehensive, long-term data on cancer rates (Cameron, 2013)
- the knowledge, attitudes and behaviour of Inuit with respect to cancer to inform ways in which cancer health literacy can be improved and to better engage Inuit in prevention and screening programs (Pauktuutit Inuit Women of Canada, 2013).

Lower Respiratory Tract Infections (LRTIs)

- the risk factors for lower respiratory tract infection hospitalizations among infants in Canada's North (Young et al., 2007). Further research is also needed to determine optimal measures to decrease rates of hospital admissions for lower respiratory tract infections in regions of the North that are experiencing high rates (Banerji et al., 2013).
- ways of enhancing the efficacy of tele-health to address respiratory diseases in remote communities (Wesche et al., 2011).



SakKijānginnatuk Nunalik: An integrated action plan for healthy homes in thriving Nunatsiavut communities

SakKijānginnatuk Nunalik is a Knowledge to Action plan for housing in Nunatsiavut that originates from the communities in the region and builds on a solid knowledge base. It is part of the broader Nunatsiavut Sustainable Communities Initiative, an inter-governmental, inter-departmental, multidisciplinary research program that aims to provide information and guidance for best practices and community sustainability in coastal subarctic environments. SakKijānginnatuk Nunalik will build and evaluate a pilot multi-unit residential dwelling tailored to the needs of Nunatsiavummiut—culturally relevant, affordable, energy efficient, technologically “smart”, and adapted to new climatic and environmental realities. The Knowledge to Action plan integrates expert knowledge of current housing challenges, local knowledge of housing needs and preferences, and professional knowledge of construction methods and materials in order to build modern healthy housing as a cornerstone of sustainable communities in Nunatsiavut. Equally important, the information gained will offer priceless lessons for future homes in other Arctic regions. This project was a winner of the 2013 Arctic Inspiration Prize.



Understanding Environmental Change through knowledge in the natural sciences

Overview

The polar regions are displaying the consequences of climatic warming more acutely than elsewhere in the world. This distinction makes northern Canada a prime location for the study of global warming and its implications for the planet. It also brings a degree of urgency to Canada's northern climate-related research so that the ecosystemic consequences of a warming North can be understood in time to develop and implement the appropriate adaptive responses. Canadian researchers at the federal, territorial, regional and university levels are providing leadership in this critical area while working cooperatively with other nations. This was demonstrated by our country's quarter billion dollar investment in International Polar Year (IPY), and by Canada's commitment to open a cutting-edge, world-class northern research station, CHARS, in Cambridge Bay, Nunavut in 2017.

Much scientific knowledge has been created in the seven years covered by this report. The period commences in 2007 with International Polar Year (IPY), the accomplishments of which were covered in the Polar Commission's 2012 *IPY Canadian Science Report: Highlights* (Canadian Polar Commission, 2012), as well as in a number of other reports and journal articles (e.g. Environment Canada, 2010; Fisheries and Oceans Canada, 2010a; Aboriginal Affairs and Northern Development Canada, 2012a; Kulkarni et al., 2012; Parlee & Furgal, 2012; Perrie et al., 2012; Derksen et al., 2012; Melling et al., 2012; Barber et al., 2012a & b; Tremblay et al., 2012b; Darnis et al., 2012; Henry et al., 2012; Ferguson et al., 2012). IPY, with its increased cooperation between scientists and communities, significantly improved our understanding of Canada's North, contributing greatly to predictive modeling and decision making. The international Working Groups of the Arctic Council, currently under Canada's leadership, continue to undertake collaborative research to better understand environmental change, the associated impacts and potential ways forward. As well, major interdisciplinary initiatives such as ArcticNet and the Beaufort Regional Environmental Assessment are working with local people to collaboratively advance our knowledge of Canada's Arctic marine and coastal environments. As successful as these initiatives have been, critical knowledge gaps remain. Unless they are addressed expeditiously, the consequences for northern ecosystems and northern communities could be severe and the costs to the country significant.

Recent Advances and Current Challenges

Cryosphere

- **Sea ice is changing:** The extent and duration of sea ice has been rapidly declining in recent years, with the 2012 minimum extent the lowest on satellite record (Arctic Monitoring and Assessment Program, 2012; National Snow and Ice Data Center, 2014). Projections now indicate that the Arctic Ocean will be almost ice-free during late summer by mid-century (Arctic Monitoring and Assessment Program, 2012).
- **Glaciers and ice caps are melting more rapidly:** The rate of glacier mass loss in the Canadian High Arctic has increased extensively since 2000 (Environment Canada, 2010; Sharp et al., 2012). These melting glaciers and ice caps may contribute as much freshwater to the Arctic Basin as the Greenland Ice Sheet (Wolken et al., 2013), with significant implications for ocean circulation and global climate (Arctic Monitoring and Assessment Program, 2012).
- **Permafrost is warming and losing integrity:** Analysis of long-term records indicates that permafrost is warming across almost all regions of northern Canada and the US, with greater warming in colder permafrost and in sites above treeline (Smith et al., 2010). For example, at Alert, Nunavut the rate of warming has been increasing since 2000, with permafrost temperatures in 2012 being the highest since measurements began in 1978 (Romanovsky et al., 2013). Widespread monitoring activities have contributed to a better understanding of the current thermal state of permafrost and the impact of environmental factors and substrate characteristics on permafrost integrity (Environment Canada, 2010; Smith et al., 2010; Bonnaventure et al., 2012; Throop et al., 2012).

Ocean and Marine Ecosystems

- **Changing ocean ecosystems:** An integrated assessment of the physical, chemical, and biological structure of sub-Arctic and Arctic waters found that ocean currents are shifting, non-Arctic species are encroaching, food webs are changing, and the ocean is acidifying (Fisheries and Oceans Canada, 2010a). Current and anticipated impacts of climate change on fish species include the northward migration of species, competition with invasive species, and changes in population size, distribution and recruitment (e.g. Reist et al., 2006; Prowse et al., 2009; Fisheries and Oceans Canada, 2010a; Chavarie et al., 2010).
- **Important ecological areas:** In order to support ecosystem-based management, ecologically and biologically significant areas (EBSAs) have been identified across Canadian waters (Paulic et al., 2009; Fisheries and Oceans Canada, 2010b, 2011 & 2013), with a detailed assessment of the Beaufort Sea (Cobb et al., 2008; Beaufort Sea Planning Office, 2009; Niemi et al., 2012). The Canadian Arctic Archipelago was noted as particularly significant given its multi-year ice, the high productivity of Lancaster Sound, and its association with the Northwest Passage (Fisheries and Oceans Canada, 2011).
- **Informing fisheries management:** In addition to the impacts of climate change, recent gains in knowledge regarding anthropogenic activities (e.g. van der Velden et al., 2013a & b), commercial fisheries (e.g. Dempson et al., 2008; Zeller et al., 2011), and subsistence fisheries (e.g. Roux et al., 2011; Felt et al., 2012) will help inform conservation and sustainable fishery management plans.
- **National maritime boundaries:** Recent seismic and bathymetric surveys have been undertaken to assist in defining the extended limits of Canada's continental shelf. This has significantly advanced our understanding of the sea floor and sub-sea geology of the Arctic Ocean, the product in many cases of cutting-edge joint international effort. This knowledge is needed for seeking international recognition of Canada's sovereign limits under the United Nations Convention on the Law of the Sea (UNCLOS), and in turn the rights to the related seabed resources as well as jurisdiction over scientific research within these limits (Foreign Affairs, Trade and Development Canada, 2012).

Terrestrial Ecosystems

- **Declining caribou populations:** Many populations of caribou and reindeer across the circum-Arctic have been in decline (Vors & Boyce, 2009), including most herds of migratory tundra caribou in Canada (Festa-Bianchet et al., 2011). Although tundra caribou populations fluctuate with multi-decadal cycles, changes in harvest technologies, climate change, and increases in industrial development and human presence are prompting concerns over the ability of populations to recover from the recent declines (Festa-Bianchet et al., 2011). Meanwhile, extensive gains in understanding of the diversity and impacts of caribou pathogens (Ducrocq et al., 2012; Forde et al., 2012; Hoar et al., 2012; Hoberg et al., 2012; Kutz et al., 2012) will be integral to informing management decisions.
- **Food webs and climate change:** The IPY project ArcticWOLVES has improved knowledge of the linkages within Arctic food webs (Gauthier & Berteaux [Eds.], 2011), enabling better predictions of climate change impacts on species. For example, climate change may increase goose populations via an expansion of suitable range, however this may be counteracted by mismatches in the dates of hatching and peak food quality, by increased polar bear predation, and by habitat loss due to permafrost degradation (Gauthier & Berteaux [Eds.], 2011).
- **Tundra shrub expansion:** There is widespread evidence of circum-Arctic vegetation change, and specifically an increase in deciduous shrubs (Hudson & Henry, 2009; Jia et al., 2009; Forbes et al., 2009; Elmendorf et al., 2012b; Epstein et al., 2012; Ropars & Boudreau, 2012; Tremblay et al., 2012a). As berry-producing plants get shaded out by taller shrubs, berry production may decline, with important implications for the health and culture of Northerners (Lévesque et al., 2012) and for wildlife habitats.

Pollutants and Contaminants

- **Pathways for impact:** Contaminant cycling, bio-accumulation, and human exposure is becoming better understood (Ancil [prepared by], 2008; Arctic Monitoring and Assessment Program, 2009a and 2011;



ArcticNet: Together, tackling the impacts and opportunities of the changing Canadian Arctic

Climate change and modernization are having significant impacts on the people and the ecosystems of the Canadian Arctic. ArcticNet, a Network of Centres of Excellence of Canada, is working with its partners in Canada's four Inuit regions—the Inuvialuit Settlement Region, Nunavut, Nunavik, and Nunatsiavut—as well as with stakeholders from the public, private, and government sectors, to focus its research efforts on priority issues for Canadians as they deal with today's challenges and opportunities.

As part of this ongoing effort, ArcticNet has released the first of four regional impact studies, Nunavik and Nunatsiavut: From Science to Policy. An Integrated Regional Impact Study (IRIS) of Climate Change and Modernization. The document, a synthesis of research results, makes recommendations to policy makers, highlighting key concerns for Canadians such as human health, safety and security, infrastructure vulnerability, and resource exploitation in the changing Canadian North.



Donaldson et al., 2010; Conservation of Arctic Flora and Fauna, 2010; Chan et al., 2012; Aboriginal Affairs and Northern Development Canada, 2012b; Northern Contaminants Program, 2012; Donaldson et al., 2013).

- **Increasing levels of some contaminants:** Mercury toxicity remains a major concern since the levels in certain Arctic species have continued to rise despite reduction in emissions from anthropogenic activities in some parts of the world over the past 30 years (Arctic Monitoring and Assessment Program, 2011).
- **Decreasing levels of many pollutants:** The levels of many persistent organic pollutants (POPs) in Arctic air and biota have been declining, in association with historic decreases in emissions (Arctic Monitoring and Assessment Program, 2009a; Muir & de Wit, 2010).

Monitoring

- **Large-scale regional initiatives:** Environmental monitoring and reporting at the territory level continues to provide baseline and trend information on climate and weather, air quality, snow and ice, vegetation, and marine, freshwater, and terrestrial fish and wildlife. This is helping to inform resource development activities and wildlife management through the Nunavut General Monitoring Plan (Nunavut General Monitoring Plan, 2012), the State of the Environment reports of the governments of the NWT and Yukon (Environment and Natural Resources – Government of the Northwest Territories, 2012; Environment Yukon – Government of Yukon, 2013), and the NWT Cumulative Impact Monitoring Program (Environment and Natural Resources – Government of the Northwest Territories, 2012).
- **Circum-Arctic initiatives:** Both on-going and recently established monitoring initiatives and networks are furthering understanding of the interconnected impacts of environmental change on wildlife and terrestrial ecosystems. Examples include the Arctic Council's Circumpolar Biodiversity Monitoring Program (CBMP) (Gill et al., 2008), the CircumArctic Rangifer Monitoring and Assessment Network (CircumArctic Rangifer Monitoring and Assessment Network, n.d.), the International Tundra Experiment (ITEX) (Elmendorf et al., 2012a), and the Arctic Program for Regional and International Shorebird Monitoring (Arctic PRISM) (Environment Canada, 2012).
- **Technological developments:** Enhanced ecological monitoring of federal parks and reserves across the North can be facilitated by new remote sensing protocols developed and tested under the ParkSPACE program from 2008-2012 (Natural Resources Canada, 2011; Parks Canada, 2012).
- **Community-based monitoring:** Some of the challenges and opportunities with respect to community-based monitoring are better understood (Huntington, 2008; Johnson et al., 2013).

Knowledge Gaps and Research Opportunities

Cryosphere: Further knowledge is needed respecting

- climate-vegetation-hydrology-permafrost relationships, feedback loops, and the broader ecosystem implications of warming permafrost (Arctic Monitoring and Assessment Program, 2012)
- subsurface carbon, methane and contaminant stores estimates and characterization in order to determine the potential for their release into the atmosphere as permafrost and seabeds warm, as well as the resulting feedbacks to the atmospheric carbon cycle (Smith et al., 2010; Arctic Monitoring and Assessment Program, 2012; Xu et al., 2013)
- socio-economic and environmental impacts of a changing cryosphere, including impacts on resource development, marine productivity, and northern lifestyles (Arctic Monitoring and Assessment Program, 2012)
- permafrost change and terrain instability through improved mapping and modeling to facilitate the development of adaptive management plans for communities.

Ocean and Marine Ecosystems: Further knowledge is needed respecting

- ocean-ice-atmosphere interactions and the effects on marine ecosystems to better predict future cryospheric change and implications for resource management, communities, and economies (Arctic Monitoring and Assessment Program, 2012; Council of Canadian Academies, 2012; National Science and Technology Council, 2013)

- long-term impacts of climate change, ocean acidification and invasive species on marine biodiversity, especially as they relate to ecosystem services and human health and well-being (Archambault et al., 2010; Council of Canadian Academies, 2012; Fisheries and Oceans Canada, 2012)
- fish life history traits and population trends (Felt & Natcher, 2011; Five Arctic Coastal States, 2013) and the cumulative impacts of climate change and anthropogenic activities (Conservation of Arctic Flora and Fauna, 2013) to inform sustainable fisheries management
- measures to enable and encourage the participation of coastal communities in marine management and governance (Council of Canadian Academies, 2012).

Terrestrial Ecosystems: Further knowledge is needed respecting

- changing ecosystem structure, including its nature, rate of change and associated implications. This includes changes in tundra vegetation and soil community composition (Callaghan et al., 2011; Elmendorf et al., 2012b; Henry et al., 2012), the boreal to tundra transition (Jia et al., 2009; Lévesque et al. 2012; Scheffer et al., 2012), and encroachment by southern species (Post et al., 2009; Hofgaard et al., 2012)
- reproductive timing, including the cues for breeding timing and the impacts of mismatches in reproduction and peak food resources on growth, survival, and recruitment to help manage wildlife populations and identify species at risk (Gauthier & Berteaux [Eds.], 2011)
- wildlife population sizes, trends, and geographic ranges of animals, and the impacts of habitat alteration and other ecological changes in order that rapid declines can be detected before populations become threatened. This data is presently lacking for caribou populations and is essential for the development of caribou and land-use management plans (Festa-Bianchet et al., 2011).

Pollutants and Contaminants: Further knowledge is needed respecting

- the effects of local sources of contaminants, such as fuel spills and abandoned mines (Northern Contaminants Program, 2014)
- how global climate and socio-economic changes affect emissions, movement and accumulation of contaminants in order to better predict environmental and human health impacts (Muir & de Wit, 2010; Stow et al., 2013)
- impacts of contaminants on human development and health including effects on physical, cognitive, behavioural, and emotional development from infancy through to adulthood, as well as implications for diabetes, cardiovascular disease, other chronic diseases, and immune system function (Donaldson et al., 2013)
- how people perceive and act upon information regarding contaminant risks, and how to best communicate contaminant information to a variety of audiences to mitigate human health risks (Donaldson et al., 2013).

Environmental Monitoring: There is a need to

- further develop and optimize monitoring networks with dedicated long-term funding to support their maintenance and operation in order to continue providing baseline and trend data to support sound decision-making in prioritized geographic areas. As well, better coordination is needed between site-based (e.g. research stations), regionally-based (e.g. programs based on regional areas or themes such as caribou herds), and remotely-based (e.g. satellite and aerial observing systems) research and monitoring systems to help integrate knowledge across these scales (Christensen et al., 2013)
- increase environmental baseline research for a range of ecosystem components through geographically broad and representative networks to inform decision-making (Conservation of Arctic Flora and Fauna, 2010 & 2013; Arctic Monitoring and Assessment Program, 2012), especially in areas where changes are occurring in the absence of adequate baseline data
- increase community involvement in monitoring through low-cost, low-maintenance and easy-to-deploy tools that can be used for outreach and capacity building by engaging stakeholders such as the northern colleges and community organizations (Post et al., 2009; Stow et al., 2013).



CHARS: Arctic Science and Technology: Building a Research Station in Canada's Arctic – the Canadian High Arctic Research Station

The Canadian High Arctic Research Station, or CHARS, is being built in Cambridge Bay, Nunavut and is a signature initiative of Canada's Northern Strategy.

Through a series of workshops, commissioned studies and reports, Aboriginal Affairs and Northern Development Canada has sought advice and engaged Inuit and other Northerners, members of the Cambridge Bay community, Aboriginal organizations, academia, government (federal and territorial) and the private sector. This broad range of scientific and institutional experience and geographic scope has informed the design of the infrastructure as well as the science and technology (S&T) research program that will be undertaken.

Acting on the proposed plans for CHARS, the Government of Canada announced an investment of \$142.4 million over six years for the construction, equipment, and fit-up of CHARS and an additional \$46.2 million over six years for the phase-in of its S&T program. As of 2018-2019, an additional \$26.5 million has been set aside for the ongoing program and operations of the station.

As Northerners are engaging more and more in cutting-edge S&T to address their needs and to adapt to the changing North, CHARS will provide a world-class hub that complements and that further strengthens the network of smaller regional research facilities across Canada's North.

The new station will strive to provide a suite of services including a technology development centre, a knowledge sharing centre, and advanced laboratories, such as a necropsy lab. Both the infrastructure and the S&T program will focus on the mandated themes of: Resource Development; Exercising Sovereignty; Strong and Healthy Communities; and Environmental Stewardship and Climate Change.



Concluding Observations

This report recognizes that Northerners have a central role in shaping their destinies and the destiny of their region, and this should apply to the research that underpins the policies and programs influencing those destinies. Thus, northern research experts and practitioners were consulted extensively from the outset of our work to ensure that northern views and values prevailed in this report. This consultation also helped to ensure that the research opportunities this report identifies are relevant to Northerners.

This report was guided by another principle important to effective “knowledge to action” research. That is the premise of the inter-related nature of all things. This is the basis of the four cross-cutting themes along which this report’s findings are organized. It is also the basis for these concluding observations. If research is to successfully address the challenges of Canada’s North, it must reflect the elegant complexity inherent in that North and in its peoples. In the highly differentiated world of science this demands conscious collaboration and deliberate cross-disciplinary effort. It also demands continued openness to Aboriginal ways of knowing. Especially in the North, traditional knowledge should not be viewed as supplementary to western science, but rather as a model of the very cross-cutting research values advocated throughout this report. The concluding observations of this report are intended to demonstrate those values.

The focus of the concluding observations is on ways in which northern capacity can be increased to support greater involvement of Northerners in research and decision-making. Numerous challenges are also faced by southern-based researchers when conducting research in the North. They include, but are not limited to establishing and maintaining relationships with communities; satisfying an array of permitting, research licensing and funding agency requirements; incorporating traditional knowledge; and securing adequate funding for all stages of the research process including consultation and dissemination of findings with Northern communities. While these are important challenges to address, they are outside of the scope of this report.

Preparing for Large-Scale Resource Development: Mitigating Impacts, Maximizing Benefits

Canada’s North has an enviable resource endowment providing diverse employment opportunities, with some of the highest skilled and semi-skilled wages in the country. The region’s resource development sector, however, continues to rely on southern-based workers to meet its labour requirements while Aboriginal Northerners who lack the requisite education and skills remain disproportionately unemployed or under-employed. This paradox illustrates perhaps the most significant resource development issue facing the region today: the job-readiness gap relating to the region’s Aboriginal peoples. Its causes are complex, rooted simultaneously in the region’s dual economy, educational and training methods, high school success rates, labour mobility, cultural norms, family and community structures, as well as social and personal circumstances.

These causal factors lend themselves well to cross-disciplinary, collaborative research responses integrating the specialized knowledge of cultural anthropologists, educational theorists, industry, workers and union officials, Aboriginal elders, community-based researchers, labour market analysts, adult educators, school boards and government. Cross-disciplinary synergies, difficult at first to realize, could launch more true-to-life, evidence-based, and perhaps more integrated solutions to the challenge of Aboriginal participation, including those which address the skills shortage. Northern society stands to gain significantly from the direct and indirect economic and fiscal benefits that those solutions imply.



WWF Canadian Arctic Program: Polar Bear sea-ice habitat—future scenarios in the Arctic Archipelago

Reductions in Arctic sea ice extent, thickness and duration have raised concerns about the long-term future of polar bears. The Arctic Archipelago is an important future refuge for ice-dependent species like the polar bear. The WWF has developed and funded an interdisciplinary research collaboration with the University of Alberta, McGill University and the Nunavut Department of Environment to investigate the potential future of polar bears in the Arctic Archipelago. WWF developed the concept, Nunavut Department of Environment provided their archive of polar bear location data, McGill University developed the sea ice projections (2006-2100), and University of Alberta contributed its polar bear ecology and habitat modeling expertise. By working together it is possible to model critical thresholds of habitat loss and the potential effects on polar bear distribution and populations. The results are anticipated to be beneficial in the development of long-term polar bear conservation and management.



Increasing Community Sustainability: Affordability

The geographic realities of the North make it a uniquely high-cost environment. This makes “affordability” one of the most fundamental challenges to the sustainability of communities in the region. The concept of affordability places cost of living in the multi-variant context of income and livelihood, economics, social economy, mobility, community infrastructure, access to health and social services, socio-cultural circumstances and wild game endowment.

Affordability is most critical in the region's smaller communities that are faced with higher transportation costs, lower incomes, remoteness from central services, diseconomies of scale, and lower levels of educational attainment. Further collaborative work can be helpful in identifying innovative ways to reduce the high cost of living, increase income levels, and optimize resources to support the sustainability of these smaller communities.

Climate change, with its impacts on community and transportation infrastructures and building integrity, imposes one of the most acute affordability challenges throughout the region now and in the foreseeable future. This is due to increased weather extremes and permafrost degradation that are among its consequences. These factors make improved modeling essential for the evidence-based plans, policies, programs, procedures and product development needed to avert the very significant affordability implications of climatic change for all northern communities. Effective mitigation calls for more research collaborations involving physical scientists, traditional knowledge practitioners, planners, building technologists and engineers in partnership with the communities affected by these changes.

Strengthening Resilience: Mental Wellness

The mental wellness of the North's Aboriginal peoples is critical to the region's vitality and success. Cultural dislocation, rapid social and economic change and a “colonial” past—epitomized in the residential school system—have left a legacy of dysfunction that by extension touches every Northerner. The issue of mental wellness manifests itself across all aspects of northern life: emotional, spiritual, physical health, educational, economic, familial, societal. It is evident in correctional facilities and in treatment centres across the North. Its common yet multi-variant roots and its inter-related consequences call for a more integrated approach to the research that will inform the various policies and programs intended to deal with this complex issue. This integrated approach must have a strong community base while responding to ethnographic, gender and age diversity.

In a more populous region, an issue of this magnitude might give rise to a special research institute integrating the work of psychologists, cultural anthropologists, shamans, educational theorists, curriculum professionals, political scientists, historians, language specialists, traditional healers, linguists, elders and experts in early childhood development, all vigilantly focused on the related objectives of cultural integrity, language preservation, empowerment, recovery, treatment and healing. In the absence of such an institution, the North and its sub-regions must find ways of mirroring this integrative research mode through pooled resources, enhanced communication, collaborative efforts and strong leadership. Aboriginal heritage, research and training institutes exist within the region, many of them concerned with healing; in addition, an Aboriginal mental wellness research network exists in southern Canada. These could form the collective nucleus around which a broader, rigorous, northern-oriented research effort could be built. At stake are human cultures and human potential, neither of which can be recovered once lost.

Also at stake, in the case of suicide, are human lives. The problem is particularly acute among Aboriginal youth, especially Inuit youth for whom suicide accounts for one half of all deaths (Oliver et al., 2012). That is 11 times the national average and twice the rate of First Nations' young people (Health Canada, 2013). Enhanced knowledge that could underpin a comprehensive suicide prevention strategy is urgently needed for the North incorporating strength, resilience and protective factors (McMaster Health Forum, 2012) and built on a variety of coordinated research foundations including comparative analysis of the influence of life events on suicide risk and an evidence-based assessment of culturally sensitive intervention models (Aboriginal Affairs and Northern Development Canada, 2012c). Ethnographic variables need to be considered to facilitate transferability across cultural lines. Collaborative and community-based approaches will be necessary, involving health workers, youth, psychologists, elders, doctors, nurses, public health educators and community leaders.

Understanding Environmental Change: Integrated, Long-term Monitoring

Sophisticated, high quality monitoring data is critical to our understanding of the causes and consequences of rapid environmental change in the North. It is also paramount if Northerners are to adapt their communities and diversify their livelihoods accordingly.

Current monitoring efforts in the North could benefit from greater coordination that encompasses a more global, long-term perspective to better generate outputs that have broader applicability. This suggests a need for more comprehensive, better organized, and integrated monitoring systems that:

- balance technical sophistication with community capabilities and values
- cover in an integrated manner the necessary continuum of spatial scales from site-based sampling to satellite-based remote sensing
- span a representative range of ecosystems and geographical regions
- serve the necessary breadth of interrelated research disciplines
- better capture data generated by resource development projects, and
- are sustainable to facilitate the collection of long-term data and observations.

Implementing well-structured, broader monitoring systems will produce more robust, meaningful, applicable, standardized data thereby enabling more reliable modeling.

Monitoring also needs to focus on community involvement through attention to community needs and values, the active engagement of community members and the incorporation of their unique local knowledge and perspectives. For research integrity purposes, this extends to their participation in developing, implementing, and evaluating monitoring programs. A local focus is also necessary if monitoring is to keep up with the real time, rapid rate of change on the ground. It is also required if Northerners, especially Aboriginal Northerners, are going to have faith in the products of that monitoring. Finally, community involvement can be a window on traditional knowledge and the additional dimensions that that form of knowledge can lend to physical and social sciences in the North.

Additional Observations: Northern Capacity Building

Input to this study by northern researchers and practitioners, corroborated by peer-reviewed and “grey” literature, signals a desire for more community-based, culturally relevant, and locally-driven research across the North. Increased northern capacity building can help in supporting greater involvement of Northerners in knowledge creation and research decision-making.

The increased empowerment of Northerners stemming in part from devolution, self-government agreements, and land claims obligations and conditions is changing the way in which governmental policy is developed and implemented. Strengthened capacity is also important in this regard. In some regions of the North where school attendance and educational attainment is low, collaborative research could inform strategies and programs to better engage and support students and their families. The following additional measures would stimulate increased northern involvement in northern knowledge creation:

- 1) Increased outreach, engagement and education support for Northern elementary and secondary students, teachers and boards of education
- 2) Increased levels and availability of targeted higher education based in the North, including additional college-based degree partnerships with southern institutions



Scotty Creek: Studying changing northern boreal landscapes

The integrative research program at Scotty Creek, a lowland site surrounded by black spruce and muskeg near Fort Simpson, Northwest Territories, exemplifies the importance of partnerships in northern research. There, scientists from university, federal and territorial agencies—with diverse expertise, interests, and objectives—are studying the landscape change that is occurring as discontinuous permafrost under the forest disappears rapidly due to climate warming. The hydrology and ecology is changing and affecting wildlife habitat, a major concern to neighbouring communities and First Nations. These local groups have become partners in the program's field research and planning. Regular consultations with local partners provide opportunities for exchange of information, advice and support, and these have enhanced the program's success at every stage. Scotty Creek represents one of Wilfrid Laurier University's key nodes in the NWT, contributing to a formal ten-year research and training partnership between Laurier and the territorial government.



- 3) The extension of eligibility for funding from the three federal funding agencies* to the region's public colleges, their affiliated research institutes and other qualified northern research establishments
- 4) Increased research partnerships involving Aboriginal governments and their affiliated research institutes
- 5) More field-based and other meaningful mentored research relationships
- 6) An examination of integrated capacity-building opportunities involving northern research institutes, southern-based research institutes and the nascent Canadian High Arctic Research Station (CHARS) and its pan-northern research program
- 7) Development of mechanisms and policies to nurture and expand the resident northern research community
- 8) Greater acknowledgement of the northern knowledge industry as a distinct economic sector with growth needs and income-generating potential.

Steps such as these would prompt increased northern ownership of northern research and the outcomes of that research. Additionally, it could infuse an already exemplary and dynamic research community with even greater energy and creativity, leveraging Canada to new heights of northern knowledge creation.

* The three federal funding agencies are a major source of research funding for post-secondary institutions in Canada. They include the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council (SSHRC). All research that is funded by the tri-agencies must be in accordance with the Agreement on the Administration of Agency Grants and Awards by Research Institution (see <http://science.gc.ca/default.asp?lang=En&n=56B87BE5-1>) and the Tri-Agency Framework: Responsible Conduct of Research (see <http://www.rcr.ethics.gc.ca/eng/policy-politique/framework-cadre/#2>).



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